MiCOM
P941, P943

Frequency Relays

P94x/EN M/F32

Software Version	12
Hardware Suffix	A or C

Technical Manual

CONTENTS

SAFETY SECTION

STANDARD SAFETY STATEMENTS AND EXTERNAL LABEL INFORMATION FOR SCHNEIDER ELECTRIC EQUIPMENT

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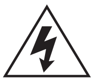
1. INTRODUCTION

This guide and the relevant equipment documentation provide full information on safe handling, commissioning and testing of this equipment. This Safety Guide also includes descriptions of equipment label markings.

Documentation for equipment ordered from Schneider Electric is despatched separately from manufactured goods and may not be received at the same time. Therefore this guide is provided to ensure that printed information which may be present on the equipment is fully understood by the recipient.

The technical data in this safety guide is typical only, see the technical data section of the relevant product publication(s) for data specific to a particular equipment.



Before carrying out any work on the equipment the user should be familiar with the contents of this Safety Guide and the ratings on the equipment's rating label.

Reference should be made to the external connection diagram before the equipment is installed, commissioned or serviced.

Language specific, self-adhesive User Interface labels are provided in a bag for some equipment.

2. HEALTH AND SAFETY

The information in the Safety Section of the equipment documentation is intended to ensure that equipment is properly installed and handled in order to maintain it in a safe condition.

It is assumed that everyone who will be associated with the equipment will be familiar with the contents of that Safety Section, or this Safety Guide.

When electrical equipment is in operation, dangerous voltages will be present in certain parts of the equipment. Failure to observe warning notices, incorrect use, or improper use may endanger personnel and equipment and also cause personal injury or physical damage.

Before working in the terminal strip area, the equipment must be isolated.

Proper and safe operation of the equipment depends on appropriate shipping and handling, proper storage, installation and commissioning, and on careful operation, maintenance and servicing. For this reason only qualified personnel may work on or operate the equipment.

Qualified personnel are individuals who:

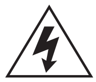
- Are familiar with the installation, commissioning, and operation of the equipment and of the system to which it is being connected;
- Are able to safely perform switching operations in accordance with accepted safety engineering practices and are authorised to energize and de-energize equipment and to isolate, ground, and label it;
- Are trained in the care and use of safety apparatus in accordance with safety engineering practices;
- Are trained in emergency procedures (first aid).

The equipment documentation gives instructions for its installation, commissioning, and operation. However, the manual cannot cover all conceivable circumstances or include detailed information on all topics. In the event of questions or specific problems, do not take any action without proper authorization. Contact the appropriate Schneider Electric technical sales office and request the necessary information.

3. SYMBOLS AND EXTERNAL LABELS ON THE EQUIPMENT

For safety reasons the following symbols and external labels, which may be used on the equipment or referred to in the equipment documentation, should be understood before the equipment is installed or commissioned.

3.1 Symbols

 Caution: refer to equipment documentation	 Caution: risk of electric shock
 Protective Conductor (*Earth) terminal	 Functional/Protective Conductor (*Earth) terminal. Note: This symbol may also be used for a Protective Conductor (Earth) Terminal if that terminal is part of a terminal block or sub-assembly e.g. power supply.

*NOTE: THE TERM EARTH USED THROUGHOUT THIS GUIDE IS THE DIRECT EQUIVALENT OF THE NORTH AMERICAN TERM GROUND.

3.2 Labels

See Safety Guide (SFTY/4L M/G11) for equipment labelling information.

4. INSTALLING, COMMISSIONING AND SERVICING

Equipment connections

Personnel undertaking installation, commissioning or servicing work for this equipment should be aware of the correct working procedures to ensure safety.

The equipment documentation should be consulted before installing, commissioning, or servicing the equipment.

Terminals exposed during installation, commissioning and maintenance may present a hazardous voltage unless the equipment is electrically isolated.

The clamping screws of all terminal block connectors, for field wiring, using M4 screws shall be tightened to a nominal torque of 1.3 Nm.

Equipment intended for rack or panel mounting is for use on a flat surface of a Type 1 enclosure, as defined by Underwriters Laboratories (UL).

Any disassembly of the equipment may expose parts at hazardous voltage, also electronic parts may be damaged if suitable electrostatic voltage discharge (ESD) precautions are not taken.

If there is unlocked access to the rear of the equipment, care should be taken by all personnel to avoid electric shock or energy hazards.

Voltage and current connections shall be made using insulated crimp terminations to ensure that terminal block insulation requirements are maintained for safety.

Watchdog (self-monitoring) contacts are provided in numerical relays to indicate the health of the device. Schneider Electric strongly recommends that these contacts are hardwired into the substation's automation system, for alarm purposes.

To ensure that wires are correctly terminated the correct crimp terminal and tool for the wire size should be used.

The equipment must be connected in accordance with the appropriate connection diagram.

Protection Class I Equipment

- Before energizing the equipment it must be earthed using the protective conductor terminal, if provided, or the appropriate termination of the supply plug in the case of plug connected equipment.
- The protective conductor (earth) connection must not be removed since the protection against electric shock provided by the equipment would be lost.
- When the protective (earth) conductor terminal (PCT) is also used to terminate cable screens, etc., it is essential that the integrity of the protective (earth) conductor is checked after the addition or removal of such functional earth connections. For M4 stud PCTs the integrity of the protective (earth) connections should be ensured by use of a locknut or similar.

The recommended minimum protective conductor (earth) wire size is 2.5 mm^2 (3.3 mm^2 for North America) unless otherwise stated in the technical data section of the equipment documentation, or otherwise required by local or country wiring regulations.

The protective conductor (earth) connection must be low-inductance and as short as possible.

All connections to the equipment must have a defined potential. Connections that are pre-wired, but not used, should preferably be grounded when binary inputs and output relays are isolated. When binary inputs and output relays are connected to common potential, the pre-wired but unused connections should be connected to the common potential of the grouped connections.

Before energizing the equipment, the following should be checked:

- Voltage rating/polarity (rating label/equipment documentation),
- CT circuit rating (rating label) and integrity of connections,
- Protective fuse rating,
- Integrity of the protective conductor (earth) connection (where applicable),
- Voltage and current rating of external wiring, applicable to the application.

Accidental touching of exposed terminals

If working in an area of restricted space, such as a cubicle, where there is a risk of electric shock due to accidental touching of terminals which do not comply with IP20 rating, then a suitable protective barrier should be provided.

Equipment use

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Removal of the equipment front panel/cover

Removal of the equipment front panel/cover may expose hazardous live parts, which must not be touched until the electrical power is removed.

UL and CSA/CUL Listed or Recognized equipment

To maintain UL and CSA/CUL Listing/Recognized status for North America the equipment should be installed using UL or CSA Listed or Recognized parts for the following items: connection cables, protective fuses/fuseholders or circuit breakers, insulation crimp terminals and replacement internal battery, as specified in the equipment documentation.

For external protective fuses a UL or CSA Listed fuse shall be used. The Listed type shall be a Class J time delay fuse, with a maximum current rating of 15 A and a minimum d.c. rating of 250 Vd.c., for example type AJT15.

Where UL or CSA Listing of the equipment is not required, a high rupture capacity (HRC) fuse type with a maximum current rating of 16 Amps and a minimum d.c. rating of 250 Vd.c. may be used, for example Red Spot type NIT or TIA.

Equipment operating conditions

The equipment should be operated within the specified electrical and environmental limits.

Current transformer circuits

Do not open the secondary circuit of a live CT since the high voltage produced may be lethal to personnel and could damage insulation. Generally, for safety, the secondary of the line CT must be shorted before opening any connections to it.

For most equipment with ring-terminal connections, the threaded terminal block for current transformer termination has automatic CT shorting on removal of the module. Therefore external shorting of the CTs may not be required, the equipment documentation should be checked to see if this applies.

For equipment with pin-terminal connections, the threaded terminal block for current transformer termination does NOT have automatic CT shorting on removal of the module.

External resistors, including voltage dependent resistors (VDRs)

Where external resistors, including voltage dependent resistors (VDRs), are fitted to the equipment, these may present a risk of electric shock or burns, if touched.

Battery replacement

Where internal batteries are fitted they should be replaced with the recommended type and be installed with the correct polarity to avoid possible damage to the equipment, buildings and persons.

Insulation and dielectric strength testing

Insulation testing may leave capacitors charged up to a hazardous voltage. At the end of each part of the test, the voltage should be gradually reduced to zero, to discharge capacitors, before the test leads are disconnected.

Insertion of modules and pcb cards

Modules and PCB cards must not be inserted into or withdrawn from the equipment whilst it is energized, since this may result in damage.

Insertion and withdrawal of extender cards

Extender cards are available for some equipment. If an extender card is used, this should not be inserted or withdrawn from the equipment whilst it is energized. This is to avoid possible shock or damage hazards. Hazardous live voltages may be accessible on the extender card.

External test blocks and test plugs

Great care should be taken when using external test blocks and test plugs such as the MMLG, MMLB and MiCOM P990 types, hazardous voltages may be accessible when using these. *CT shorting links must be in place before the insertion or removal of MMLB test plugs, to avoid potentially lethal voltages.

*Note: When a MiCOM P992 Test Plug is inserted into the MiCOM P991 Test Block, the secondaries of the line CTs are automatically shorted, making them safe.

Fiber optic communication

Where fiber optic communication devices are fitted, these should not be viewed directly. Optical power meters should be used to determine the operation or signal level of the device.

Cleaning

The equipment may be cleaned using a lint free cloth dampened with clean water, when no connections are energized. Contact fingers of test plugs are normally protected by petroleum jelly, which should not be removed.

5. DECOMMISSIONING AND DISPOSAL

De-commissioning

The supply input (auxiliary) for the equipment may include capacitors across the supply or to earth. To avoid electric shock or energy hazards, after completely isolating the supplies to the equipment (both poles of any dc supply), the capacitors should be safely discharged via the external terminals prior to de-commissioning.

Disposal

It is recommended that incineration and disposal to water courses is avoided. The equipment should be disposed of in a safe manner. Any equipment containing batteries should have them removed before disposal, taking precautions to avoid short circuits. Particular regulations within the country of operation, may apply to the disposal of the equipment.

6. TECHNICAL SPECIFICATIONS FOR SAFETY

Unless otherwise stated in the equipment technical manual, the following data is applicable.

6.1 Protective fuse rating

The recommended maximum rating of the external protective fuse for equipments is 16A, high rupture capacity (HRC) Red Spot type NIT, or TIA, or equivalent. Unless otherwise stated in equipment technical manual, the following data is applicable. The protective fuse should be located as close to the unit as possible.

CAUTION - **CTs must NOT be fused since open circuiting them may produce lethal hazardous voltages.**

6.2 Protective Class

IEC 60255-27: 2005 EN 60255-27: 2006	Class I (unless otherwise specified in the equipment documentation). This equipment requires a protective conductor (earth) connection to ensure user safety.

6.3 Installation Category

IEC 60255-27: 2005	Installation Category III (Overvoltage Category III):
EN 60255-27: 2006	Distribution level, fixed installation.
	Equipment in this category is qualification tested at 5 kV peak, 1.2/50 μs, 500 Ω, 0.5 J, between all supply circuits and earth and also between independent circuits.

6.4 Environment

The equipment is intended for indoor installation and use only. If it is required for use in an outdoor environment then it must be mounted in a specific cabinet or housing which will enable it to meet the requirements of IEC 60529 with the classification of degree of protection IP54 (dust and splashing water protected).

Pollution Degree - Pollution Degree 2 Altitude - Operation up to 2000m	Compliance is demonstrated by reference to safety standards.
IEC 60255-27:2005	
EN 60255-27: 2006	

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INTRODUCTION

Date:	**2008**
Hardware Suffix:	**A or C**
Software Version:	**12**
Connection Diagrams:	**10P94yxx (y = 1 or 3) (x = 01 to 06)**

CONTENTS

FIGURES

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1. MiCOM DOCUMENTATION STRUCTURE

The manual provides a functional and technical description of the MiCOM protection relay and a comprehensive set of instructions for the relay's use and application.

The section content is summarized below:

P94x/EN IT Introduction

A guide to the MiCOM range of relays and the documentation structure. General safety aspects of handling Electronic Equipment is discussed with particular reference to relay safety symbols. Also a general functional overview of the relay and brief application summary is given.

P94x/EN TD Technical Data

Technical data including setting ranges, accuracy limits, recommended operating conditions, ratings and performance data. Compliance with norms and international standards is quoted where appropriate.

P94x/EN GS Getting Started

A guide to the different user interfaces of the protection relay describing how to start using it. This section provides detailed information regarding the communication interfaces of the relay, including a detailed description of how to access the settings database stored within the relay.

P94x/EN ST Settings

List of all relay settings, including ranges, step sizes and defaults, together with a brief explanation of each setting.

P94x/EN OP Operation

A comprehensive and detailed functional description of all protection and non-protection functions.

P94x/EN AP Application Notes

This section includes a description of common power system applications of the relay, calculation of suitable settings, some typical worked examples, and how to apply the settings to the relay.

P94x/EN PL Programmable Logic

Overview of the programmable scheme logic and a description of each logical node. This section includes the factory default (PSL) and an explanation of typical applications.

P94x/EN MR Measurements and Recording

Detailed description of the relays recording and measurements functions including the configuration of the event and disturbance recorder and measurement functions.

P94x/EN FD Firmware Design

Overview of the operation of the relay's hardware and software. This section includes information on the self-checking features and diagnostics of the relay.

P94x/EN CM Commissioning

Instructions on how to commission the relay, comprising checks on the calibration and functionality of the relay.

P94x/EN MT Maintenance

A general maintenance policy for the relay is outlined.

P94x/EN TS Troubleshooting

Advice on how to recognize failure modes and the recommended course of action. Includes guidance on whom within Schneider Electric to contact for advice.

P94x/EN SC SCADA Communications

This section provides an overview regarding the SCADA communication interfaces of the relay. Detailed protocol mappings, semantics, profiles and interoperability tables are not provided within this manual. Separate documents are available per protocol, available for download from our website.

P94x/EN SG Symbols and Glossary

List of common technical abbreviations found within the product documentation.

P94x /EN IN Installation

Recommendations on unpacking, handling, inspection and storage of the relay. A guide to the mechanical and electrical installation of the relay is provided, incorporating earthing recommendations. All external wiring connections to the relay are indicated.

P94x /EN VH Firmware and Service Manual Version History

History of all hardware and software releases for the product.

2. INTRODUCTION TO MiCOM

MiCOM is a comprehensive solution capable of meeting all electricity supply requirements. It comprises a range of components, systems and services from Schneider Electric.

Central to the MiCOM concept is flexibility.

MiCOM provides the ability to define an application solution and, through extensive communication capabilities, integrate it with your power supply control system.

The components within MiCOM are:

– P range protection relays;

– C range control products;

– M range measurement products for accurate metering and monitoring;

– S range versatile PC support and substation control packages.

MiCOM products include extensive facilities for recording information on the state and behavior of the power system using disturbance and fault records. They can also provide measurements of the system at regular intervals to a control center enabling remote monitoring and control to take place.

For up-to-date information on any MiCOM product, visit our website:

www.schneider-electric.com

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3. PRODUCT SCOPE

The MiCOM P940 relays have been designed to provide protection against network disruption that causes the frequency to deviate from nominal system limits, as well as providing protection for generators running outside of normal frequency limits. The relay also offers automatic load restoration facilities once the system frequency has recovered after load shedding.

A comprehensive range of non-protection features are included to aid with power system diagnosis and fault analysis which can be accessed remotely from one of the relays serial communication options.

3.1 Functional overview

The P940 frequency relays contain a wide variety of protection features designed to provide protection against network disruption. All models have the same protection, control and monitoring features, with only the configuration of digital inputs and outputs providing any differentiation. The protection features available are summarized below:

- Frequency based protection with independent stages, each stage containing four elements.

f+t	[81U/81O]	nine (9) stages	–	frequency
f+df/dt	[81RF]	six (6) stages	–	frequency supervised rate of change of frequency
df/dt +t	[81R]	six (6) stages	–	rate of change of frequency
f+Df/Dt	[81RAV]	six (6) stages	–	frequency supervised average rate of change of frequency

Each element can be independently configured in all respects for use as an over/rising frequency element or an under/falling frequency element.

- Undervoltage protection [27] - Two stage, configurable as either phase to phase or phase to neutral measuring. Stage 1 may be selected as either IDMT or DT and stage 2 is DT only.
- Overvoltage protection [59] - Two stage, configurable as either phase to phase or phase to neutral measuring. Stage 1 may be selected as either IDMT or DT and stage 2 is DT only.
- Generator abnormal protection [81AB] - Four (4) independent bands for the protection of generators against prolonged abnormal frequency operation. Each band can be set for independent frequency and time settings.
- Load restoration - Load restoration stages (nine) for automatic load restoration. Each stage has independent time settings for restoration and holding band timers.
- Programmable scheme logic - Allows user defined protection and control logic to suit particular customer applications.

The following table details all protection functions with their associated ANSI symbols:

PROTECTION FUNCTIONS OVERVIEW		P941	P943
81U/81O	Under or over frequency (9-stage)	✓	✓
81R	Rate of Change of Frequency (ROCOF) (6-stage)	✓	✓
81RF	Frequency supervised Rate of Change of Frequency (6-stage)	✓	✓
81RAV	Frequency supervised Average Rate of Change of Frequency (6-stage)	✓	✓
27	Under voltage (2-stage)	✓	✓
59	Over voltage (2-stage)	✓	✓
81AB	Generator Abnormal Frequency protection (4-stage)	✓	✓
	Automatic frequency based load restoration (up to 6 stages)	✓	✓
	Programmable LED’s	8	8
	Digital inputs (order option)	8 to 16	16 to 32
	Output relays (order option)	7 to 15	14 to 30
	Front communication port (EIA(RS)232)	✓	✓
	Rear communication port (KBus/EIA(RS)485)	✓	✓
	Rear communication port (Optic instead of metallic for IEC60870-5-103 protocol only)	Option	Option
	Time synchronization port (IRIG-B)	Option	Option

The P940 relays support the following management functions in addition to the functions illustrated above.

- Measurement of all instantaneous & integrated values
- Trip circuit and coil supervision
- 4 Alternative setting groups
- Control inputs
- Programmable scheme logic
- Programmable allocation of digital inputs and outputs
- Sequence of event recording
- Comprehensive disturbance recording (waveform capture)
- Fully customizable menu texts
- Multi-level password protection
- Power-up diagnostics and continuous self-monitoring of relay

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Application overview

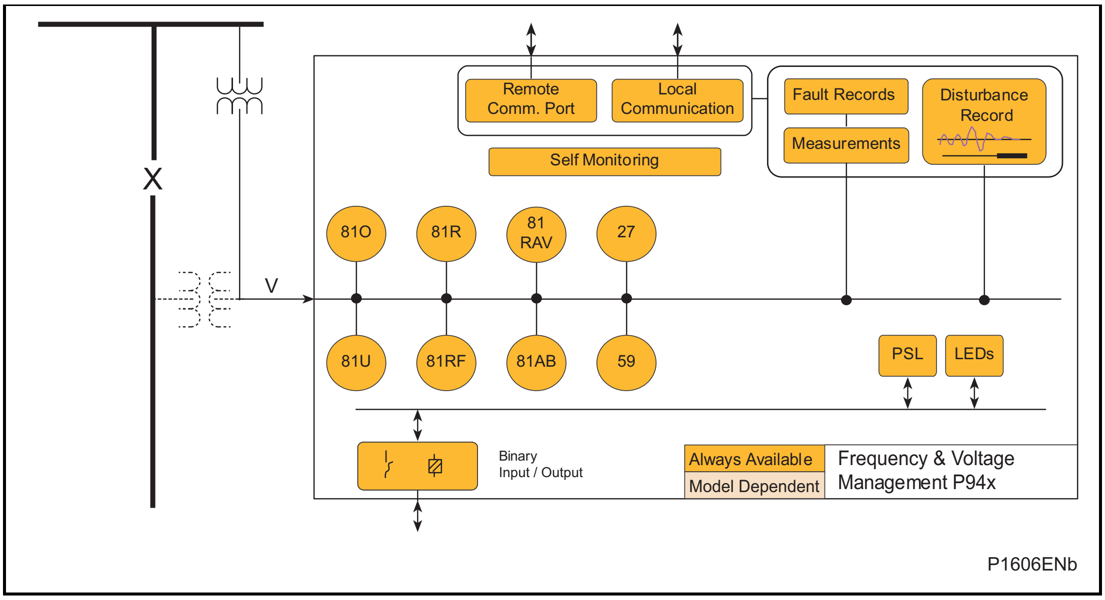

Figure 1: Functional diagram

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3.2 Ordering options

Information Required with Order

MiCOM P941 FREQUENCY LOAD SHEDDING RELAY NOMENCLATURE

Character Type (A=Alpha, N=Numeric, X=Alpha-numeric)

Character Numbering (Maximum = 15)

A	N	N	N	A	X	X	X	A	X	X	N	N	X	A
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
P	**9**	**4**	**1**	*****	*****	*****	*****	*****	**M**	**0**	*****	*****	**0**	*****

Vx Aux Rating

24 - 48 Vdc	1
48 - 110 Vdc, 30 - 100 Vac	2
110 - 250 Vdc, 100 - 240 Vac	3

Vn Rating

Vn = 100 - 120Vac	1
Vn = 380 - 480Vac	2

Hardware Options

Nothing	1
IRIG-B only	2
Fibre Optic Converter Only (IEC60870-5-103)	3
IRIG-B & Fibre Optic Converter (IEC60870-5-103)	4

Product Specific

Size 40TE Case, No Option (8 Optos + 7 Relays)	A
Size 40TE Case, 12 Optos + 11 Relays *	B
Size 40TE Case, 16 Optos + 7 Relays *	C
Size 40TE Case, 8 Optos + 15 Relays *	D

Protocol Options

K-Bus/Courier	1
MODBUS	2
IEC60870-5-103	3
DNP3.0	4

Mounting

Panel Mounting, Schneider Electric Livery	M

Software Version

Unless specified otherwise, the latest available software version will be provided.	XX

Design Suffix

Original Hardware	A
Enhanced Hardware	C

Note Design Suffix

A = Original hardware (48V opto inputs only, lower contact rating, no I/O expansion available)
C = Enhanced Hardware (Multi-rated "Universal" opto inputs, uprated output relays, inrush limited power supply)

* Not available in design suffix A relays

MiCOM P941 ACCESSORIES

			Please quote on order
Rack Frame (in accordance with IEC60297)			FX0021 001
Case to rack sealing gaskets are available to improve the overall IP rating of the panel (10 per order)			GN2044 001
M4 90° pre-insulated ring terminals:	Blue Red	– Wire size 1.04 – 2.63mm^2 (100 per order) – Wire size 1.04 – 2.63mm^2 (100 per order)	ZB9124 900 ZB9124 901
Secondary Cover, size 40TE			GN0037 001
Blanking Plates:	Size 10TE Size 20TE Size 30TE Size 40TE		GJ2028 002 GJ2028 004 GJ2028 006 GJ2028 008
Monitor/Download port test box containing 8 LEDs and switchable audible indicator			ZG1094 001

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MiCOM P943 FREQUENCY LOAD SHEDDING RELAY NOMENCLATURE

Character Type (A=Alpha, N=Numeric, X=Alpha-numeric)	A	N	N	N	A	X	X	X	A	X	X	N	N	X	A
Character Numbering (Maximum = 15)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	P	**9**	**4**	**3**	*****	*****	*****	*****	*****	**M**	**0**	*****	*****	**0**	*****

Vx Aux Rating

24 - 48 Vdc	1
48 - 110 Vdc, 30 - 100 Vac	2
110 - 250 Vdc, 100 - 240 Vac	3

Vn Rating

Vn = 100 - 120Vac	1
Vn = 380 - 480Vac	2

Hardware Options

Nothing	1
IRIG-B only	2
Fibre Optic Converter Only (IEC60870-5-103)	3
IRIG-B & Fibre Optic Converter (IEC60870-5-103)	4

Product Specific

Size 60TE Case, No Option (16 Optos + 14 Relays)	A
Size 60TE Case, 24 Optos + 14 Relays *	C
Size 60TE Case, 16 Optos + 22 Relays *	D
Size 60TE Case, 24 Optos + 22 Relays *	E
Size 60TE Case, 32 Optos + 14 Relays *	F
Size 60TE Case, 16 Optos + 30 Relays *	G

Protocol Options

K-Bus / Courier	1
MODBUS	2
IEC60870-5-103	3
DNP3.0	4

Mounting

Panel Mounting, Schneider Electric Livery	M

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Secondary Cover, size 60TE			GN0038 001
Blanking Plates:	Size 10TE Size 20TE Size 30TE Size 40TE		GJ2028 002 GJ2028 004 GJ2028 006 GJ2028 008
Monitor/Download port test box containing 8 LEDs and switchable audible indicator			ZG1094 001

TD

TECHNICAL DATA

Date:	**2008**
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Connection Diagrams:	**10P94yxx (y = 1 or 3) (x = 01 to 06)**

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Technical Data

Mechanical Specifications

Design
Modular MiCOM Px40 platform relay, P941-40TE (206mm (8")) case and P943-60TE (309.6mm (12")) case. Mounting is front of panel flush mounting, or 19" rack mounted (ordering options).

Enclosure Protection
Per IEC 60529: 1989
IP 52 Protection (front panel) against dust and dripping water.
IP 50 Protection for sides of the case.
IP 10 Protection for the rear.

Weight
Case 40TE (P941): approx. 5.4 kg
Case 60TE (P943): approx. 7.0 kg

Terminals

AC Voltage Measuring Inputs
Located on heavy duty (black) terminal block:
Threaded M4 terminals, for ring lug connection.

General Input/Output Terminals
For power supply, opto inputs, output contacts and COM1 rear communications.
Located on general purpose (grey) blocks:
Threaded M4 terminals, for ring lug connection.

Case Protective Earth Connection
Two rear stud connections, threaded M4.
Must be earthed (grounded) for safety, minimum earth wire size $2.5mm^2$.

Front Port Serial PC Interface
EIA(RS)232 DCE, 9 pin D-type female connector.
Courier protocol for interface to MiCOM S1 software.
Isolation to ELV level.
Maximum cable length 15m.

Front Download/Monitor Port
EIA(RS)232, 25 pin D-type female connector.
For firmware downloads.
Isolation to ELV level.

Rear Communications Port
EIA(RS)485 signal levels, two wire
Connections located on general purpose block, M4 screw.
For screened twisted pair cable, multi-drop, 1000m max.
For K-Bus, MODBUS, IEC-870-5-103, or DNP3.0 protocol (ordering options).
Isolation to SELV level.

Optional Rear IRIG-B Interface
BNC plug
Isolation to SELV level.
50 ohm coaxial cable.

Optional Rear Fiber Connection for SCADA/DCS
BFOC 2.5 -(ST®)-interface for glass fiber, as per IEC 874-10.
850nm short-haul fibers, one Tx and one Rx.
For IEC-870-5-103 protocol (ordering option).

TD

Ratings

AC Measuring Inputs
Nominal frequency: 50 and 60Hz (settable)
Operating range: 40 to 70Hz
Phase rotation: ABC

AC Voltage
Nominal voltage (Vn): 100 to 120 V or 380 to 480V phase-phase.
Nominal burden per phase:
< 0.02 VA at 110V (Vn = 100 - 120V),
< 0.15VA at 440V (Vn = 380 - 480V).
Thermal withstand:
continuous 2 Vn
for 10s: 2.6 Vn

Power Supply

Auxiliary Voltage (Vx)
Three ordering options:
(i) Vx: 24 to 48 Vdc
(ii) Vx: 48 to 110 Vdc, and 30 to 100Vac (rms)
(iii) Vx: 110 to 250 Vdc, and 100 to 240Vac (rms)

Operating Range
(i) 19 to 65V (dc only for this variant)
(ii) 37 to 150V (dc), 24 to 110V (ac)
(iii) 87 to 300V (dc), 80 to 265V (ac)
With a tolerable ac ripple of up to 12% for a dc supply, per IEC 60255-11: 1979.

Nominal Burden
Quiescent burden: 11W.

Additional burden for energized binary inputs/outputs on hardware suffix A relays:
Per opto input: 0.26W
Per energized output relay: 0.55W

Additional burden for energized binary inputs/outputs on hardware suffix C relays:
Per opto input:
0.09W (24 to 54V),
0.12W (110/125V),
0.19W (220/120V).
Per energized output relay: 0.13W

Power-up Time

Time to power up < 11s.

Power Supply Interruption

Per IEC 60255-11: 1979
The relay will withstand a 20ms interruption in the DC auxiliary supply, without de-energizing.
Per IEC 61000-4-11: 1994
The relay will withstand a 20ms interruption in an AC auxiliary supply, without de-energizing.

Battery Backup

Front panel mounted
Type ½ AA, 3.6V
Expected Life: >10 years (assuming relay energized for 90% of time)

Field Voltage Output

Regulated 48Vdc
Current limited at 112mA maximum output

Digital (“Opto”) Inputs

Digital (“Opto”) Inputs (Hardware Suffix A)

Opto inputs with fixed voltage threshold. May be energized from the 48V field voltage, or a 48V external battery supply.
Rated nominal voltage: 48Vdc
Operating range: 25 to 60Vdc
Withstand: 60Vdc.
Nominal pick-up and reset thresholds:
Pick-up: 25 to 60Vdc,
Reset: 0 to 12Vdc.
Recognition time:
<¾ cycle with half-cycle ac immunity filter on.

Digital (“Opto”) Inputs (Hardware Suffix C)

Universal opto inputs with programmable voltage thresholds. May be energized from the 48V field voltage, or the external battery supply.
Rated nominal voltage: 24 to 250Vdc
Operating range: 19 to 265Vdc
Withstand: 300Vdc.
Nominal pick-up and reset thresholds:
Pick-up: approx. 75% of battery nominal set,
Reset: approx. 64% of battery nominal set.
Recognition time:
<¾ cycle with half-cycle ac immunity filter on.

Output Contacts

Standard Contacts (Hardware Suffix A)

General purpose relay outputs for signaling, tripping and alarming:
Rated voltage: 300 V
Continuous current: 5 A
Short-duration current: 30 A for 3s
Making capacity: 250A for 30ms
Breaking capacity:
DC: 50W resistive
DC: 25W inductive (L/R = 40ms)
AC: 1250VA
Response to command: < 5ms
Durability:
Loaded contact: 10 000 operations minimum,
Unloaded contact: 100 000 operations minimum.

Standard Contacts (Hardware Suffix C)

General purpose relay outputs for signaling, tripping and alarming:
Rated voltage: 300 V
Continuous current: 10 A
Short-duration current: 30 A for 3s
Making capacity: 250A for 30ms
Breaking capacity:
DC: 50W resistive
DC: 62.5W inductive (L/R = 50ms)
AC: 2500VA resistive (cos ϕ = unity)
AC: 2500VA inductive (cos ϕ = 0.7)
Response to command: < 5ms
Durability:
Loaded contact: 10 000 operations minimum,
Unloaded contact: 100 000 operations minimum.

Watchdog Contacts

Non-programmable contacts for relay healthy/relay fail indication:
Breaking capacity:
DC: 30W resistive
DC: 15W inductive (L/R = 40ms)
AC: 375VA inductive (cos ϕ = 0.7)

Schneider Electric strongly recommends that these contacts are hardwired into the substation’s automation system, for alarm purposes.

IRIG-B Interface

External clock synchronization per IRIG standard 200-98, format B.
Input impedance 6kΩ at 1000Hz
Modulation ratio: 3:1 to 6:1
Input signal, peak-peak: 200mV to 20V

Environmental Conditions

Ambient Temperature Range
Per IEC 60255-6: 1988
Operating temperature range:
-25°C to +55°C (or -13°F to +131°F).
Storage and transit:
-25°C to +70°C (or -13°F to +158°F).

Ambient Humidity Range
Per IEC 60068-2-3: 1969:
56 days at 93% relative humidity and +40°C
Per IEC 60068-2-30: 1980:
Damp heat cyclic, six (12 + 12) hour cycles, 93% RH, +25 to +55°C

Type Tests

Insulation
Per IEC 60255-5: 2000,
Insulation resistance > 100MΩ at 500Vdc (Using only electronic/brushless insulation tester).

Creepage Distances and Clearances
Per EN 61010-1: 2001
Pollution degree 2,
Overvoltage category III,
Impulse test voltage 5 kV.

High Voltage (Dielectric) Withstand
EIA(RS)232 ports excepted.
(i) Per IEC 60255-5: 2000, 2 kV rms AC, 1 minute:
Between all case terminals connected together, and the case earth.
Also, between all terminals of independent circuits.
1kV rms AC for 1 minute, across open watchdog contacts.
1kV rms AC for 1 minute, across open contacts of changeover output relays.
(ii) Per ANSI/IEEE C37.90-1989 (reaffirmed 1994):
1.5 kV rms AC for 1 minute, across open contacts of changeover output relays.

Impulse Voltage Withstand Test
Per IEC 60255-5: 2000
Front time: 1.2 µs, Time to half-value: 50 µs,
Peak value: 5 kV, 0.5J
Between all terminals, and all terminals and case earth.

Electromagnetic Compatibility (EMC)

1 MHz Burst High Frequency Disturbance Test
Per IEC 60255-22-1: 1988, Class III,
Common-mode test voltage: 2.5 kV,
Differential test voltage: 1.0 kV,
Test duration: 2s, Source impedance: 200Ω
EIA(RS)232 ports excepted.

Immunity to Electrostatic Discharge
Per IEC 60255-22-2: 1996, Class 4,
15kV discharge in air to user interface, display, and exposed metalwork.
Per IEC 60255-22-2: 1996, Class 3,
8kV discharge in air to all communication ports.
6kV point contact discharge to any part of the front of the product.

Electrical Fast Transient or Burst Requirements
Per IEC 60255-22-4: 2002. Test severity Class III and IV:
Amplitude: 2 kV, burst frequency 5kHz (Class III),
Amplitude: 4 kV, burst frequency 2.5kHz (Class IV).
Applied directly to auxiliary supply, and applied to all other inputs. EIA(RS)232 ports excepted.

Surge Withstand Capability
IEEE/ANSI C37.90.1:2002:
4kV fast transient and 2.5kV oscillatory applied common mode and differential mode to opto inputs (filtered), output relays, CTs, VTs, power supply, field voltage.
4kV fast transient and 2.5kV oscillatory applied common mode to communications, IRIG- B.

Surge Immunity Test
EIA(RS)232 ports excepted.
Per IEC 61000-4-5: 2002 Level 4,
Time to half-value: 1.2/50 µs,
Amplitude: 4kV between all groups and case earth,
Amplitude: 2kV between terminals of each group.

Immunity to Radiated Electromagnetic Energy
Per IEC 60255-22-3: 2000, Class III:
Test field strength, frequency band 80 to 1000 MHz:
10 V/m,
Test using AM: 1 kHz / 80%,
Spot tests at 80, 160, 450, 900 MHz

Per IEEE/ANSI C37.90.2: 1995:
25MHz to 1000MHz, zero and 100% square wave modulated.
Field strength of 35V/m.

Radiated Immunity from Digital Communications
Per EN61000-4-3: 2002, Level 4:
Test field strength, frequency band 800 to 960 MHz, and 1.4 to 2.0 GHz:
30 V/m,
Test using AM: 1 kHz / 80%.

Radiated Immunity from Digital Radio Telephones
Per ENV 50204: 1995
10 V/m, 900MHz and 1.89GHz.

Test using 50% Duty Cycle, 200Hz ±2Hz keying frequency.

Immunity to Conducted Disturbances Induced by Radio Frequency Fields
Per IEC 61000-4-6: 1996, Level 3,
Disturbing test voltage: 10 V

Test using AM: 1kHz/80%

Power Frequency Magnetic Field Immunity
Per IEC 61000-4-8: 1994, Level 5,
100A/m applied continuously,
1000A/m applied for 3s.
Per IEC 61000-4-9: 1993, Level 5,
1000A/m applied in all planes.
Per IEC 61000-4-10: 1993, Level 5,
100A/m applied in all planes at 100kHz/1MHz with a burst duration of 2s.

Conducted Emissions
Per EN 55022: 1998:
0.15 - 0.5MHz, 79dBμV (quasi peak) 66dBμV (average)
0.5 - 30MHz, 73dBμV (quasi peak) 60dBμV (average).

Radiated Emissions
Per EN 55022: 1998:
30 - 230MHz, 40dBμV/m at 10m measurement distance
230 - 1GHz, 47dBμV/m at 10m measurement distance.

EU Directives

EMC Compliance
Per 89/336/EEC:
Compliance to the European Commission Directive on EMC is claimed via the Technical Construction File route. Product Specific Standards were used to establish conformity:
EN50263: 2000

Product Safety
Per 73/23/EEC:
Compliance with European Commission Low Voltage Directive.
Compliance is demonstrated by reference to generic safety standards:
EN61010-1: 2001
EN60950-1: 2002

Mechanical Robustness

Vibration Test
Per IEC 60255-21-1: 1996
Response Class 2
Endurance Class 2

Shock and Bump
Per IEC 60255-21-2: 1995
Shock response Class 2
Shock withstand Class 1
Bump Class 1

Seismic Test
Per IEC 60255-21-3: 1995
Class 2

Protection Functions

Over/Under Frequency ‘f+t’ Protection [81U/81O]

Accuracy
Pick-up: Setting±10mHz
Drop-off:
  Setting +20mHz, ±10mHz (underfrequency)
  Setting -20mHz, ±10mHz (overfrequency)
Operating timer:
  ±2% or 50ms whichever is greater

Operating & Reset Time
Operating time* (underfrequency):
  <100ms for Fs/Ff ratios less than 2
  <160ms for Fs/Ff ratios less than 6
  <230ms otherwise
Operating time* (overfrequency):
  <125ms for Fs/Ff ratios less than 2
  <150ms for Fs/Ff ratios less than 30
  <200ms otherwise
Reset time*: <200ms

* *Reference conditions: Tested using step changes in frequency with Freq.Av.Cycles setting = 0 and no intentional time delay. Fs/Ff ratios as stated, where:*
Fs = start frequency - frequency setting
Ff = frequency setting - end frequency

Frequency Supervised Rate of Change of Frequency ‘f+df/dt’ Protection [81RF]

Accuracy
Pick-up:
  Setting±10mHz (frequency threshold)
  Setting ±3% or ±10mHz/s, whichever is greater (df/dt threshold)
Drop-off (frequency threshold):
  Setting +20mHz, ±10mHz (underfrequency)
  Setting -20mHz, ±10mHz (overfrequency)
Drop-off (df/dt threshold, falling frequency):
  Setting +0.005Hz/s, ±10mHz/s
  (for settings between 0.01Hz/s and 0.1Hz/s)
  Setting +0.05Hz/s, ±5% or ±55mHz/s, whichever is greater
  (for settings greater than 0.1Hz/s)
Drop-off (df/dt threshold, rising frequency):
  Setting -0.005Hz/s, ±10mHz/s
  (for settings between 0.01Hz/s and 0.1Hz/s)
  Setting -0.05Hz/s, ±5% or ±55mHz/s, whichever is greater
  (for settings greater than 0.1Hz/s)

Operating & Reset Time
Instantaneous operating time:
  <125ms for Freq.Av.Cycles setting = 0
Reset time:
  <400ms for df/dt.Av.Cycles setting = 0

Independent Rate of Change of Frequency ‘df/dt+t’ Protection [81R]

Accuracy
Pick-up:
  Setting ±3% or ±10mHz/s, whichever is greater
Drop-off (falling frequency):
  Setting +0.005Hz/s, ±10mHz/s
  (for settings between 0.01Hz/s and 0.1Hz/s)
  Setting +0.05Hz/s, ±5% or ±55mHz/s, whichever is greater
  (for settings greater than 0.1Hz/s)
Drop-off (rising frequency):
  Setting -0.005Hz/s, ±10mHz/s
  (for settings between 0.01Hz/s and 0.1Hz/s)
  Setting -0.05Hz/s, ±5% or ±55mHz/s, whichever is greater
  (for settings greater than 0.1Hz/s)
Operating timer:
  ±2% or 50ms whichever is greater

Operating & Reset Time
Operating time*:
  <200ms for ramps 2x setting or greater
  <300ms for ramps 1.3x setting or greater
Reset time*: <250ms

* *Reference conditions: Tested with df/dt.Av.Cycles setting = 0, for df/dt settings greater than 0.1Hz/s (positive or negative, as relevant) and no intentional time delay.*

Average Rate of Change of Frequency ‘f+Df/Dt’ Protection [81RAV]

Accuracy
Pick-up:
  Setting±10mHz (frequency threshold)
  Setting ±0.1Hz/s (Df/Dt threshold)*
Drop-off:
  Setting +20mHz, ±10mHz (falling frequency)
  Setting -20mHz, ±10mHz (rising frequency)
Operating timer:
  ±2% or 30ms whichever is greater

* *Reference conditions: To maintain accuracy the minimum time delay setting, Dt, should be:*
Dt > 0.375xDf + 0.23 (for Df setting < 1Hz)
Dt > 0.156xDf + 0.47 (for Df setting ≥ 1Hz)

Operating Time
Typically <125ms with Freq.Av.Cycles = 0

TD

Generator Abnormal Protection [81AB]

Accuracy
Pick-up: Setting±10mHz
Drop-off:
Setting +20mHz, ±10mHz (band upper limit)
Setting -20mHz, ±10mHz (band lower limit)
Operating timer: ±3% of setting

Load Restoration

TD

Accuracy
Pick-up: Setting±10mHz
Drop-off: Setting -20mHz, ±10mHz
Restoration timer:
±2% or 50ms whichever is greater
Holding timer:
±2% or 50ms whichever is greater

Under Voltage Protection [27]

Accuracy
Pick-up: Setting ±1%
Drop-off: 1.02 x Setting ±1%
IDMT shape*:
±2% or 50ms whichever is greater
DT operation:
±1% or 20ms whichever is greater

Operating & Reset Time
Instantaneous Operating Time: <60ms
Reset: <75ms
* *Reference conditions TMS = 1, and applied voltages less than 0.95x setting*

Over Voltage Protection [59]

Accuracy
Pick-up: Setting ±1%
Drop-off: 0.98 x Setting ±1%
IDMT shape*:
±1% or 70ms whichever is greater for voltages > 1.05 x setting
DT operation:
±1% or 20ms whichever is greater

Operating & Reset Time
Instantaneous Operating Time: <50ms
Reset: <75ms
* *Reference conditions TMS = 1, and applied voltages greater than 1.05x setting*

Undervoltage Blocking

Accuracy
Pick-up: Setting ±1%
Drop-off: 1.05 x Setting ±1%

Operating & Reset Time
Operating Time: <40ms, but always fast enough to block protection elements
Reset: <110ms

Programmable Scheme Logic

Accuracy
Output conditioner timer: Setting ±2% or 50ms whichever is greater
Dwell conditioner timer: Setting ±2% or 50ms whichever is greater
Pulse conditioner timer: Setting ±2% or 50ms whichever is greater

Measurements and Recording Facilities

Measurements
Voltage: 0.05…2Vn
Accuracy: ±1.0% of reading
Phase accuracy: 0°…360°
Accuracy: ±0.5%°
Frequency: 45…65Hz
Accuracy: ±0.01Hz

IRIG-B & Real Time Clock Performance
Year 2000: Compliant
Real time clock accuracy: <±2% seconds/day
Modulation ratio: 1/3 or 1/6
Input signal peak-peak amplitude:
200mV…20V
Input impedance at 1000Hz:
6000Ω
External clock synchronization:
Conforms to IRIG standard 200-98, format B

Disturbance Records

Accuracy
Magnitude and relative phases:
±5% of applied quantities
Duration: ±2%
Trigger position: ±2% (minimum Trigger 100ms)

Settings, Measurements and Records List

Settings List

Global Settings (System Data)

Language: English/French/German/Spanish
Frequency: 50/60Hz

Date and Time

IRIG-B Sync.: Disabled/Enabled
Battery Alarm: Disabled/Enabled

Configuration

Setting Group:
Select via Menu
Select via Opto
Active Settings: Group 1/2/3/4
Setting Group 1: Disabled/Enabled
Setting Group 2: Disabled/Enabled
Setting Group 3: Disabled/Enabled
Setting Group 4: Disabled/Enabled
Load Restoration: Disabled/Enabled
Genr Abn Protn: Disabled/Enabled
Volt Protection: Disabled/Enabled
Input Labels: Invisible/Visible
Output Labels: Invisible/Visible
CT & VT Ratios: Invisible/Visible
Record Control: Invisible/Visible
Disturb Recorder: Invisible/Visible
Measure't Setup: Invisible/Visible
Comms Settings: Invisible/Visible
Commission Test: Invisible/Visible
Setting Values: Primary/Secondary
Control Inputs: Invisible/Visible

CT and VT Ratios

Main VT Primary: 100V...1MV
Main VT Sec'y: 80...140V

Sequence of Event Recorder (Record Control)

Alarm Event: Disabled/Enabled
Relay O/P Event: Disabled/Enabled
Opto Input Event: Disabled/Enabled
General Event: Disabled/Enabled
Fault Rec. Event: Disabled/Enabled
Maint. Rec. Event: Disabled/Enabled
Protection Event: Disabled/Enabled
DDB 31 - 0: *(up to):*
DDB 1022 - 992:
Binary function link strings, selecting which DDB signals will be stored as events, and which will be filtered out.

Oscillography (Disturb. Recorder)

Duration: 0.10…10.50s
Trigger Position: 0.0…100.0%
Trigger Mode: Single/Extended
Analog Channel 1: *(up to):*
Analog Channel 4:
Disturbance channels selected from:
VA/VB/VC/Frequency
Digital Input 1: *(up to):*
Digital Input 32:
Selected binary channel assignment from any DDB status point within the relay (opto input, output contact, alarms, starts, trips, controls, logic…).
Input 1 Trigger: No Trigger/Trigger L/H/Trigger H/L
(up to):
Input 32 Trigger: No Trigger/Trigger L/H/Trigger H/L

Measured Operating Data (Measure't. Setup)

Default Display:
3Ph Voltage
Date and Time
Description
Plant Reference
Frequency
Access Level
Local Values: Primary/Secondary
Remote Values: Primary/Secondary
Measurement Ref: VA/VB/VC

Communications

Rear Protocol:
Courier
MODBUS
IEC870-5-103
DNP 3.0
Remote Address: *(Courier or IEC870-5-103):*
0…255
Remote Address: *(MODBUS):*
0…247
Remote Address: *(DNP3.0):*
0…65519
InactivTimer: 1…30mins
Baud Rate: *(MODBUS):*
9600 bits/s
19200 bits/s
38400 bits/s
Baud Rate: *(IEC870-5-103):*
9600/19200 bits/s
Baud Rate: *(DNP3.0):*
1200 bits/s
2400 bits/s
4800 bits/s
9600 bits/s
19200 bits/s
38400 bits/s
Parity: *(MODBUS or DNP3.0)*
Odd/Even/None

TD

*MODBUS IEC Time: *(MODBUS only)*
Standard
Reverse
Measure't Period: *(IEC870-5-103 only)*
1…60s
Physical Link: *(IEC870-5-103 only)*
RS485
Fiber Optic
Function Type: *(IEC870-5-103 only)*
0…255
Time Sync: *(DNP3.0 only)*
Disabled/Enabled
* *The MODBUS IEC Time setting is only available on software version 11.*

Commission Tests

Monitor Bit 1:
(up to):
Monitor Bit 8:
Binary function link strings, selecting which DDB signals have their status visible in the Commissioning menu, for test purposes
Test Mode:
Disabled
Test Mode
Blocked Contacts
Test Pattern:
Configuration of which output contacts are to be energized when the contact test is applied.

Optocoupled Binary Inputs (Opto Config.)*

Global threshold:
24 - 27V
30 - 34V
48 - 54V
110 - 125V
220 - 250V
Custom
Opto Input 1:
(up to):
Opto Input #. *(# = max. opto no. fitted):*
Custom options allow independent thresholds to be set per opto, from the same range as above.
* *These settings are only available if the relay is fitted with universal opto inputs (hardware suffix C).*

Settings in Multiple Groups

Note: All settings here onwards apply for setting groups # = 1 to 4.

Protection Functions

Common Settings

V<B Status:
Disabled
Enabled
V<B Voltage Set:
20…120V for Vn = 100 – 120Vac
80…480V for Vn = 380 – 440Vac
V<B Measur Mode*:
Phase - Phase
Phase - Neutral
V<B Operat Mode*
Any Phase
Three Phase
Freq.Av.Cycles:
0…12 (for software version 10)
0…48 (for software version 11)
df/dt.Av.Cycles:
0…12 (for software version 10)
0…48 (for software version 11)
Holding Timer: 1…300s
* *These settings are only available on software version 11.*

Over/Under Frequency Protection (f+t [81U/81O])

Stage 1 f+t Status:
Disabled
Enabled
1 (f+t) f: 40.00…70.00Hz
1 (f+t) t: 0.00…100.00s
Stage 2 f+t Status
(up to):
9 (f+t)t
All settings and options chosen from the same ranges as per the first stage over/underfrequency, Stage 1 f+t.

Frequency Supervised Rate of Change of Frequency Protection (f+df/dt [81RF]

Stage 1 f+df/dt Status:
Disabled
Enabled
1 (f+df/dt) f: 40.00…70.00Hz
1 (f+df/dt) df/dt:
0.1…10.0Hz/s (for software version 10)
0.01…10.0Hz/s (for software version 11)
Stage 2 f+df/dt Status
(up to):
6 (f+df/dt) df/dt
All settings and options chosen from the same ranges as per the first stage frequency supervised rate of change of frequency, Stage 1 f+df/dt.

Independent Rate of Change of Frequency Protection (df/dt+t [81R])

For software version 10, the following settings are applicable:

Stage 1 df/dt+t Status:
  Disabled
  Enabled
1 (df/dt+t) df/dt: -10.0…+10.0Hz/s
1 (df/dt+t) t: 0.00…100.00 s
Stage 2 df/dt+t Status
  (up to):
6 (df/dt+t) t
  All settings and options chosen from the same ranges as per the first stage independent rate of change of frequency, Stage 1 df/dt+t.

For software version 11, the following settings are applicable:

Stage 1 df/dt+t Status:
  Disabled
  Negative
  Positive
1 (df/dt+t) df/dt: 0.01…10.00Hz/s
1 (df/dt+t) t: 0.00…100.00 s
Stage 2 df/dt+t Status
  (up to):
6 (df/dt+t) t
  All settings and options chosen from the same ranges as per the first stage independent rate of change of frequency, Stage 1 df/dt+t.

Average Rate of Change of Frequency Protection (f+Df/Dt [81RAV])

Stage 1 f+Df/Dt Status:
  Disabled
  Enabled
1 (f+Df/Dt) f: 40.00…70.00Hz
1 (f+Df/Dt) Df: 0.2…10.0Hz
1 (f+Df/Dt) Dt: 0.02…2.00 s
Stage 2 f+Df/Dt Status
  (up to):
6 (f+Df/Dt) Dt
  All settings and options chosen from the same ranges as per the first stage average rate of change of frequency, Stage 1 f+Df/Dt.

Generator Abnormal Protection (Genr Abn [81AB])

Band1 Freq.Low: 40.00…70.00Hz
Band1 Freq.High: 40.00…70.00Hz
Band1 Delay: 0.0…999.0
Band2 Freq.Low
  (up to):
Band4 Delay
  All settings and options chosen from the same ranges as per the first stage generator abnormal protection.
Time Units: Minutes/Hours

Load Restoration

Restore1 Status:
  Disabled
  Enabled
Restore1 Freq.: 40.00…70.00Hz
Restore1 Time: 0…7200s
Restore2 Status
  (up to):
Restore9 Time
  All settings and options chosen from the same ranges as per the first stage load restoration, Restore1.

Under/Over Voltage Protection (Volt Prot [27/59])

Undervoltage

V< Measure't Mode:
  Phase-Phase
  Phase-Neutral
V< Operate Mode:
  Any Phase
  Three Phase
V<1 Function:
  Disabled
  DT
  IDMT
V<1 Voltage Set:
  10…120V for Vn = 100 - 120Vac
  40…480V for Vn = 380 - 440Vac
V<1 Time Delay: 0.00…100.00s
V<1 TMS: 0.5…100.0
V<2 Status:
  Disabled
  Enabled
V<2 Voltage Set:
  10…120V for Vn = 100 – 120Vac
  40…480V for Vn = 380 – 440Vac
V<2 Time Delay: 0.00…100.00s

Overvoltage

V> Measure't Mode:
  Phase-Phase
  Phase-Neutral
V> Operate Mode:
  Any Phase
  Three Phase
V>1 Function:
  Disabled
  DT
  IDMT
V>1 Voltage Set:
  60…185V for Vn = 100 - 120Vac
  240…740V for Vn = 380 - 440Vac
V>1 Time Delay: 0.00…100.00s
V>1 TMS: 0.5…100.0
V>2 Status:
  Disabled
  Enabled
V>2 Voltage Set:
  60…185V for Vn = 100 - 120Vac
  240…740V for Vn = 380 - 440Vac
V>2 Time Delay: 0.00…100.00s

TD

TD

Opto Input Labels

Opto Input 1:

(up to):

Opto Input 24:

User defined text string to describe the function of the particular opto input.

Output Labels

Relay 1:

(up to):

Relay 32:

User defined text string to describe the function of the particular relay output contact.

Measurements List

Measurements 1

Vφ-φ Magnitude

Vφ-φ Phase Angle

Vφ Magnitude

Vφ Phase Angle

All phase-phase and phase-neutral voltages (φ = A, B, C)

V1 Magnitude.

V2 Magnitude

V0 Magnitude

Vφ RMS

All phase-neutral voltages (φ = A, B, C)

Frequency

V1 Magnitude

V1 Phase Angle

V2 Magnitude

V2 Phase Angle

V0 Magnitude

V0 Phase Angle

Stage Statistics

StgX f+t Sta

StgX f+t Trip

StgX f+df/dt Trp

StgX df/dt+t Sta

StgX df/dt+t Trp

StgX f+Df/Dt Sta

StgX f+Df/Dt Trp

StgX Revn Date

(X = 1, 2, 3, 4, 5, 6)

Genr Abn Timers

Freq. Band1 Timer

Freq. Band2 Timer

Freq. Band3 Timer

Freq. Band4 Timer

Fault Record Proforma

The following data is recorded for any relevant elements that operated during a fault, and can be viewed in each fault record.

Time & Date

Event Text

Event Value

Select Fault: [0...n]

f+t Start

1 2 3 4 5 6 7 8 9

df/dt+t Start

1 2 3 4 5 6

f+Df/Dt Start

1 2 3 4 5 6

V<1 Start

A B C 3

V<2 Start

A B C 3

V>1 Start

A B C 3

V>2 Start

A B C 3

Gen Abn Start

1 2 3 4

f+t Trip

1 2 3 4 5 6 7 8 9

f+df/dt Trip

1 2 3 4 5 6

df/dt+t Trip

1 2 3 4 5 6

f+Df/Dt Trip

1 2 3 4 5 6

V<1 Trip

A B C 3

V<2 Trip

A B C 3

V>1 Trip

A B C 3

V>2 Trip

A B C 3

Gen Abn Trip

1 2 3 4

Start Elements:

Trip Elements:

Binary data strings for fast polling of which protection elements started or tripped for the fault recorded.

Date & Time:

Active Group: 1/2/3/4

System Frequency: Hz

VAB

VBC

VCA

Df/dt

GS

GETTING STARTED

Date:	**2008**
Hardware Suffix:	**A or C**
Software Version:	**12**
Connection Diagrams:	**10P94yxx (y = 1 or 3) (x = 01 to 06)**

GS

CONTENTS

FIGURES

1. GETTING STARTED

1.1 User interfaces and menu structure

The settings and functions of the MiCOM protection relay can be accessed both from the front panel keypad and LCD, and via the front and rear communication ports. Information on each of these methods is given in this section to describe how to start using the relay.

1.2 Introduction to the relay

1.2.1 Front panel

The front panel of the relay is shown in Figure 1, with the hinged covers at the top and bottom of the relay shown open. Extra physical protection for the front panel can be provided by an optional transparent front cover. With the cover in place read only access to the user interface is possible. Removal of the cover does not compromise the environmental withstand capability of the product, but allows access to the relay settings. When full access to the relay keypad is required, for editing the settings, the transparent cover can be unclipped and removed when the top and bottom covers are open. If the lower cover is secured with a wire seal, this will need to be removed. Using the side flanges of the transparent cover, pull the bottom edge away from the relay front panel until it is clear of the seal tab. The cover can then be moved vertically down to release the two fixing lugs from their recesses in the front panel.

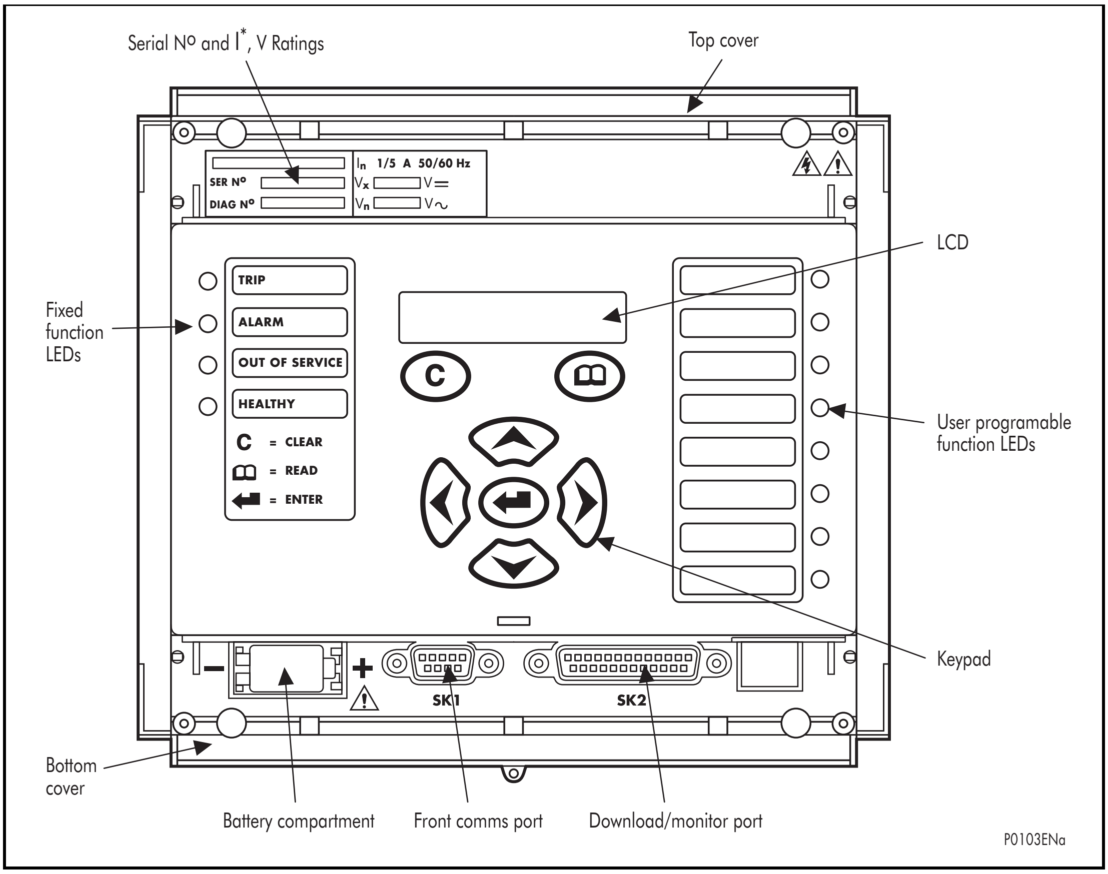

Figure 1: Relay front view

The front panel of the relay includes the following, as indicated in Figure 1:

– a 16-character by 2-line alphanumeric liquid crystal display (LCD)

– a 7-key keypad comprising 4 arrow keys (, , and), an enter key (), a clear key (), a read key ()

– 12 LEDs; 4 fixed function LEDs on the left hand side of the front panel and 8 programmable function LEDs on the right hand side

- Under the top hinged cover:
  - The relay serial number, and the relay's current and voltage rating information∗
- Under the bottom hinged cover:
  - Battery compartment to hold the 1/2 AA size battery which is used for memory back-up for the real time clock, event, fault and disturbance recordsA 9-pin female D-type front port for communication with a PC locally to the relay (up to 15m distance) via an EIA(RS)232 serial data connection
  - A 25-pin female D-type port providing internal signal monitoring and high speed local downloading of software and language text via a parallel data connection

1.2.1.1 LED indications

Fixed Function

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The 4 fixed function LEDs on the left-hand side of the front panel are used to indicate the following conditions:

Trip (Red) indicates that the relay has issued a trip signal. It is reset when the associated fault record is cleared from the front display. (Alternatively the trip LED can be configured to be self-resetting)*.

Alarm (Yellow) flashes to indicate that the relay has registered an alarm. This may be triggered by a fault, event or maintenance record. The LED will flash until the alarms have been accepted (read), after which the LED will change to constant illumination, and will extinguish, when the alarms have been cleared.

Out of service (Yellow) indicates that the relay's protection is unavailable.

Healthy (Green) indicates that the relay is in correct working order, and should be on at all times. It will be extinguished if the relay's self-test facilities indicate that there is an error with the relay's hardware or software. The state of the healthy LED is reflected by the watchdog contact at the back of the relay.

Programmable LEDs

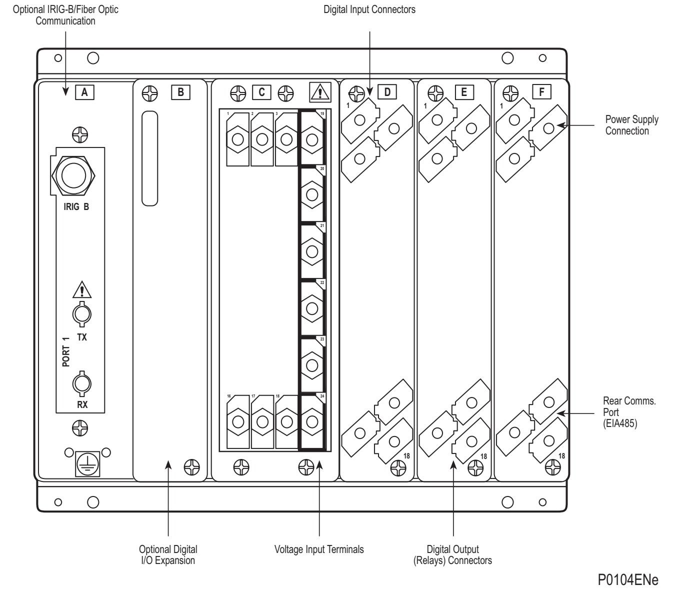
The 8 programmable LEDs on the right-hand side are suitable for alarm and trip indications as required by the user. Their functionality is assigned in the Programmable Scheme Logic (PSL) of the relay and can be latched or self-resetting. All of these LEDs are red when energized and the default mapping for the P940 relays are shown below:

LED Number	**Assignment**	
	P941	**P943**
1	Any Stage 1 Frequency Start	Any Stage 1 Frequency Start
2	Any Stage 2 Frequency Start	Any Stage 2 Frequency Start
3	Any Stage 3 Frequency Start	Any Stage 3 Frequency Start
4	Any Stage 4 Frequency Start	Any Stage 4 Frequency Start
5	Any Stage 5 Frequency Start	Any Stage 5 Frequency Start
6	Any Voltage Start	Any Voltage Start
7	Any Voltage Trip	Stage 1 or Stage 2 Load Restoration
8	Undervoltage Block Active	Undervoltage Block Active

∗ Device type and model dependent

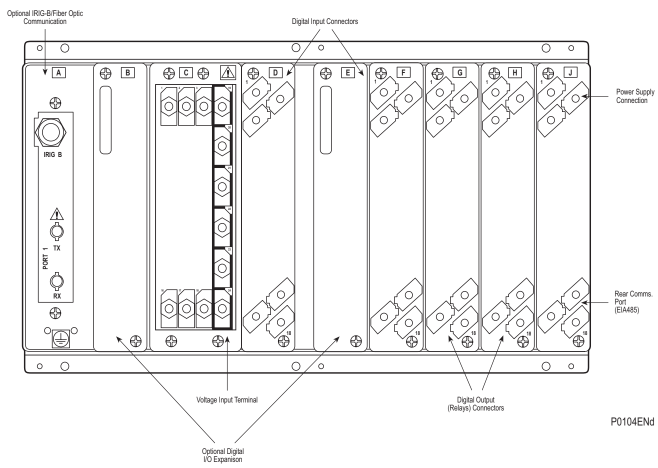
1.2.2 Relay rear panel

The rear panel of the relay is shown in Figures 2 and Figure 3. All current and voltage signals*, digital logic input signals and output contacts are connected at the rear of the relay. Also connected at the rear is the twisted pair wiring for the rear EIA(RS)485 communication port, the IRIG-B time synchronizing input and the optical fiber rear communication port which are both optional.



Slot Ref.	Board Function
A	IRIG-B/IEC60870-5-103 Fiber Optic Comms. (optional)
B	Blank for hardware suffix A relays
	Optional digital I/O expansion slot for hardware suffix C relays
C	Analog (VT) Input Board
D	Opto-isolated inputs (L1 - L8)
E	Relay output contacts (R1 - R7)
F	Power Supply/EIA(RS)485 Communications

Figure 2: P941 relay rear view (40TE)



Slot Ref.	Board Function
A	IRIG-B/IEC60870-5-103 Fiber Optic Comms. (optional)
B	Blank for hardware suffix A relays
	Optional digital I/O expansion slot for hardware suffix C relays
C	Analog (VT) Input Board
D	Opto-isolated inputs (L1 - L8)
E	Blank for hardware suffix A relays
	Optional digital I/O expansion slot for hardware suffix C relays
F	Opto-isolated inputs (L9 - L16)
G	Relay output contacts (R8 - R14)
H	Relay output contacts (R1 - R7)
J	Power Supply/EIA(RS)485 Communications

Figure 3: P943 relay rear view (60TE)

Refer to the wiring diagram in the Installation section for complete connection details.

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1.3 Relay connection and power-up

Before powering-up the relay, confirm that the relay power supply voltage and nominal ac signal magnitudes are appropriate for your application. The relay serial number, voltage and auxiliary supply rating information can be viewed under the top hinged cover. The relay is available in the following auxiliary voltage versions and these are specified in the table below:

Nominal Ranges	Operative dc Range	Operative ac Range
24 - 48V dc	19 to 65V	-
48 - 110V dc (30 - 100V ac rms)*	37 to 150V	24 to 110V
110 - 250V dc (100 - 240V ac rms)*	87 to 300V	80 to 265V

* rated for ac or dc operation.

Please note that the P940 relays may be fitted with two different types of digital input. Relays with hardware suffix A (last digit in the full model number) use fixed threshold 48V dc opto-isolated inputs, with a maximum withstand rating of 60Vdc. Relays with hardware suffix C use “universal” opto-isolated inputs that can be programmed for the nominal battery voltage of the circuit of which they are a part and have a maximum withstand rating of 300Vdc. See ‘Universal Opto input’ in the Firmware section for more information on logic input specifications.

Once the ratings have been verified for the application, connect external power capable of delivering the power requirements specified on the label to perform the relay familiarization procedures. Figures 2 and 3 indicate the location of the power supply terminals but please refer to the wiring diagrams in the Installation section for complete installation details ensuring that the correct polarities are observed in the case of DC supply.

1.4 Introduction to the user interfaces and settings options

The relay has three user interfaces:

– The front panel user interface via the LCD and keypad

– The front port which supports Courier communication

– The rear port which supports one protocol of either Courier, MODBUS, IEC 60870-5-103 or DNP3.0. The protocol for the rear port must be specified when the relay is ordered

The measurement information and relay settings that can be accessed from the three interfaces are summarized in Table 1.

	Keypad/ LCD	Courier	MODBUS	IEC870-5-103	DNP3.0
Display & modification of all settings	•	•	•		
Digital I/O signal status	•	•	•	•	•
Display/extraction of measurements	•	•	•	•	•
Display/extraction of fault records	•	•	•		
Extraction of disturbance records		•	•		
Programmable scheme logic settings		•			
Reset of fault & alarm records	•	•	•	•	•
Clear event & fault records	•	•	•		•
Time synchronization		•	•	•	•
Control commands	•	•	•	•	•

Table 1

1.5 Menu structure

The relay's menu is arranged in a tabular structure. Each setting in the menu is referred to as a cell, and each cell in the menu may be accessed by reference to a row and column address. The settings are arranged so that each column contains related settings, for example all of the disturbance recorder settings are contained within the same column. As shown in Figure 4, the top row of each column contains the heading that describes the settings contained within that column. Movement between the columns of the menu can only be made at the column heading level. A complete list of all of the menu settings is given in the Menu Content Map at the end of this section.

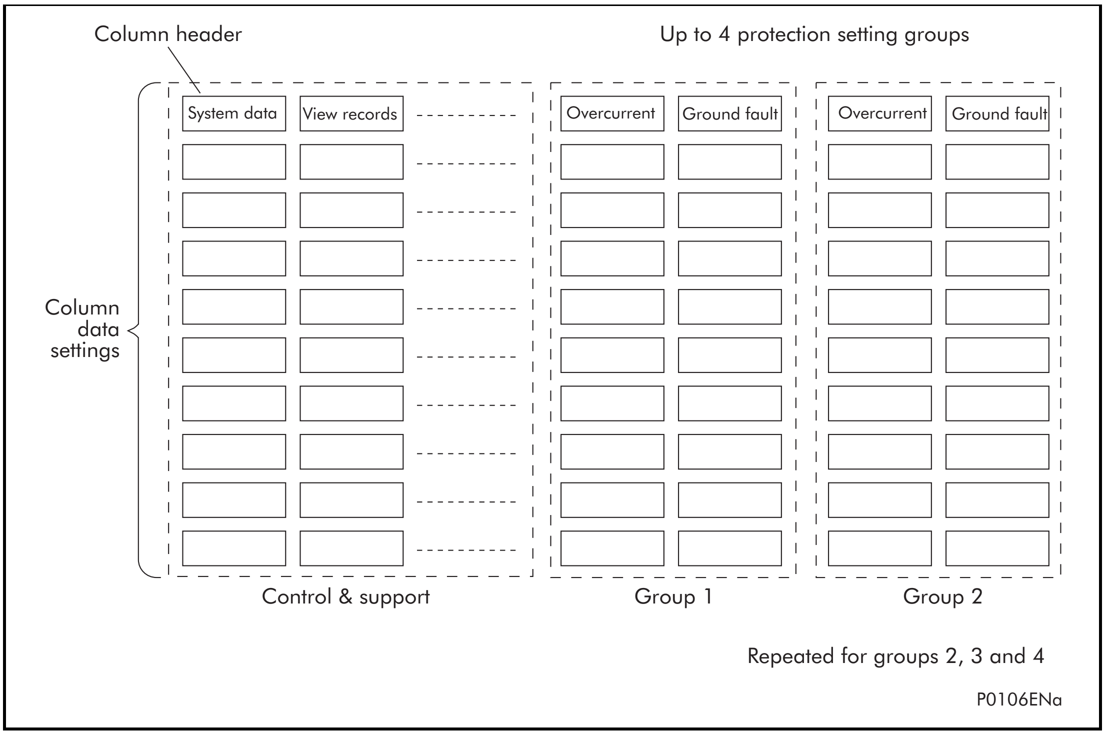

Figure 4: Menu structure

All of the settings in the menu fall into one of three categories; protection settings, disturbance recorder settings, or control and support (C&S) settings. One of two different methods is used to change a setting depending on which category the setting falls into. Control and support settings are stored and used by the relay immediately after they are entered. For either protection settings or disturbance recorder settings, the relay stores the new setting values in a temporary 'scratchpad'. It activates all the new settings together, but only after it has been confirmed that the new settings are to be adopted. This technique is employed to provide extra security, and so that several setting changes that are made within a group of protection settings will all take effect at the same time.

1.5.1 Protection settings

The protection settings include the following items:

– Protection element settings

– Scheme logic settings

There are four groups of protection settings, with each group containing the same setting cells. One group of protection settings is selected as the active group, and is used by the protection elements.

1.5.2 Disturbance recorder settings

The disturbance recorder settings include the record duration and trigger position, selection of analog and digital signals to record, and the signal sources that trigger the recording.

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1.5.3 Control and support settings

The control and support settings include:

- Relay configuration settings
- VT ratio settings
- Reset LEDs
- Active protection setting group
- Password & language settings
- Communications settings
- Measurement settings
- Event & fault record settings
- User interface settings
- Commissioning settings

1.6 Password protection

The menu structure contains three levels of access. The level of access that is enabled determines which of the relay's settings can be changed and is controlled by entry of two different passwords. The levels of access are summarized in Table 2.

Access level	Operations enabled
Level 0 No password required	Read access to all settings, alarms, event records and fault records
Level 1 Password 1 or 2 required	As level 0 plus: Control commands, e.g. Circuit breaker open/close. Reset of fault and alarm conditions. Reset LEDs. Clearing of event and fault records.
Level 2 Password 2 required	As level 1 plus: All other settings

Table 2

Each of the two passwords are 4 characters of upper case text. The factory default for both passwords is AAAA. Each password is user-changeable once it has been correctly entered. Entry of the password is achieved either by a prompt when a setting change is attempted, or by moving to the 'Password' cell in the 'System data' column of the menu. The level of access is independently enabled for each interface, that is to say if level 2 access is enabled for the rear communication port, the front panel access will remain at level 0 unless the relevant password is entered at the front panel. The access level enabled by the password entry will time-out independently for each interface after a period of inactivity and revert to the default level. If the passwords are lost an emergency password can be supplied - contact Schneider Electric with the relay's serial number. The current level of access enabled for an interface can be determined by examining the 'Access level' cell in the 'System data' column, the access level for the front panel User Interface (UI), can also be found as one of the default display options.

The relay is supplied with a default access level of 2, such that no password is required to change any of the relay settings. It is also possible to set the default menu access level to either level 0 or level 1, preventing write access to the relay settings without the correct password. The default menu access level is set in the 'Password control' cell which is found in the 'System data' column of the menu (note that this setting can only be changed when level 2 access is enabled).

1.7 Relay configuration

The relay is a multi-function device that supports numerous different protection, control and communication features. In order to simplify the setting of the relay, there is a configuration settings column which can be used to enable or disable many of the functions of the relay. The settings associated with any function that is disabled are made invisible, i.e. they are not shown in the menu. To disable a function change the relevant cell in the 'Configuration' column from 'Enabled' to 'Disabled'.

The configuration column controls which of the four protection settings groups is selected as active through the 'Active settings' cell. A protection setting group can also be disabled in the configuration column, provided it is not the present active group. Similarly, a disabled setting group cannot be set as the active group.

1.8 Front panel user interface (keypad and LCD)

When the keypad is exposed it provides full access to the menu options of the relay, with the information displayed on the LCD.

The ◁, ▷, △ and ▽ keys which are used for menu navigation and setting value changes include an auto-repeat function that comes into operation if any of these keys are held continually pressed. This can be used to speed up both setting value changes and menu navigation; the longer the key is held depressed, the faster the rate of change or movement becomes.

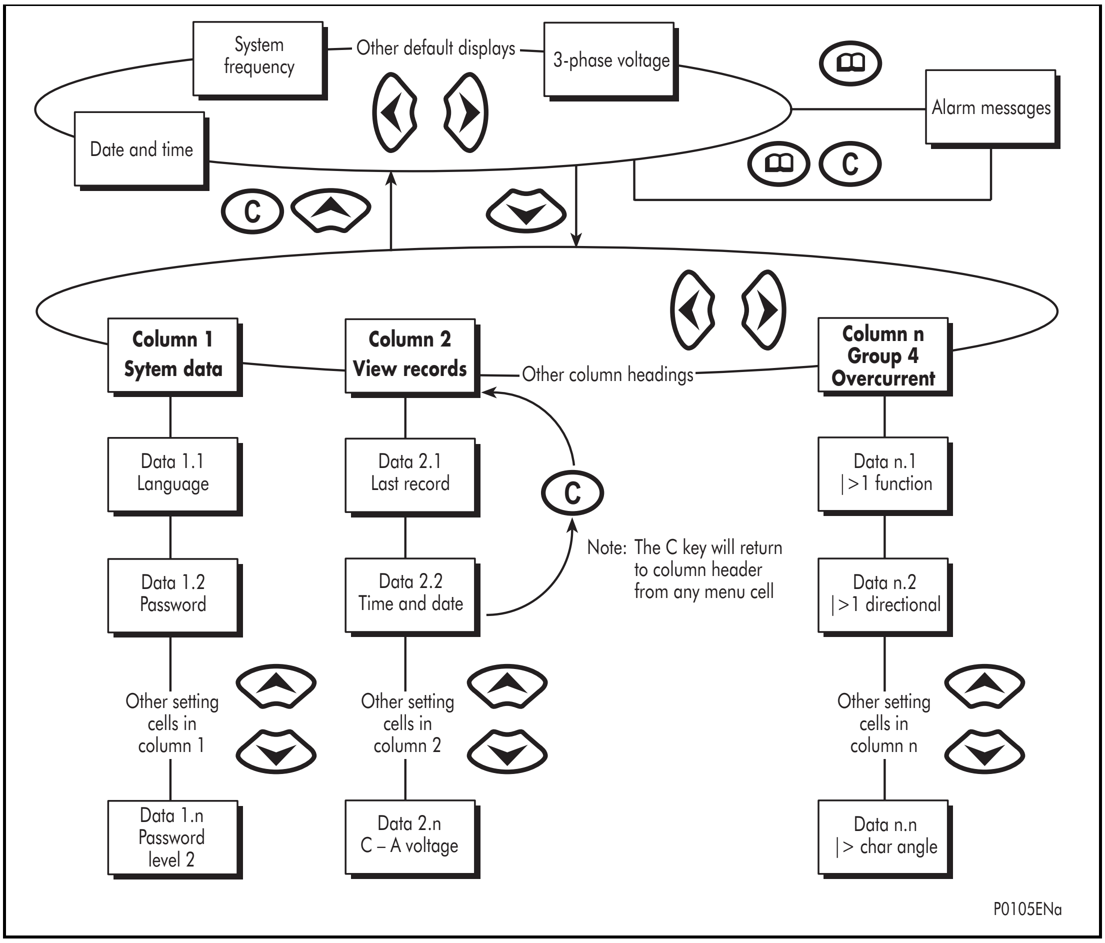

Figure 5: Front panel user interface

1.8.1 Default display and menu time-out

The front panel menu has a default display, the contents of which can be selected from the following options in the 'default display' cell of the 'Measure't setup' column:

– Date and time

– Relay description (user defined)

– Plant reference (user defined)

– System frequency

– 3 phase voltage

– Access level

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From the default display it is also possible to view the other default display options using the ← and → keys. However, if there is no keypad activity for the 15 minute timeout period, the default display will revert to that selected by the setting and the LCD backlight will turn off. If this happens any setting changes that have not been confirmed will be lost and the original setting values maintained.

Whenever there is an uncleared alarm present in the relay (e.g. fault record, protection alarm, control alarm etc.) the default display will be replaced by:

```
Alarms/Faults
Present
```

Entry to the menu structure of the relay is made from the default display and is not affected if the display is showing the 'Alarms/Faults present' message.

1.8.2 Menu navigation and setting browsing

The menu can be browsed using the four arrow keys, following the structure shown in Figure 5. Thus, starting at the default display the ↓ key will display the first column heading. To select the required column heading use the ← and → keys. The setting data contained in the column can then be viewed by using the ↓ and ↑ keys. It is possible to return to the column header either by holding the ↑ key down or by a single press of the clear key Ⓒ. It is only possible to move across columns at the column heading level. To return to the default display press the ↑ key or the clear key Ⓒ from any of the column headings. It is not possible to go straight to the default display from within one of the column cells using the auto-repeat facility of the ↑ key, as the auto-repeat will stop at the column heading. To move to the default display, the ↑ key must be released and pressed again.

1.8.3 Password entry

When entry of a password is required the following prompt will appear:

```
Enter password
**** Level 2
```

Note: The password required to edit the setting is the prompt as shown above.

A flashing cursor will indicate which character field of the password may be changed. Press the ↑ and ↓ keys to vary each character between A and Z. To move between the character fields of the password, use the ← and → keys. The password is confirmed by pressing the enter key ↵. The display will revert to 'Enter Password' if an incorrect password is entered. At this point a message will be displayed indicating whether a correct password has been entered and if so what level of access has been unlocked. If this level is sufficient to edit the selected setting then the display will return to the setting page to allow the edit to continue. If the correct level of password has not been entered then the password prompt page will be returned to. To escape from this prompt press the clear key . Alternatively, the password can be entered using the ‘Password’ cell of the ‘System data’ column.

For the front panel user interface the password protected access will revert to the default access level after a keypad inactivity time-out of 15 minutes. It is possible to manually reset the password protection to the default level by moving to the ‘Password’ menu cell in the ‘System data’ column and pressing the clear key instead of entering a password.

1.8.4 Reading and clearing of alarm messages and fault records

The presence of one or more alarm messages will be indicated by the default display and by the yellow alarm LED flashing. The alarm messages can either be self-resetting or latched, in which case they must be cleared manually. To view the alarm messages press the read key . When all alarms have been viewed, but not cleared, the alarm LED will change from flashing to constant illumination and the latest fault record will be displayed (if there is one). To scroll through the pages of this use the key. When all pages of the fault record have been viewed, the following prompt will appear:

Press clear to reset alarms

To clear all alarm messages press ; to return to the alarms/faults present display and leave the alarms uncleared, press . Depending on the password configuration settings, it may be necessary to enter a password before the alarm messages can be cleared (see section on password entry). When the alarms have been cleared the yellow alarm LED will extinguish, as will the red trip LED if it was illuminated following a trip.

Alternatively it is possible to accelerate the procedure, once the alarm viewer has been entered using the key, the key can be pressed, and this will move the display straight to the fault record. Pressing again will move straight to the alarm reset prompt where pressing once more will clear all alarms.

1.8.5 Setting changes

To change the value of a setting, first navigate the menu to display the relevant cell. To change the cell value press the enter key , which will bring up a flashing cursor on the LCD to indicate that the value can be changed. This will only happen if the appropriate password has been entered, otherwise the prompt to enter a password will appear. The setting value can then be changed by pressing the or keys. If the setting to be changed is a binary value or a text string, the required bit or character to be changed must first be selected using the and keys. When the desired new value has been reached it is confirmed as the new setting value by pressing . Alternatively, the new value will be discarded either if the clear button is pressed or if the menu time-out occurs.

For protection group settings and disturbance recorder settings, the changes must be confirmed before they are used by the relay. To do this, when all required changes have been entered, return to the column heading level and press the key. Prior to returning to the default display the following prompt will be given:

Update settings? Enter or clear

Pressing will result in the new settings being adopted, pressing will cause the relay to discard the newly entered values. It should be noted that, the setting values will also be discarded if the menu time out occurs before the setting changes have been confirmed. Control and support settings will be updated immediately after they are entered, without the ‘Update settings?’ prompt.

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1.9 Front communication port user interface

The front communication port is provided by a 9-pin female D-type connector located under the bottom hinged cover. It provides EIA(RS)232 serial data communication and is intended for use with a PC locally to the relay (up to 15m distance) as shown in Figure 7. This port supports the Courier communication protocol only. Courier is the communication language developed by Schneider Electric to allow communication with its range of protection relays. The front port is particularly designed for use with the relay settings program MiCOM S1 that is a Windows 98, Windows NT4.0, Windows 2000 or Windows XP based software package.

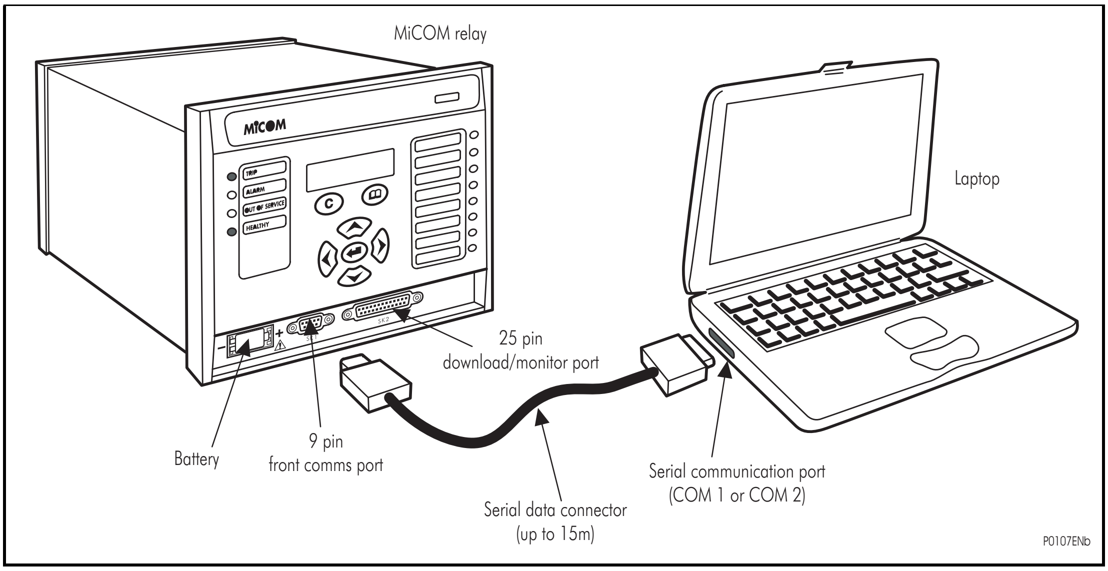

Figure 6: Front port connection

The relay is a Data Communication Equipment (DCE) device. Thus the pin connections of the relay's 9-pin front port are as follows:

Pin no. 2	Tx Receive data
Pin no. 3	Rx Transmit data
Pin no. 5	0V Zero volts common

None of the other pins are connected in the relay. The relay should be connected to the serial port of a PC, usually called COM1 or COM2. PCs are normally Data Terminal Equipment (DTE) devices which have a serial port pin connection as below (if in doubt check your PC manual):

	25 Way	9 Way	
Pin no. 2	3	2	Rx Receive data
Pin no. 3	2	3	Tx Transmit data
Pin no. 5	7	5	0V Zero volts common

For successful data communication, the Tx pin on the relay must be connected to the Rx pin on the PC, and the Rx pin on the relay must be connected to the Tx pin on the PC, as shown in Figure 7. Therefore, providing that the PC is a DTE with pin connections as given above, a 'straight through' serial connector is required, i.e. one that connects pin 2 to pin 2, pin 3 to pin 3, and pin 5 to pin 5. Note that a common cause of difficulty with serial data communication is connecting Tx to Tx and Rx to Rx. This could happen if a 'cross-over' serial connector is used, i.e. one that connects pin 2 to pin 3, and pin 3 to pin 2, or if the PC has the same pin configuration as the relay.

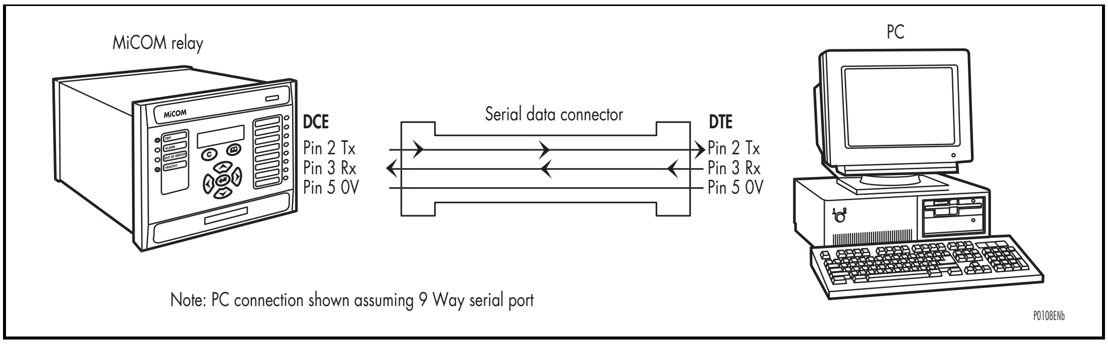

Figure 7: PC - relay signal connection

Having made the physical connection from the relay to the PC, the PC's communication settings must be configured to match those of the relay. The relay's communication settings for the front port are fixed as shown in the table below:

Protocol	Courier
Baud rate	19,200 bits/s
Courier address	1
Message format	11 bit - 1 start bit, 8 data bits, 1 parity bit (even parity), 1 stop bit

The inactivity timer for the front port is set at 15 minutes. This controls how long the relay will maintain its level of password access on the front port. If no messages are received on the front port for 15 minutes then any password access level that has been enabled will be revoked.

1.9.1 Front courier port

The front EIA(RS)232[1] 9 pin port supports the Courier protocol for one to one communication. It is designed for use during installation and commissioning/maintenance and is not suitable for permanent connection. Since this interface will not be used to link the relay to a substation communication system, some of the features of Courier are not implemented. These are as follows:

Automatic Extraction of Event Records:

– Courier Status byte does not support the Event flag

– Send Event/Accept Event commands are not implemented

Automatic Extraction of Disturbance Records:

– Courier Status byte does not support the Disturbance flag

Busy Response Layer:

– Courier Status byte does not support the Busy flag, the only response to a request will be the final data

Fixed Address:

– The address of the front courier port is always 1, the Change Device address command is not supported.

Fixed Baud Rate:

– 19200 bps

It should be noted that although automatic extraction of event and disturbance records is not supported it is possible to manually access this data via the front port.

[1] This port is actually compliant to EIA(RS)574; the 9-pin version of EIA(RS)232, see www.tiaonline.org.

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1.10 MiCOM S1 relay communications basics

The front port is particularly designed for use with the relay settings program MiCOM S1 that is a Windows 98, Windows NT4.0, Windows 2000 or Windows XP based software package. MiCOM S1 is the universal MiCOM IED Support Software and provides users a direct and convenient access to all stored data in any MiCOM IED using the EIA(RS)232 front communication port.

MiCOM S1 provides full access to:

- MiCOM Px20, Px30, Px40 relays
- MiCOM Mx20 measurements units

1.10.1 PC requirements

The following minimum requirements must be met for the MiCOM S1 software to properly work on a PC.

- IBM computer or 100% compatible,
- WindowsTM 98 or NT 4.0 (Not WindowsTM 95)
- Pentium II 300 Mhz minimum,
- Screen VGA 256 colours minimum,
- Resolution 640 x 400 minimum (1024 x 768 recommended),
- 48Mb RAM minimum,
- 500Mb free on computer hard-disk.

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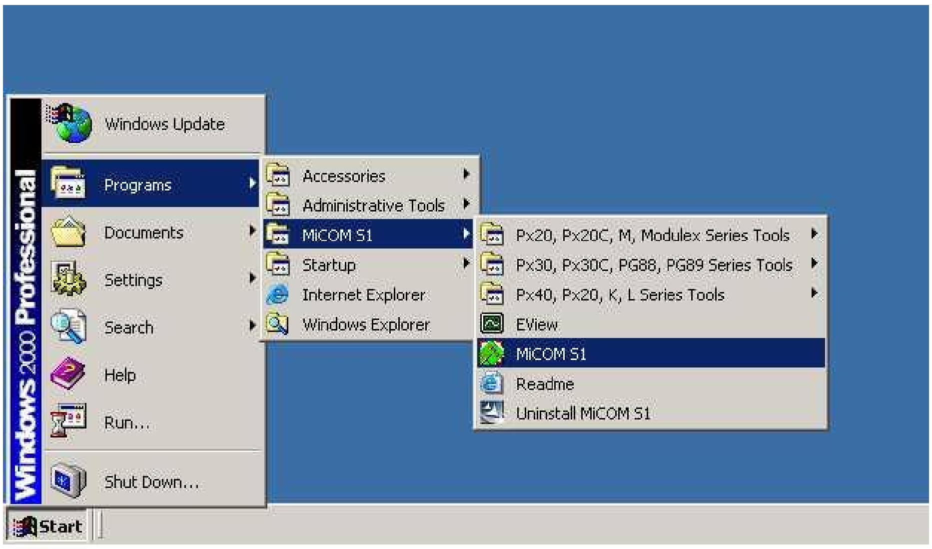
1.10.2 Connecting to the P940 relay using MiCOM S1

Before starting, verify that the EIA(RS)232 serial cable is properly connected to the EIA(RS)232 port on the front panel of the relay. Please follow the instructions in section 1.9 to ensure a proper connection is made between the PC and the relay before attempting to communicate with the relay.

This section is intended as a quick start guide to using MiCOM S1. Please refer to the MiCOM S1 User Manual for more detailed information.

To start MiCOM S1, click on the icon: 

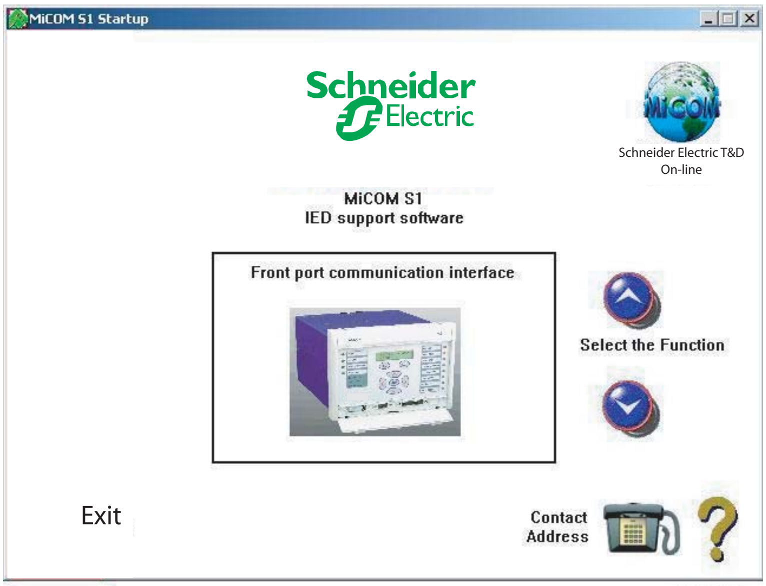
In the "Programs" menu, select "MiCOM S1" then "MiCOM S1 Start-up".



S0013ENb

WARNING: CLICKING ON "UNINSTALL MiCOM S1", WILL UNINSTALL MiCOM S1, AND ALL DATA AND RECORDS USED IN MiCOM S1.

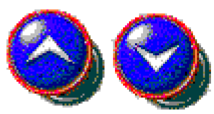
You access the MiCOM S1 launcher screen.



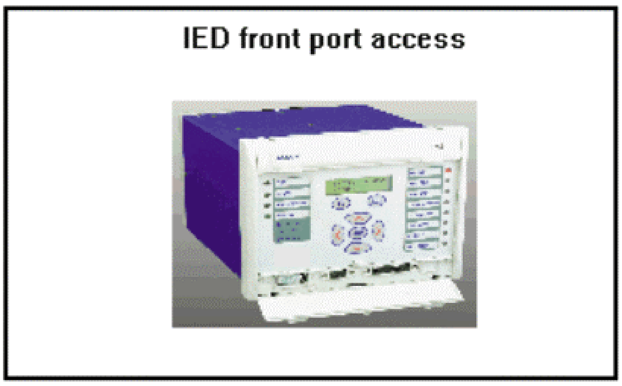
The MiCOM S1 launcher is the software that gives access to the different application programs:

- MiCOM S1 for MiCOM M/Px20 IEDs
- MiCOM S1 for MiCOM Px30 IEDs
- MiCOM S1 for MiCOM Px40 IEDs
- MiCOM S1 disturbance application

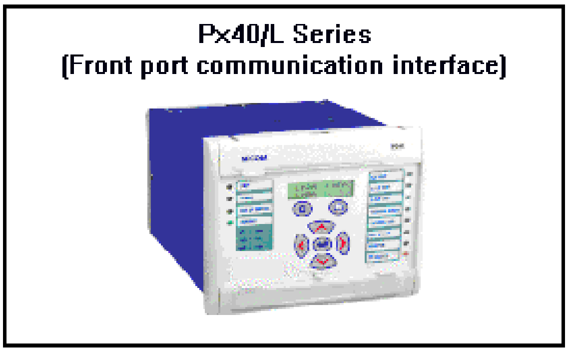
To access these different programs, use the blue arrows,



Click on the desired type of access



and click on the required MiCOM Px40 series



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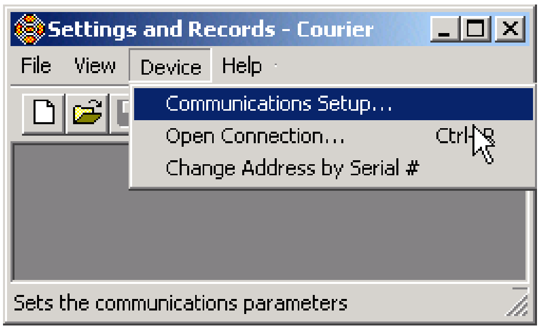
1.10.3 Open communication link with relay

To open the communications link from S1 to the P940 relay the following procedure must be followed:

First the communication setup must be adjusted if necessary. In the "Device" menu, select "Communications Setup…"



This brings up the following screen:

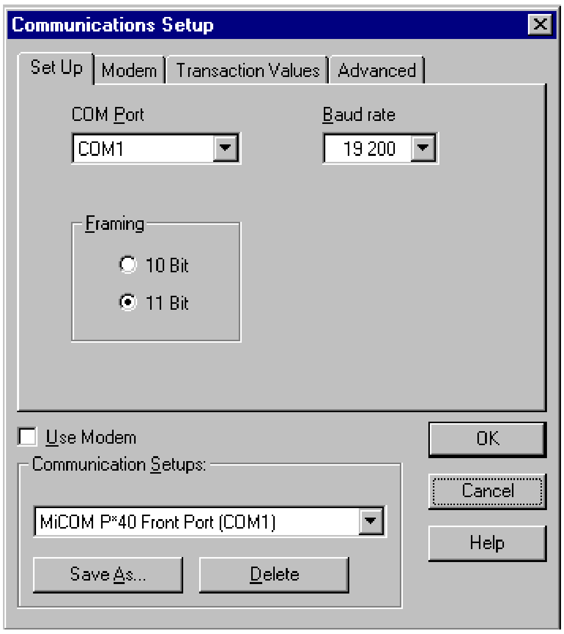
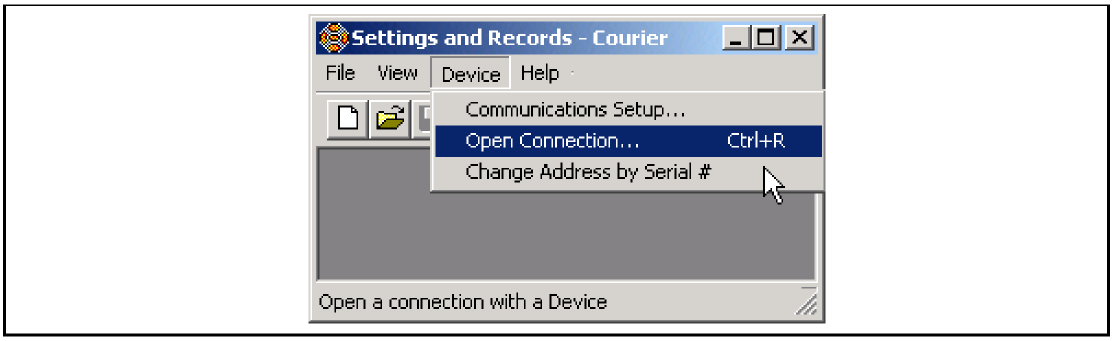
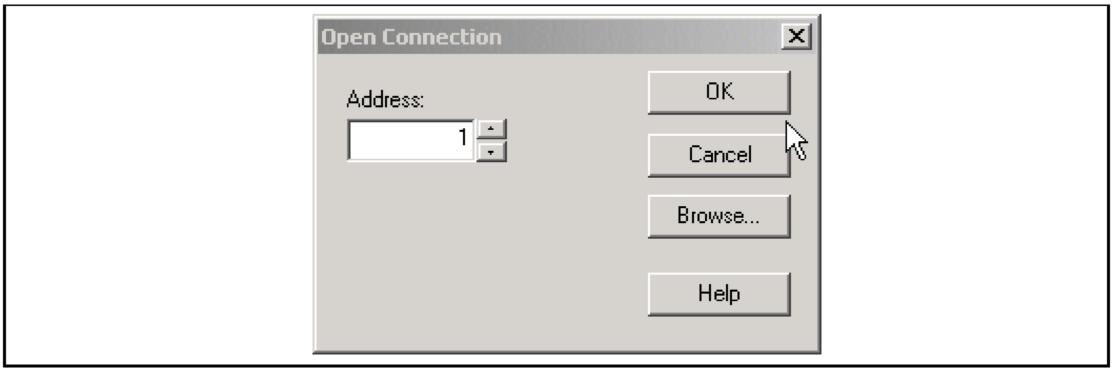


Figure 8: Communication set-up screen

When the communications setup is correct the link with the relay can be initialized. In the "Device" menu, select "Open Connection…"

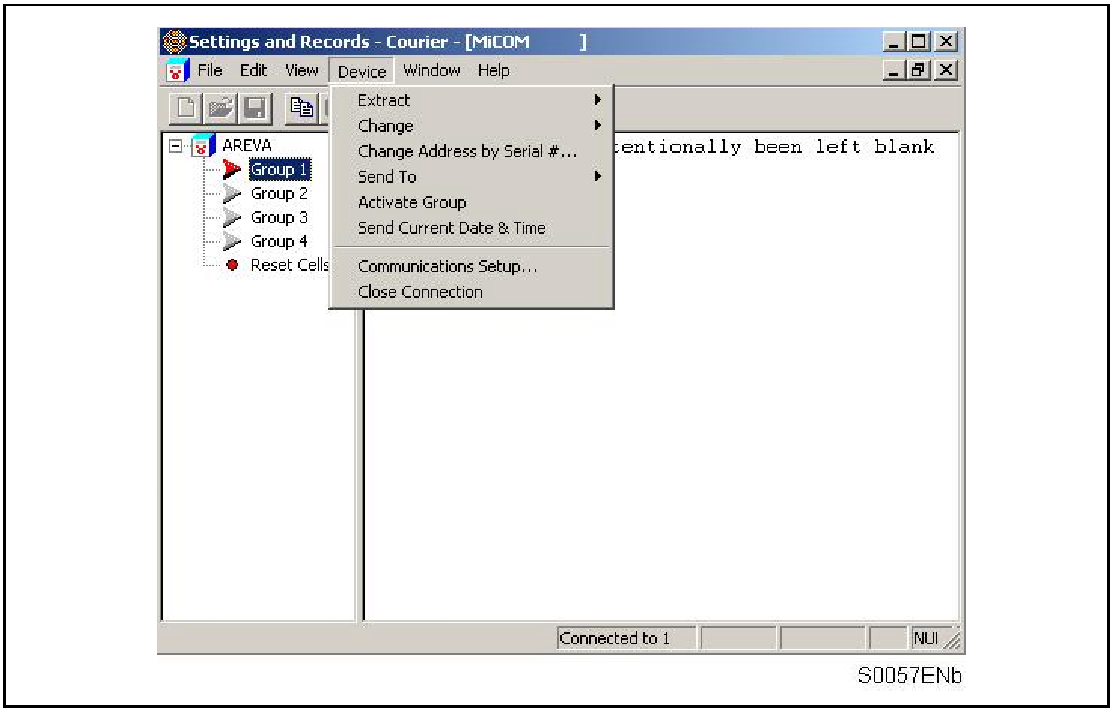


This brings up a prompt for the address of the relay to be interrogated (for front port access, the relay address is always “1” - regardless of any address settings for the rear ports).



When this has been entered a prompt for the password appears.

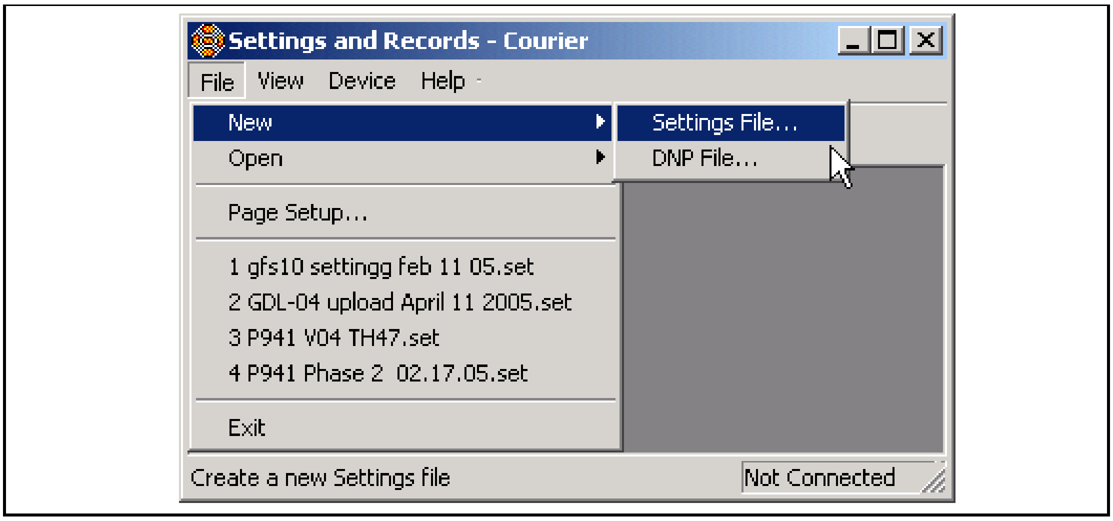
When these have been entered satisfactorily the relay is then able to communicate with MiCOM S1. When a communication link has been established between the PC and a MiCOM IED, both are said to be online. Data and information can be directly transferred from and to the IED using the menu available under the “DEVICE” menu.



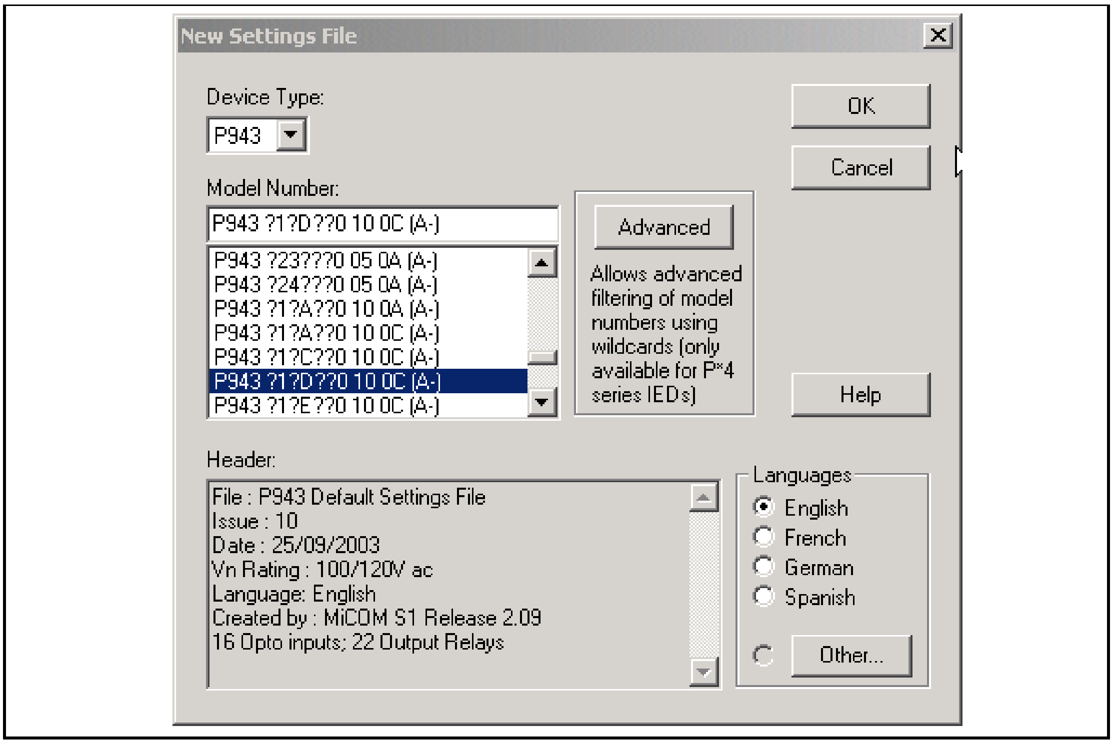
For further instruction on how to extract, download and modify settings files, please refer to the MiCOM S1 User Manual.

1.10.4 Off-line use of MiCOM S1

As well as being used for the on-line editing of settings, MiCOM S1 can also be used as an off-line tool to prepare settings without access to the relay. In order to open a default setting file for modification, in the “File” menu, select “New” and then “Settings File…”



This brings up a prompt for the relay model type where you can select the correct relay for your application:

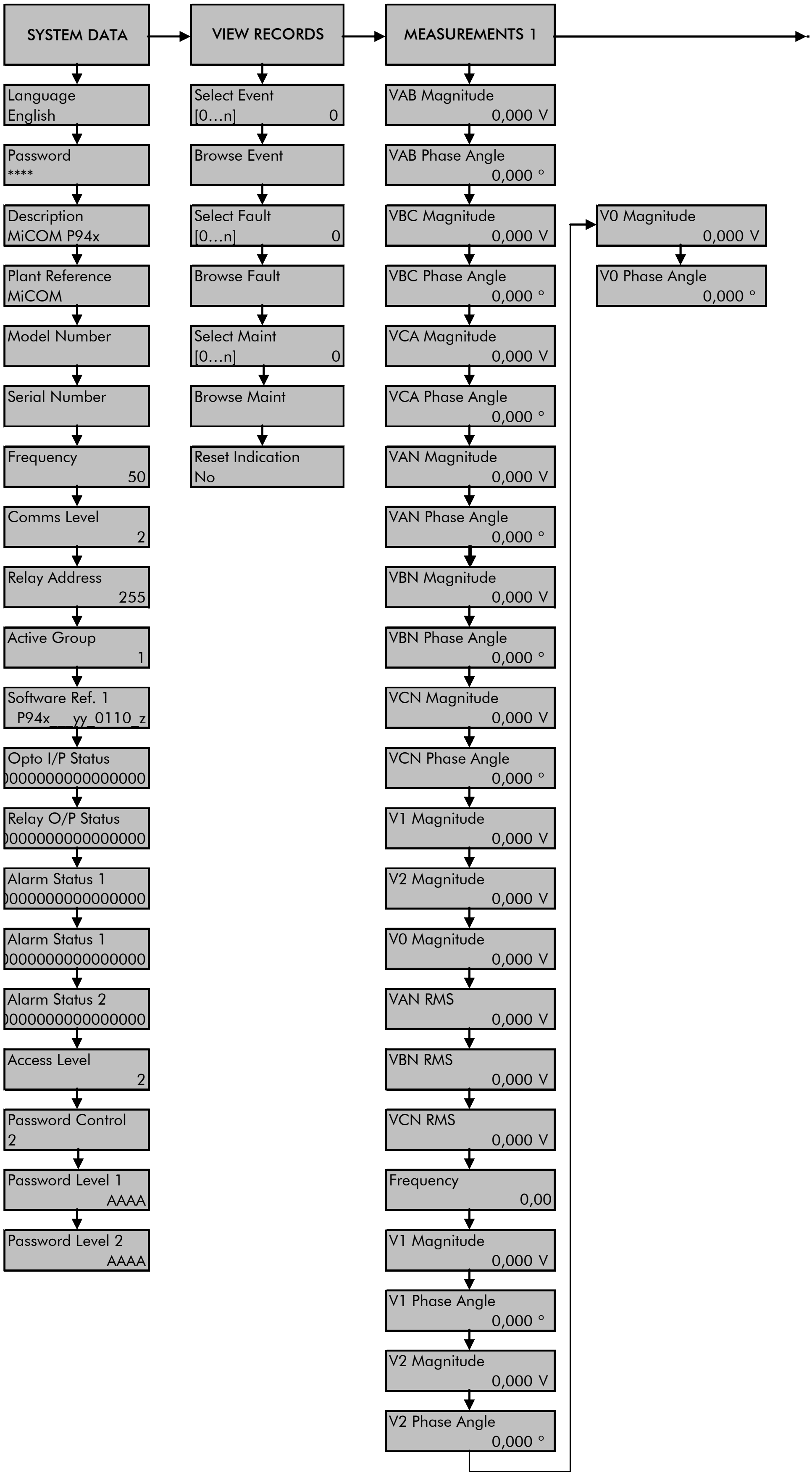


Clicking on OK will open the default file and you can start to edit settings. For further instruction on how to extract, download and modify settings files, please refer to the MiCOM S1 User Manual.

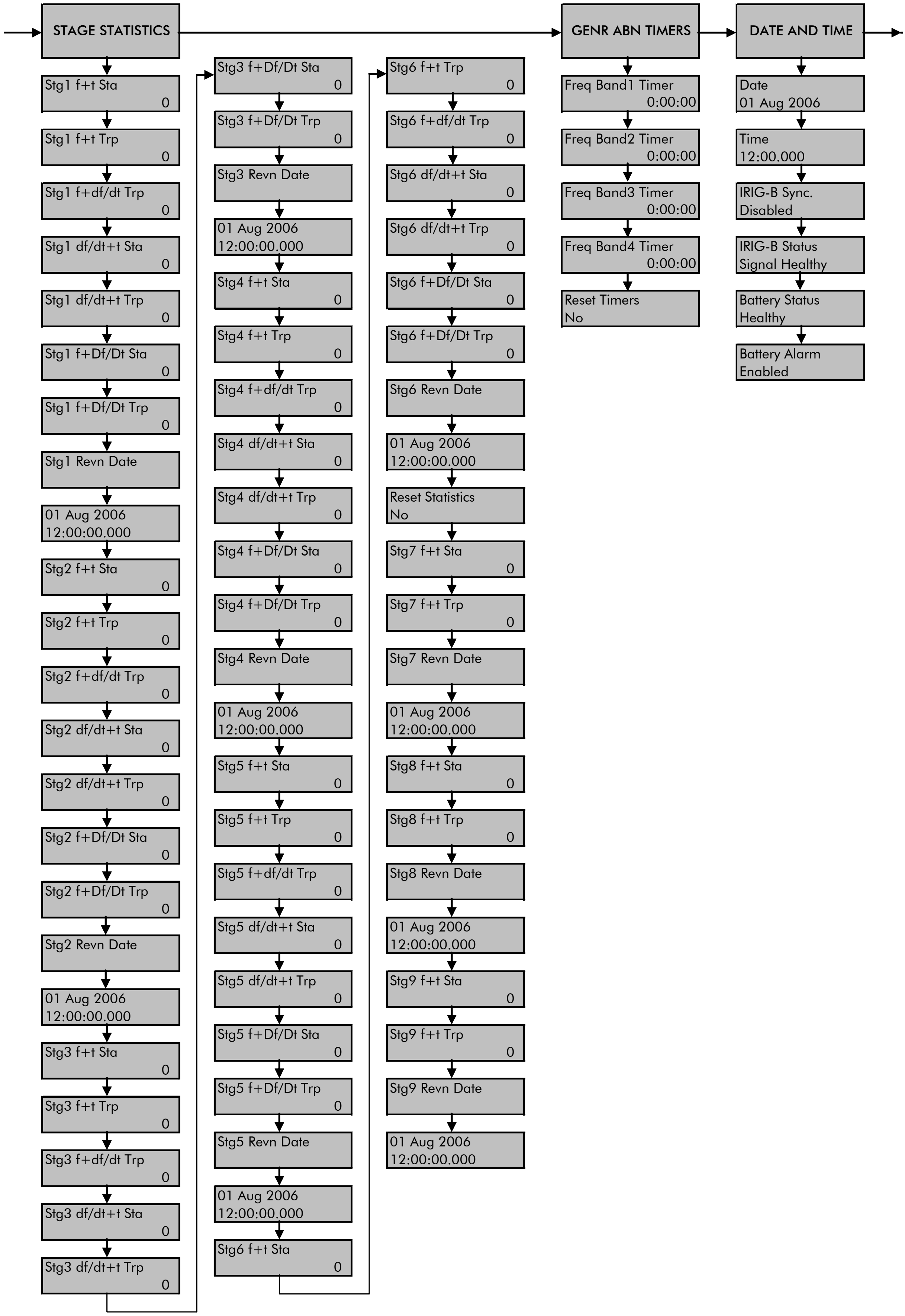
Appendix – Relay Menu Map (Default)

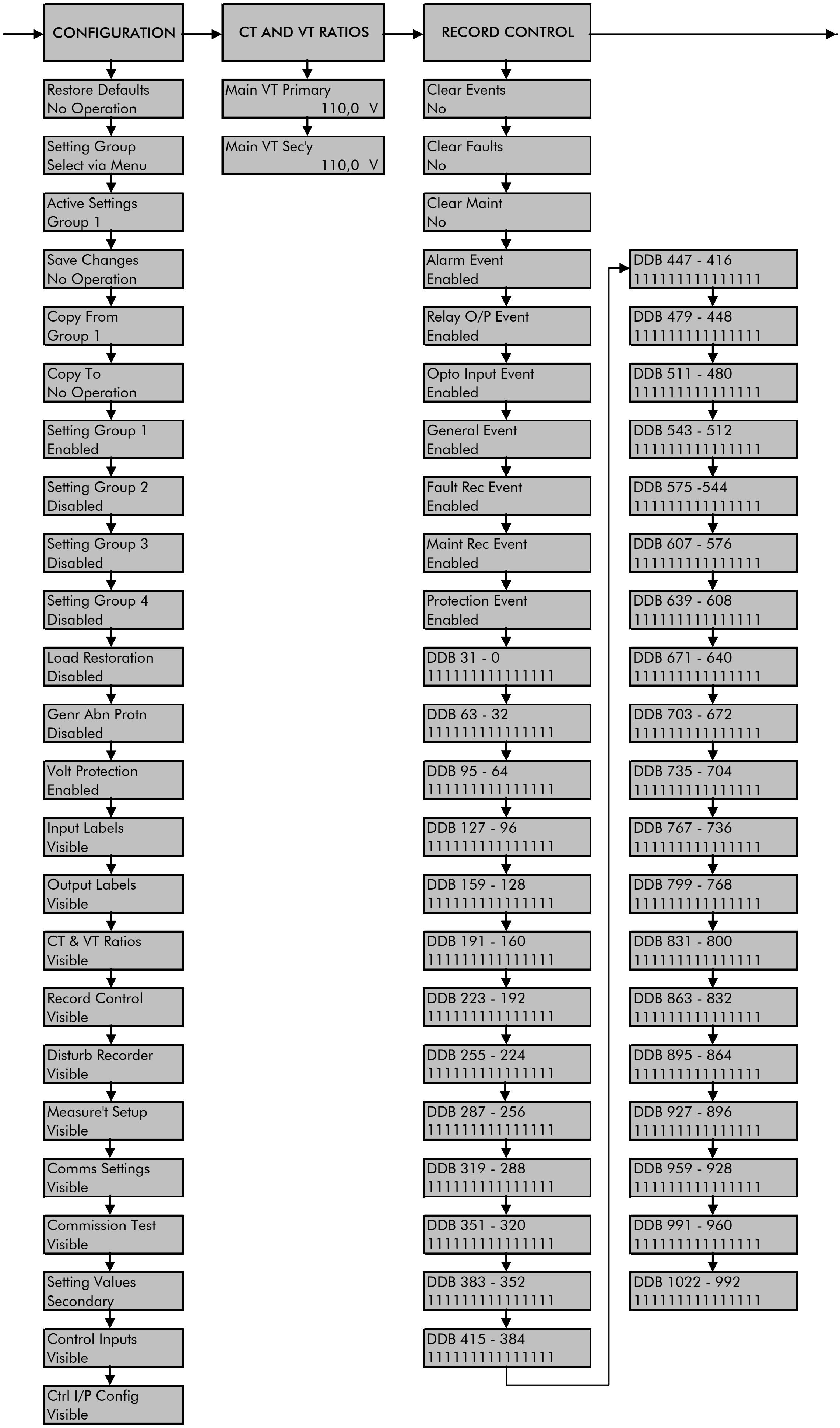
Software Version 12

Note: This menu map is annotated with the factory menu settings.

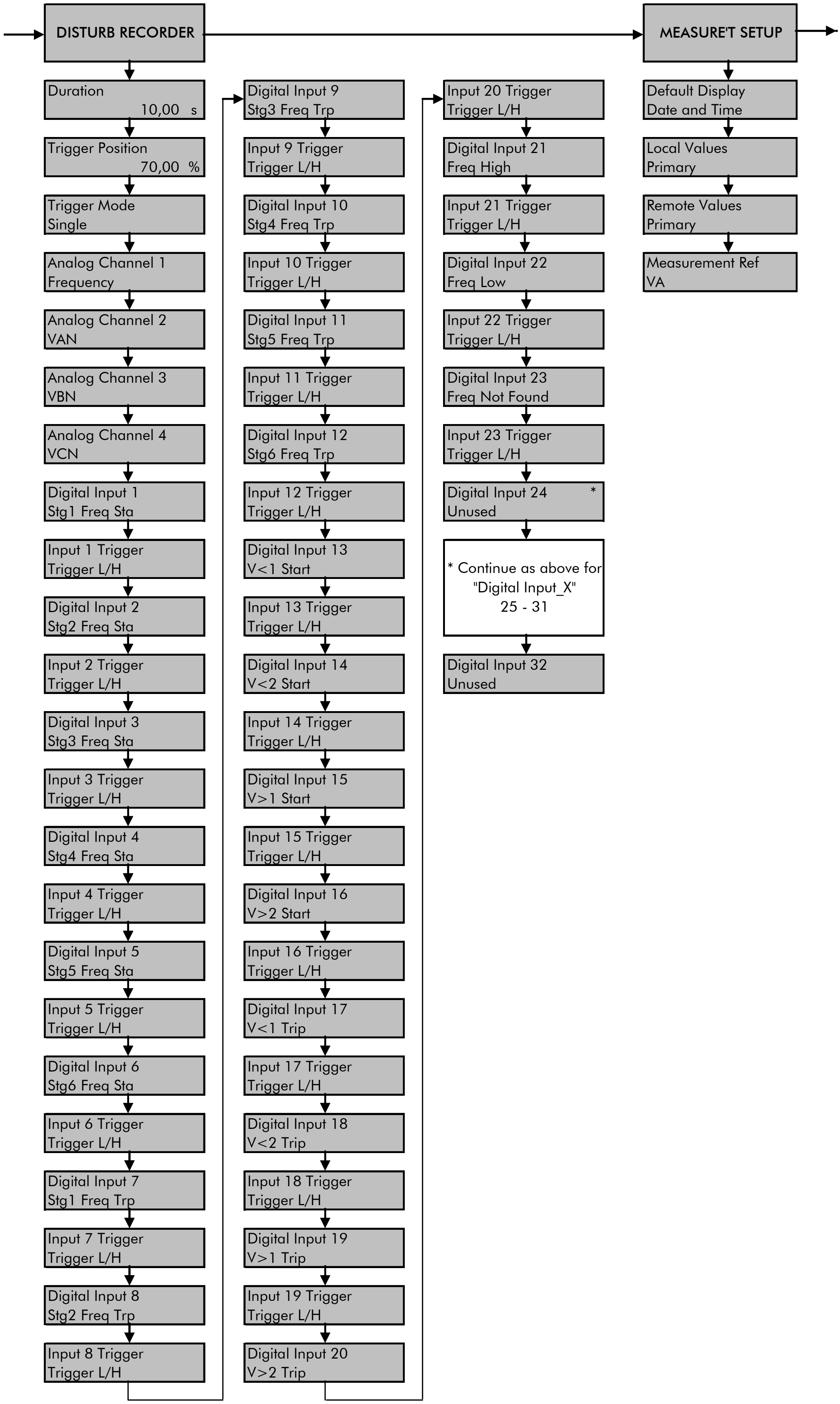


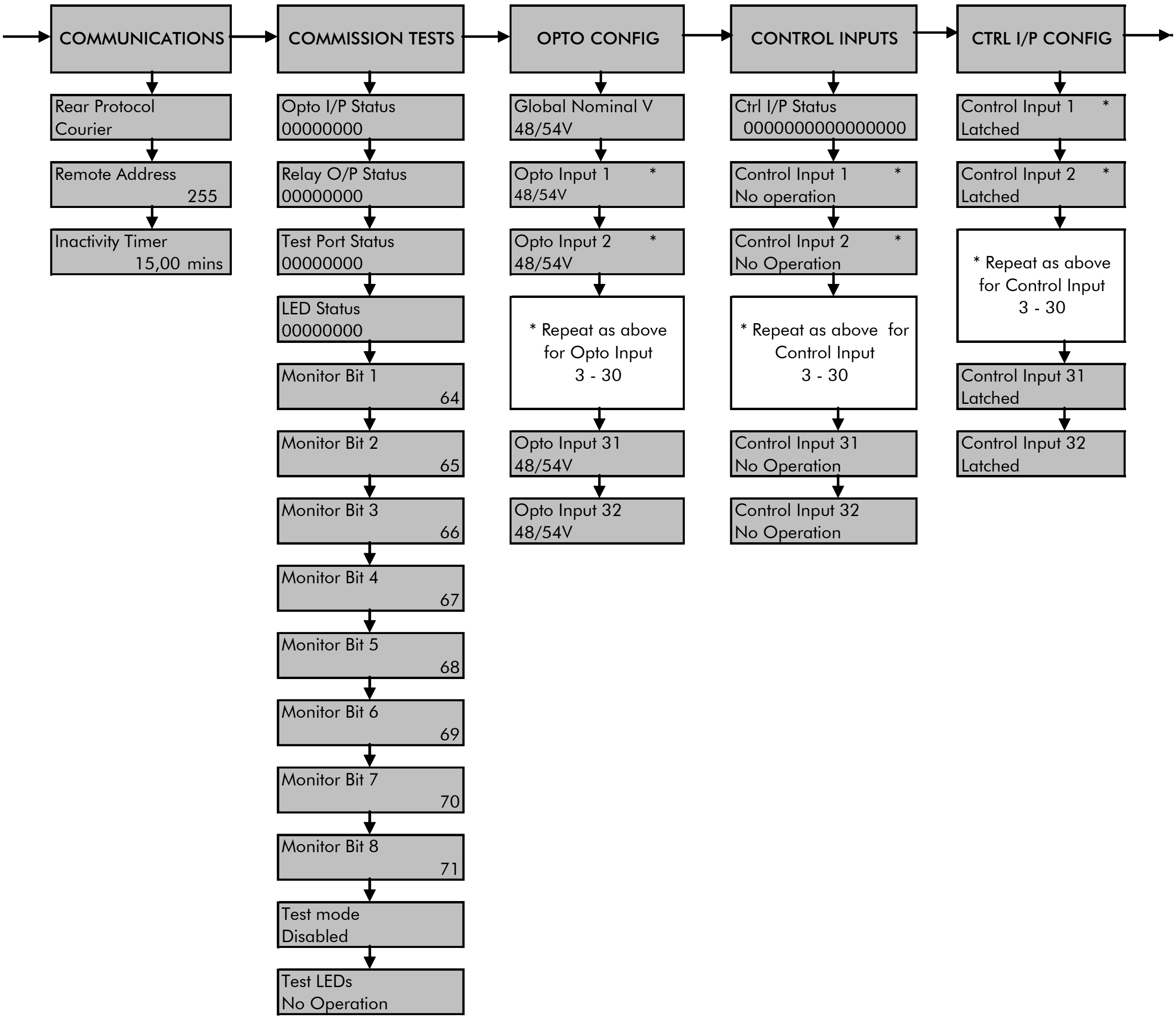
GS


STAGE STATISTICS
Stg1 f+t Sta 0
Stg1 f+t Trp 0
Stg1 f+df/dt Trp 0
Stg1 df/dt+t Sta 0
Stg1 df/dt+t Trp 0
Stg1 f+Df/Dt Sta 0
Stg1 f+Df/Dt Trp 0
Stg1 Revn Date
01 Aug 2006 12:00:00.000
Stg2 f+t Sta 0
Stg2 f+t Trp 0
Stg2 f+df/dt Trp 0
Stg2 df/dt+t Sta 0
Stg2 df/dt+t Trp 0
Stg2 f+Df/Dt Sta 0
Stg2 f+Df/Dt Trp 0
Stg2 Revn Date
01 Aug 2006 12:00:00.000
Stg3 f+t Sta 0
Stg3 f+t Trp 0
Stg3 f+df/dt Trp 0
Stg3 df/dt+t Sta 0
Stg3 df/dt+t Trp 0
Stg3 f+Df/Dt Sta 0
Stg3 f+Df/Dt Trp 0
Stg3 Revn Date
01 Aug 2006 12:00:00.000
Stg4 f+t Sta 0
Stg4 f+t Trp 0
Stg4 f+df/dt Trp 0
Stg4 df/dt+t Sta 0
Stg4 df/dt+t Trp 0
Stg4 f+Df/Dt Sta 0
Stg4 f+Df/Dt Trp 0
Stg4 Revn Date
01 Aug 2006 12:00:00.000
Stg5 f+t Sta 0
Stg5 f+t Trp 0
Stg5 f+df/dt Trp 0
Stg5 df/dt+t Sta 0
Stg5 df/dt+t Trp 0
Stg5 f+Df/Dt Sta 0
Stg5 f+Df/Dt Trp 0
Stg5 Revn Date
01 Aug 2006 12:00:00.000
Stg6 f+t Sta 0
Stg6 f+t Trp 0
Stg6 f+df/dt Trp 0
Stg6 df/dt+t Sta 0
Stg6 df/dt+t Trp 0
Stg6 f+Df/Dt Sta 0
Stg6 f+Df/Dt Trp 0
Stg6 Revn Date
01 Aug 2006 12:00:00.000
Reset Statistics No
Stg7 f+t Sta 0
Stg7 f+t Trp 0
Stg7 Revn Date
01 Aug 2006 12:00:00.000
Stg8 f+t Sta 0
Stg8 f+t Trp 0
Stg8 Revn Date
01 Aug 2006 12:00:00.000
Stg9 f+t Sta 0
Stg9 f+t Trp 0
Stg9 Revn Date
01 Aug 2006 12:00:00.000
GENR ABN TIMERS
Freq Band1 Timer 0:00:00
Freq Band2 Timer 0:00:00
Freq Band3 Timer 0:00:00
Freq Band4 Timer 0:00:00
Reset Timers No
DATE AND TIME
Date 01 Aug 2006
Time 12:00.000
IRIG-B Sync. Disabled
IRIG-B Status Signal Healthy
Battery Status Healthy
Battery Alarm Enabled


CONFIGURATION
Restore Defaults
No Operation
Setting Group
Select via Menu
Active Settings
Group 1
Save Changes
No Operation
Copy From
Group 1
Copy To
No Operation
Setting Group 1
Enabled
Setting Group 2
Disabled
Setting Group 3
Disabled
Setting Group 4
Disabled
Load Restoration
Disabled
Genr Abn Protn
Disabled
Volt Protection
Enabled
Input Labels
Visible
Output Labels
Visible
CT & VT Ratios
Visible
Record Control
Visible
Disturb Recorder
Visible
Measure't Setup
Visible
Comms Settings
Visible
Commission Test
Visible
Setting Values
Secondary
Control Inputs
Visible
Ctrl I/P Config
Visible
CT AND VT RATIOS
Main VT Primary
110,0 V
Main VT Sec'y
110,0 V
RECORD CONTROL
Clear Events
No
Clear Faults
No
Clear Maint
No
Alarm Event
Enabled
Relay O/P Event
Enabled
Opto Input Event
Enabled
General Event
Enabled
Fault Rec Event
Enabled
Maint Rec Event
Enabled
Protection Event
Enabled
DDB 31 - 0
111111111111111
DDB 63 - 32
111111111111111
DDB 95 - 64
111111111111111
DDB 127 - 96
111111111111111
DDB 159 - 128
111111111111111
DDB 191 - 160
111111111111111
DDB 223 - 192
111111111111111
DDB 255 - 224
111111111111111
DDB 287 - 256
111111111111111
DDB 319 - 288
111111111111111
DDB 351 - 320
111111111111111
DDB 383 - 352
111111111111111
DDB 415 - 384
111111111111111
DDB 447 - 416
111111111111111
DDB 479 - 448
111111111111111
DDB 511 - 480
111111111111111
DDB 543 - 512
111111111111111
DDB 575 -544
111111111111111
DDB 607 - 576
111111111111111
DDB 639 - 608
111111111111111
DDB 671 - 640
111111111111111
DDB 703 - 672
111111111111111
DDB 735 - 704
111111111111111
DDB 767 - 736
111111111111111
DDB 799 - 768
111111111111111
DDB 831 - 800
111111111111111
DDB 863 - 832
111111111111111
DDB 895 - 864
111111111111111
DDB 927 - 896
111111111111111
DDB 959 - 928
111111111111111
DDB 991 - 960
111111111111111
DDB 1022 - 992
111111111111111

GS


DISTURB RECORDER
MEASURE'T SETUP
Duration
10,00 s
Trigger Position
70,00 %
Trigger Mode
Single
Analog Channel 1
Frequency
Analog Channel 2
VAN
Analog Channel 3
VBN
Analog Channel 4
VCN
Digital Input 1
Stg1 Freq Sta
Input 1 Trigger
Trigger L/H
Digital Input 2
Stg2 Freq Sta
Input 2 Trigger
Trigger L/H
Digital Input 3
Stg3 Freq Sta
Input 3 Trigger
Trigger L/H
Digital Input 4
Stg4 Freq Sta
Input 4 Trigger
Trigger L/H
Digital Input 5
Stg5 Freq Sta
Input 5 Trigger
Trigger L/H
Digital Input 6
Stg6 Freq Sta
Input 6 Trigger
Trigger L/H
Digital Input 7
Stg1 Freq Trp
Input 7 Trigger
Trigger L/H
Digital Input 8
Stg2 Freq Trp
Input 8 Trigger
Trigger L/H
Digital Input 9
Stg3 Freq Trp
Input 9 Trigger
Trigger L/H
Digital Input 10
Stg4 Freq Trp
Input 10 Trigger
Trigger L/H
Digital Input 11
Stg5 Freq Trp
Input 11 Trigger
Trigger L/H
Digital Input 12
Stg6 Freq Trp
Input 12 Trigger
Trigger L/H
Digital Input 13
V<1 Start
Input 13 Trigger
Trigger L/H
Digital Input 14
V<2 Start
Input 14 Trigger
Trigger L/H
Digital Input 15
V>1 Start
Input 15 Trigger
Trigger L/H
Digital Input 16
V>2 Start
Input 16 Trigger
Trigger L/H
Digital Input 17
V<1 Trip
Input 17 Trigger
Trigger L/H
Digital Input 18
V<2 Trip
Input 18 Trigger
Trigger L/H
Digital Input 19
V>1 Trip
Input 19 Trigger
Trigger L/H
Digital Input 20
V>2 Trip
Input 20 Trigger
Trigger L/H
Digital Input 21
Freq High
Input 21 Trigger
Trigger L/H
Digital Input 22
Freq Low
Input 22 Trigger
Trigger L/H
Digital Input 23
Freq Not Found
Input 23 Trigger
Trigger L/H
Digital Input 24 *
Unused
* Continue as above for "Digital Input_X" 25 - 31
Digital Input 32
Unused
Default Display
Date and Time
Local Values
Primary
Remote Values
Primary
Measurement Ref
VA


COMMUNICATIONS
Rear Protocol
Courier
Remote Address
255
Inactivity Timer
15,00 mins
COMMISSION TESTS
Opto I/P Status
00000000
Relay O/P Status
00000000
Test Port Status
00000000
LED Status
00000000
Monitor Bit 1
64
Monitor Bit 2
65
Monitor Bit 3
66
Monitor Bit 4
67
Monitor Bit 5
68
Monitor Bit 6
69
Monitor Bit 7
70
Monitor Bit 8
71
Test mode
Disabled
Test LEDs
No Operation
OPTO CONFIG
Global Nominal V
48/54V
Opto Input 1 *
48/54V
Opto Input 2 *
48/54V
* Repeat as above for Opto Input 3 - 30
Opto Input 31
48/54V
Opto Input 32
48/54V
CONTROL INPUTS
Ctrl I/P Status
0000000000000000
Control Input 1 *
No operation
Control Input 2 *
No Operation
* Repeat as above for Control Input 3 - 30
Control Input 31
No Operation
Control Input 32
No Operation
CTRL I/P CONFIG
Control Input 1 *
Latched
Control Input 2 *
Latched
* Repeat as above for Control Input 3 - 30
Control Input 31
Latched
Control Input 32
Latched

GS

COMMON SETTINGS GROUP 1

- V<B Status: Enabled
- V<B Voltage Set: 25,00 V
- V<B Measur Mode: Phase-Phase
- V<B Operate Mode: Three Phase
- Freq. Av. Cycles: 5
- Df/dt Av. Cycles: 5
- Holding Timer: 5,000 s

f+t [81U/81O] GROUP 1

- Stage1 f+t: Enabled
- 1(f+t) f: 49,00 Hz
- 1(f+t) t: 20,00 s
- Stage2 f+t: Enabled
- 2(f+t) f: 48,60 Hz
- 2(f+t) t: 20,00 s
- Stage3 f+t: Enabled
- 3(f+t) f: 48,20 Hz
- 3(f+t) t: 10,00 s
- Stage4 f+t: Enabled
- 4(f+t) f: 47,80 Hz
- 4(f+t) t: 10,00 s
- Stage5 f+t: Enabled
- 5(f+t) f: 50,50 Hz
- 5(f+t) t: 30,00 s
- Stage6 f+t: Enabled
- 6(f+t) f: 51,00 Hz
- 6(f+t) t: 20,00 s
- Stage7 f+t: Enabled
- 7(f+t) f: 47,40 Hz
- 7(f+t) t: 10,00 s
- Stage8 f+t: Enabled
- 8(f+t) f: 47,00 Hz
- 8(f+t) t: 10,00 s
- Stage9 f+t: Enabled
- 9(f+t) f: 46,40 Hz
- 9(f+t) t: 10,00 s

f+df/dt [81RF] GROUP 1

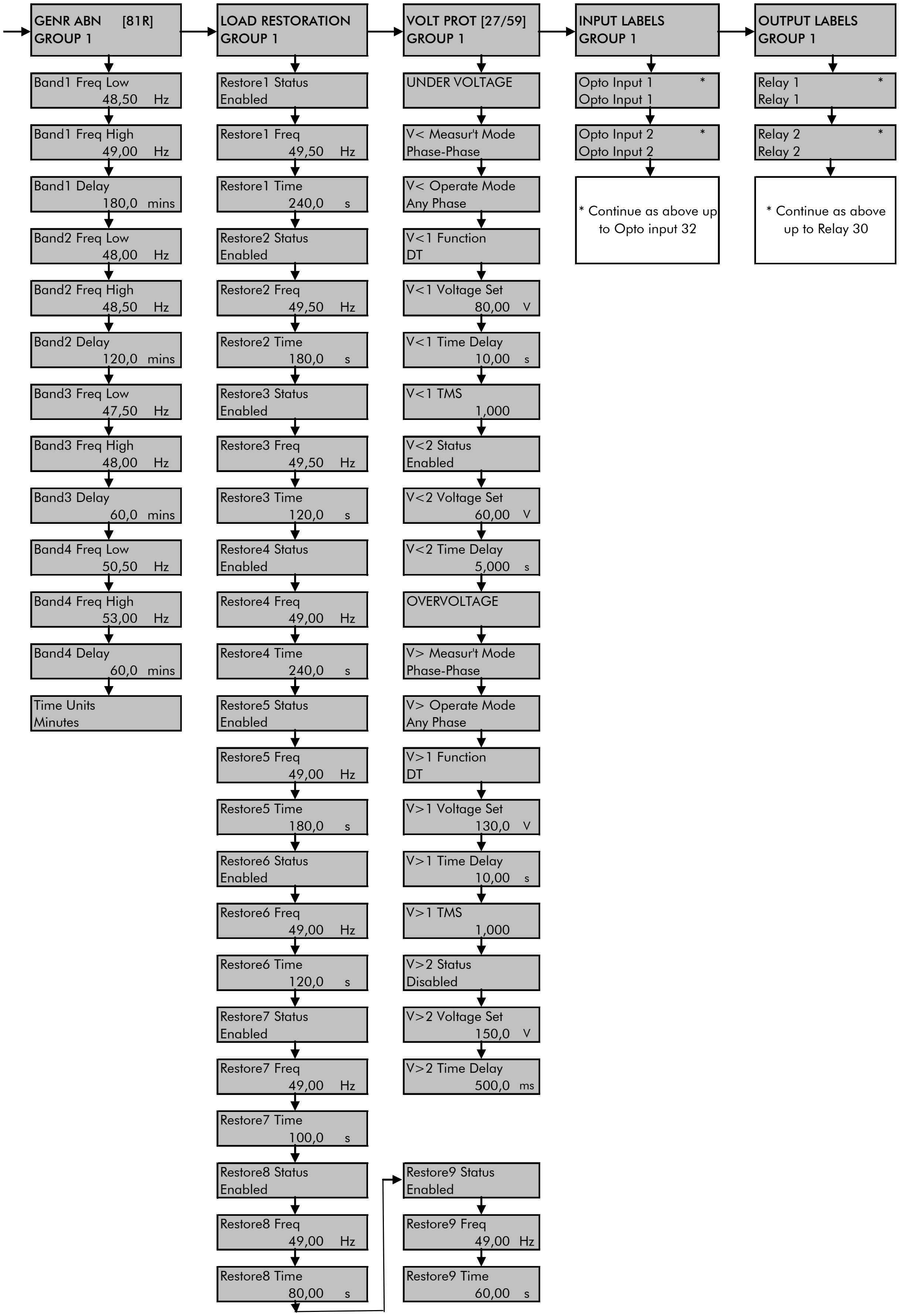
- Stage1 f+df/dt: Enabled
- 1(f+df/dt) f: 49,00 Hz
- 1(f+df/dt) df/dt: 1,000 Hz/s
- Stage2 f+df/dt: Enabled
- 2(f+df/dt) f: 48,60 Hz
- 2(f+df/dt) df/dt: 1,000 Hz/s
- Stage3 f+df/dt: Enabled
- 3(f+df/dt) f: 48,20 Hz
- 3(f+df/dt) df/dt: 1,000 Hz/s
- Stage4 f+df/dt: Enabled
- 4(f+df/dt) f: 47,80 Hz
- 4(f+df/dt) df/dt: 1,000 Hz/s
- Stage5 f+df/dt: Enabled
- 5(f+df/dt) f: 50,50 Hz
- 5(f+df/dt) df/dt: 1,000 Hz/s
- Stage6 f+df/dt: Enabled
- 6(f+df/dt) f: 51,00 Hz
- 6(f+df/dt) df/dt: 1,000 Hz/s

df/dt+t [81R] GROUP 1

- Stage1 df/dt+t: Negative
- 1(df/dt+t) df/dt: 2,000 Hz/s
- 1(df/dt+t) t: 500,0 ms
- Stage2 df/dt+t: Negative
- 2(df/dt+t) df/dt: 2,000 Hz/s
- 2(df/dt+t) t: 1,000 s
- Stage3 df/dt+t: Negative
- 3(df/dt+t) df/dt: 2,000 Hz/s
- 3(df/dt+t) t: 2,000 s
- Stage4 df/dt+t: Negative
- 4(df/dt+t) df/dt: 2,000 Hz/s
- 4(df/dt+t) t: 3,000 s
- Stage5 df/dt+t: Positive
- 5(df/dt+t) df/dt: 2,000 Hz/s
- 5(df/dt+t) t: 500,0 ms
- Stage6 df/dt+t: Positive
- 6(df/dt+t) df/dt: 2,000 Hz/s
- 6(df/dt+t) t: 1,000 s

f+DF/DT [81RAV] GROUP 1

- Stage1 f+Df/Dt: Enabled
- 1(f+Df/Dt)) f: 49,00 Hz
- 1(f+Df/Dt) Df: 500,0 mHz
- 1(f+Df/Dt) Dt: 500,0 ms
- Stage2 f+Df/Dt: Enabled
- 2(f+Df/Dt)) f: 49,00 Hz
- 2(f+Df/Dt) Df: 1,000 Hz
- 2(f+Df/Dt) Dt: 1,000 s
- Stage3 f+Df/Dt: Enabled
- 3(f+Df/Dt)) f: 48,50 Hz
- 3(f+Df/Dt) Df: 500,0 mHz
- 3(f+Df/Dt) Dt: 500,0 ms
- Stage4 f+Df/Dt: Enabled
- 4(f+Df/Dt)) f: 48,50 Hz
- 4(f+Df/Dt) Df: 1,000 Hz
- 4(f+Df/Dt) Dt: 1,000 s
- Stage5 f+Df/Dt: Enabled
- 5(f+Df/Dt)) f: 50,50 Hz
- 5(f+Df/Dt) Df: 500,0 mHz
- 5(f+Df/Dt) Dt: 500,0 ms
- Stage6 f+Df/Dt: Enabled
- 6(f+Df/Dt)) f: 51,00 Hz
- 6(f+Df/Dt) Df: 500,0 mHz
- 6(f+Df/Dt) Dt: 500,0 ms


GENR ABN [81R]
GROUP 1
Band1 Freq Low
48,50 Hz
Band1 Freq High
49,00 Hz
Band1 Delay
180,0 mins
Band2 Freq Low
48,00 Hz
Band2 Freq High
48,50 Hz
Band2 Delay
120,0 mins
Band3 Freq Low
47,50 Hz
Band3 Freq High
48,00 Hz
Band3 Delay
60,0 mins
Band4 Freq Low
50,50 Hz
Band4 Freq High
53,00 Hz
Band4 Delay
60,0 mins
Time Units
Minutes
LOAD RESTORATION
GROUP 1
Restore1 Status
Enabled
Restore1 Freq
49,50 Hz
Restore1 Time
240,0 s
Restore2 Status
Enabled
Restore2 Freq
49,50 Hz
Restore2 Time
180,0 s
Restore3 Status
Enabled
Restore3 Freq
49,50 Hz
Restore3 Time
120,0 s
Restore4 Status
Enabled
Restore4 Freq
49,00 Hz
Restore4 Time
240,0 s
Restore5 Status
Enabled
Restore5 Freq
49,00 Hz
Restore5 Time
180,0 s
Restore6 Status
Enabled
Restore6 Freq
49,00 Hz
Restore6 Time
120,0 s
Restore7 Status
Enabled
Restore7 Freq
49,00 Hz
Restore7 Time
100,0 s
Restore8 Status
Enabled
Restore8 Freq
49,00 Hz
Restore8 Time
80,00 s
Restore9 Status
Enabled
Restore9 Freq
49,00 Hz
Restore9 Time
60,00 s
VOLT PROT [27/59]
GROUP 1
UNDER VOLTAGE
V< Measur't Mode
Phase-Phase
V< Operate Mode
Any Phase
V<1 Function
DT
V<1 Voltage Set
80,00 V
V<1 Time Delay
10,00 s
V<1 TMS
1,000
V<2 Status
Enabled
V<2 Voltage Set
60,00 V
V<2 Time Delay
5,000 s
OVERVOLTAGE
V> Measur't Mode
Phase-Phase
V> Operate Mode
Any Phase
V>1 Function
DT
V>1 Voltage Set
130,0 V
V>1 Time Delay
10,00 s
V>1 TMS
1,000
V>2 Status
Disabled
V>2 Voltage Set
150,0 V
V>2 Time Delay
500,0 ms
INPUT LABELS
GROUP 1
Opto Input 1 *
Opto Input 1
Opto Input 2 *
Opto Input 2
* Continue as above up to Opto input 32
OUTPUT LABELS
GROUP 1
Relay 1 *
Relay 1
Relay 2 *
Relay 2
* Continue as above up to Relay 30

GS

GS

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ST

SETTINGS

Date:	**2008**
Hardware Suffix:	**A or C**
Software Version:	**12**
Connection Diagrams:	**10P94yxx (y = 1 or 3) (x = 01 to 06)**

ST

CONTENTS

1. SETTINGS

The P940 relays must be configured to the system and application by means of appropriate settings. The sequence in which the settings are listed and described in this chapter will be the protection setting, control and configuration settings and the disturbance recorder settings (see section P9x/EN GS for the detailed relay menu map). The relay is supplied with a factory-set configuration of default settings.

1.1 Relay settings configuration

The relay is a multi-function device that supports numerous different protection, control and communication features. In order to simplify the setting of the relay, there is a configuration settings column which can be used to enable or disable many of the functions of the relay. The settings associated with any function that is disabled are made invisible; i.e. they are not shown in the menu. To disable a function change the relevant cell in the 'Configuration' column from 'Enabled' to 'Disabled'.

The configuration column controls which of the four protection settings groups is selected as active through the 'Active settings' cell. A protection setting group can also be disabled in the configuration column, provided it is not the present active group. Similarly, a disabled setting group cannot be set as the active group.

The column also allows all of the setting values in one group of protection settings to be copied to another group.

To do this firstly set the 'Copy from' cell to the protection setting group to be copied, then set the 'copy to' cell to the protection group where the copy is to be placed. The copied settings are initially placed in the temporary scratchpad, and will only be used by the relay following confirmation.

ST

Menu Text	Default Setting	Available Settings
Restore Defaults	No Operation	No Operation All Settings Setting Group 1 Setting Group 2 Setting Group 3 Setting Group 4
Setting to restore a setting group to factory default settings.		
Setting Group	Select via Menu	Select via Menu Select via Optos
Allows setting group changes to be initiated via Opto Input or via Menu.		
Active Settings	Group 1	Group 1, Group 2, Group 3, Group 4
Selects the active setting group.		
Save Changes	No Operation	No Operation, Save, Abort
Saves all relay settings.		
Copy from	Group 1	Group 1, 2, 3 or 4
Allows displayed settings to be copied from a selected setting group.		
Copy to	No Operation	No Operation Group 1, 2, 3 or 4
Allows displayed settings to be copied to a selected setting group (ready to paste).		
Setting Group 1	Enabled	Enabled or Disabled
If the setting group is disabled from the configuration, then all associated settings and signals are hidden, with the exception of this setting (paste).		

Menu Text	Default Setting	Available Settings
Setting Group 2 (as above)	Disabled	Enabled or Disabled
Setting Group 3 (as above)	Disabled	Enabled or Disabled
Setting Group 4 (as above)	Disabled	Enabled or Disabled
Load Restoration	Disabled	Enabled or Disabled
To enable (activate) or disable (turn off) the frequency based Load Restoration function.		
Genr Abn Protn	Disabled	Enabled or Disabled
To enable (activate) or disable (turn off) the Generator Abnormal frequency Protection function. Four bands: ANSI 81AB		
Volt Protection	Disabled	Enabled or Disabled
To enable (activate) or disable (turn off) the Voltage Protection (under/overvoltage) function. V<, V> stages: ANSI 27/59.		
Input Labels	Visible	Invisible or Visible
Sets the Input Labels menu visible further on in the relay settings menu.		
Output Labels	Visible	Invisible or Visible
Sets the Output Labels menu visible further on in the relay settings menu.		
CT & VT Ratios	Visible	Invisible or Visible
Sets the Current & Voltage Transformer Ratios menu visible further on in the relay settings menu.		
Record Control	Invisible	Invisible or Visible
Sets the Record Control menu visible further on in the relay settings menu.		
Disturb. Recorder	Invisible	Invisible or Visible
Sets the Disturbance Recorder menu visible further on in the relay settings menu.		
Measure't. Set-up	Invisible	Invisible or Visible
Sets the Measurement Setup menu visible further on in the relay settings menu.		
Comms. Settings	Visible	Invisible or Visible
Sets the Communications Settings menu visible further on in the relay settings menu. These are the settings associated with the rear communications port.		
Commission Tests	Visible	Invisible or Visible
Sets the Commissioning Tests menu visible further on in the relay settings menu.		
Setting Values	Primary	Primary or Secondary
This affects all protection settings that are dependent upon CT and VT ratio’s.		
Control Inputs	Visible	Invisible or Visible
Activates the Control Input status and operation menu further on in the relay setting menu.		
Ctrl I/P Config [*]	Visible	Invisible or Visible
Sets the CTRL I/P Config menu visible further on in the relay settings menu		

[*] This setting is only available in software version v12.

1.1.1 Default settings restore

To restore the default values to the settings in any protection settings group, set the ‘restore defaults’ cell to the relevant group number. Alternatively it is possible to set the ‘restore defaults’ cell to ‘all settings’ to restore the default values to all of the relay’s settings, not just the protection groups’ settings. The default settings will initially be placed in the scratchpad and will only be used by the relay after they have been confirmed. Note that restoring defaults to all settings includes the rear communication port settings, which may result in communication via the rear port being disrupted if the new (default) settings do not match those of the master station.

1.2 Protection settings

The protection settings include all the following items that become active once enabled in the configuration column of the relay menu database:

– Protection element settings.

– Scheme logic settings.

– Load restoration settings.

ST

There are four groups of protection settings, with each group containing the same setting cells. One group of protection settings is selected as the active group, and is used by the protection elements. The settings for group 1 is shown. The settings are discussed in the same order in which they are displayed in the menu.

1.2.1 Common settings

The frequency based protection features on the P940 relays are controlled by a number of general features that can be found in the “Common Settings” relay menu column and are shown below:

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
GROUP 1 COMMON SETTINGS				
V<B Status	Enabled	Disabled, Enabled		
To enable (activate) or disable (turn off) the undervoltage blocking of the frequency protection functions.				
V<B Voltage Set	For 100 - 120V rated relays			
	25V	20V	120V	1V
	For 380 - 480V rated relays			
	100V	80V	480V	4V
Pick-up setting for the undervoltage blocking element. When operated this will prevent any frequency (except under/over frequency [81U/81O]) based protection function from operating.				
V<B Measur Mode*	Phase-Phase	Phase-Phase, Phase-Neutral		
Sets the measured input voltage that will be used for the undervoltage blocking.				
V<B Operat Mode*	Any Phase	Any Phase, Three Phase		
Setting that determines whether any phase or all three phases has to satisfy the undervoltage criteria before a decision is made.				

* This setting is only available in software version v11. In software version v10, the undervoltage blocking measurement mode is fixed as Phase-Phase, with Any Phase operation mode.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Freq. Av. Cycles	5	0	48**	1
Sets the number of power system cycles that are used to average the frequency measurement. This setting will effect the f+t [81U/81O], f+df/dt [81RF], and f+Df/Dt [81RAV] protection elements.				
df/dt. Av. Cycles	5	0	48**	1
Sets the number of power system cycles that are used to average the rate of change of frequency measurement. This setting will effect the df/dt+t [81R] and f+df/dt [81RF] protection elements.				
Holding Timer	5.0s	1.0s	300.0s	1.0s
Sets the holding time as used by all stages of the load restoration function.				

1.2.2 Under/over-frequency protection f+t [81U/81O]

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Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
GROUP 1 f+t [81U/81O]				
Stage 1 f+t	Enabled	Disabled or Enabled		
Setting to enable or disable the first stage frequency protection.				
1 (f+t) f	49.00Hz	40.00Hz	70.00Hz	0.01Hz
Pick-up setting for the first stage frequency protection element. If this is set below the nominal system frequency setting, the element will be an underfrequency element. If this is set above the nominal system frequency the element will be an overfrequency element.				
1 (f+t) t	20.00s	0.00s	100.00s	0.01s
Setting for the operating time-delay for the first stage frequency protection element.				
Stage 2 f+t	Enabled	Disabled or Enabled		
Setting to enable or disable the second stage frequency protection.				
2 (f+t) f	48.60Hz	40.00Hz	70.00Hz	0.01Hz
Pick-up setting for the second stage frequency protection element. If this is set below the nominal system frequency setting, the element will be an underfrequency element. If this is set above the nominal system frequency the element will be an overfrequency element.				
2 (f+t) t	20.00s	0.00s	100.00s	0.01s
Setting for the operating time-delay for the second stage frequency protection element.				
Stage 3 f+t	Enabled	Disabled or Enabled		
Setting to enable or disable the third stage frequency protection.				
3 (f+t) f	48.20Hz	40.00Hz	70.00Hz	0.01Hz
Pick-up setting for the third stage frequency protection element. If this is set below the nominal system frequency setting, the element will be an underfrequency element. If this is set above the nominal system frequency the element will be an overfrequency element.				
3 (f+t) t	10.00s	0.00s	100.00s	0.01s
Setting for the operating time-delay for the third stage frequency protection element.				

** This maximum value applies to software version v11. In software version v10, the maximum number of averaging cycles that can be selected is 12.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Stage 4 f+t	Enabled	Disabled or Enabled		
Setting to enable or disable the fourth stage frequency protection.				
4 (f+t) f	47.80Hz	40.00Hz	70.00Hz	0.01Hz
Pick-up setting for the fourth stage frequency protection element. If this is set below the nominal system frequency setting, the element will be an underfrequency element. If this is set above the nominal system frequency the element will be an overfrequency element.				
4 (f+t) t	10.00s	0.00s	100.00s	0.01s
Setting for the operating time-delay for the fourth stage frequency protection element.				
Stage 5 f+t	Enabled	Disabled or Enabled		
Setting to enable or disable the fifth stage frequency protection.				
5 (f+t) f	50.50Hz	40.00Hz	70.00Hz	0.01Hz
Pick-up setting for the fifth stage frequency protection element. If this is set below the nominal system frequency setting, the element will be an underfrequency element. If this is set above the nominal system frequency the element will be an overfrequency element.				
5 (f+t) t	30.00s	0.00s	100.00s	0.01s
Setting for the operating time-delay for the fifth stage frequency protection element.				
Stage 6 f+t	Enabled	Disabled or Enabled		
Setting to enable or disable the sixth stage frequency protection.				
6 (f+t) f	51.00Hz	40.00Hz	70.00Hz	0.01Hz
Pick-up setting for the sixth stage frequency protection element. If this is set below the nominal system frequency setting, the element will be an underfrequency element. If this is set above the nominal system frequency the element will be an overfrequency element.				
6 (f+t) t	20.00s	0.00s	100.00s	0.01s
Setting for the operating time-delay for the sixth stage frequency protection element.				
Stage 7 f+t *	Enabled	Disabled or Enabled		
Setting to enable or disable the seventh stage frequency protection.				
7 (f+t) f *	47.40Hz	40.00Hz	70.00Hz	0.01Hz
Pick-up setting for the seventh stage frequency protection element. If this is set below the nominal system frequency setting, the element will be an underfrequency element. If this is set above the nominal system frequency the element will be an overfrequency element.				
7 (f+t) t *	10.00s	0.00s	100.00s	0.01s
Setting for the operating time-delay for the seventh stage frequency protection element.				
Stage 8 f+t *	Enabled	Disabled or Enabled		
Setting to enable or disable the eighth stage frequency protection.				
8 (f+t) f *	47.00Hz	40.00Hz	70.00Hz	0.01Hz
Pick-up setting for the eighth stage frequency protection element. If this is set below the nominal system frequency setting, the element will be an underfrequency element. If this is set above the nominal system frequency the element will be an overfrequency element.				
8 (f+t) t *	10.00s	0.00s	100.00s	0.01s
Setting for the operating time-delay for the eighth stage frequency protection element.				
Stage 9 f+t *	Enabled	Disabled or Enabled		
Setting to enable or disable the ninth stage frequency protection.				

* This setting is only available in software version v12

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
9 (f+t) f *	46.40Hz	40.00Hz	70.00Hz	0.01Hz
Pick-up setting for the ninth stage frequency protection element. If this is set below the nominal system frequency setting, the element will be an underfrequency element. If this is set above the nominal system frequency the element will be an overfrequency element.				
9 (f+t) t *	10.00s	0.00s	100.00s	0.01s
Setting for the operating time-delay for the ninth stage frequency protection element.				

1.2.3 Frequency supervised rate of change of frequency f+df/dt [81RF]

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
GROUP 1 f+df/dt [81RF]				
Stage 1 f+df/dt	Enabled	Disabled or Enabled		
Setting to enable or disable the first stage frequency supervised rate of change of frequency protection.				
1 (f+df/dt) f	49.00Hz	40.00Hz	70.00Hz	0.01Hz
Supervising frequency threshold for the first stage. If this is set below the nominal system frequency setting, this threshold will apply underfrequency supervision and the frequency must be falling for element operation. If this is set above the nominal system frequency setting, this threshold will apply overfrequency supervision and the frequency must be rising for element operation.				
1 (f+df/dt) df/dt	1.00Hz/s	0.01Hz/s*	10Hz/s	0.01Hz/s
Rate of change of frequency threshold for the first stage. This setting must be exceeded as well as the supervising frequency threshold, 1 (f+df/dt) f, for element operation.				
Stage 2 f+df/dt	Enabled	Disabled or Enabled		
Setting to enable or disable the second stage frequency supervised rate of change of frequency protection				
2 (f+df/dt) f	48.60Hz	40.00Hz	70.00Hz	0.01Hz
Supervising frequency threshold for the second stage. If this is set below the nominal system frequency setting, this threshold will apply underfrequency supervision and the frequency must be falling for element operation. If this is set above the nominal system frequency setting, this threshold will apply overfrequency supervision and the frequency must be rising for element operation.				
2 (f+df/dt) df/dt	1.00Hz/s	0.01Hz/s*	10Hz/s	0.01Hz/s
Rate of change of frequency threshold for the second stage. This setting must be exceeded as well as the supervising frequency threshold, 2 (f+df/dt) f, for element operation.				
Stage 3 f+df/dt	Enabled	Disabled or Enabled		
Setting to enable or disable the third stage frequency supervised rate of change of frequency protection.				

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* This minimum value is only available in software version v11. In software version v10, the minimum setting is 0.1Hz/s.

<table>
<tr><th rowspan="2">Menu Text</th><th rowspan="2">Default Setting</th><th colspan="2">Setting Range</th><th rowspan="2">Step Size</th></tr>
<tr><th>Min.</th><th>Max.</th></tr>
<tr><td>3 (f+df/dt) f</td><td>48.20Hz</td><td>40.00Hz</td><td>70.00Hz</td><td>0.01Hz</td></tr>
<tr><td colspan="5">Supervising frequency threshold for the third stage. If this is set below the nominal system frequency setting, this threshold will apply underfrequency supervision and the frequency must be falling for element operation. If this is set above the nominal system frequency setting, this threshold will apply overfrequency supervision and the frequency must be rising for element operation.</td></tr>
<tr><td>3 (f+df/dt) df/dt</td><td>1.00Hz/s</td><td>0.01Hz/s*</td><td>10Hz/s</td><td>0.01Hz/s</td></tr>
<tr><td colspan="5">Rate of change of frequency threshold for the third stage. This setting must be exceeded as well as the supervising frequency threshold, 3 (f+df/dt) f, for element operation.</td></tr>
<tr><td>Stage 4 f+df/dt</td><td>Enabled</td><td colspan="3">Disabled or Enabled</td></tr>
<tr><td colspan="5">Setting to enable or disable the fourth stage frequency supervised rate of change of frequency protection.</td></tr>
<tr><td>4 (f+df/dt) f</td><td>47.80Hz</td><td>40.00Hz</td><td>70.00Hz</td><td>0.01Hz</td></tr>
<tr><td colspan="5">Supervising frequency threshold for the fourth stage. If this is set below the nominal system frequency setting, this threshold will apply underfrequency supervision and the frequency must be falling for element operation. If this is set above the nominal system frequency setting, this threshold will apply overfrequency supervision and the frequency must be rising for element operation.</td></tr>
<tr><td>4 (f+df/dt) df/dt</td><td>1.00Hz/s</td><td>0.01Hz/s*</td><td>10Hz/s</td><td>0.01Hz/s</td></tr>
<tr><td colspan="5">Rate of change of frequency threshold for the fourth stage. This setting must be exceeded as well as the supervising frequency threshold, 4 (f+df/dt) f, for element operation.</td></tr>
<tr><td>Stage 5 f+df/dt</td><td>Enabled</td><td colspan="3">Disabled or Enabled</td></tr>
<tr><td colspan="5">Setting to enable or disable the fifth stage frequency supervised rate of change of frequency protection.</td></tr>
<tr><td>5 (f+df/dt) f</td><td>50.50Hz</td><td>40.00Hz</td><td>70.00Hz</td><td>0.01Hz</td></tr>
<tr><td colspan="5">Supervising frequency threshold for the fifth stage. If this is set below the nominal system frequency setting, this threshold will apply underfrequency supervision and the frequency must be falling for element operation. If this is set above the nominal system frequency setting, this threshold will apply overfrequency supervision and the frequency must be rising for element operation.</td></tr>
<tr><td>5 (f+df/dt) df/dt</td><td>1.00Hz/s</td><td>0.01Hz/s*</td><td>10Hz/s</td><td>0.01Hz/s</td></tr>
<tr><td colspan="5">Rate of change of frequency threshold for the fifth stage. This setting must be exceeded as well as the supervising frequency threshold, 5 (f+df/dt) f, for element operation.</td></tr>
<tr><td>Stage 6 f+df/dt</td><td>Enabled</td><td colspan="3">Disabled or Enabled</td></tr>
<tr><td colspan="5">Setting to enable or disable the sixth stage frequency supervised rate of change of frequency protection.</td></tr>
<tr><td>6 (f+df/dt) f</td><td>51.00Hz</td><td>40.00Hz</td><td>70.00Hz</td><td>0.01Hz</td></tr>
<tr><td colspan="5">Supervising frequency threshold for the sixth stage. If this is set below the nominal system frequency setting, this threshold will apply underfrequency supervision and the frequency must be falling for element operation. If this is set above the nominal system frequency setting, this threshold will apply overfrequency supervision and the frequency must be rising for element operation.</td></tr>
</table>

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* This minimum value is only available in software version v11. In software version v10, the minimum setting is 0.1Hz/s.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
6 (f+df/dt) df/dt	1.00Hz/s	0.01Hz/s*	10Hz/s	0.01Hz/s
Rate of change of frequency threshold for the sixth stage. This setting must be exceeded as well as the supervising frequency threshold, 6 (f+df/dt) f, for element operation.				

1.2.4 Independent rate of change of frequency df/dt+t [81R]

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
GROUP 1 df/dt+t [81R]				
Stage 1 df/dt+t	Negative	Disabled, Negative or Positive**		
Setting to enable or disable the first stage of independent rate of change of frequency protection. If negative is selected, the frequency must be falling for element operation. If positive is selected, the frequency must be rising for element operation.				
1 (df/dt+t) df/dt	2.00Hz/s	0.01Hz/s***	10Hz/s	0.01Hz/s
Pick-up setting for the first stage independent rate of change of frequency element.				
1 (df/dt+t) t	0.50s	0.00s	100.00s	0.01s
Time-delay setting for the first stage independent rate of change of frequency element.				
Stage 2 df/dt+t	Negative	Disabled, Negative or Positive**		
Setting to enable or disable the second stage of independent rate of change of frequency protection. If negative is selected, the frequency must be falling for element operation. If positive is selected, the frequency must be rising for element operation.				
2 (df/dt+t) df/dt	2.00Hz/s	0.01Hz/s***	10Hz/s	0.01Hz/s
Pick-up setting for the second stage independent rate of change of frequency element.				
2 (df/dt+t) t	1.00s	0.00s	100.00s	0.01s
Time-delay setting for the second stage independent rate of change of frequency element.				
Stage 3 df/dt+t	Negative	Disabled, Negative or Positive**		
Setting to enable or disable the second stage of independent rate of change of frequency protection. If negative is selected, the frequency must be falling for element operation. If positive is selected, the frequency must be rising for element operation.				
3 (df/dt+t) df/dt	2.00Hz/s	0.01Hz/s***	10Hz/s	0.01Hz/s
Pick-up setting for the third stage independent rate of change of frequency element.				
3 (df/dt+t) t	2.00s	0.00s	100.00s	0.01s
Time-delay setting for the third stage independent rate of change of frequency element.				

ST

* This minimum value is only available in software version v11. In software version v10, the minimum setting is 0.1Hz/s.

** This setting is only available in software version v11. In software version v10, the selection is simply enabled or disabled and the direction is determined by the sign of the df/dt setting. A negative setting indicates that the frequency must be falling, or a positive setting indicates that the frequency must be rising.

*** This minimum value is only available in software version v11. In software version v10, the minimum setting is –10.0Hz/s.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Stage 4 df/dt+t	Negative	Disabled, Negative or Positive*		
Setting to enable or disable the fourth stage of independent rate of change of frequency protection. If negative is selected, the frequency must be falling for element operation. If positive is selected, the frequency must be rising for element operation.				
4 (df/dt+t) df/dt	2.00Hz/s	0.01Hz/s**	10Hz/s	0.01Hz/s
Pick-up setting for the fourth stage independent rate of change of frequency element.				
4 (df/dt+t) t	3.00s	0.00s	100.00s	0.01s
Time-delay setting for the fourth stage independent rate of change of frequency element.				
Stage 5 df/dt+t	Positive	Disabled, Negative or Positive*		
Setting to enable or disable the fifth stage of independent rate of change of frequency protection. If negative is selected, the frequency must be falling for element operation. If positive is selected, the frequency must be rising for element operation.				
5 (df/dt+t) df/dt	2.00Hz/s	0.01Hz/s**	10Hz/s	0.01Hz/s
Pick-up setting for the fifth stage independent rate of change of frequency element.				
5 (df/dt+t) t	0.50s	0.00s	100.00s	0.01s
Time-delay setting for the fifth stage independent rate of change of frequency element.				
Stage 6 df/dt+t	Positive	Disabled, Negative or Positive*		
Setting to enable or disable the sixth stage of independent rate of change of frequency protection. If negative is selected, the frequency must be falling for element operation. If positive is selected, the frequency must be rising for element operation.				
6 (df/dt+t) df/dt	2.00Hz/s	0.01Hz/s**	10Hz/s	0.01Hz/s
Pick-up setting for the sixth stage independent rate of change of frequency element.				
6 (df/dt+t) t	1.00s	0.00s	100.00s	0.01s
Time-delay setting for the sixth stage independent rate of change of frequency element.				

1.2.5 Average rate of change of frequency f+Df/Dt [81RAV]

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
GROUP 1 f+Df/Dt [81RAV]				
Stage 1 f+Df/Dt	Enabled	Disabled or Enabled		
Setting to enable or disable the first stage of average rate of change of frequency protection				
1 (f+Df/Dt) f	49.00Hz	40Hz	70Hz	0.01Hz
Frequency at which the first stage average rate of change of frequency starts to perform its calculation. If this is set below the nominal system frequency setting, the overall frequency trend must be falling for element operation. If this is set above the nominal system frequency setting, the overall frequency trend must be rising for element operation.				

ST

* This setting is only available in software version v11. In software version v10, the selection is simply enabled or disabled and the direction is determined by the sign of the df/dt setting. A negative setting indicates that the frequency must be falling, or a positive setting indicates that the frequency must be rising.

** This minimum value is only available in software version v11. In software version v10, the minimum setting is –10.0Hz/s.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
1 (f+Df/Dt) Df	0.50Hz	0.2Hz	10.0Hz	0.1Hz
Change in frequency that must be measured within the set time, 1 (f+Df/Dt) Dt, for first stage operation.				
1 (f+Df/Dt) Dt	0.50s	0.02s	2.00s	0.02s
The time period over which a change in frequency in excess of the setting 1 (f+Df/Dt) Df must be measured, for first stage operation.				
Stage 2 f+Df/Dt	Enabled	Disabled or Enabled		
Setting to enable or disable the second stage of average rate of change of frequency protection				
2 (f+Df/Dt) f	49.00Hz	40Hz	70Hz	0.01Hz
Frequency at which the second stage average rate of change of frequency starts to perform its calculation. If this is set below the nominal system frequency setting, the overall frequency trend must be falling for element operation. If this is set above the nominal system frequency setting, the overall frequency trend must be rising for element operation.				
2 (f+Df/Dt) Df	1.00Hz	0.2Hz	10.0Hz	0.1Hz
Change in frequency that must be measured within the set time, 2 (f+Df/Dt) Dt, for second stage operation.				
2 (f+Df/Dt) Dt	1.00s	0.02s	2.00s	0.02s
The time period over which a change in frequency in excess of the setting 2 (f+Df/Dt) Df must be measured, for second stage operation.				
Stage 3 f+Df/Dt	Enabled	Disabled or Enabled		
Setting to enable or disable the third stage of average rate of change of frequency protection				
3 (f+Df/Dt) f	48.50Hz	40Hz	70Hz	0.01Hz
Frequency at which the third stage average rate of change of frequency starts to perform its calculation. If this is set below the nominal system frequency setting, the overall frequency trend must be falling for element operation. If this is set above the nominal system frequency setting, the overall frequency trend must be rising for element operation.				
3 (f+Df/Dt) Df	0.50Hz	0.2Hz	10.0Hz	0.1Hz
Change in frequency that must be measured within the set time, 3 (f+Df/Dt) Dt, for third stage operation.				
3 (f+Df/Dt) Dt	0.50s	0.02s	2.00s	0.02s
The time period over which a change in frequency in excess of the setting 3 (f+Df/Dt) Df must be measured, for third stage operation.				
Stage 4 f+Df/Dt	Enabled	Disabled or Enabled		
Setting to enable or disable the fourth stage of average rate of change of frequency protection				
4 (f+Df/Dt) f	48.50Hz	40Hz	70Hz	0.01Hz
Frequency at which the fourth stage average rate of change of frequency starts to perform its calculation. If this is set below the nominal system frequency setting, the overall frequency trend must be falling for element operation. If this is set above the nominal system frequency setting, the overall frequency trend must be rising for element operation.				
4 (f+Df/Dt) Df	1.00Hz	0.2Hz	10.0Hz	0.1Hz
Change in frequency that must be measured within the set time, 4 (f+Df/Dt) Dt, for fourth stage operation.				

<table>
<tr><th rowspan="2">Menu Text</th><th rowspan="2">Default Setting</th><th colspan="2">Setting Range</th><th rowspan="2">Step Size</th></tr>
<tr><th>Min.</th><th>Max.</th></tr>
<tr><td>4 (f+Df/Dt) Dt</td><td>1.00s</td><td>0.02s</td><td>2.00s</td><td>0.02s</td></tr>
<tr><td colspan="5">The time period over which a change in frequency in excess of the setting 4 (f+Df/Dt) Df must be measured, for fourth stage operation.</td></tr>
<tr><td>Stage 5 f+Df/Dt</td><td>Enabled</td><td colspan="3">Disabled or Enabled</td></tr>
<tr><td colspan="5">Setting to enable or disable the fifth stage of average rate of change of frequency protection.</td></tr>
<tr><td>5 (f+Df/Dt) f</td><td>50.50Hz</td><td>40Hz</td><td>70Hz</td><td>0.01Hz</td></tr>
<tr><td colspan="5">Frequency at which the fifth stage average rate of change of frequency starts to perform its calculation. If this is set below the nominal system frequency setting, the overall frequency trend must be falling for element operation. If this is set above the nominal system frequency setting, the overall frequency trend must be rising for element operation.</td></tr>
<tr><td>5 (f+Df/Dt) Df</td><td>0.50Hz</td><td>0.2Hz</td><td>10.0Hz</td><td>0.1Hz</td></tr>
<tr><td colspan="5">Change in frequency that must be measured within the set time, 5 (f+Df/Dt) Dt, for fifth stage operation.</td></tr>
<tr><td>5 (f+Df/Dt) Dt</td><td>0.50s</td><td>0.02s</td><td>2.00s</td><td>0.02s</td></tr>
<tr><td colspan="5">The time period over which a change in frequency in excess of the setting 5 (f+Df/Dt) Df must be measured, for fifth stage operation.</td></tr>
<tr><td>Stage 6 f+Df/Dt</td><td>Enabled</td><td colspan="3">Disabled or Enabled</td></tr>
<tr><td colspan="5">Setting to enable or disable the sixth stage of average rate of change of frequency protection.</td></tr>
<tr><td>6 (f+Df/Dt) f</td><td>51.00Hz</td><td>40Hz</td><td>70Hz</td><td>0.01Hz</td></tr>
<tr><td colspan="5">Frequency at which the sixth stage average rate of change of frequency starts to perform its calculation. If this is set below the nominal system frequency setting, the overall frequency trend must be falling for element operation. If this is set above the nominal system frequency setting, the overall frequency trend must be rising for element operation.</td></tr>
<tr><td>6 (f+Df/Dt) Df</td><td>0.50Hz</td><td>0.2Hz</td><td>10.0Hz</td><td>0.1Hz</td></tr>
<tr><td colspan="5">Change in frequency that must be measured within the set time, 6 (f+Df/Dt) Dt, for sixth stage operation.</td></tr>
<tr><td>6 (f+Df/Dt) Dt</td><td>0.50s</td><td>0.02s</td><td>2.00s</td><td>0.02s</td></tr>
<tr><td colspan="5">The time period over which a change in frequency in excess of the setting 6 (f+Df/Dt) Df must be measured, for sixth stage operation.</td></tr>
</table>

1.2.6 Generator abnormal protection [81AB]

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
GROUP 1 GENR ABN [81AB]				
Band1 Freq. Low	48.50Hz	40.00Hz	70.00Hz	0.01Hz
Lower limit of the first generator abnormal frequency band.				
Band1 Freq. High	49.00Hz	40.00Hz	70.00Hz	0.01Hz
Upper limit of the first generator abnormal frequency band.				
Band1 Delay	180.0	0.0	999.0	0.5
Amount of time that must be spent within the first band for element operation. This is a cumulative timer that will integrate the periods of time the measured frequency is within the band until the limit is reached. The units of this delay are selectable between minutes and hours (see Time Units setting).				
Band2 Freq. Low	48.00Hz	40.00Hz	70.00Hz	0.01Hz
Lower limit of the second generator abnormal frequency band.				
Band2 Freq. High	48.50Hz	40.00Hz	70.00Hz	0.01Hz
Upper limit of the second generator abnormal frequency band.				
Band2 Delay	120.0	0.0	999.0	0.5
Amount of time that must be spent within the second band for element operation. This is a cumulative timer that will integrate the periods of time the measured frequency is within the band until the limit is reached. The units of this delay are selectable between minutes and hours (see Time Units setting).				
Band3 Freq. Low	47.50Hz	40.00Hz	70.00Hz	0.01Hz
Lower limit of the third generator abnormal frequency band.				
Band3 Freq. High	48.00Hz	40.00Hz	70.00Hz	0.01Hz
Upper limit of the third generator abnormal frequency band.				
Band3 Delay	60.0	0.0	999.0	0.5
Amount of time that must be spent within the third band for element operation. This is a cumulative timer that will integrate the periods of time the measured frequency is within the band until the limit is reached. The units of this delay are selectable between minutes and hours (see Time Units setting).				
Band4 Freq. Low	50.50Hz	40.00Hz	70.00Hz	0.01Hz
Lower limit of the fourth generator abnormal frequency band.				
Band4 Freq. High	53.00Hz	40.00Hz	70.00Hz	0.01Hz
Upper limit of the fourth generator abnormal frequency band.				
Band4 Delay	60.0	0.0	999.0	0.5
Amount of time that must be spent within the fourth band for element operation. This is a cumulative timer that will integrate the periods of time the measured frequency is within the band until the limit is reached. The units of this delay are selectable between minutes and hours (see Time Units setting).				
Time Units	Minutes	Minutes or Hours		
Time unit used by all delays within the generator abnormal frequency protection.				

1.2.7 Load restoration

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
GROUP 1 LOAD RESTORATION				
Restore1 Status	Enabled	Disabled or Enabled		
Setting to enable or disable the first stage of load restoration.				
Restore1 Freq.	49.50Hz	40.00Hz	70.00	0.01Hz
Pick-up setting for the first stage of load restoration, above which the associated load restoration time can start. If any first stage of frequency based protection is set above system nominal frequency or protecting against rising frequency conditions, this stage of load restoration is automatically inhibited and an alarm raised.				
Restore1 Time	240s	0s	7200s	0.25s
Time period for which the measured frequency must be higher than first stage restoration frequency setting to permit load restoration. This is a cumulative timer that suspends timing for periods up to the "Holding Timer" duration when the measured frequency is less than the restoration frequency setting.				
Restore2 Status	Enabled	Disabled or Enabled		
Setting to enable or disable the second stage of load restoration.				
Restore2 Freq.	49.50Hz	40.00Hz	70.00	0.01Hz
Pick-up setting for the second stage of load restoration, above which the associated load restoration time can start. If any second stage of frequency based protection is set above system nominal frequency or protecting against rising frequency conditions, this stage of load restoration is automatically inhibited and an alarm raised.				
Restore2 Time	180s	0s	7200s	0.25s
Time period for which the measured frequency must be higher than second stage restoration frequency setting to permit load restoration. This is a cumulative timer that suspends timing for periods up to the "Holding Timer" duration when the measured frequency is less than the restoration frequency setting.				
Restore3 Status	Enabled	Disabled or Enabled		
Setting to enable or disable the third stage of load restoration.				
Restore3 Freq.	49.50Hz	40.00Hz	70.00	0.01Hz
Pick-up setting for the third stage of load restoration, above which the associated load restoration time can start. If any third stage of frequency based protection is set above system nominal frequency or protecting against rising frequency conditions, this stage of load restoration is automatically inhibited and an alarm raised.				
Restore3 Time	120s	0s	7200s	0.25s
Time period for which the measured frequency must be higher than third stage restoration frequency setting to permit load restoration. This is a cumulative timer that suspends timing for periods up to the "Holding Timer" duration when the measured frequency is less than the restoration frequency setting.				
Restore4 Status	Enabled	Disabled or Enabled		
Setting to enable or disable the fourth stage of load restoration.				
Restore4 Freq.	49.00Hz	40.00Hz	70.00	0.01Hz
Pick-up setting for the fourth stage of load restoration, above which the associated load restoration time can start. If any fourth stage of frequency based protection is set above system nominal frequency or protecting against rising frequency conditions, this stage of load restoration is automatically inhibited and an alarm raised.				

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Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Restore4 Time	240s	0s	7200s	0.25s
Time period for which the measured frequency must be higher than fourth stage restoration frequency setting to permit load restoration. This is a cumulative timer that suspends timing for periods up to the “Holding Timer” duration when the measured frequency is less than the restoration frequency setting.				
Restore5 Status	Enabled	Disabled or Enabled		
Setting to enable or disable the fifth stage of load restoration.				
Restore5 Freq.	49.00Hz	40.00Hz	70.00	0.01Hz
Pick-up setting for the fifth stage of load restoration, above which the associated load restoration time can start. If any fifth stage of frequency based protection is set above system nominal frequency or protecting against rising frequency conditions, this stage of load restoration is automatically inhibited and an alarm raised.				
Restore5 Time	180s	0s	7200s	0.25s
Time period for which the measured frequency must be higher than fifth stage restoration frequency setting to permit load restoration. This is a cumulative timer that suspends timing for periods up to the “Holding Timer” duration when the measured frequency is less than the restoration frequency setting.				
Restore6 Status	Enabled	Disabled or Enabled		
Setting to enable or disable the sixth stage of load restoration.				
Restore6 Freq.	49.00Hz	40.00Hz	70.00	0.01Hz
Pick-up setting for the sixth stage of load restoration, above which the associated load restoration time can start. If any sixth stage of frequency based protection is set above system nominal frequency or protecting against rising frequency conditions, this stage of load restoration is automatically inhibited and an alarm raised.				
Restore6 Time	120s	0s	7200s	0.25s
Time period for which the measured frequency must be higher than sixth stage restoration frequency setting to permit load restoration. This is a cumulative timer that suspends timing for periods up to the “Holding Timer” duration when the measured frequency is less than the restoration frequency setting.				
Restore7 Status *	Enabled	Disabled or Enabled		
Setting to enable or disable the seventh stage of load restoration.				
Restore7 Freq.*	49.00Hz	40.00Hz	70.00	0.01Hz
Pick-up setting for the seventh stage of load restoration, above which the associated load restoration time can start. If any seventh stage of frequency based protection is set above system nominal frequency or protecting against rising frequency conditions, this stage of load restoration is automatically inhibited and an alarm raised.				
Restore7 Time *	100s	0s	7200s	0.25s
Time period for which the measured frequency must be higher than sixth stage restoration frequency setting to permit load restoration. This is a cumulative timer that suspends timing for periods up to the “Holding Timer” duration when the measured frequency is less than the restoration frequency setting.				
Restore8 Status *	Enabled	Disabled or Enabled		
Setting to enable or disable the eighth stage of load restoration.				

* This setting is only available in software version v12

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Restore8 Freq. *	49.00Hz	40.00Hz	70.00	0.01Hz
Pick-up setting for the eighth stage of load restoration, above which the associated load restoration time can start. If any sixth stage of frequency based protection is set above system nominal frequency or protecting against rising frequency conditions, this stage of load restoration is automatically inhibited and an alarm raised.				
Restore8 Time	80.00s	0s	7200s	0.25s
Time period for which the measured frequency must be higher than eighth stage restoration frequency setting to permit load restoration. This is a cumulative timer that suspends timing for periods up to the "Holding Timer" duration when the measured frequency is less than the restoration frequency setting.				
Restore9 Status *	Enabled	Disabled or Enabled		
Setting to enable or disable the ninth stage of load restoration.				
Restore9 Freq.*	49.00Hz	40.00Hz	70.00	0.01Hz
Pick-up setting for the ninth stage of load restoration, above which the associated load restoration time can start. If any sixth stage of frequency based protection is set above system nominal frequency or protecting against rising frequency conditions, this stage of load restoration is automatically inhibited and an alarm raised.				
Restore9 Time *	60.00s	0s	7200s	0.25s
Time period for which the measured frequency must be higher than ninth stage restoration frequency setting to permit load restoration. This is a cumulative timer that suspends timing for periods up to the "Holding Timer" duration when the measured frequency is less than the restoration frequency setting.				

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1.2.8 Voltage protection [27/59]

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
GROUP 1 VOLT PROT [27/59]				
UNDERVOLTAGE	Sub-heading			
V< Measur't. Mode	Phase-Phase	Phase-Phase or Phase-Neutral		
Sets the measured input voltage that will be used for the undervoltage elements.				
V< Operate Mode	Any Phase	Any Phase or Three-Phase		
Setting that determines whether any phase or all three phases has to satisfy the undervoltage criteria before a decision is made.				
V<1 Function	DT	Disabled, DT or IDMT		
Tripping characteristic for the first stage undervoltage function. The IDMT characteristic available on the first stage is defined by the following formula: $t = K / (1 - M)$ Where: K = Time multiplier setting t = Operating time in seconds M = Measured voltage/relay setting voltage (V<1 Voltage Set)				

* This setting is only available in software version v12

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
V<1 Voltage Set	For 100 - 120V rated relays			
	80V	10V	120V	1V
	For 380 - 480V rated relays			
	320V	40V	480V	4V
Sets the pick-up setting for first stage undervoltage element.				
V<1 Time Delay	10s	0.00s	100.00s	0.01s
Setting for the operating time-delay for the first stage definite time undervoltage element.				
V<1 TMS	1	0.5	100	0.5
Setting for the time multiplier setting to adjust the operating time of the IDMT characteristic.				
V<2 Status	Enabled	Disabled or Enabled		
Setting to enable or disable the second stage undervoltage element.				
V<2 Voltage Set	For 100 - 120V rated relays			
	60V	10V	120V	1V
	For 380 - 480V rated relays			
	240V	40V	480V	4V
This setting determines the pick-up setting for second stage undervoltage element.				
V<2 Time Delay	5s	0.00s	100.00s	0.01s
Setting for the operating time-delay for the second stage definite time undervoltage element.				
OVERVOLTAGE	Sub-heading			
V> Measur't. Mode	Phase-Phase	Phase-Phase or Phase-Neutral		
Sets the measured input voltage that will be used for the overvoltage elements.				
V> Operate Mode	Any Phase	Any Phase or Three-Phase		
Setting that determines whether any phase or all three phases has to satisfy the overvoltage criteria before a decision is made.				
V>1 Function	DT	Disabled, DT or IDMT		
Tripping characteristic setting for the first stage overvoltage element. The IDMT characteristic available on the first stage is defined by the following formula: t = K / (M - 1) Where: K = Time multiplier setting t = Operating time in seconds M = Measured voltage/relay setting voltage (V>1 Voltage Set)				
V>1 Voltage Set	For 100 - 120V rated relays			
	130V	60V	185V	1V
	For 380 - 480V rated relays			
	520V	240V	740V	4V
Sets the pick-up setting for first stage overvoltage element.				

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
V>1 Time Delay	10s	0.00s	100.00s	0.01s
Setting for the operating time-delay for the first stage definite time overvoltage element.				
V>1 TMS	1	0.5	100	0.5
Setting for the time multiplier setting to adjust the operating time of the IEC IDMT characteristic.				
V>2 Status	Disabled	Disabled or Enabled		
Setting to enable or disable the second stage overvoltage element.				
V>2 Voltage Set	For 100 - 120V rated relays			
	150V	60V	185V	1V
	For 380 - 480V rated relays			
	600V	240V	740V	4V
This setting determines the pick-up setting for the second stage overvoltage element.				
V>2 Time Delay	0.5s	0.00s	100.00s	0.01s
Setting for the operating time-delay for the second stage definite time overvoltage element.				

1.2.9 Opto input labels

Menu Text	Default Setting		Available Settings
	Software Version 10	Software Version 11	
GROUP 1 INPUT LABELS			
Opto Input 1	L1 Setting Group	Opto Input 1	16 Character Text
Setting to change the text associated with each individual opto input. This text will be displayed when an opto input is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			
Opto Input 2	L2 Setting Group	Opto Input 2	16 Character Text
Setting to change the text associated with each individual opto input. This text will be displayed when an opto input is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			
Opto Input 3	L3 Stg1f+t Block	Opto Input 3	16 Character Text
Setting to change the text associated with each individual opto input. This text will be displayed when an opto input is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			
Opto Input 4	L4 Stg2f+t Block	Opto Input 4	16 Character Text
Setting to change the text associated with each individual opto input. This text will be displayed when an opto input is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			
Opto Input 5	L5 Stg3f+t Block	Opto Input 5	16 Character Text
Setting to change the text associated with each individual opto input. This text will be displayed when an opto input is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			
Opto Input 6	L6 Stg4f+t Block	Opto Input 6	16 Character Text
Setting to change the text associated with each individual opto input. This text will be displayed when an opto input is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			

Menu Text	Default Setting		Available Settings
	Software Version 10	Software Version 11	
Opto Input 7	L7 Stg6f+t Block	Opto Input 7	16 Character Text
Setting to change the text associated with each individual opto input. This text will be displayed when an opto input is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			
Opto Input 8	L8 Voltage Block	Opto Input 8	16 Character Text
Setting to change the text associated with each individual opto input. This text will be displayed when an opto input is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			
Opto Input 9 - 32	L9 Not Used - L32 Not Used	Opto Input 9 - Opto Input 32	16 Character Text
Setting to change the text associated with each individual opto input. This text will be displayed when an opto input is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			

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1.2.10 Relay output labels

1.2.10.1 Relay output labels for P941

Menu Text	Default Setting		Available Settings
	Software Version 10	Software Version 11	
GROUP 1 OUTPUT LABELS			
Relay 1	R1 Stg1 f+t Trip	Relay 1	16 Character Text
Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			
Relay 2	R2 Stg2 f+t Trip	Relay 2	16 Character Text
Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			
Relay 3	R3 Stg3 f+t Trip	Relay 3	16 Character Text
Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			
Relay 4	R4 Stg4 f+t Trip	Relay 4	16 Character Text
Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			
Relay 5	R5 Stg6 f+t Trip	Relay 5	16 Character Text
Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			
Relay 6	R6 Voltage Start	Relay 6	16 Character Text
Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			

Menu Text	Default Setting		Available Settings
	Software Version 10	Software Version 11	
Relay 7	R7 Voltage Trips	Relay 7	16 Character Text
Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			
Relay 8 - 15	R8 Not Used - R15 Not Used	Relay 8 - Relay 15	16 Character Text
Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			

1.2.10.2 Relay output labels for P943

Menu Text	Default Setting		Available Settings
	Software Version 10	Software Version 11	
GROUP 1 OUTPUT LABELS			
Relay 1	R1 Stg1 f+t Trip	Relay 1	16 Character Text
Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			
Relay 2	R2 Stg2 f+t Trip	Relay 2	16 Character Text
Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			
Relay 3	R3 Stg3 f+t Trip	Relay 3	16 Character Text
Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			
Relay 4	R4 Stg4 f+t Trip	Relay 4	16 Character Text
Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			
Relay 5	R5 Stg6 f+t Trip	Relay 5	16 Character Text
Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			
Relay 6	R6 Stg1f+Df/Dt T	Relay 6	16 Character Text
Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			
Relay 7	R7 Stg2f+df/dt T	Relay 7	16 Character Text
Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			
Relay 8	R8 Stg3f+df/dt T	Relay 8	16 Character Text
Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.			

<table>
<tr><th rowspan="2">Menu Text</th><th colspan="2">Default Setting</th><th rowspan="2">Available Settings</th></tr>
<tr><th>Software Version 10</th><th>Software Version 11</th></tr>
<tr><td>Relay 9</td><td>R9 Stg4f+df/dt T</td><td>Relay 9</td><td>16 Character Text</td></tr>
<tr><td colspan="4">Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.</td></tr>
<tr><td>Relay 10</td><td>R10 Voltage Strt</td><td>Relay 10</td><td>16 Character Text</td></tr>
<tr><td colspan="4">Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.</td></tr>
<tr><td>Relay 11</td><td>R11 Voltage Trip</td><td>Relay 11</td><td>16 Character Text</td></tr>
<tr><td colspan="4">Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.</td></tr>
<tr><td>Relay 12</td><td>R12 Gen Abn Trip</td><td>Relay 12</td><td>16 Character Text</td></tr>
<tr><td colspan="4">Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.</td></tr>
<tr><td>Relay 13</td><td>R13 Stg1 Restore</td><td>Relay 13</td><td>16 Character Text</td></tr>
<tr><td colspan="4">Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.</td></tr>
<tr><td>Relay 14</td><td>R14 Stg2 Restore</td><td>Relay 14</td><td>16 Character Text</td></tr>
<tr><td colspan="4">Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.</td></tr>
<tr><td>Relay 15 - 30</td><td>R15 Not Used - R30 Not Used</td><td>Relay 15 - Relay 30</td><td>16 Character Text</td></tr>
<tr><td colspan="4">Setting to change the text associated with each individual relay output. This text will be displayed when a relay output is accessed in the relay menu structure and records, and it can be displayed in the programmable scheme logic.</td></tr>
</table>

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1.3 Control and support settings

The control and support settings are part of the main menu and are used to provide the relays global configuration. It includes the following sub-menu settings and these are discussed in more detail:

– Relay function configuration settings

– CT & VT ratio settings

– Reset LEDs

– Active protection setting group

– Password & language settings

– Communications settings

– Measurement settings

– Event & fault record settings

– User interface settings

– Commissioning settings

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1.3.1 System data

This menu provides information for the device and general status of the relay.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
SYSTEM DATA				
Language	English			
The default language used by the device. Selectable as English, French, German, or Spanish.				
Password	****			
Device default password.				
Description	MiCOM P94?			
16 character relay description. Can be edited.				
Plant Reference	MiCOM*			
Associated plant description and can be edited.				
Model Number	P94????????????			
Relay model number. This is a read only cell that cannot be altered.				
Serial Number	???????			
Relay model number. This is a read only cell that cannot be altered.				
Frequency	50Hz	50Hz or 60Hz		
Relay set frequency. Settable between 50 and 60Hz				
Comms. Level	2			
Displays the conformance of the relay to the Courier Level 2 comms.				
Relay Address	255			
Sets the rear port relay address.				

* This only applies to software version v11. Software version v10 had ALSTOM as the Plant Reference

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Active Group	1			
Displays the active settings group.				
Software Ref. 1	P94?____??__??0_?			
Displays the relay software version including protocol and relay model.				
Opto I/P Status	00000000000000000000000000000000			
Display the status of opto inputs fitted.				
Relay O/P Status	00000000000000000000000000000000			
Displays the status of all output relays fitted.				
Alarm Status 1	00000000000000000000000000000000			
32 bit field gives status of first 32 alarms. Includes fixed and user settable alarms.				
Alarm Status 1	00000000000000000000000000000000			
Duplicate of Alarm Status 1 above.				
Alarm Status 2	00000000000000000000000000000000			
Next 32 alarm status defined.				
Access Level	2			
Displays the current access level. Level 0 - No password required - Read access to all settings, alarms, event records and fault records Level 1 - Password 1 or 2 required - As level 0 plus: Control commands, Reset of fault and alarm conditions, Reset LEDs Clearing of event and fault records Level 2 - Password 2 required - As level 1 plus: All other settings				
Password Control	2	0	2	1
Sets the menu access level for the relay. This setting can only be changed when level 2 access is enabled.				
Password Level 1	****			
Allows user to change password level 1.				
Password Level 2	****			
Allows user to change password level 2.				

1.3.2 Date and time

Displays the date and time as well as the battery condition.

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
DATE AND TIME				
Date/Time	Data			
Displays the relay’s current date and time.				
IRIG-B Sync.	Disabled	Disabled or Enabled		
Enable IRIG-B time synchronization.				

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
IRIG-B Status	Data	Card not fitted, Card failed, Signal healthy or No signal		
Displays the status of IRIG-B.				
Battery Status	Data			
Displays whether the battery is healthy or not.				
Battery Alarm	Enabled	Disabled or Enabled		
Setting that determines whether an unhealthy relay battery condition is alarmed or not.				

1.3.3 CT/VT ratios

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
CT AND VT RATIOS				
Main VT Primary	For 100 - 120V rated relays			
	110.0 V	100 V	1000 kV	1
	For 380 - 480V rated relays			
	440.0 V	100 V	1000 kV	1
Sets the main voltage transformer input primary voltage.				
Main VT Secondary	For 100 - 120V rated relays			
	110.0 V	80	140	1
	For 380 - 480V rated relays			
	440.0 V	320 V	560 V	4
Sets the main voltage transformer input secondary voltage.				

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1.3.4 Record control

It is possible to disable the reporting of events from all interfaces that support setting changes. The settings that control the various types of events are in the Record Control column. The effect of setting each to disabled is as follows:

Menu Text	Default Setting	Available Settings
RECORD CONTROL		
Clear Events	No	No or Yes
Selecting “Yes” will cause the existing event log to be cleared and an event will be generated indicating that the events have been erased.		
Clear Faults	No	No or Yes
Selecting “Yes” will cause the existing fault records to be erased from the relay.		
Clear Maint.	No	No or Yes
Selecting “Yes” will cause the existing maintenance records to be erased from the relay.		
Alarm Event	Enabled	Enabled or Disabled
Disabling this setting means that all the occurrences that produce an alarm will result in no event being generated.		
Relay O/P Event	Enabled	Enabled or Disabled
Disabling this setting means that no event will be generated for any change in relay output state.		

Menu Text	Default Setting	Available Settings
Opto Input Event	Enabled	Enabled or Disabled
Disabling this setting means that no event will be generated for any change in logic input state.		
General Event	Enabled	Enabled or Disabled
Disabling this setting means that no General Events will be generated		
Fault Rec. Event	Enabled	Enabled or Disabled
Disabling this setting means that no event will be generated for any fault that produces a fault record		
Maint. Rec. Event	Enabled	Enabled or Disabled
Disabling this setting means that no event will be generated for any occurrence that produces a maintenance record.		
Protection Event	Enabled	Enabled or Disabled
Disabling this setting means that any operation of protection elements will not be logged as an event.		
DDB 31 - 0	11111111111111111111111111111111	
Allows the user to individually select whether DDB signals 0 to 31 create an event or not. Setting a ‘1’ will allow an event to be generated; setting a ’0’ will prevent an event being generated.		
DDB 1022 - 992	11111111111111111111111111111111	
As above, for DDB signals 992 to 1022		

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1.3.5 Disturbance recorder

The disturbance recorder settings include the record duration and trigger position, selection of analog and digital signals to record, and the signal sources that trigger the recording.

The "DISTURBANCE RECORDER" menu column is shown in the following table:

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
DISTURB RECORDER				
Duration	10s	0.1s	10.5s	0.01s
This sets the overall recording time.				
Trigger Position	70.0%	0	100%	0.1%
This sets the trigger point as a percentage of the duration. For example, the default settings show that the overall recording time is set to 10s with the trigger point being at 70% of this, giving 7s pre-fault and 3s post fault recording times.				
Trigger Mode	Single	Single or Extended		
If set to single mode, if a further trigger occurs whilst a recording is taking place, the recorder will ignore the trigger. However, if this has been set to "Extended", the post trigger timer will be reset to zero, thereby extending the recording time.				
Analog. Channel 1	Frequency	Frequency		
This channel is fixed as the frequency channel in the disturbance recorder.				
Analog. Channel 2	VAN	VAN, VBN or VCN		
Selects any available analog input to be assigned to this channel.				

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Analog. Channel 3	VBN	As above		
Analog. Channel 4	VCN	As above		
Digital Input 1	Stg1 Freq Sta	Any of the opto input, relay output or Internal Digital Signals relating to trip or start conditions or inability to measure frequency.		
The digital channels may be mapped to any of the opto isolated inputs or output contacts, in addition to a number of internal relay digital signals, such as protection starts, trips etc.				
Digital Input 2	Stg2 Freq Sta	As above		
Digital Input 3	Stg3 Freq Sta	As above		
Digital Input 4	Stg4 Freq Sta	As above		
Digital Input 5	Stg5 Freq Sta	As above		
Digital Input 6	Stg6 Freq Sta	As above		
Digital Input 7	Stg1 Freq Trp	As above		
Digital Input 8	Stg2 Freq Trp	As above		
Digital Input 9	Stg3 Freq Trp	As above		
Digital Input 10	Stg4 Freq Trp	As above		
Digital Input 11	Stg5 Freq Trp	As above		
Digital Input 12	Stg6 Freq Trp	As above		
Digital Input 13	V<1 Start	As above		
Digital Input 14	V<2 Start	As above		
Digital Input 15	V>1 Start	As above		
Digital Input 16	V>2 Start	As above		
Digital Input 17	V<1 Trip	As above		
Digital Input 18	V<2 Trip	As above		
Digital Input 19	V>1 Trip	As above		
Digital Input 20	V>2 Trip	As above		
Digital Input 21	Freq High	As above		
Digital Input 22	Freq Low	As above		
Digital Input 23	Freq Not Found	As above		
Digital Input 24 to 32	Not Used	As above		
Inputs 1 to 32 Trigger	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				

1.3.6 Measurement setup

Menu Text	Default Setting	Available Settings
MEASURE'T SETUP		
Default Display	Date and Time	Date and Time, Description, Plant Reference, Frequency, 3Ph Voltage, or Access Level
This cell defines the default display content when the relay is initially energized or after the keypad has been inactive for a period greater than 15 minutes.		
Local Values	Primary	Primary or Secondary
This cell defines whether measurements are displayed in primary or secondary terms on the front-panel user interface and front communication port.		
Remote Values	Primary	Primary or Secondary
This cell defines whether measurements are displayed in primary or secondary terms on the rear communication port.		
Measurement Ref	VA	VA, VB or VC
This cell defines the phase reference for all angular measurements that the relay displays.		

ST

1.3.7 Communications

The communications settings apply to the rear communications port only and will depend upon the particular protocol being used. Further details are given in the SCADA communications section (P94x/EN SC).

1.3.7.1 Communications settings for courier protocol

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
COMMUNICATIONS				
Rear Protocol	Courier			
Indicates the communications protocol that will be used on the rear communications port.				
Remote Address	255	0	255	1
This cell sets the unique address for the relay such that only one relay is accessed by master station software.				
Inactivity Timer	15 mins.	1 mins.	30 mins.	1 min.
This cell controls how long the relay will wait without receiving any messages on the rear port before it reverts to its default state, including resetting any password access that was enabled.				

1.3.7.2 Communications settings for MODBUS Protocol

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
COMMUNICATIONS				
Rear Protocol	MODBUS			
Indicates the communications protocol that will be used on the rear communications port.				

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Remote Address	1	1	247	1
This cell sets the unique address for the relay such that only one relay is accessed by master station software.				
Inactivity Timer	15 mins.	1 mins.	30 mins.	1 min.
This cell controls how long the relay will wait without receiving any messages on the rear port before it reverts to its default state, including resetting any password access that was enabled.				
Baud Rate	19200 bits/s	9600 bits/s, 19200 bits/s or 38400 bits/s		
This cell controls the communication speed between relay and master station. It is important that both relay and master station are set at the same speed setting.				
Parity	None	Odd, Even or None		
This cell controls the parity format used in the data frames. It is important that both relay and master station are set with the same parity setting.				
MODBUS IEC Time*	Standard	Standard or Reverse		
When 'Standard' is selected the time format complies with IEC60870-5-4 requirements such that byte 1 of the information is transmitted first, followed by bytes 2 through to 7. If 'Reverse' is selected the transmission of information is reversed.				

ST

1.3.7.3 Communications settings for IEC60870-5-103 protocol

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
COMMUNICATIONS				
Rear Protocol	IEC60870-5-103			
Indicates the communications protocol that will be used on the rear communications port.				
Remote Address	1	0	254	1
This cell sets the unique address for the relay such that only one relay is accessed by master station software.				
Inactivity Timer	15 mins.	1 mins.	30 mins.	1 min.
This cell controls how long the relay will wait without receiving any messages on the rear port before it reverts to its default state, including resetting any password access that was enabled.				
Baud Rate	19200 bits/s	9600 bits/s or 19200 bits/s		
This cell controls the communication speed between relay and master station. It is important that both relay and master station are set at the same speed setting.				
Measure't Period	15s	1s	60s	1s
This cell controls the time interval that the relay will use between sending measurement data to the master station.				
Physical Link	RS485	RS485 or Fibre Optic		
This cell defines whether an electrical EIA(RS) 485 or fibre optic connection is being used for communication between the master station and relay. The cell will only be visible when the optional fibre optic communications board is installed in the relay.				

* This setting is only available in software version v11.

1.3.7.4 Communications settings for DNP3.0 protocol

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
COMMUNICATIONS				
Rear Protocol	DNP 3.0			
Indicates the communications protocol that will be used on the rear communications port.				
Remote Address	1	0	65519	1
This cell sets the unique address for the relay such that only one relay is accessed by master station software.				
Baud Rate	19200 bits/s	1200 bits/s, 2400 bits/s, 4800 bits/s, 9600 bits/s, 19200 bits/s or 38400 bits/s		
This cell controls the communication speed between relay and master station. It is important that both relay and master station are set at the same speed setting.				
Parity	None	Odd, Even or None		
This cell controls the parity format used in the data frames. It is important that both relay and master station are set with the same parity setting.				
Time Sync	Disabled	Disabled or Enabled		
If set to 'Enabled' the DNP3.0 master station can be used to sychronize the time on the relay. If set to 'Disabled' either the internal free running clock, or IRIG-B input are used.				

ST

1.3.8 Commissioning tests

These are menu cells which allow the status of the opto-isolated inputs, output relay contacts, internal digital data bus (DDB) signals and user-programmable LEDs to be monitored. Additionally there are cells to test the operation of the output contacts, user-programmable LEDs and, where available, the auto-reclose cycles.

Menu Text	Default Setting	Available Settings
COMMISSION TESTS		
Opto I/P Status	0000000000000000	
This menu cell displays the status of the relay's opto-isolated inputs as a binary string, a '1' indicating an energized opto-isolated input and a '0' a de-energized one		
Relay O/P Status	0000000000000000	
This menu cell displays the status of the digital data bus (DDB) signals that result in energization of the output relays as a binary string, a '1' indicating an operated state and '0' a non-operated state. When the 'Test Mode' cell is set to 'Enabled' the 'Relay O/P Status' cell does not show the current status of the output relays and hence can not be used to confirm operation of the output relays. Therefore it will be necessary to monitor the state of each contact in turn. When the 'Test Mode' cell is set to 'Contacts Disabled' the 'Relay O/P Status' cell will indicate the status of the output relays as if the relay was in normal service but does not show the actual status of the output relays.		
Test Port Status	00000000	
This menu cell displays the status of the eight digital data bus (DDB) signals that have been allocated in the 'Monitor Bit' cells.		

Menu Text	Default Setting	Available Settings
Monitor Bit 1	64 (LED 1)	0 to 1022 See PSL section for details of digital data bus signals
The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.		
Monitor Bit 8	71 (LED 8)	0 to 1022
The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.		
Test Mode	Disabled	Disabled, Test Mode or Contacts Blocked
The Test Mode menu cell is used to allow secondary injection testing to be performed on the relay without operation of the trip contacts. It also enables a facility to directly test the output contacts by applying menu controlled test signals. To select test mode this menu cell should be set to 'Test Mode', which takes the relay out of service and blocks operation of output contacts and maintenance counters. It also causes an alarm condition to be recorded and the yellow 'Out of Service' LED to illuminate and an alarm message 'Prot'n. Disabled' is given. This also freezes any information stored in the Circuit Breaker Condition column and in IEC60870-5-103 builds changes the Cause of Transmission, COT, to Test Mode. To enable testing of output contacts the Test Mode cell should be set to 'Contacts Blocked'. This blocks the protection from operating the contacts and enables the test pattern and contact test functions which can be used to manually operate the output contacts. Once testing is complete the cell must be set back to 'Disabled' to restore the relay back to service.		
Test Pattern	00000000000000000000000000000000	0 = Not Operated 1 = Operated
This cell is used to select the output relay contacts that will be tested when the 'Contact Test' cell is set to 'Apply Test'.		
Contact Test	No Operation	No Operation, Apply Test or Remove Test
When the 'Apply Test' command in this cell is issued the contacts set for operation (set to '1') in the 'Test Pattern' cell change state. After the test has been applied the command text on the LCD will change to 'No Operation' and the contacts will remain in the Test State until reset issuing the 'Remove Test' command. The command text on the LCD will again revert to 'No Operation' after the 'Remove Test' command has been issued. Note: When the 'Test Mode' cell is set to 'Enabled' the 'Relay O/P Status' cell does not show the current status of the output relays and hence can not be used to confirm operation of the output relays. Therefore it will be necessary to monitor the state of each contact in turn.		
Test LEDs	No Operation	No Operation Apply Test
When the 'Apply Test' command in this cell is issued the 8 user-programmable LEDs will illuminate for approximately 2 seconds before they extinguish and the command text on the LCD reverts to 'No Operation'.		
DDB 31 - 0	00000000000000000000001000000000	
Displays the status of DDB signals 0-31.		
DDB 1022 - 992	00000000000000000000000000000000	
Displays the status of DDB signals 1022 – 992.		

ST

1.3.9 Opto configuration

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
OPTO CONFIG.				
Global Nominal V	48/54V	24/27V, 30/34V, 48/54V, 110/125V, 220/250V or Custom		
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If 'Custom' is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 1	48/54V	24/27V, 30/34V, 48/54V, 110/125V or 220/250V		
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting.				
Opto Input 2 - 32	48/54V	24/27V, 30/34V, 48/54V, 110/125V or 220/250V		
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting.				

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1.3.10 Control input configuration

The control inputs function as software switches that can be set or reset either locally or remotely. These inputs can be used to trigger any function that they are connected to as part of the PSL.

Menu Text	Default Setting	Setting Range	Step Size
CONTROL INPUTS			
Ctrl I/P Status	00000000000000000000000000000000		
This menu cell displays the status of the relay's control inputs as a binary string, a '1' indicating a control input is in the 'Set' state and a '0' indicating that it is in the 'Reset' state. It can also be used to set the status of all of the control inputs.			
Control Input 1	No Operation	No Operation, Set or Reset	
This cell is used to individually control the status of Control Input 1. When the 'Set' command in this cell is issued, control input 1 will change to the set or '1' state and when the 'Reset' command is issued it will change to the reset or '0' state. After the command has been executed the text on the LCD reverts to 'No Operation' but the control input will remain in the programmed state until the next command is issued, or the auxiliary power removed.			
Control Input 2 to 32	No Operation	No Operation, Set or Reset	
As Control Input 1.			

1.3.11 Control I/P configuration

The Control Inputs 1 to 32 may be operated through the HMI, via the front serial Courier port, or remotely via the Courier/Modbus/CS103/DNP3 rear port communications. Each Control Input has the following command options – Set/ Reset/No Operation. Additionally, each Control Input may be configured as Latched or Pulsed.

When configured as Latched, a set command causes the corresponding Control Input DDB signal to go high. A reset command causes it to go low.

When configured as Pulsed, a set command causes the corresponding Control Input DDB signal to pulse high for about 10ms. A reset command has no effect.

Menu Text	Default Setting	Setting Range	Step Size
CTRL I/P CONFIG			
Control Input 1	Latched	Latched or Pulsed	
Each control input can individually be set to the latched or pulsed behaviour			
Control Input 2 to 32	No Operation	No Operation, Set or Reset	
As Control Input 1.			

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OP

OPERATION

Date:	**2008**
Hardware Suffix:	**A or C**
Software Version:	**12**
Connection Diagrams:	**10P94yxx (y = 1 or 3) (x = 01 to 06)**

CONTENTS

OP

FIGURES

1. OPERATION OF INDIVIDUAL PROTECTION FUNCTIONS

The following sections detail the individual protection functions.

1.1 Blocking functions

The frequency based protection features on the P940 are controlled by a number of general features that can be found in the “Common Settings” relay menu column and are shown in the following sections:

1.1.1 Frequency blocking

Within the P940 relay, the frequency is tracked between 40Hz and 70Hz based upon the voltage signals presented to the relay. If the system frequency exceeds these limits, all frequency protection elements (except the under/overfrequency “f+t” element) are prevented from operating. Signals are available within the Programmable Scheme Logic (PSL) to indicate that the system frequency is outside these limits and preventing relay operation (Frequency less than 40Hz is indicated by DDB 309 whereas frequency above 70Hz is indicated by DDB 308).

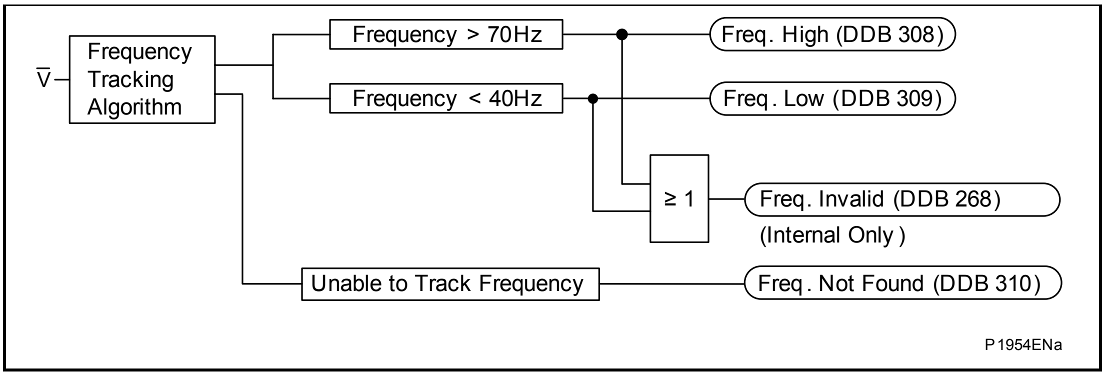

Figure 1: Frequency blocking logic diagram

1.1.2 Undervoltage blocking

An undervoltage blocking facility with user selectable settings is provided to block all frequency based protection elements if severe undervoltage conditions are experienced. This facility operates differently depending upon whether software version 10 or software version 11 is installed on the relay.

Version 12 software follows version 11 (and not version 10) for undervoltage blocking.

1.1.2.1 Undervoltage blocking for software version 10

The undervoltage blocking facility on the relay is enabled or disabled in the “V<B Status” cell of the menu. When the element is enabled and any phase-phase voltage falls below the “V<B Voltage Set” setting, all the frequency based protection elements (including the under/overfrequency “f+t” element) are prevented from operating.

The frequency elements will only be permitted to start operation again when the undervoltage blocking resets. This occurs when all the phase-phase voltages are more than 5% above the “V<B Voltage Set” setting.

A signal is available within the Programmable Scheme Logic (PSL) to indicate that undervoltage blocking is active and preventing relay operation (DDB 314).

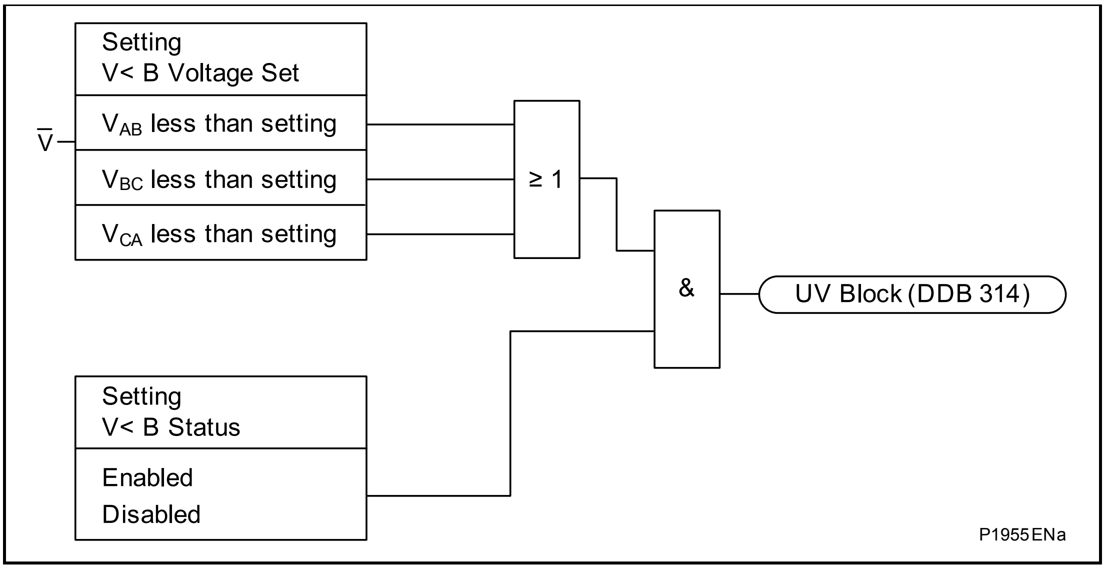

Figure 2: Undervoltage blocking logic diagram for software version v10

1.1.2.2 Undervoltage blocking for software version 11

The undervoltage blocking facility on the relay is enabled or disabled in the “V<B Status” cell of the menu. When the element is enabled, the relay will monitor either phase-phase or phase-neutral voltages as selected in the “V<B Measur Mode” setting and whether all three voltages or any one voltage falling below setting is sufficient for blocking as selected in the “V<B Operat Mode” setting. With all necessary voltage(s) below the “V<B Voltage Set” setting, all the frequency based protection elements (including the under/overfrequency “f+t” element) are prevented from operating.

The frequency elements will only be permitted to start operation again when the undervoltage blocking resets. This depends upon the “V<B Operat Mode” setting and occurs when all the voltages are more than 5% above the “V<B Voltage Set” setting when set to “Any Phase” mode, or when one of the voltages is more than 5% above the “V<B Voltage Set” setting when in “Three Phase” mode.

A signal is available within the Programmable Scheme Logic (PSL) to indicate that undervoltage blocking is active and preventing relay operation (DDB 314).

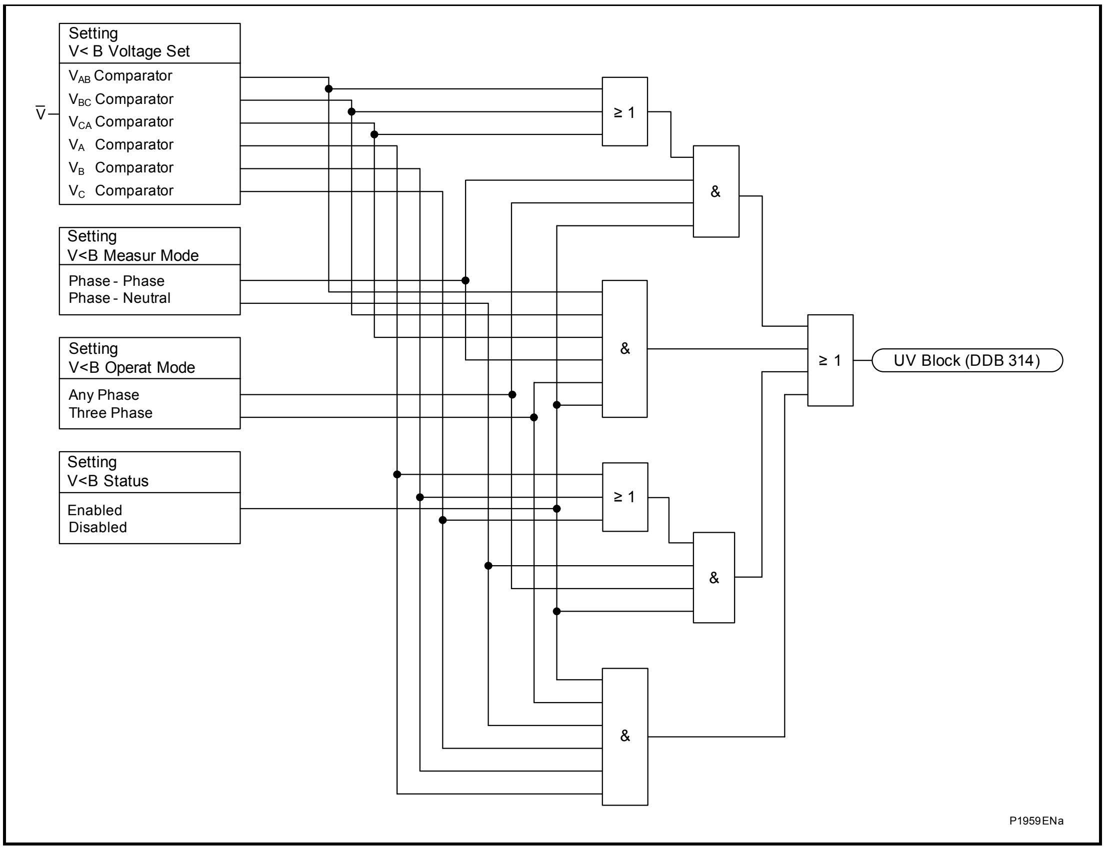

Figure 3: Undervoltage blocking logic diagram for software version v11

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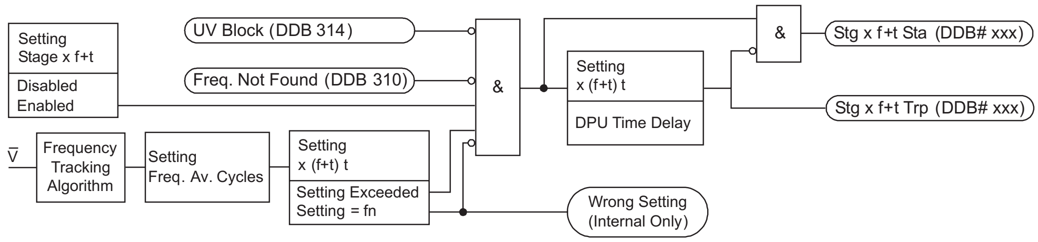
1.2 Under/over frequency protection ‘f+t’ [81U/81O]

The P940 provides six independent definite time delayed stages of frequency protection (f+t). Depending upon whether the threshold is set above or below the system nominal frequency, each stage can respond to either under or over frequency conditions. The relay will also indicate that an incorrect setting has been applied if the frequency threshold is set to the nominal system frequency. Although the elements are described as definite time delayed, by setting the time delay to zero, the element will operate instantaneously.

Within the Programmable Scheme Logic (PSL), signals are available to indicate the start and trip of each frequency stage (Starts: DDB 145, DDB 154, DDB 163, DDB 172, DDB 181, DDB 190, DDB 384*, DDB 397* and DDB 410*; Trips: DDB 146, DDB 155, DDB 164, DDB 173, DDB 182, DDB 191, DDB 385*, DDB 398* and DDB 411*). Signals are also available to indicate when any of the six stages have started or tripped (Any f+t Start = DDB 255; Any f+t Trip = DDB 258). The state of the DDB signals can be programmed to be viewed in the “Monitor Bit x” cells of the “COMMISSION TESTS” column in the relay.



Stage x f+t	DDB# xxx Stg x f+t Sta	DDB# xxx Stg x f+t Trp	Wrong Setting
Stage 1 f+t	Stg 1 f+t Sta (DDB 145)	Stg 1 f+t Trp (DDB 146)	Wrong Setting 01 (DDB 272)
Stage 2 f+t	Stg 2 f+t Sta (DDB 154)	Stg 2 f+t Trp (DDB 155)	Wrong Setting 02 (DDB 273)
Stage 3 f+t	Stg 3 f+t Sta (DDB 163)	Stg 3 f+t Trp (DDB 164)	Wrong Setting 03 (DDB 274)
Stage 4 f+t	Stg 4 f+t Sta (DDB 172)	Stg 4 f+t Trp (DDB 173)	Wrong Setting 04 (DDB 275)
Stage 5 f+t	Stg 5 f+t Sta (DDB 181)	Stg 5 f+t Trp (DDB 182)	Wrong Setting 05 (DDB 276)
Stage 6 f+t	Stg 6 f+t Sta (DDB 190)	Stg 6 f+t Trp (DDB 191)	Wrong Setting 06 (DDB 277)
Stage 7 f+t	Stg 7 f+t Sta (DDB 384)	Stg 7 f+t Trp (DDB 385)	Wrong Setting 35 (DDB 395)
Stage 8 f+t	Stg 8 f+t Sta (DDB 397)	Stg 8 f+t Trp (DDB 398)	Wrong Setting 37 (DDB 408)
Stage 9 f+t	Stg 9 f+t Sta (DDB 410)	Stg 9 f+t Trp (DDB 411)	Wrong Setting 39 (DDB 421)

P1960ENb

Figure 4: Under/over frequency logic (single stage shown)

* available in software version v12.

1.3 Frequency supervised rate of change of frequency protection ‘f+df/dt’ [81RF]

The P940 provides six independent stages of frequency supervised rate of change of frequency protection (f+df/dt). Depending upon whether the frequency threshold is set above or below the system nominal frequency, each stage can respond to either rising or falling frequency conditions. For example, if the frequency threshold is set above nominal frequency, the df/dt setting is considered as positive and the element will operate for rising frequency conditions. If the frequency threshold is set below nominal frequency, the df/dt setting is considered as negative and the element will operate for falling frequency conditions. The relay will also indicate that an incorrect setting has been applied if the frequency threshold is set to the nominal system frequency. There is no intentional time delay associated with this element although using the Programmable Scheme Logic (PSL), time delays could be applied if required.

Within the PSL, signals are available to indicate the trip of each frequency supervised rate of change of frequency stage (DDB 147, DDB 156, DDB 165, DDB 174, DDB 183 and DDB 192). Signals are also available to indicate when any of the six stages have tripped (Any f+df/dt Trip = DDB 259). The state of the DDB signals can be programmed to be viewed in the “Monitor Bit x” cells of the “COMMISSION TESTS” column in the relay.

Note: The df/dt setting range is different between software version 10 and software version 11. For software version 10 the minimum setting is 0.1Hz/s compared to 0.01Hz/s on software version 11.

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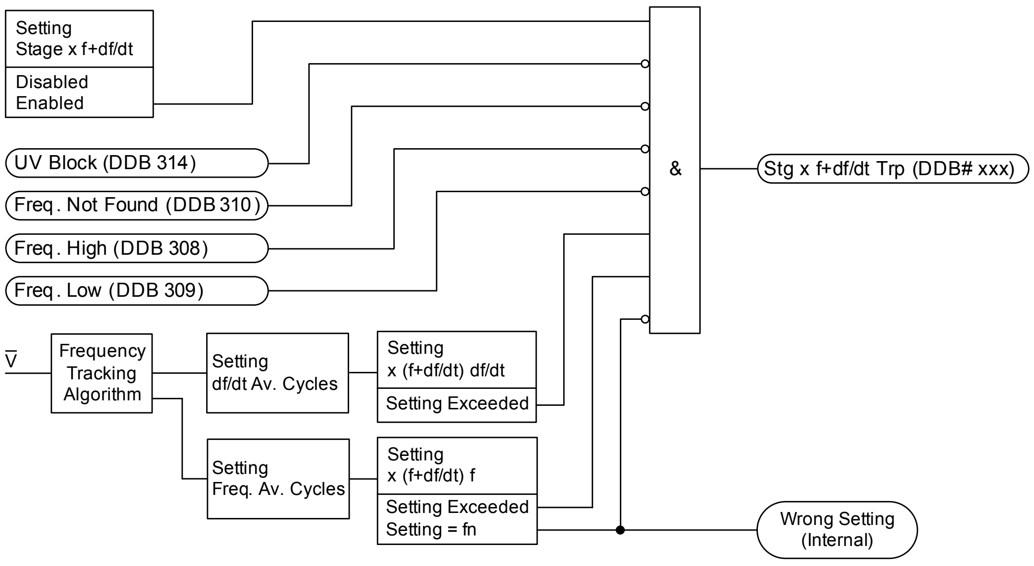


Stage x f+df/dt	DDB# xxx Stg x f+df/dt Trp	Wrong Setting
Stage 1 f+df/dt	Stg 1 f+df/dt Trp (DDB 147)	Wrong Setting 07 (DDB 278)
Stage 2 f+df/dt	Stg 2 f+df/dt Trp (DDB 156)	Wrong Setting 08 (DDB 279)
Stage 3 f+df/dt	Stg 3 f+df/dt Trp (DDB 165)	Wrong Setting 09 (DDB 280)
Stage 4 f+df/dt	Stg 4 f+df/dt Trp (DDB 174)	Wrong Setting 10 (DDB 281)
Stage 5 f+df/dt	Stg 5 f+df/dt Trp (DDB 183)	Wrong Setting 11 (DDB 282)
Stage 6 f+df/dt	Stg 6 f+df/dt Trp (DDB 192)	Wrong Setting 12 (DDB 283)

P1961ENa

Figure 5: Frequency supervised rate of change of frequency logic (single stage shown)

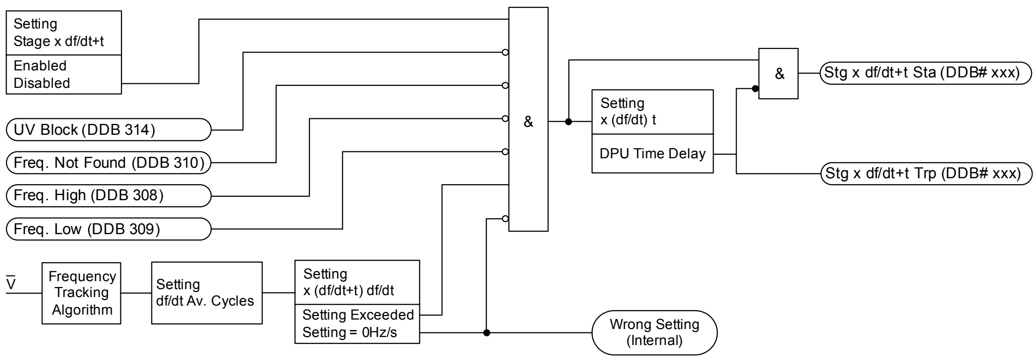
1.4 Independent rate of change of frequency protection ‘df/dt+t’ [81R]

1.4.1 Operation for software version 10

The P940 provides six independent stages of rate of change of frequency protection (df/dt+t). When enabled and depending upon whether the “X (df/dt+t) df/dt” setting is set above 0Hz/s or below 0Hz/s, the element will react to rising or falling frequency conditions respectively, with an incorrect setting being indicated if the threshold is set to zero. The output of the element would normally be given a user-selectable time delay, although it is possible to set this to zero and create an instantaneous element.

Within the Programmable Scheme Logic (PSL), signals are available to indicate the start and trip of each rate of change of frequency stage. (Starts: DDB 148, DDB 157, DDB 166, DDB 175, DDB 184, DDB 193; Trips: DDB 149, DDB 158, DDB 167, DDB 176, DDB 185, DDB 194). Signals are also available to indicate when any of the six stages have started or tripped (Any df/dt+t Start = DDB 256; Any df/dt+t Trip = DDB 260). The state of the DDB signals can be programmed to be viewed in the “Monitor Bit x” cells of the “COMMISSION TESTS” column in the relay.

OP



Stage x df/dt+t	Stg x df/dt+t Sta	Stg x df/dt+t Trp	Wrong Setting
Stage 1 df/dt+t	Stg 1 df/dt+t Sta (DDB 148)	Stg 1 df/dt+t Trp (DDB 149)	Wrong Setting 13 (DDB 284)
Stage 2 df/dt+t	Stg 2 df/dt+t Sta (DDB 157)	Stg 2 df/dt+t Trp (DDB 158)	Wrong Setting 14 (DDB 285)
Stage 3 df/dt+t	Stg 3 df/dt+t Sta (DDB 166)	Stg 3 df/dt+t Trp (DDB 167)	Wrong Setting 15 (DDB 286)
Stage 4 df/dt+t	Stg 4 df/dt+t Sta (DDB 175)	Stg 4 df/dt+t Trp (DDB 176)	Wrong Setting 16 (DDB 287)
Stage 5 df/dt+t	Stg 5 df/dt+t Sta (DDB 184)	Stg 5 df/dt+t Trp (DDB 185)	Wrong Setting 17 (DDB 288)
Stage 6 df/dt+t	Stg 6 df/dt+t Sta (DDB 193)	Stg 6 df/dt+t Trp (DDB 194)	Wrong Setting 18 (DDB 289)

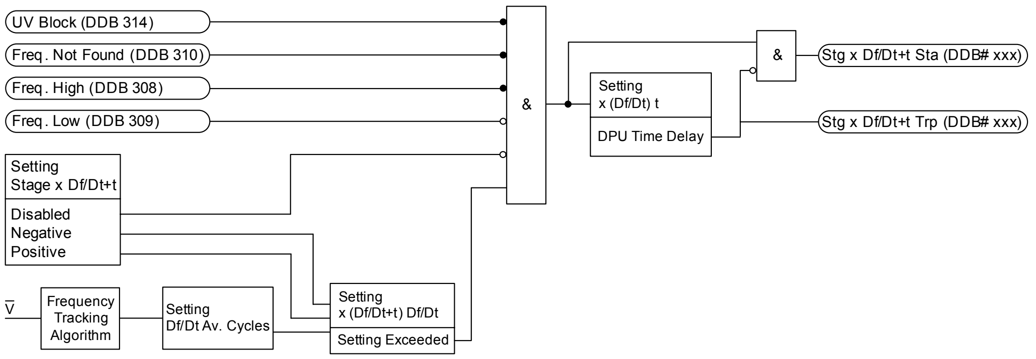
P1962ENa

Figure 6: Independent rate of change of frequency logic for software version v10 (single stage shown)

1.4.2 Operation for software version 11

The P940 provides six independent stages of rate of change of frequency protection (df/dt+t). The "Stage X df/dt+t" setting will define whether the stage is disabled, operates for rising frequency conditions (set to "Positive") or operates for falling frequency conditions (set to "Negative"). The output of the element would normally be given a user-selectable time delay, although it is possible to set this to zero and create an instantaneous element.

Within the Programmable Scheme Logic (PSL), signals are available to indicate the start and trip of each rate of change of frequency stage. (Starts: DDB 148, DDB 157, DDB 166, DDB 175, DDB 184, DDB 193; Trips: DDB 149, DDB 158, DDB 167, DDB 176, DDB 185, DDB 194). Signals are also available to indicate when any of the six stages have started or tripped (Any df/dt+t Start = DDB 256; Any df/dt+t Trip = DDB 260). The state of the DDB signals can be programmed to be viewed in the "Monitor Bit x" cells of the "COMMISSION TESTS" column in the relay.



Stage x Df/Dt+t	Stg x Df/Dt+t Sta	Stg x Df/Dt+t Trp
Stage 1 Df/Dt+t	Stg 1 Df/Dt+t Sta (DDB 148)	Stg 1 Df/Dt+t Trp (DDB 149)
Stage 2 Df/Dt+t	Stg 2 Df/Dt+t Sta (DDB 157)	Stg 2 Df/Dt+t Trp (DDB 158)
Stage 3 Df/Dt+t	Stg 3 Df/Dt+t Sta (DDB 166)	Stg 3 Df/Dt+t Trp (DDB 167)
Stage 4 Df/Dt+t	Stg 4 Df/Dt+t Sta (DDB 175)	Stg 4 Df/Dt+t Trp (DDB 176)
Stage 5 Df/Dt+t	Stg 5 Df/Dt+t Sta (DDB 184)	Stg 5 Df/Dt+t Trp (DDB 185)
Stage 6 Df/Dt+t	Stg 6 Df/Dt+t Sta (DDB 193)	Stg 6 Df/Dt+t Trp (DDB 194)

P1963ENa

Figure 7: Independent rate of change of frequency logic for software version v11 (single stage shown)

OP

1.5 Average rate of change of frequency protection ‘f+Df/Dt’ [81RAV]

The rate of change of frequency elements described in sections 1.4 and 1.3 both use an “instantaneous” measurement of “df/dt” based upon a 3 cycle, filtered “rolling” average technique. Due to the oscillatory nature of frequency excursions, this instantaneous value can sometimes be misleading, either causing unexpected operation or excessive stability. For this reason, the P940 relays also provide an element for monitoring the longer term frequency trend, thereby reducing the effects of non-linearities in the system and providing increased security to the rate of change of frequency decision.

Using the average rate of change of frequency element “f+Df/Dt”, when the measured frequency crosses the supervising frequency threshold a timer is initiated. At the end of this time period, Δt, the frequency difference, Δf, is evaluated and if this exceeds the setting, a trip output is given.

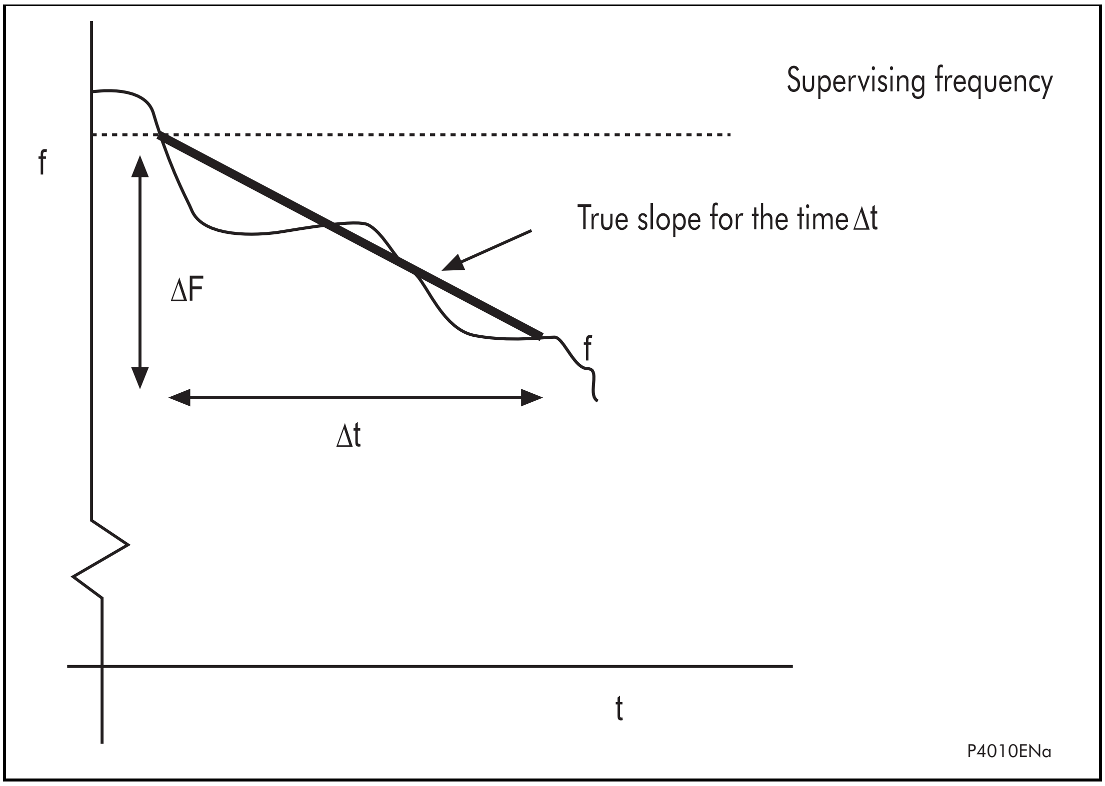
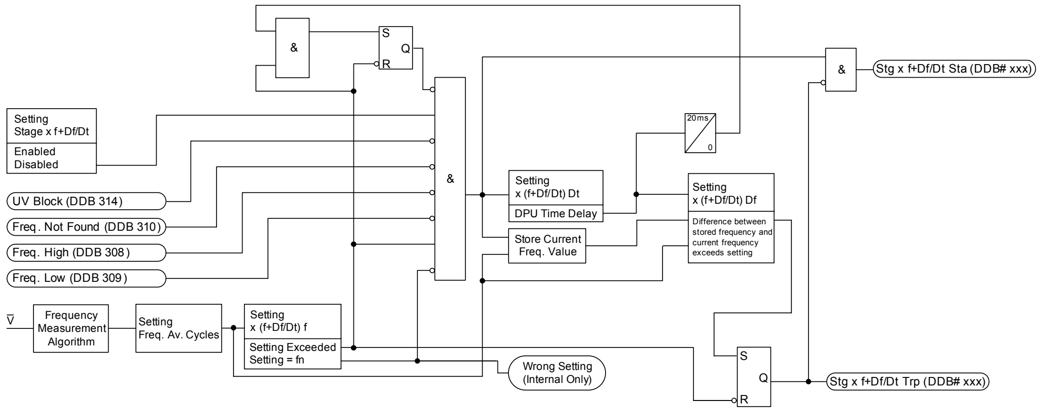


Figure 8: Average rate of change of frequency protection

After time Δt, regardless of the outcome of the comparison, the element is blocked from further operation until the frequency recovers to a value above the supervising frequency threshold (or below in the case where the element is configured for overfrequency operation). If the element has operated, the trip DDB signal will be on until the frequency recovers to a value above the supervising frequency threshold.

The P940 provides six stages of average rate of change of frequency protection (f+Df/Dt). Depending upon whether the frequency threshold is set above or below the system nominal frequency, each stage can respond to either rising or falling frequency conditions. For example, if the frequency threshold is set above nominal frequency, the element will operate for rising frequency conditions. The average rate of change of frequency is then measured based upon the frequency difference, Df over the settable time period, Dt. The relay will also indicate that an incorrect setting has been applied if the frequency threshold is set to the nominal system frequency.

Within the Programmable Scheme Logic (PSL), signals are available to indicate the start and trip of each average rate of change of frequency stage. (Starts: DDB 150, DDB 159, DDB 168, DDB 177, DDB 186, DDB 195; Trips: DDB 151, DDB 160, DDB 169, DDB 178, DDB 187, DDB 196). Signals are also available to indicate when any of the six stages have started or tripped (Any f+Df/Dt Start = DDB 257; Any f+Dt/Dt Trip = DDB 261). The state of the DDB signals can be programmed to be viewed in the “Monitor Bit x” cells of the “COMMISSION TESTS” column in the relay.



Stage x f+Df/Dt	Stg x f+Df/Dt Sta	Stg x f+Df/Dt Trp	Wrong Setting
Stage 1 f+Df/Dt	Stg 1 f+Df/Dt Sta (DDB 150)	Stg 1 f+Df/Dt Trp (DDB 151)	Wrong Setting 19 (DDB 290)
Stage 2 f+Df/Dt	Stg 2 f+Df/Dt Sta (DDB 159)	Stg 2 f+Df/Dt Trp (DDB 160)	Wrong Setting 20 (DDB 291)
Stage 3 f+Df/Dt	Stg 3 f+Df/Dt Sta (DDB 168)	Stg 3 f+Df/Dt Trp (DDB 169)	Wrong Setting 21 (DDB 292)
Stage 4 f+Df/Dt	Stg 4 f+Df/Dt Sta (DDB 177)	Stg 4 f+Df/Dt Trp (DDB 178)	Wrong Setting 22 (DDB 293)
Stage 5 f+Df/Dt	Stg 5 f+Df/Dt Sta (DDB 186)	Stg 5 f+Df/Dt Trp (DDB 187)	Wrong Setting 23 (DDB 294)
Stage 6 f+Df/Dt	Stg 6 f+Df/Dt Sta (DDB 195)	Stg 6 f+Df/Dt Trp (DDB 196)	Wrong Setting 24 (DDB 295)

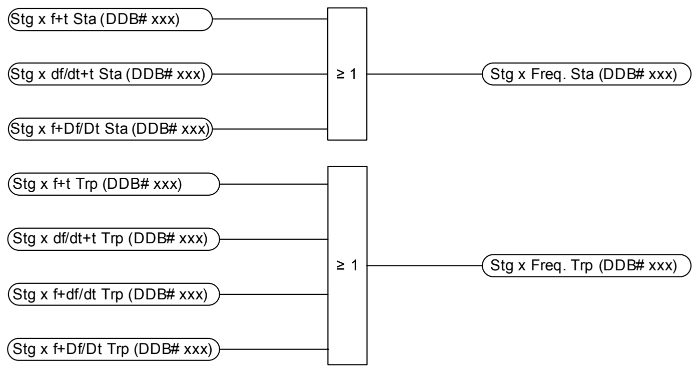
P1964ENa

Figure 9: Average rate of change of frequency logic (single stage shown)

OP

1.6 Frequency protection additional logic

In addition to the element logic described in sections 1.2 to 1.5, there is also some additional fixed logic within the P940 relays which is used to group start and trip signals. Figure 10 shows the logic used to create the per stage start and trip signals.



Stage x f+t Sta	Stg x df/dt+t Sta	Stg x f+Df/Dt Sta	Stg x Freq. Sta
Stage 1 f+t Sta (DDB 145)	Stg 1 df/dt+t Sta (DDB 148)	Stg 1 f+Df/Dt Sta (DDB 150)	Stg 1 Freq. Sta (DDB 152)
Stage 2 f+t Sta (DDB 154)	Stg 2 df/dt+t Sta (DDB 157)	Stg 2 f+Df/Dt Sta (DDB 159)	Stg 2 Freq. Sta (DDB 161)
Stage 3 f+t Sta (DDB 163)	Stg 3 df/dt+t Sta (DDB 166)	Stg 3 f+Df/Dt Sta (DDB 168)	Stg 3 Freq. Sta (DDB 170)
Stage 4 f+t Sta (DDB 172)	Stg 4 df/dt+t Sta (DDB 175)	Stg 4 f+Df/Dt Sta (DDB 177)	Stg 4 Freq. Sta (DDB 179)
Stage 5 f+t Sta (DDB 181)	Stg 5 df/dt+t Sta (DDB 184)	Stg 5 f+Df/Dt Sta (DDB 186)	Stg 5 Freq. Sta (DDB 188)
Stage 6 f+t Sta (DDB 190)	Stg 6 df/dt+t Sta (DDB 193)	Stg 6 f+Df/Dt Sta (DDB 195)	Stg 6 Freq. Sta (DDB 197)

Stage x f+t Trp	Stg x f+df/dt Trp	Stg x df/dt+t Trp	Stg x f+Df/Dt Trp	Stg x Freq. Trp
Stage 1 f+t Trp (DDB 146)	Stg 1 f+df/dt Trp (DDB 147)	Stg 1 df/dt+t Trp (DDB 149)	Stg 1 f+Df/Dt Trp (DDB 151)	Stg 1 Freq. Trp (DDB 153)
Stage 2 f+t Trp (DDB 155)	Stg 2 f+df/dt Trp (DDB 156)	Stg 2 df/dt+t Trp (DDB 158)	Stg 2 f+Df/Dt Trp (DDB 160)	Stg 2 Freq. Trp (DDB 162)
Stage 3 f+t Trp (DDB 164)	Stg 3 f+df/dt Trp (DDB 165)	Stg 3 df/dt+t Trp (DDB 167)	Stg 3 f+Df/Dt Trp (DDB 169)	Stg 3 Freq. Trp (DDB 171)
Stage 4 f+t Trp (DDB 173)	Stg 4 f+df/dt Trp (DDB 174)	Stg 4 df/dt+t Trp (DDB 176)	Stg 4 f+Df/Dt Trp (DDB 178)	Stg 4 Freq. Trp (DDB 180)
Stage 5 f+t Trp (DDB 182)	Stg 5 f+df/dt Trp (DDB 183)	Stg 5 df/dt+t Trp (DDB 185)	Stg 5 f+Df/Dt Trp (DDB 187)	Stg 5 Freq. Trp (DDB 189)
Stage 6 f+t Trp (DDB 191)	Stg 6 f+df/dt Trp (DDB 192)	Stg 6 df/dt+t Trp (DDB 194)	Stg 6 f+Df/Dt Trp (DDB 196)	Stg 6 Freq. Trp (DDB 198)

P1965ENa

Figure 10: Combination logic of frequency elements (single stage shown)

1.7 Generator abnormal protection [81AB]

Four bands of generator abnormal protection are provided within the P940 relays. Operation within each of these bands is monitored and the time added to a cumulative timer, stored within the battery backed RAM. This ensures that on loss of auxiliary supply to the relay, the information is not lost. The amount of time spent in each band can be viewed in the “GENR ABN TIMERS” column in the relay. The time delay for each band can be set in either minutes or hours, depending upon the time unit selected at the bottom of the “GEN. ABN. [81AB]” column.

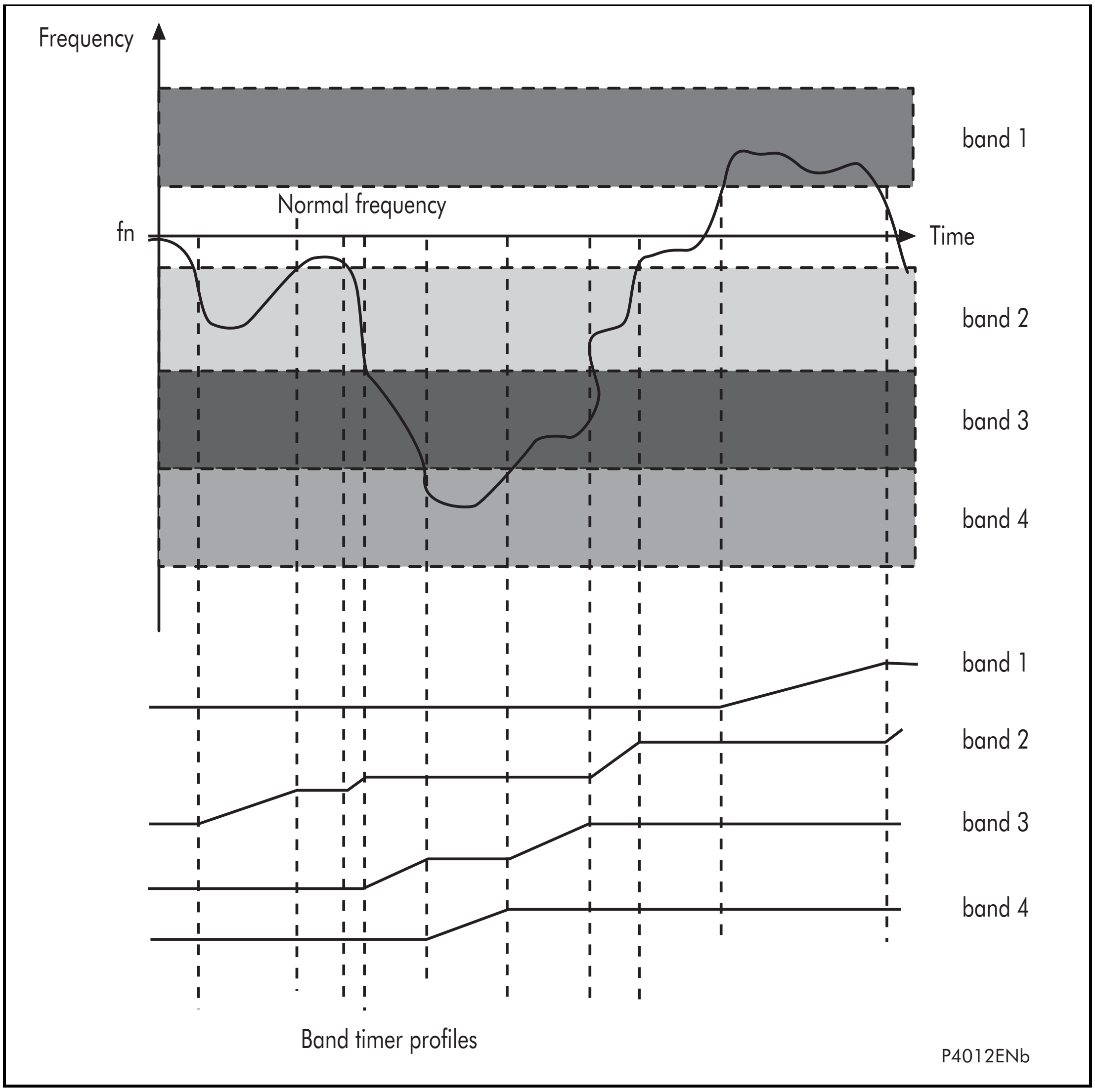
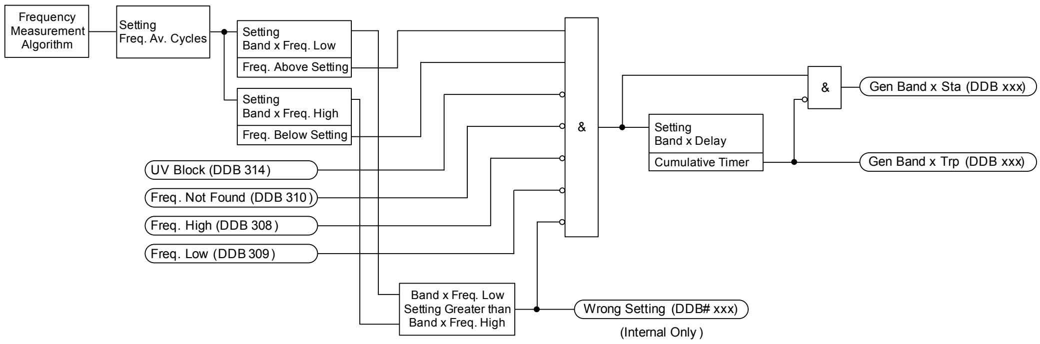


Figure 11: Generator abnormal frequency protection

Figure 11 shows the integrating timer behavior for abnormal frequency conditions over a long period of time. The timer for a particular band is incremented as long as the frequency is within the band lower and upper frequency settings. If two bands have overlapping frequency settings and the system frequency happens to be within both bands then the timers for both bands are incremented.

DDB signals are available in the PSL to indicate when the generator is currently operating in each band (DDB 231, DDB 233, DDB 235, DDB 237) and when the cumulative timer has reached its setting limit in each band (DDB 232, DDB 234, DDB 236, DDB 238). In addition, DDB 239 will operate when the generator is currently operating in any of the four bands and DDB 240 will operate when any of the four generator abnormal timers have exceeded their setting. The state of the DDB signals can be programmed to be viewed in the “Monitor Bit x” cells of the “COMMISSION TETS” column in the relay.



Gen Band x Sta	Gen Band x Trp	Wrong Setting
Gen Band 1 Sta (DDB 231)	Gen Band 1 Trp (DDB 232)	Wrong Setting 25 (DDB 296)
Gen Band 2 Sta (DDB 233)	Gen Band 2 Trp (DDB 234)	Wrong Setting 26 (DDB 297)
Gen Band 3 Sta (DDB 235)	Gen Band 3 Trp (DDB 236)	Wrong Setting 27 (DDB 298)
Gen Band 4 Sta (DDB 237)	Gen Band 4 Trp (DDB 238)	Wrong Setting 28 (DDB 299)

P1966ENa

Figure 12: Generator abnormal logic (single stage shown)

1.8 Load restoration

The P940 uses the measurement of system frequency as its main criteria for load restoration. For each stage of restoration, it is necessary that the same stage of load shedding has occurred previously and that no elements within that stage are configured for overfrequency or rising frequency conditions. If load shedding has not occurred based upon the frequency protection elements, the load restoration for that stage is inactive.

Load restoration for a given stage begins when the system frequency rises above the “RestoreX Freq.” setting for that stage and the stage restoration timer “RestoreX Time” is initiated. If the system frequency remains above the frequency setting for the set time delay, load restoration of that stage will be triggered. Unfortunately, frequency recovery profiles are highly non-linear and it would be reasonably common for the system frequency to transiently fall below the restoration frequency threshold. If the restoration timer immediately reset whenever a frequency dip occurred, it is likely that load restoration would never be successful and for this reason a “holding band” is also implemented on the relay. The holding band is a region defined by the restoration frequency and the highest frequency setting used in the load shedding elements for that stage. The difference between these two settings must always be greater than 0.02Hz, otherwise a “Wrong Setting” alarm will be generated. Whenever the system frequency dips into the holding band, operation of the stage restoration timer is suspended until the frequency rises above the restoration frequency setting, at which point timing will continue. If the system frequency dip is sufficiently large to cause any frequency element to start or trip in this stage i.e. if the frequency falls below the lower limit of the holding band, the restoration timer will immediately be reset.

Figure 13 illustrates the operation of the load restoration facility and holding band.

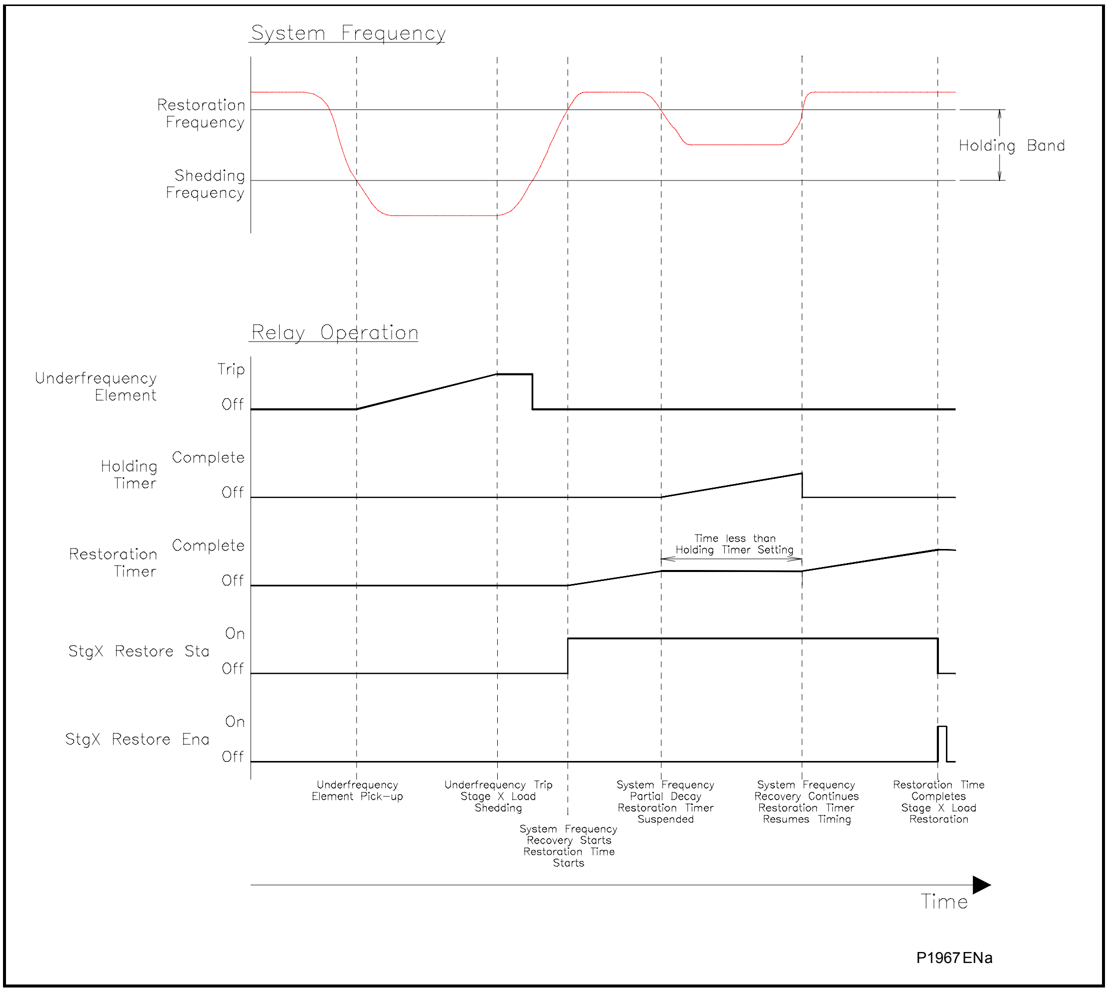


Figure 13: Load restoration with short deviation into holding band

If the system frequency remains in the holding band for too long it is likely that other system frequency problems are occurring and it would be prudent to reset the restoration timer for that stage. For this reason, as soon as the system frequency is measured to be within the holding band, the “Holding Timer” is initiated. If the system frequency doesn’t leave the holding band before the holding timer setting has been exceeded, the load restoration time delay for that stage is immediately reset. It should be noted that the holding timer has a common setting for all stages of load restoration.

An example of the case when the time in the holding band is excessive is shown in Figure 14.

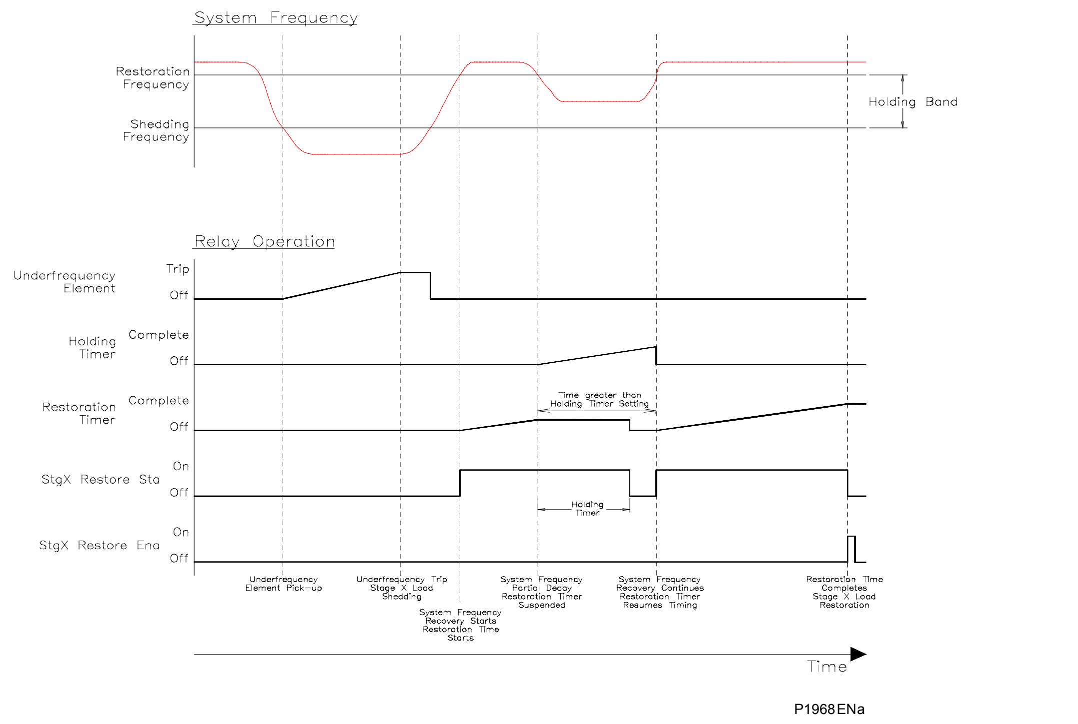


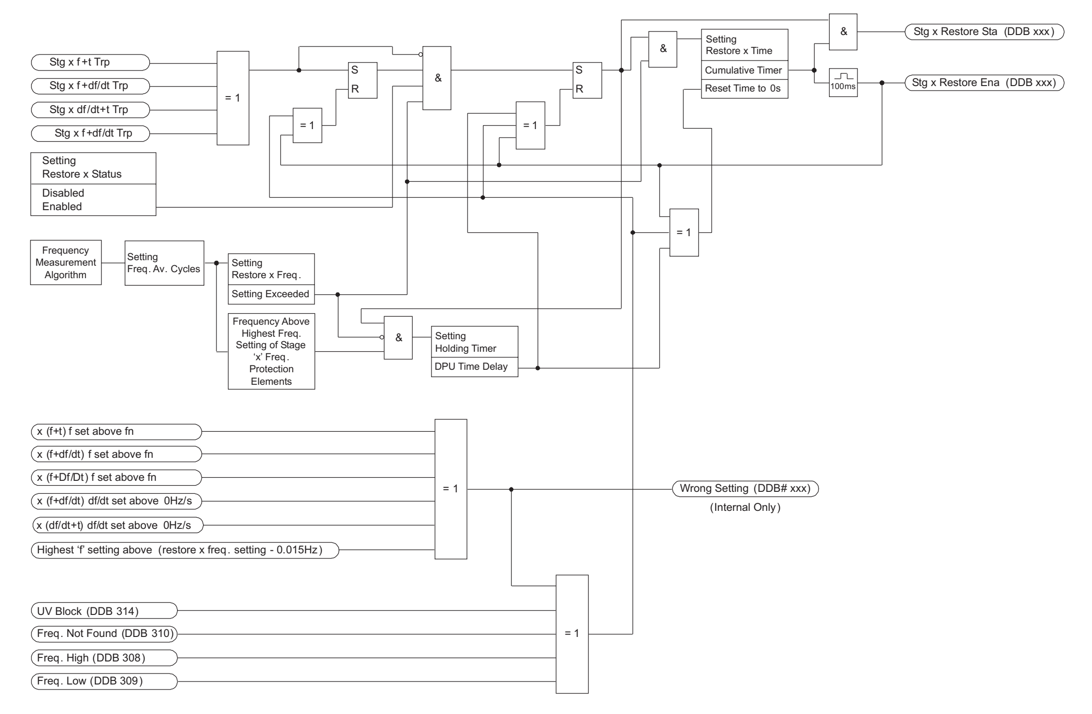
Figure 14: Load restoration with long deviation into holding band

The P940 provides up to six stages of load restoration with individual restoration frequency and time delays. Each stage of load restoration can be enabled or disabled but operation is also linked to the number of load shedding stages that have been configured using the frequency protection elements. Within a stage, if any frequency protection element is set for overfrequency operation or has a positive rate of change of frequency setting, the load restoration for that stage is automatically inhibited and a wrong setting alarm will be raised. For example, if stage 5 frequency protection “f+t” was set above nominal frequency, it would not be possible to use the stage 5 load restoration facility, even if other stage 5 frequency protection elements were set for load shedding. This means that the number of load restoration stages is always less than or equal to the number of load shedding stages. In addition, the stage load restoration can only occur if that stage of load shedding has been tripped from any of the frequency protection elements. For example, for stage 5 load restoration to occur, a stage 5 frequency protection element must have previously operated to shed load. Although the load restoration on the P940 is based upon frequency measurement, it is possible to use the Programmable Scheme Logic (PSL) of the relay to interlock with other plant items.

Within the Programmable Scheme Logic (PSL), signals are available to indicate when the stage load restoration frequency has been reached (start) and when the restoration timer for that stage has completed thereby enabling a close command to be given (enable). (Starts: DDB 241, DDB 243, DDB 245, DDB 247, DDB 249, DDB 251, DDB 393*, DDB 406*, DDB 419*; Enable: DDB 242, DDB 244, DDB 246, DDB 248, DDB 250, DDB 252, DDB 394*, DDB 407*, DDB 420*. The state of the DDB signals can be programmed to be viewed in the “Monitor Bit x” cells of the “COMMISSION TESTS” column in the relay.

* Available in software version v12.

OP



Stg x Restore Sta	Stg x Restore Ena	Wrong Setting
Stg 1 Restore Sta (DDB 241)	Stg 1 Restore Ena (DDB 242)	Wrong Setting 29 (DDB 300)
Stg 2 Restore Sta (DDB 243)	Stg 2 Restore Ena (DDB 244)	Wrong Setting 30 (DDB 301)
Stg 3 Restore Sta (DDB 245)	Stg 3 Restore Ena (DDB 246)	Wrong Setting 31 (DDB 302)
Stg 4 Restore Sta (DDB 247)	Stg 4 Restore Ena (DDB 248)	Wrong Setting 32 (DDB 303)
Stg 5 Restore Sta (DDB 249)	Stg 5 Restore Ena (DDB 250)	Wrong Setting 33 (DDB 304)
Stg 6 Restore Sta (DDB 251)	Stg 6 Restore Ena (DDB 252)	Wrong Setting 34 (DDB 305)
Stg 7 Restore Sta (DDB 393)	Stg 7 Restore Ena (DDB 394)	Wrong Setting 36 (DDB 395)
Stg 8 Restore Sta (DDB 406)	Stg 8 Restore Ena (DDB 407)	Wrong Setting 38 (DDB 408)
Stg 9 Restore Sta (DDB 419)	Stg 9 Restore Ena (DDB 420)	Wrong Setting 40 (DDB 422)

P1969ENb

Figure 15: Load restoration logic

1.9 Undervoltage protection

Two stage undervoltage protection is provided within the P940 relays and can be set to operate from phase-phase or phase-neutral voltages. Additionally, the "V< Operate Mode" setting allows for single or three phase operation to be selected. Each stage has an independent time delay that can be set to zero to permit instantaneous operation. Alternatively, the first stage can be selected to operate according to an inverse time characteristic which is defined by the following formula:

$$\text{Operating Time (seconds)} = \frac{TMS}{\left(1 - {}^{V_A}\!/\!{}_{V_S}\right)}$$

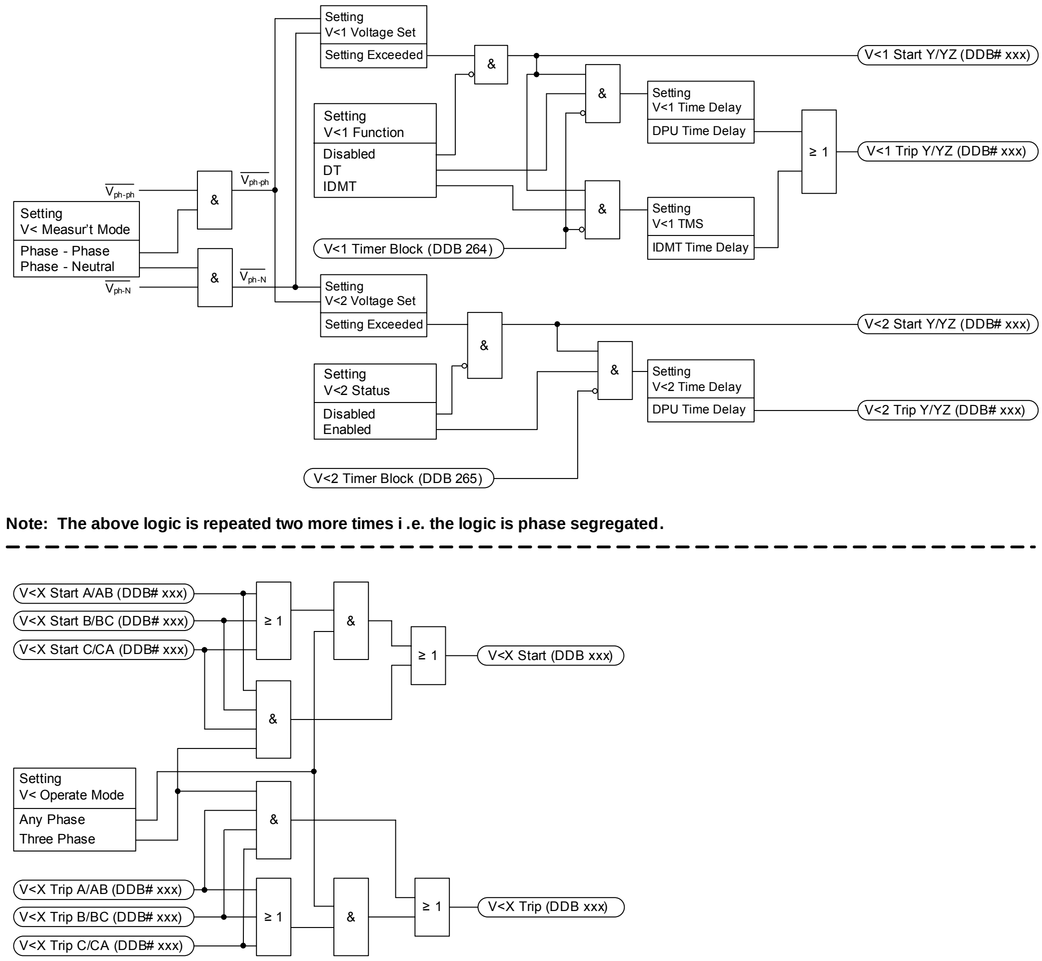
Where:

TMS = Time multiplier setting (V<1 TMS)
V_A = Actual measured voltage
V_S = Relay setting voltage (V<1 Voltage Set)

Each stage of undervoltage protection can be blocked by energizing the relevant DDB signal via the PSL (DDB 264, DDB 265), and DDB signals are also available to indicate 3 phase and per phase start and trips (Starts: DDB 199-206, Trips: DDB 207-214). The state of each of these DDB signals can be programmed to be viewed in the "Monitor Bit x" cells of the "COMMISSION TEST" column in the relay menu.

OP

Note: Each of the start and trip DDB signals is qualified by a phase indication, A/AB, B/BC or C/CA. If the undervoltage protection is set for phase-phase operation then the phase indicators should be referred as AB, BC or CA. If the undervoltage protection is set for phase-neutral operation then the phase indicators should be referred as A, B or C.



DDB xxx V<X Start Y/YZ	DDB xxx V<X Trip Y/YZ
V<1 Start A/AB (DDB 200)	V<1 Trip A/AB (DDB 208)
V<1 Start B/BC (DDB 201)	V<1 Trip B/BC (DDB 209)
V<1 Start C/CA (DDB 202)	V<1 Trip C/CA (DDB 210)
V<2 Start A/AB (DDB 204)	V<2 Trip A/AB (DDB 212)
V<2 Start B/BC (DDB 205)	V<2 Trip B/BC (DDB 213)
V<2 Start C/CA (DDB 206)	V<2 Trip C/CA (DDB 214)

V<X Start	V<X Trip
V<1 Start (DDB 199)	V<1 Trip (DDB 207)
V<2 Start (DDB 203)	V<2 Trip (DDB 211)

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Figure 16: Undervoltage logic (both stages shown)

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1.10 Overvoltage protection

Two stage overvoltage protection is provided within the P940 relays and can be set to operate from phase-phase or phase-neutral voltages. Additionally, the "V> Operate Mode" setting allows for single or three phase operation to be selected. Each stage has an independent time delay that can be set to zero to permit instantaneous operation. Alternatively, the first stage can be selected to operate according to an inverse time characteristic which is defined by the following formula:

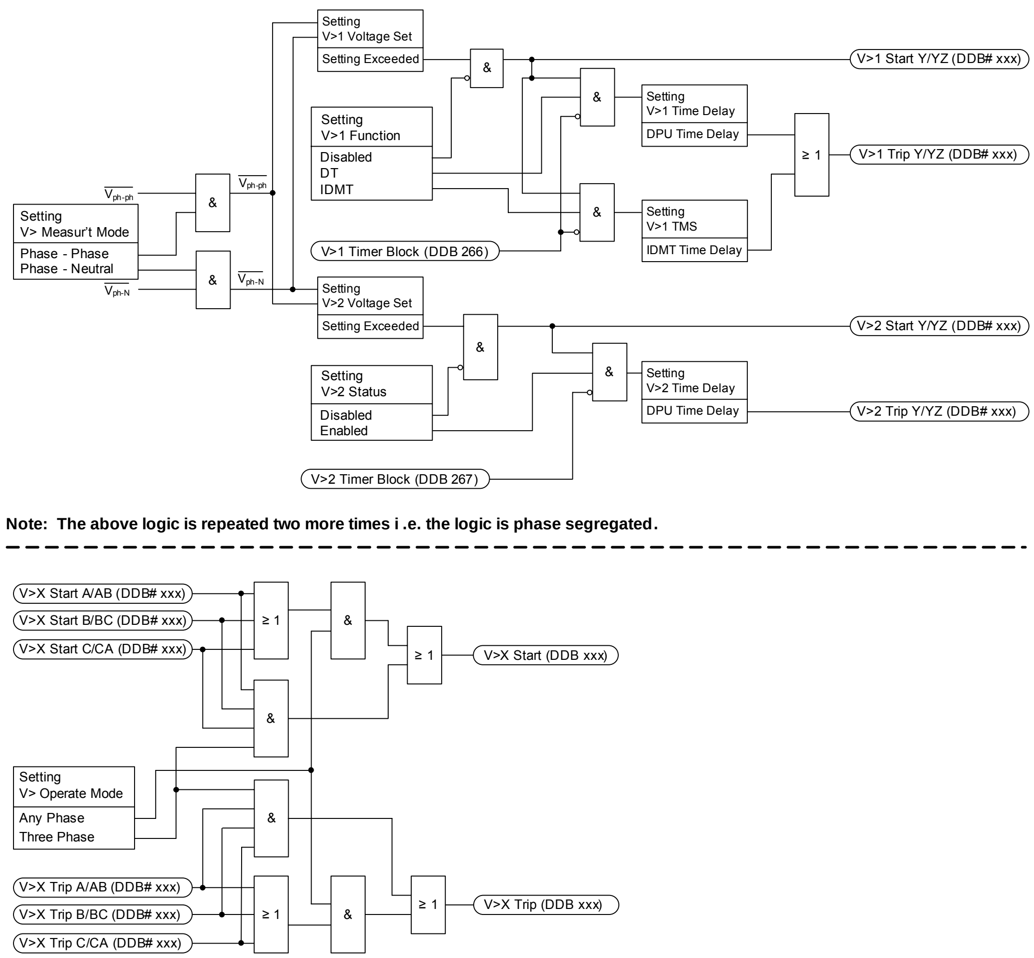
$$\text{Operating Time (seconds)} = \frac{\text{TMS}}{\left(V_A/V_S - 1\right)}$$

Where:

TMS = Time multiplier setting (V>1 TMS)
V_A = Actual measured voltage
V_S = Relay setting voltage (V>1 Voltage Set)

Each stage of overvoltage protection can be blocked by energizing the relevant DDB signal via the PSL (DDB 266, DDB 267), and DDB signals are also available to indicate 3 phase and per phase start and trips (Starts: DDB 215 - 222, Trips: DDB 223 - 230). The state of each of these DDB signals can be programmed to be viewed in the "Monitor Bit x" cells of the "COMMISSION TEST" column in the relay menu.

Note: Each of the start and trip DDB signals is qualified by a phase indication, A/AB, B/BC or C/CA. If the overvoltage protection is set for phase-phase operation then the phase indicators should be referred as AB, BC or CA. If the overvoltage protection is set for phase-neutral operation then the phase indicators should be referred as A, B or C.



DDB xxx V>X Start Y/YZ	DDB xxx V>X Trip Y/YZ
V>1 Start A/AB (DDB 216)	V>1 Trip A/AB (DDB 224)
V>1 Start B/BC (DDB 217)	V>1 Trip B/BC (DDB 225)
V>1 Start C/CA (DDB 218)	V>1 Trip C/CA (DDB 226)
V>2 Start A/AB (DDB 220)	V>2 Trip A/AB (DDB 228)
V>2 Start B/BC (DDB 221)	V>2 Trip B/BC (DDB 229)
V>2 Start C/CA (DDB 222)	V>2 Trip C/CA (DDB 230)

V>X Start	V>X Trip
V>1 Start (DDB 215)	V>1 Trip (DDB 223)
V>2 Start (DDB 219)	V>2 Trip (DDB 227)

P1971ENa

Figure 17: Overvoltage logic (both stages shown)

OP

2. OPERATION OF NON PROTECTION FUNCTIONS

2.1 Trip LED logic

There is no fixed scheme logic to cause the Trip LED to illuminate and the user must configure its operation using the Trip LED Enables signal (DDB 302) in the PSL. As soon as this signal is energized the red Trip LED and the amber Alarm LED will be illuminated. These LED’s can only be reset when the initiating condition has been removed which implies that all the initiating signals to the Trip LED Enabled DDB must be self-resetting. After the initiating signal has been removed, the Trip LED will remain lit until reset using the C key.

2.2 Fault recorder logic

There is no fixed scheme logic to cause a fault record to be generated and the user must configure its operation using the fault record trigger signal (DDB 144) in the PSL.

The fault record trigger requires a rising edge for operation. In other words, the input to the FRT signal must go from a low (de-energized) to a high (energized) state. When the rising edge occurs, a fault record is generated and the amber Alarm LED is illuminated (flashing). When a fault record is generated, the data can be viewed on the LCD using the key, and reset by the C key if the correct password level is active. Any subsequent fault record will only be generated on a new rising edge of the fault recorder trigger DDB signal. It is therefore recommended that all the initiating signals to the fault recorder trigger are self-resetting.

Note: Since the data is captured on the rising edge, it is possible to clear the record on the default display even though the initiating signals are still active. However, the information may still be viewed in the “VIEW RECORDS” column of the menu.

2.3 Setting groups selection

The setting groups can be changed either via opto inputs or via a menu selection. In the Configuration column if 'Setting Group- select via optos' is selected, optos 1 and 2 which are dedicated for setting group selection, can be used to select the setting group as shown in the table below. If 'Setting Group- select via menu' is selected in the Configuration column, the 'Active Settings - Group1/2/3/4' can be used to select the setting group. If this option is used, opto inputs 1 and 2 can be used for other functions in the programmable scheme logic.

OPTO 1	OPTO 2	Selected Setting Group
0 (de-energized)	0 (de-energized)	1
1 (energized)	0 (de-energized)	2
0 (de-energized)	1 (energized)	3
1 (energized)	1 (energized)	4

Note: Each setting group has its own settings and PSL that are independent of other setting groups. Once the settings or PSL have been designed it can be sent to any one of 4 setting groups within the relay. When downloading to the relay the user will be prompted to enter the desired setting group to which it will be sent. (This is also the case when extracting settings or PSL from the relay). If the user fails to download the required settings or PSL to any setting group that may be brought into service, the factory default settings will still be resident. This may have severe operational and safety consequences if the default settings are not suitable for the particular application.

2.4 Control inputs

Control inputs give a user access into the programmable scheme from the user interface or via rear port (SCADA) communications. Within the PSL, the control inputs can be used to enable or disable protection elements, initiate sections of logic, perform control functions or any other purpose that requires a logic set (1) or reset (0) state. They can also be used during the commissioning process to aid in fault finding within application specific PSL.

The P940 provides 32 control inputs within the PSL (DDB 512 - 543) which may be controlled from the "Control Inputs" relay menu column. This section of the menu allows the status of all 32 inputs to be viewed in the "Ctrl I/P Status" menu cell with a 1 indicating that the input is set (or high) and a 0 indicating that the input is reset (or low). The remaining cells allow the individual control inputs to be set or reset via the user interface.

Similar setting capability is also available using the SCADA communication facilities of the relay.

Note: The status of the control inputs on the P940 are stored in volatile memory and therefore the status of the input will automatically reset to 0 if there is an auxiliary power supply interruption.

AP

APPLICATION NOTES

Date:	**2008**
Hardware Suffix:	**A or C**
Software Version:	**12**
Connection Diagrams:	**10P94yxx (y = 1 or 3) (x = 01 to 06)**

AP

CONTENTS

FIGURES

1. INTRODUCTION

1.1 Frequency protection

Generation and utilization need to be well balanced in any industrial, distribution or transmission network. As load increases, the generation needs to be stepped up to maintain frequency of the supply because there are many frequency sensitive electrical apparatus that can be damaged when network frequency departs from the allowed band for safe operation. At times, when sudden overloads occur, the frequency drops at a rate decided by the system inertia constant, magnitude of overload, system damping constant and various other parameters. Unless corrective measures are taken at the appropriate time, frequency decay can go beyond the point of no return and cause widespread network collapse. In a wider scenario, this can result in “Blackouts”. To put the network back in healthy condition, considerable amount of time and effort is required to re-synchronize and re-energize.

Protective relays that can detect a low frequency condition are generally used in such cases to disconnect unimportant loads in order to save the network, by re-establishing the “generation-load equation”. However, with such devices, the action is initiated only after the event and while some salvaging of the situation can be achieved, this form of corrective action may not be effective enough and cannot cope with sudden load increases, causing large frequency decays in very short times. In such cases a device that can anticipate the severity of frequency decay and act to disconnect loads before the frequency actually reaches dangerously low levels, can become very effective in containing damage.

During severe disturbances, the frequency of the system oscillates as various generators try to synchronize on to a common frequency. The measurement of instantaneous rate of change of frequency can be misleading during such a disturbance. The frequency decay needs to be monitored over a longer period of time to make the correct decision for load shedding.

Normally, generators are rated for a lifetime operation in a particular band of frequency and operation outside this band can cause mechanical damage to the turbine blades. Protection against such contingencies is required when frequency does not improve even after load shedding steps have been taken and can be used for operator alarms or turbine trips in case of severe frequency decay.

Whilst load shedding leads to an improvement in the system frequency, the disconnected loads need to be reconnected after the system is stable again. Loads should only be restored if the frequency remains stable for some period of time, but minor frequency excursions can be ignored during this time period. The number of load restoration steps are normally less than the load shedding steps to reduce repeated disturbances while restoring load.

2. APPLICATION OF INDIVIDUAL PROTECTION FUNCTIONS

The following sections detail individual protection functions in addition to where and how they may be applied. Each section provides some worked examples on how the settings are applied to the relay

2.1 Underfrequency protection 'f+t' [81U]

Frequency variations on a power system are an indication that the power balance between generation and load has been lost. In particular, under-frequency implies that the net load is in excess of the available generation. Such a condition can arise, when an interconnected system splits, and the load left connected to one of the subsystems is in excess of the capacity of the generators in that particular subsystem. Industrial plants that are dependent on utilities to supply part of their loads will experience under-frequency conditions when the incoming lines are lost.

An underfrequency condition at nominal voltage can result in over-fluxing of generators and transformers and many types of industrial loads have limited tolerances on the operating frequency and running speeds e.g. synchronous motors. Sustained underfrequency has implications on the stability of the system, whereby any subsequent disturbance may lead to damage to frequency sensitive equipment and even blackouts, if the underfrequency condition is not corrected sufficiently fast.

The underfrequency protection settings are found in the "f+t [81U/81O]" relay menu column.

2.1.1 Setting guidelines

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In order to minimize the effects of underfrequency on a system, a multi stage load shedding scheme may be used with the plant loads prioritized and grouped. During an underfrequency condition, the load groups are disconnected sequentially depending on the level of underfrequency, with the highest priority group being the last one to be disconnected.

The effectiveness of each stage of load shedding depends on what proportion of the power deficiency it represents. If the load shedding stage is too small compared to the prevailing generation deficiency, then the improvement in frequency may be non-existent. This aspect should be taken into account when forming the load groups.

Time delays should be sufficient to override any transient dips in frequency, as well as to provide time for the frequency controls in the system to respond. This should be balanced against the system survival requirement since excessive time delays may jeopardize system stability. Time delay settings of 5 - 20s are typical.

An example of a four-stage load shedding scheme for 50Hz systems is shown below:

Stage	Element	Frequency Setting (Hz)	Time Setting (Sec)
1	Stage 1(f+t)	49.0	20s
2	Stage 2(f+t)	48.6	20s
3	Stage 3(f+t)	48.2	10s
4	Stage 4(f+t)	47.8	10s

The relatively long time delays are intended to provide time for the system controls to respond and will work well in a situation where the decline of system frequency is slow. For situations where rapid decline of frequency is expected, the load shedding scheme above should be supplemented by rate of change of frequency protection elements.

It may be noted that the protection package for generators at site may include underfrequency relays. The settings made on the P940 should be co-ordinated with the generator protection frequency relays.

2.2 Overfrequency protection 'f+t' [81O]

Over frequency running of a generator arises when the mechanical power input to the machine exceeds the electrical output. This could happen, for instance, when there is a sudden loss of load due to tripping of an outgoing feeder from the plant to a load center. Under such over speed conditions, the governor should respond quickly so as to obtain a balance between the mechanical input and electrical output, thereby restoring normal frequency. Over frequency protection is required as a back-up to cater for slow response of frequency control equipment.

The overfrequency protection settings are found in the "f+t [81U/81O]" relay menu column.

2.2.1 Setting guidelines

Following faults on the network, or other operational requirements, it is possible that various subsystems will be formed within the power network and it is likely that each of these subsystems will suffer from a generation to load imbalance. The "islands" where generation exceeds the existing load will be subject to over frequency conditions, the level of frequency being a function of the percentage of excess generation. Severe over frequency conditions may be unacceptable to many industrial loads, since running speeds of motors will be affected. The "f+t" element of the MiCOM P940 can be suitably set to sense this contingency.

An example of two-stage over frequency protection is shown below using stages 5 and 6 of the "f+t" element. However, it should be considered that settings for a real system will depend upon the maximum frequency that equipment can tolerate for a given period of time.

Stage	Element	Frequency Setting (Hz)	Time Setting (Sec.)
1	Stage 5(f+t)	50.5	30
2	Stage 6(f+t)	51.0	20

The relatively long time delays are intended to provide time for the system controls to respond and will work well in a situation where the increase of system frequency is slow.

For situations where rapid increase of frequency is expected, the protection scheme above could be supplemented by rate of change of frequency protection elements, possibly utilized to split the system further. For example, in the system shown in Figure 1: the generation in the MV bus is sized according to the loads on that bus, whereas the generators linked to the HV bus produce energy for export to utility. If the links to the grid are lost, the IPP generation will cause the system frequency to rise. This rate of rise can be used to isolate the MV bus from the HV system, if operationally acceptable.

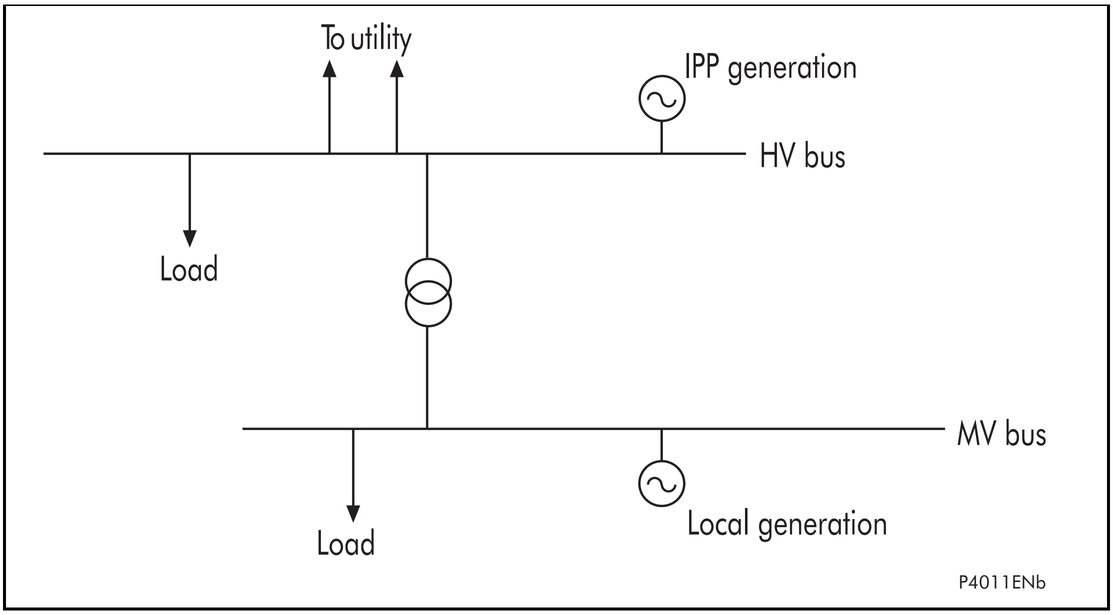

Figure 1: Power system segregation based upon frequency measurements

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The following tables give possible settings that could be used to speed up the process of segregating the system as outlined above, in conjunction with the overfrequency element:

Stage	Frequency "f+t [81U/81O]" Elements		Frequency Supervised Rate of Change of Frequency "f+df/dt dt [81RF]" Elements	
	Frequency Setting (Hz)	Time Setting (Sec.)	Frequency Setting (Hz)	Rate of Change of Frequency Setting (Hz/Sec)
1	50.5	30	50.5	1.0
2	51	20	51	1.0

Table 1: Typical settings for over frequency with frequency supervised rate of change of frequency

Stage	Frequency "f+t [81U/81O]" Elements		Average Rate of Change of Frequency "f+Df/Dt [81RAV]" Elements		
	Frequency Setting (Hz)	Time Setting (Sec.)	Frequency Setting (Hz)	Frequency Difference Setting, Df (Hz)	Time Period, Dt (Sec.)
1	50.5	30	50.5	0.5	0.5
2	51	20	51	0.5	0.5

Table 2: Overfrequency protection with average rate of change of frequency

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Stage	Frequency "f+t [81U/81O]" Elements		Rate of Change of Frequency "df/dt+t [81R]" Elements	
	Frequency Setting (Hz)	Time Setting (Sec.)	Rate of Change of Frequency Setting (Hz/Sec.)	Time Setting (Sec.)
1	50.5	30	3.0	0.5
2	51	20	2.0	0.5

Table 3: Overfrequency protection with independent rate of change of frequency

It may be noted that the protection package for generators at site may include overfrequency relays. The settings made on the P940 should be co-ordinated with the generator protection frequency relays.

2.3 Frequency supervised rate of change of frequency protection 'f+df/dt' [81RF]

Conditions may arise in an electrical network where the load to generation imbalance is considerable and this may result in relatively rapid changes of the system frequency. In such a case, maintaining the system stability is an onerous task, and calls for quick corrective action.

High speed load shedding cannot be achieved by monitoring the system frequency alone and the rate of change of system frequency becomes an equally critical parameter to use.

In the load shedding scheme below, it is assumed under falling frequency conditions that by shedding a stage of load, the system can be stabilized at frequency f2. For slow rates of decay, this can be achieved using the underfrequency protection element set at frequency f1 with a suitable time delay. However, if the generation deficit is substantial, the frequency will rapidly decrease and it is possible that the time delay imposed by the underfrequency protection will not allow for frequency stabilization. In this case, the chance of system recovery will be enhanced by disconnecting the load stage based upon a measurement of rate of change of frequency and bypassing the time delay.

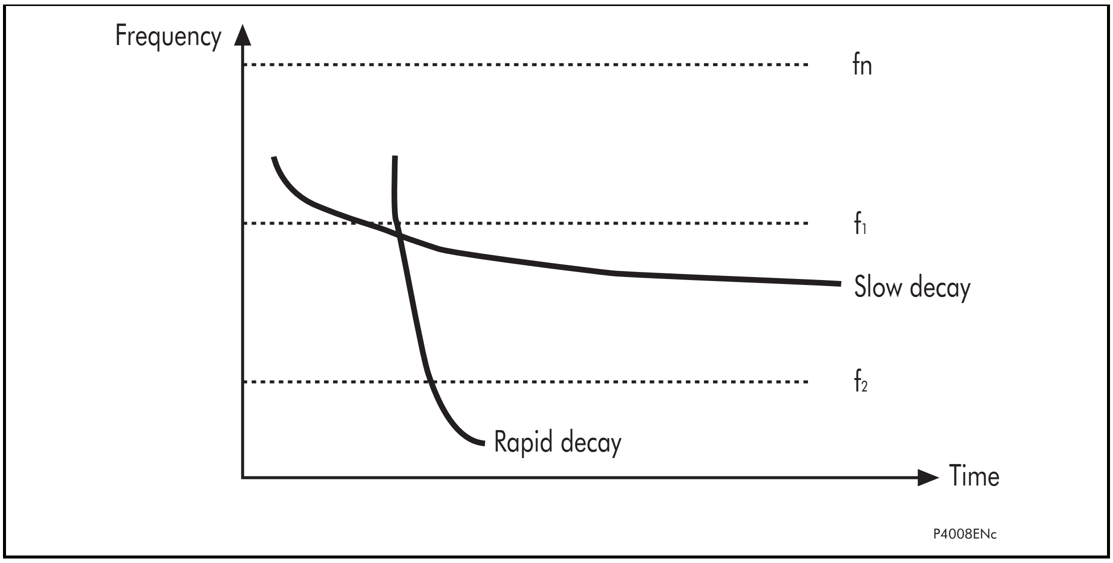

Figure 2: Frequency supervised rate of change of frequency protection

With the frequency supervised rate of change of frequency element, the basic rate of change of frequency measurement is supervised by an additional frequency measurement. As such, the rate of change of frequency AND the frequency must exceed the set thresholds before an output can be given.

The frequency supervised rate of change of frequency protection settings may be found in the “f+df/dt [81RF]” relay menu column.

AP

2.3.1 Setting guidelines

It is recommended that the frequency supervised rate of change of frequency protection (f+df/dt) element be used in conjunction with the time delayed frequency protection (f+t) elements.

A four stage high speed load shedding scheme may be configured as indicated below, noting that in each stage, both the ”f+t” and the “f+df/dt” elements are enabled.

Stage	Frequency “f+t [81U/81O]” Elements		Frequency Supervised Rate of Change of Frequency “f+df/dt [81RF]” Elements	
	Frequency Setting (Hz)	Time Setting (Sec.)	Frequency Setting (Hz)	Rate of Change of Frequency Setting (Hz/sec.)
1	49	20	49	1.0
2	48.6	20	48.6	1.0
3	48.2	10	48.2	1.0
4	47.8	10	47.8	1.0

It may be possible to further improve the speed of load shedding in critical cases by changing the frequency setting on the frequency supervised rate of change of frequency element. In the settings outlined below, the frequency settings for the “f+df/dt” element have been set slightly higher than the frequency settings for the “f+t” element. This difference will allow for the measuring time of the relay, assuming the set rate of frequency change and default frequency averaging cycles, and will result in the tripping of the two elements at approximately the same frequency value. Thus, with this scheme, the slow frequency decline and fast frequency decline scenarios are independently monitored and optimized without sacrificing system security.

Stage	Frequency "f+t [81U/81O]" Elements		Frequency Supervised Rate of Change of Frequency "f+df/dt [81RF]" Elements	
	Frequency Setting (Hz)	Time Setting (Sec.)	Frequency Setting (Hz)	Rate of Change of Frequency Setting (Hz/sec.)
1	49	20	49.2	1.0
2	48.6	20	48.8	1.0
3	48.2	10	48.4	1.0
4	47.8	10	48.0	1.0

2.4 Independent rate of change of frequency protection 'df/dt+t' [81R]

This element is a plain rate of change of frequency monitoring element, and is not supervised by a frequency setting as per the "f+df/dt" element. However, a timer is included to provide a time delayed operation. The element can be utilized to provide extra flexibility to a load shedding scheme in dealing with severe load to generation imbalances.

As mentioned in other sections, conditions involving very large load - generation imbalances may occur, accompanied by rapid decline in system frequency. Shedding of one or two stages of load is unlikely to stop the decline in frequency, if the discrepancy is still large. In such a situation, it is advantageous to have an element that identifies the high rate of decline of frequency, and adapts the load shedding scheme accordingly.

Since the rate of change monitoring is independent of frequency, the element can identify frequency variations occurring close to nominal frequency and thus provide early warning to the operator on a developing frequency problem. Additionally, the element could also be used as an alarm to warn operators of unusually high system frequency variations.

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The rate of change of frequency protection settings may be found in the "df/dt+t [81R]" relay menu column.

2.4.1 Setting guidelines

Considerable care should be taken when setting this element because it is not supervised by a frequency setting. Setting of the time delay or increasing the number of df/dt averaging cycles will lead to a more stable element but this should be considered against the loss of fast tripping capability as the tripping time is extended.

It is likely that this element would be used in conjunction with other frequency based protection elements to provide a scheme that accounts for severe frequency fluctuations. An example scheme is shown below:

Stage	Frequency “f+t [81U/81O]” Elements		Frequency Supervised Rate of Change of Frequency “f+df/dt [81RF]” Elements	
	Frequency Setting (Hz)	Time Setting (Sec.)	Frequency Setting (Hz)	Rate of Change of Frequency Setting (Hz/Sec.)
1	49	20	49.2	1.0
2	48.6	20	48.8	1.0
3	48.2	10	48.4	1.0
4	47.8	10	48.0	1.0
5	-	-	-	-

Stage	Rate of Change of Frequency “df/dt+t [81R]” Elements	
	Rate of Change of Frequency Setting (Hz/Sec.)	Time Setting (Sec.)
1	-	-
2	-	-
3	-3.0	0.5
4	-3.0	0.5
5	-3.0	0.1

In the above scheme, tripping of the last two stages is accelerated by using the independent rate of change of frequency element. If the frequency starts falling at a high rate (> 3Hz/s in this example), then stages 3 & 4 are shed at around 48.5Hz, with the objective of a better chance of system stability. Stage 5 serves as an alarm and gives operators advance warning that the situation is critical and if it persists, there is the likelihood for all stages of load being shed.

2.5 Average rate of change of frequency protection ‘f+Df/Dt’ [81RAV]

Owing to the complex dynamics of power systems, variations in frequency during times of generation - load imbalance do not follow any regular patterns and are highly non-linear. Oscillations will occur as the system seeks to address the imbalance, resulting in frequency oscillations typically in the order of 0.1Hz to 1Hz, in addition to the basic change in frequency.

The rate of change of frequency elements discussed in sections 2.3 and 2.4 both use an “instantaneous” measurement of “df/dt” based upon a 3 cycle, filtered, “rolling” average technique. Due to the oscillatory nature of frequency excursions, this instantaneous value can sometimes be misleading, either causing unexpected operation or excessive stability. For this reason, the P940 relays also provide an element for monitoring the longer term frequency trend, thereby reducing the effects of non-linearity’s in the system and providing increased security to the rate of change of frequency decision.

Using the average rate of change of frequency element “f+Df/Dt”, when the measured frequency crosses the supervising frequency threshold a timer is initiated. At the end of this time period, Δt, the frequency difference, Δf, is evaluated and if this exceeds the setting, a trip output is given.

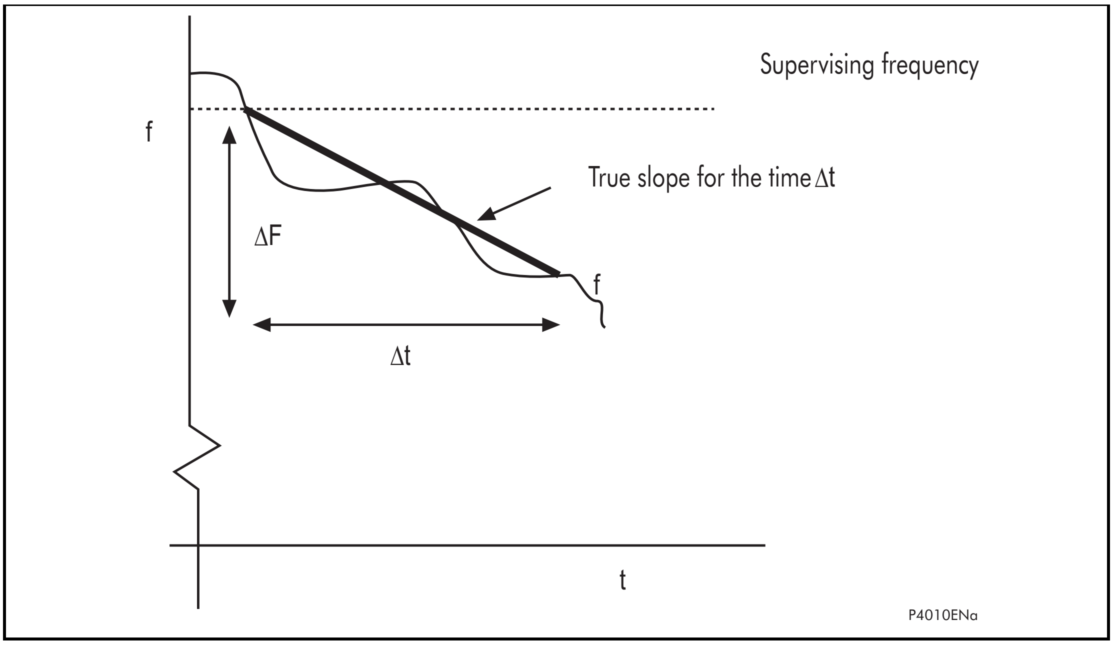

Figure 3: Average rate of change of frequency protection

After time Δt, regardless of the outcome of the comparison, the element is blocked from further operation until the frequency recovers to a value above the supervising frequency threshold (or below in the case where the element is configured for overfrequency operation).

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The average rate of change of frequency protection settings may be found in the “f+Df/Dt [81RAV]” relay menu column.

2.5.1 Setting guidelines

As for the other rate of change of frequency elements, it is recommended that the ”f+Df/Dt” element be used in conjunction with the ”f+t” element. The average rate of change of frequency element can be set to measure the rate of change over a short period as low as 20ms (1 cycle @ 50Hz) or a relatively long period up to 2s (100 cycles @ 50Hz). With a time setting, Dt, towards the lower end of this range, the element becomes similar to the frequency supervised rate of change function, “f+df/dt”. With high Dt settings, the element acts as a frequency trend monitor.

Although the element has a wide range of setting possibilities, it is recommended that the Dt setting is set greater than 100ms to ensure the accuracy of the element as described in P94x/EN TD.

A possible four stage load shedding scheme using the average rate of change frequency element is shown below:

Stage	Frequency “f+t [81U/81O]” Elements		Average Rate of Change of Frequency “f+Df/Dt [81RAV]” Elements		
	(f+t) f Frequency Setting (Hz)	(f+t) t Time Setting (Sec.)	(f+Df/Dt) f Frequency Setting (Hz)	(f+Df/Dt) Df Frequency Diff Setting, (Hz)	(f+Df/Dt) Dt Time Period, (Sec.)
1	49	20	49	0.5	0.5
2	48.6	20	48.6	0.5	0.5
3	48.2	10	48.2	0.5	0.5
4	47.8	10	47.8	0.5	0.5

In the above scheme, the faster load shed decisions are made by monitoring the frequency change over 500ms. Hence tripping takes place slower than in schemes employing the frequency supervised rate of change element (f+df/dt [81RF]), but the difference is not very much at this setting. If the delay is unacceptable for system stability, then the scheme can be improved by increasing the independent “f” setting of the element. Depending upon how much this value is increased, the frequency at which the “f+Df/Dt” element will trip also increases and hence reduces the time delay to load shedding under more severe frequency fluctuations. For example, with the settings shown below and assuming the set average rate of frequency decline, the first stage of load shedding would be tripped approximately 300msecs after 49.0Hz had been reached and at a frequency of approximately 48.7Hz.

Stage	Frequency “f+t [81U/81O]” Elements		Average Rate of Change of Frequency “f+Df/Dt [81RAV]” Elements		
	(f+t) f Frequency Setting (Hz)	(f+t) t Time Setting (Sec)	(f+Df/Dt) f Frequency Setting (Hz)	(f+Df/Dt) Df Frequency Diff Setting (Hz)	(f+Df/Dt) Dt Time Period, (Sec.)
1	49	20	49.2	0.5	0.5 s
2	48.6	20	48.8	0.5	0.5 s
3	48.2	10	48.4	0.5	0.5 s
4	47.8	10	48.0	0.5	0.5 s

2.6 Generator abnormal protection [81AB]

Generator sets are normally rated for a lifetime of operation within a defined operating frequency band. Operation outside of this “normal” region can produce mechanical stress in the turbine blades and reduce the useful life of the generator. In order to protect against this condition, it is useful to monitor the time spent running at abnormal frequencies to indicate when maintenance may be required.

Four bands of generator abnormal protection are provided within the P940 relays. Operation within each of these bands is monitored and the time added to a cumulative timer, stored within the battery backed RAM. This ensures that on loss of auxiliary supply to the relay, the information is not lost. The amount of time spent in each band can be viewed in the “GENR ABN TIMERS” column in the relay.

The generator abnormal protection settings may be found in the “GEN. ABN. [81AB]” relay menu column.

2.6.1 Setting guidelines

The withstand of the generator for abnormal speeds is normally given by the generator manufacturer. Default settings have been provided as a guide for setting the relay.

The output of the element can be used as either as an operator alarm or for shutting down the generator.

2.7 Load restoration

It is the goal of load shedding to stabilize the frequency on a system and to re-establish the load to generation imbalance that initially caused the frequency to decline. As the system stabilizes and the generation capability improves, the system frequency will recover to near normal levels and after some time delay it is possible to consider the restoration of load onto the healthy system. However, load restoration needs to be performed carefully and systematically so that system stability is not jeopardized again. A careful balance needs to be sought to minimize the length of time that the loads are disconnected but at the same time, not re-connect loads that will cause the problem to immediately re-occur.

In the case of industrial plants with captive generation, restoration should be linked to the available generation since connecting additional load when the generation is still inadequate, will only result in declining frequency and consequent load shedding. If the in-plant generation is insufficient to meet the load requirements, then load restoration should be interlocked with recovery of the utility supply.

The load restoration settings may be found in the “Load Restoration” relay menu column.

2.7.1 Setting guidelines

A four stage, single frequency load restoration scheme is illustrated below. The frequency setting has been chosen such that there is sufficient separation between the highest load shed frequency (49.0 Hz from the underfrequency protection elements - see section 2.1.1) and the restoration frequency to prevent any possible hunting. A restoration frequency setting closer to nominal frequency may be chosen if an operating frequency of 49.3 Hz is unacceptable.

Stage	Restoration Frequency Setting (Hz)	Restoration Time Delay (secs)	Holding Time Delay (secs)
1	49.3Hz	240 sec	20 sec
2	49.3Hz	180 sec	20 sec
3	49.3Hz	120 sec	20 sec
4	49.3Hz	60 sec	20 sec

In this scheme, the time delays ensure that the most critical loads are reconnected first assuming that the higher stages refer to more important loads. By sequentially restoring the load, it is also hoped that system stability is maintained and that the frequency problems are not re-instated. These time settings are system dependent; higher or lower settings may be required depending on the particular application.

It is possible to set up restoration schemes involving multiple frequencies. This allows faster restoration of loads, but the possibility of continuous system operation at frequencies far removed from the nominal must be considered in this case. A typical scheme using two frequencies is illustrated below:

Stage	Restore Freq.Restoration Frequency Setting (Hz)	Restore DelayRestoration Time Delay (S)	Holding Time Delay (S)
1	49.5Hz	120 sec	20 sec
2	49.5Hz	60 sec	20 sec
3	49.0Hz	120 sec	20 sec
4	49.0Hz	60 sec	20 sec

Staggered time settings may be used in this scheme as well, but the time separation among the restoration of stages will be a function of the frequency recovery pattern. Time co-ordinated restoration can only be guaranteed for those stages with a common restoration frequency setting.

2.8 Undervoltage protection [27]

Undervoltage conditions may occur on a power system for a variety of reasons, some of which are outlined below:

- Increased system loading. Generally, some corrective action would be taken by voltage regulating equipment such as AVR’s or On Load Tap Changers, in order to bring the system voltage back to its nominal value. If the regulating equipment is unsuccessful in restoring healthy system voltage, then tripping by means of an undervoltage relay will be required following a suitable time delay.

- Faults occurring on the power system result in a reduction in voltage of the phases involved in the fault. The proportion by which the voltage decreases is directly dependent upon the type of fault, method of system earthing and its location with respect to the relaying point. Consequently, co-ordination with other voltage and current-based protection devices is essential in order to achieve correct discrimination.

- Complete loss of busbar voltage. This may occur due to fault conditions present on the incomer or busbar itself, resulting in total isolation of the incoming power supply. For this condition, it may be a requirement for each of the outgoing circuits to be isolated, such that when supply voltage is restored, the load is not connected. Hence, the automatic tripping of a feeder upon detection of complete loss of voltage may be required. This may be achieved by a three phase undervoltage element.
- Where outgoing feeders from a busbar are supplying induction motor loads, excessive dips in the supply may cause the connected motors to stall, and should be tripped for voltage reductions which last longer than a pre-determined time. Such undervoltage protection may be present in the protective device on the motor feeder itself. However, if it is not, the inclusion of this functionality within the feeder protection relay on the incomer may prove beneficial.

The undervoltage settings may be found in the “Volt Prot.[27/59]” relay menu column.

2.8.1 Setting guidelines

In the majority of applications, undervoltage protection is not required to operate during system earth fault conditions and therefore “Phase-Phase” should be selected in the “V< Measur’t Mode” setting cell, as this is less affected by single phase voltage depressions.

The voltage threshold setting for the undervoltage protection should be set at some value below the voltage excursions that may be expected under normal system operating conditions. This threshold is dependent upon the system in question but typical healthy system voltage excursions may be in the order of 10% below nominal voltage.

Similar comments apply with regard to a time setting for this element, i.e. the required time delay is dependent upon the time for which the system is able to withstand a depressed voltage. For majority motor loads, this may typically be in the order of ½ second.

To prevent unwanted operation when the feeder is de-energized or the circuit breaker is open, blocking signals are available within the PSL for each stage (DDB 264 and DDB 265).

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2.9 Overvoltage protection [59]

As discussed in section 2.8, undervoltage conditions are relatively common because they are related to fault conditions etc. However, overvoltage conditions are also a possibility and are generally related to loss of load conditions as described below;

Under conditions of load rejection, the supply voltage will increase in magnitude. This situation would normally be rectified by voltage regulating equipment such as AVR’s or on-load tap changers. However, failure of this equipment to bring the system voltage back within prescribed limits leaves the system with an overvoltage condition which must be cleared in order to preserve the life of the system insulation. Hence, overvoltage protection that is suitably time delayed to allow for normal regulator action, may be applied.

During earth fault conditions on a power system there may be an increase in the healthy phase voltages. Ideally, the system should be designed to withstand such overvoltages for a defined period of time. Normally, there will be a primary protection element employed to detect the earth fault condition and to issue a trip command if the fault is uncleared after a nominal time. However, it would be possible to use an overvoltage element as a back-up protection in this instance. A single stage of protection would be sufficient, having a definite time delay.

The overvoltage settings may be found in the “Volt Prot.[27/59]” relay menu column.

2.9.1 Setting guidelines

In the majority of applications, overvoltage protection is not required to operate during system earth fault conditions and therefore “Phase-Phase” should be selected in the “V> Measur’t Mode” setting cell, as this is less affected by single phase voltage depressions.

The voltage setting for the overvoltage protection should be set at some value above the voltage excursions which may be expected under normal system operating conditions. This is dependent upon the system in question but typical healthy system voltage excursions may be in the order of 10% - 20% above nominal voltage.

Similar comments apply with regard to a time setting for this element, i.e. the required time delay is dependent upon the time for which the system is able to withstand an increased voltage voltage.

The inclusion of the two stages and their respective operating characteristics allows for a number of possible applications:

- Use of the IDMT characteristic gives the option of a longer time delay if the overvoltage condition is only slight but results in a fast trip for a severe overvoltage. As the voltage settings for both of the stages are independent, the second stage could then be set lower than the first to provide a time delayed alarm stage if required.
- Alternatively, if preferred, both stages could be set to definite time and configured to provide the required alarm and trip stages.
- If only one stage of overvoltage protection is required, or if the element is required to provide an alarm only, the remaining stage may be disabled within the relay menu.

This type of protection must be co-ordinated with any other overvoltage relays at other locations on the system.

3. APPLICATION CONSIDERATIONS

3.1 Calculating the rate of change of frequency for load shedding

In the event of severe system overload or loss of generation conditions, the system frequency will decline exponentially and theoretically stabilize at a steady state level somewhere below the nominal frequency. The time constant of the exponential decay as well as the steady state level is governed by certain parameters such as the system inertia constant, system damping constant etc. The following is an available theory for calculating the rate of change of frequency for a particular system contingency.

Assuming that the load and generation remain constant as the frequency changes, the instantaneous rate of change of frequency at the time of an overload is given by:

$$\text{Instantaneous rate of change of frequency, } {}^{df}\!/_{dt} = -\frac{\Delta P.f_n}{2H} \qquad \text{-----[1]}$$

Where :

$$\Delta P = \text{overload in per unit}$$
$$= \frac{\text{Connected Load - Available Generation}}{\text{Available Generation}}$$
$$f_n = \text{nominal system frequency (in Hz)}$$
$$H = \text{combined inertia constant of the power system (MWsec/MVA)}$$
$$= \left(\frac{H_1 MVA_1 + ... + H_n MVA_n}{MVA_1 + ... + MVA_n}\right)$$

where n subscripts 1, 2,..., n refer to individual generating units

The inertia constant used in formula [1] above, is essentially a measure of the kinetic energy in a generator rotor. For some types of large steam generator sets, the inertia constant can have a value of 10 but a figure of less than 5 is more prevalent especially when considering other generator types. Lower values tend to dominate with smaller rotor masses e.g. wind turbines, and can make the power system more prone to serious frequency disturbances for sudden load changes. Typically values between 2 and 5 may be used if no other knowledge is available.

Real loads, particularly motor loads, do vary with frequency and have a tendency to decrease as frequency reduces. This will have some beneficial effect on system stability and will reduce the effects of the overload condition. Taking this load reduction factor into account, the frequency deviation from nominal is given by:

$$\text{Frequency deviation from nominal, } \Delta f = \frac{\Delta P.f_n}{d}\left(1 - e^{-\left(t.d/2H\right)}\right) \qquad \text{-----[2]}$$

Where :

$$d = \text{load reduction (or damping) factor}$$
$$= \frac{\text{Percentage change in load}}{\text{Percentage change in frequency}}$$

The above equations are a result of vast simplifications. The actual frequency change will be influenced by governor droop characteristics, load dynamics, interconnections between various generators, system stabilizers etc. However the frequency deviations calculated in the formulae described may be a good measure of the rate of change of frequency for the purpose of setting the relay.

It must be noted that the frequency profile is system and situation specific; a good knowledge of the system behavior under a variety of conditions is essential for arriving at the settings for the frequency protection.

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3.1.1 Example of frequency behavior during overload conditions

Using the theoretical formulae given in section 3.1, it is possible to calculate the theoretical behavior of a simple network, shown below:

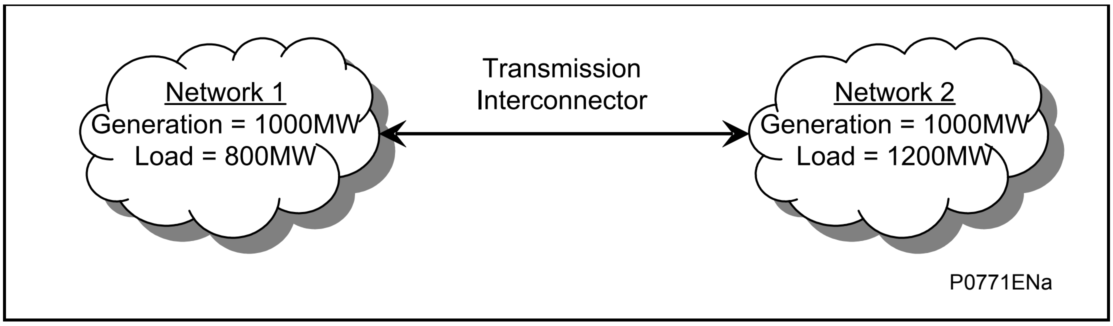

Figure 4: Simple interconnected system to highlight frequency behavior calculations

In the simple network of Figure 4, it can be easily seen that Network 2 has a generation deficit of 200MW which is normally supplied from Network 1 through the transmission interconnector. In the event of loss of this interconnection, and assuming that the system inertia constant (H) of Network 2 is equal to 4, we can calculate that the rate of change of frequency at the time of the overload using equation [1].

$$\text{Instantaneous rate of change of frequency, } {}^{df}\!/_{dt} = -\frac{\Delta P.f_n}{2H}$$

$$= -\frac{\left(\frac{1200 - 1000}{1000}\right).50}{8}$$

$$= -1.25\text{Hz}/\text{s}$$

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It is clear from this calculation that if the inertia constant reduces, the rate of change will increase. For example if H=1, then df/dt = -5Hz/s

We can also introduce the concept of damping factor that assumes that as the frequency reduces, there is a corresponding load reduction, by using equation [2]. If we assume that there is a 1% change in load for every 1% change in frequency, we have a damping factor of 1, and the frequency deviation after 1s will be:

$$\text{Frequency deviation from nominal, } \Delta f = \frac{\Delta P.f_n}{d}\left(1 - e^{-\left({}^{t.d}\!/_{2H}\right)}\right)$$

$$= \frac{0.2\text{x}50}{1}\left(1 - e^{-\left({}^{1}\!/_{8}\right)}\right)$$

$$= 1.175\text{Hz}$$

In other words, if the system was originally operating at 50Hz, after 1s the system frequency would have dropped to 48.825Hz. Here we notice the effects of the damping factor since the first calculation assumed an initial rate of change of frequency of -1.25Hz/s, which in turn would lead us to consider a system frequency of 48.75Hz after 1s of overload.

Figure 5 shows a set of curves highlighting the frequency of the example system assuming different overload levels and inertia constants for 35s after onset of the overload condition. The damping factor, d, in all cases is 1.

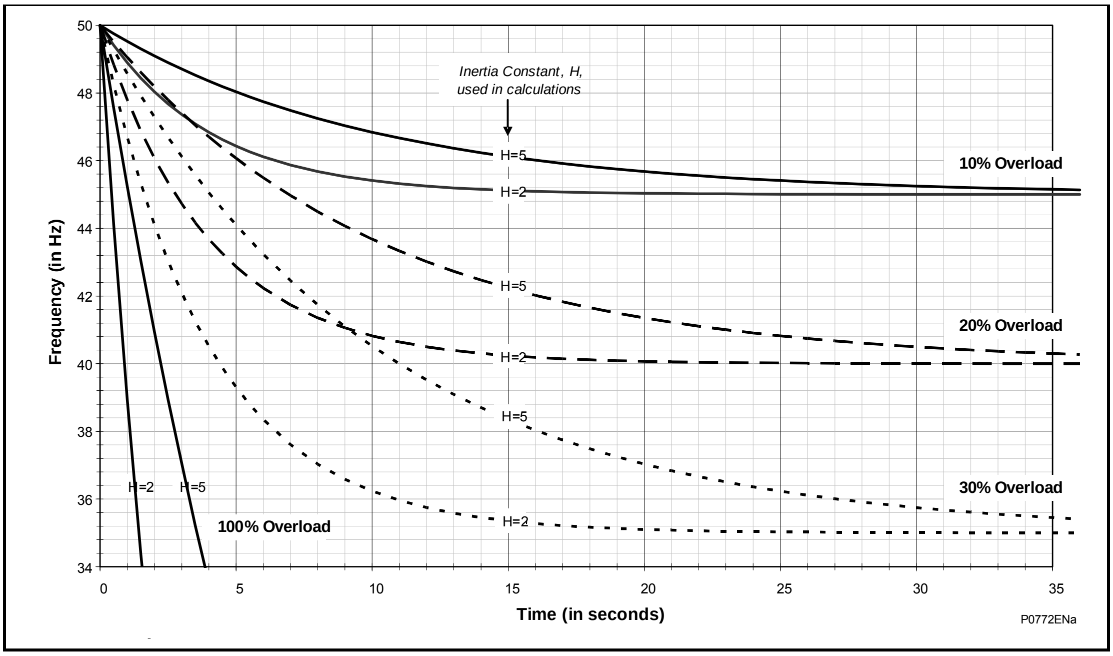

Figure 5: Frequency profile of the example system for various overload conditions

3.2 Effect of averaging cycles

The P940 relays use a 1-cycle discrete Fourier transform (DFT) in order to track the system frequency and maintain the sampling rate (see P94x/EN FD). Four times per cycle, a new frequency measurement is made available to the frequency protection algorithms. However, in order to assist stability of the measurement, various averaging techniques are used and their effects are discussed in the following two sections.

3.2.1 Frequency averaging cycles

Four times per cycle, a new “raw” frequency measurement is made available by the DFT and placed into the frequency averaging buffer. The size of this buffer is user-selectable up to 48 cycles for software version 11, and up to 12 for software version 10. It is the output of this buffer that is checked against any frequency setting to establish whether the element should start operation or not. The purpose of this averaging process is to smooth the frequency measurement since real frequency excursions are highly oscillatory, but as a consequence the operating and reset times will extend depending upon the exact system conditions and relay settings.

Due to the techniques used and the myriad of different frequency conditions that can be exposed to the relay, it is difficult to provide an exact formula to calculate the extension of times associated with the number of frequency averaging cycles. However, as a result of extensive relay testing, it is possible to give the following graphs that indicate typical additional times. These values must be added to the operation time for the relay with a frequency averaging cycle setting of zero (see P94x/EN TD).

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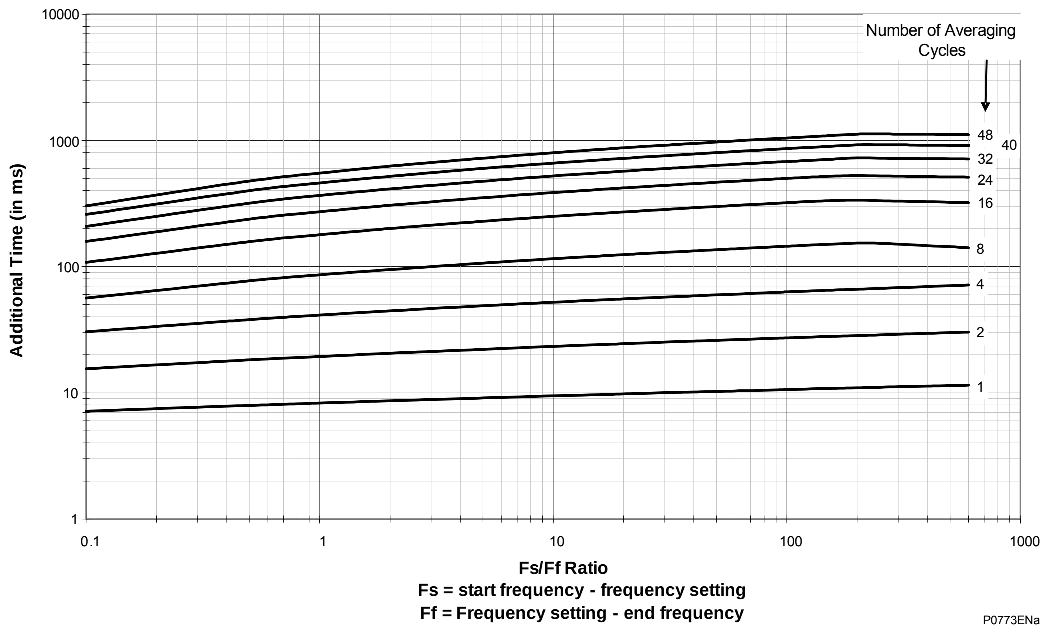

Figure 6: Additional operating time for underfrequency thresholds

In Figure 6, the Fs/Ff ratio is related to a test scenario where the start frequency is above the underfrequency setting and the end frequency is below the frequency setting.

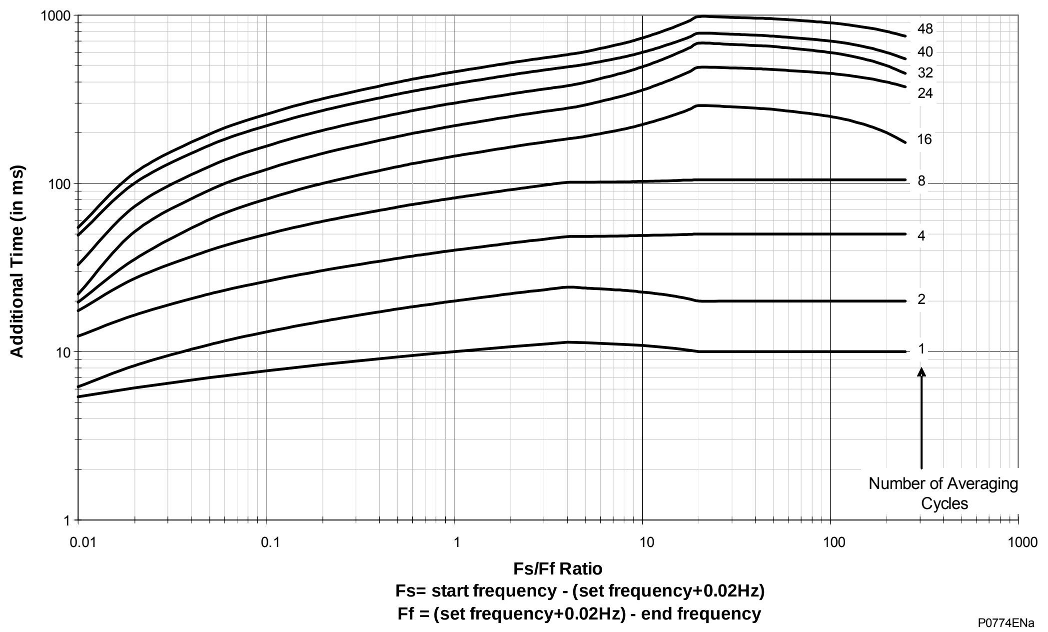

Figure 7: Additional reset time for underfrequency thresholds

In Figure 7, the Fs/Ff ratio is related to a test scenario where the start frequency is below the underfrequency setting and the end frequency is above the frequency setting.

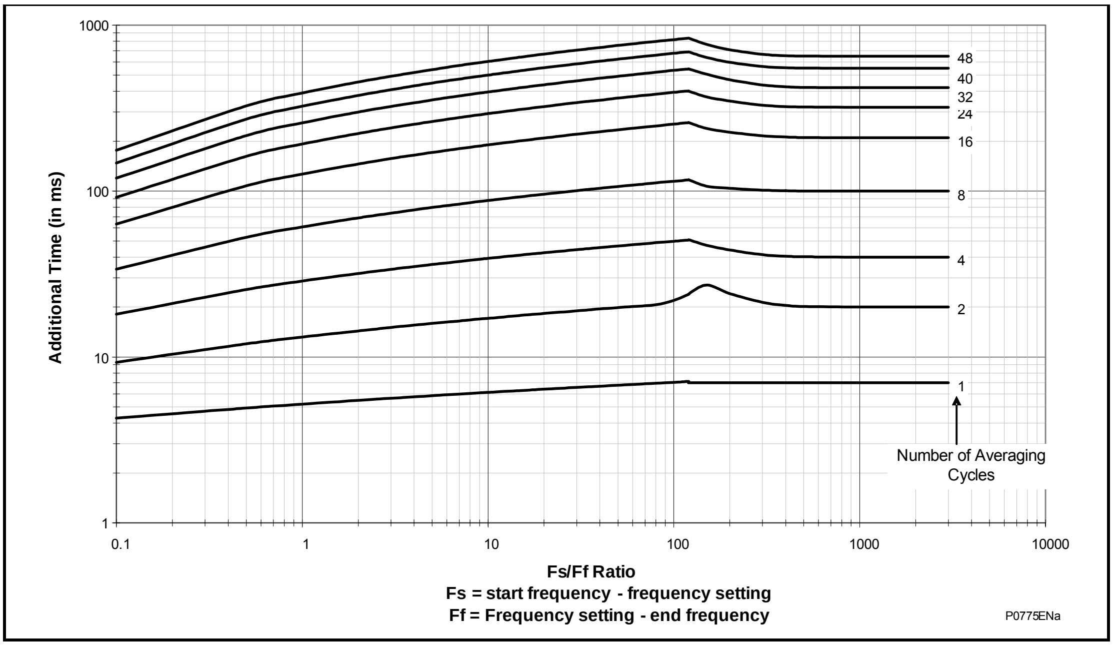

Figure 8: Additional operating time for overfrequency thresholds

In Figure 8, the Fs/Ff ratio is related to a test scenario where the start frequency is below the overfrequency setting and the end frequency is above the frequency setting.

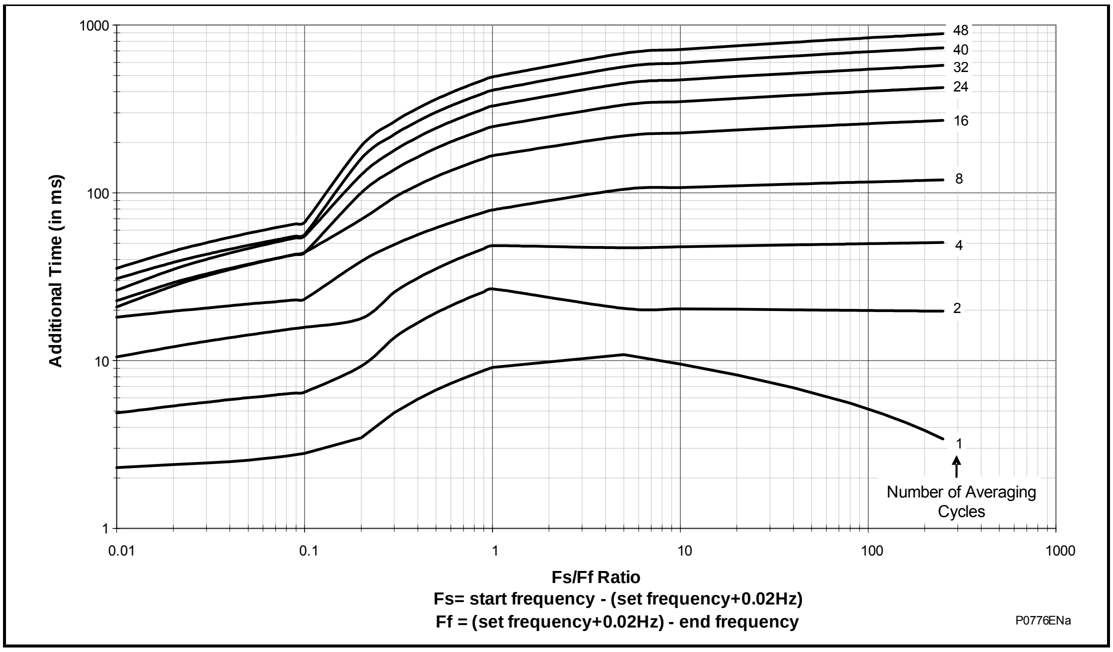

Figure 9: Additional reset time for overfrequency thresholds

In Figure 9, the Fs/Ff ratio is related to a test scenario where the start frequency is above the overfrequency setting and the end frequency is below the frequency setting.

All frequency settings are affected by the selection of frequency averaging cycles. In other words, the f+t [81O/81U], the f+df/dt [81RF], the f+Df/Dt [81RAV], load restoration and generator abnormal protection [81AB] will all use the averaged frequency measurements.

3.2.2 df/dt averaging cycles

As for the frequency measurements, four times per cycle a new “raw” df/dt measurement is passed into the df/dt averaging buffer. The size of this buffer is user-selectable up to 48 cycles for software version 11, and up to 12 for software version 10. It is the output of this buffer that is checked against any df/dt setting to establish whether the element should start operation or not. The purpose of this averaging process is to smooth the df/dt measurement since real frequency excursions are highly oscillatory, but as a consequence the operating and reset times will extend depending upon the exact system conditions and relay settings.

Due to the techniques used and the myriad of different conditions that can be exposed to the relay, it is difficult to provide an exact formula to calculate the extension of times associated with the number of df/dt averaging cycles. However, as a result of extensive relay testing, it is possible to give the following graphs that indicate typical additional times. These values must be added to the operation time for the relay with a df/dt averaging cycle setting of zero (see P94x/EN TD).

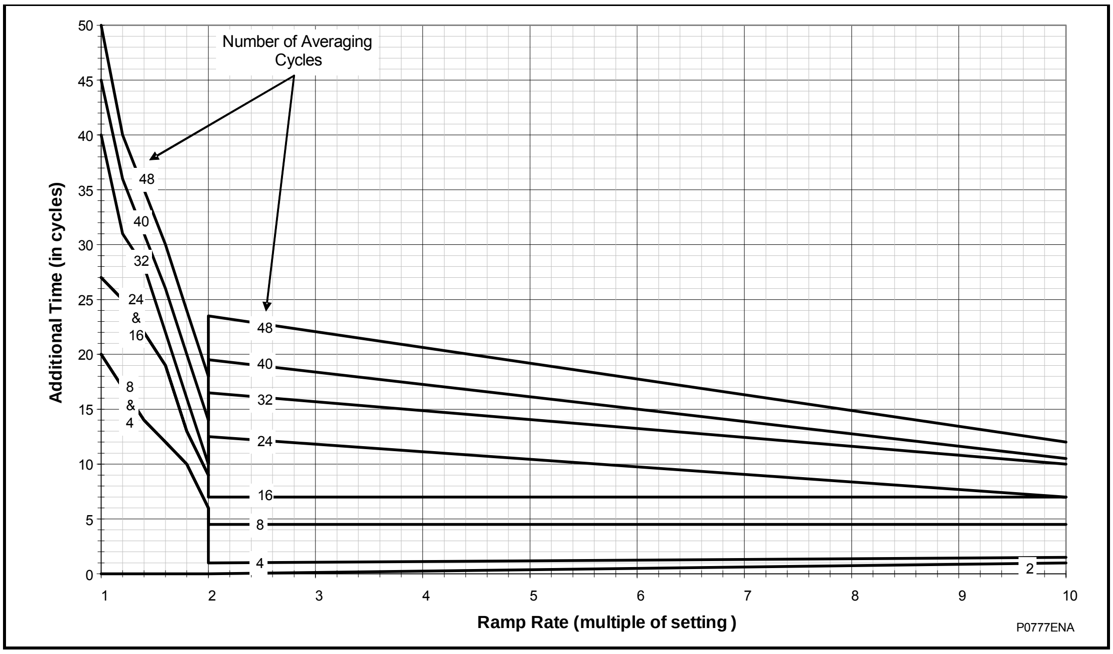

Figure 10: Additional operating time for falling frequency conditions

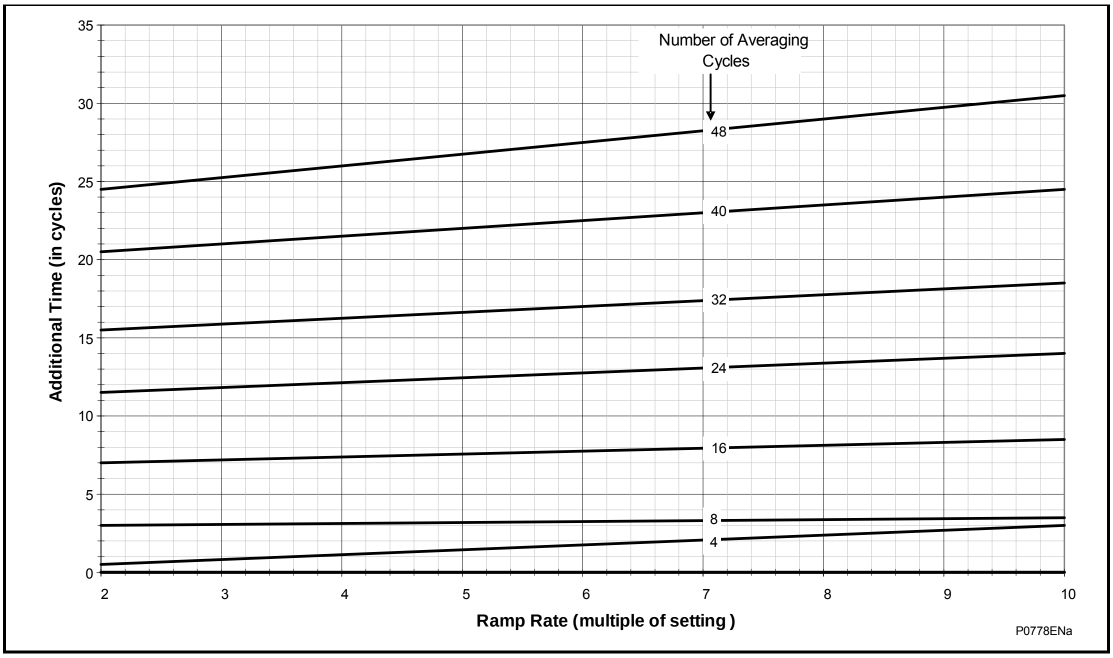

Figure 11: Additional reset time for falling frequency conditions

In Figure 11, the ramp rate refers to the rate of rise of frequency as a multiple of the df/dt setting.

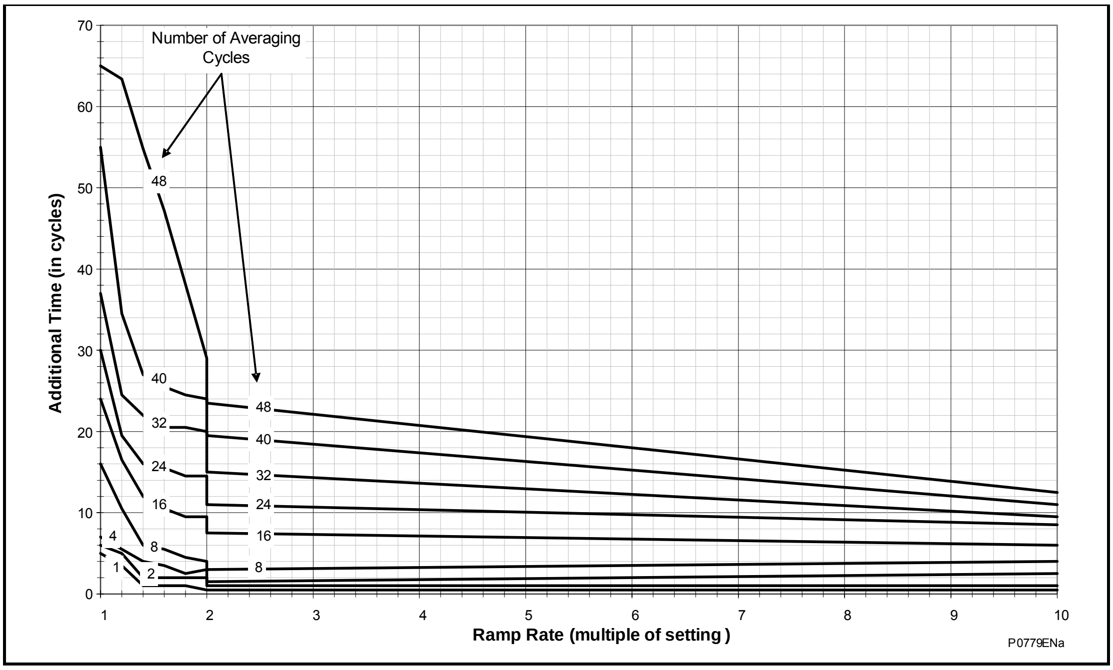

Figure 12: Additional operating time for rising frequency conditions

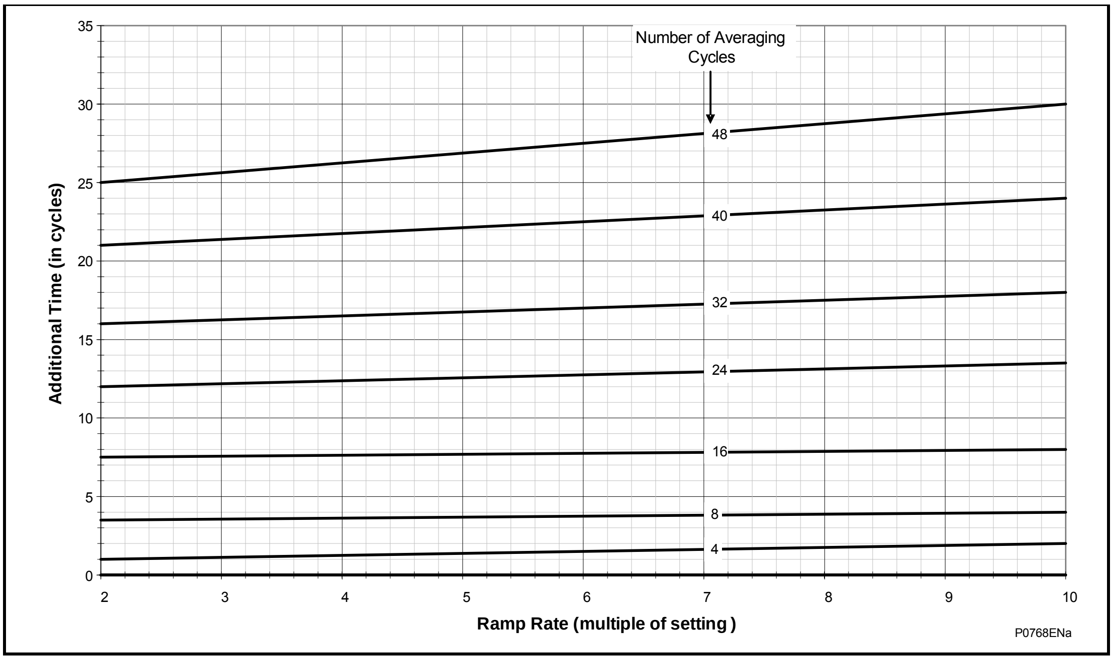

Figure 13: Additional reset time for rising frequency conditions

In Figure 13, the ramp rate refers to the rate of fall of frequency as a multiple of the df/dt setting.

All instantaneous rate of change of frequency settings are affected by the selection of df/dt averaging cycles. In other words, the df/dt+t [81R] and the f+df/dt [81RF] will both use the averaged df/dt measurements. The f+Df/Dt[81RAV] is unaffected by the df/dt averaging cycles setting as both the frequency and average rate of change of frequency measurements are based upon actual frequency measurements which are controlled by the frequency averaging cycles setting.

3.2.3 Setting recommendation for df/dt averaging cycles

One of the enhancements in version 11 software was the reduction of the lower setting limit of the df/dt threshold to 0.01Hz/s (previously the lower limit was 0.1Hz/s). This sensitive setting range makes the relay prone to "chatter" as a result of the oscillations that will be present during the frequency excursion, and therefore it is necessary to stabilize the relay using the averaging cycles setting and/or time delays. Figure 14 shows the minimum recommended df/dt averaging cycles that should be used if no intentional time delays are set for the element.

Figure 14: Additional reset time for rising frequency conditions

It is also suggested that these minimum settings are utilized for the lower df/dt settings in software version 10.

4. APPLICATION EXTENSIONS USING PSL

The following sections highlight possible schemes that can be used to improve the overall load shedding capabilities of the P940 relays using the programmable scheme logic and suitable settings.

4.1 Increasing load restoration stages

Up to six stages of load restoration are available within the fixed logic of the P940 relays but using the Programmable Scheme Logic (PSL), it is possible to increase the effective number of restoration stages. This will enhance the stability of the system during load restoration by restoring the load in smaller sections. For example, assume that two feeders are tripped when a single stage of load shedding operates. The restoration of this single stage may be split using the PSL as shown below:

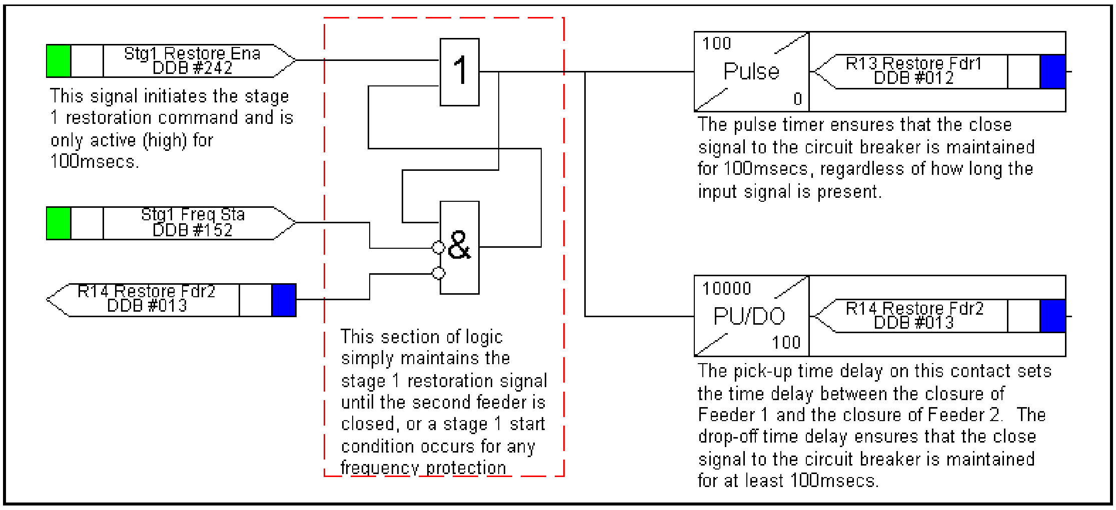

Figure 15: Example PSL for segregating a single stage of load shedding

The contact conditioners (timers) available in the PSL can be used along with the restoration timer of a stage to smooth the impact of sudden load restoration, provided sufficient output relays are available.

4.2 Cyclic load shedding to reduce customer dissatisfaction

In some networks there may always be a deficit in the generating capability which leads to regular disconnection of customer loads. By prioritizing the loads, critical loads are maintained for the majority of the time but loads defined as “less essential” will suffer from regular disconnection. This may lead to customer dissatisfaction.

The logic in Figure 16: outlines a method that could be used to ensure that a group of loads are cyclically disconnected so that no one set of customers are affected more frequently than others. In other words, the first load shedding stage will cause group 1 to be disconnected the first time it operates, group 2 the second time and so on.

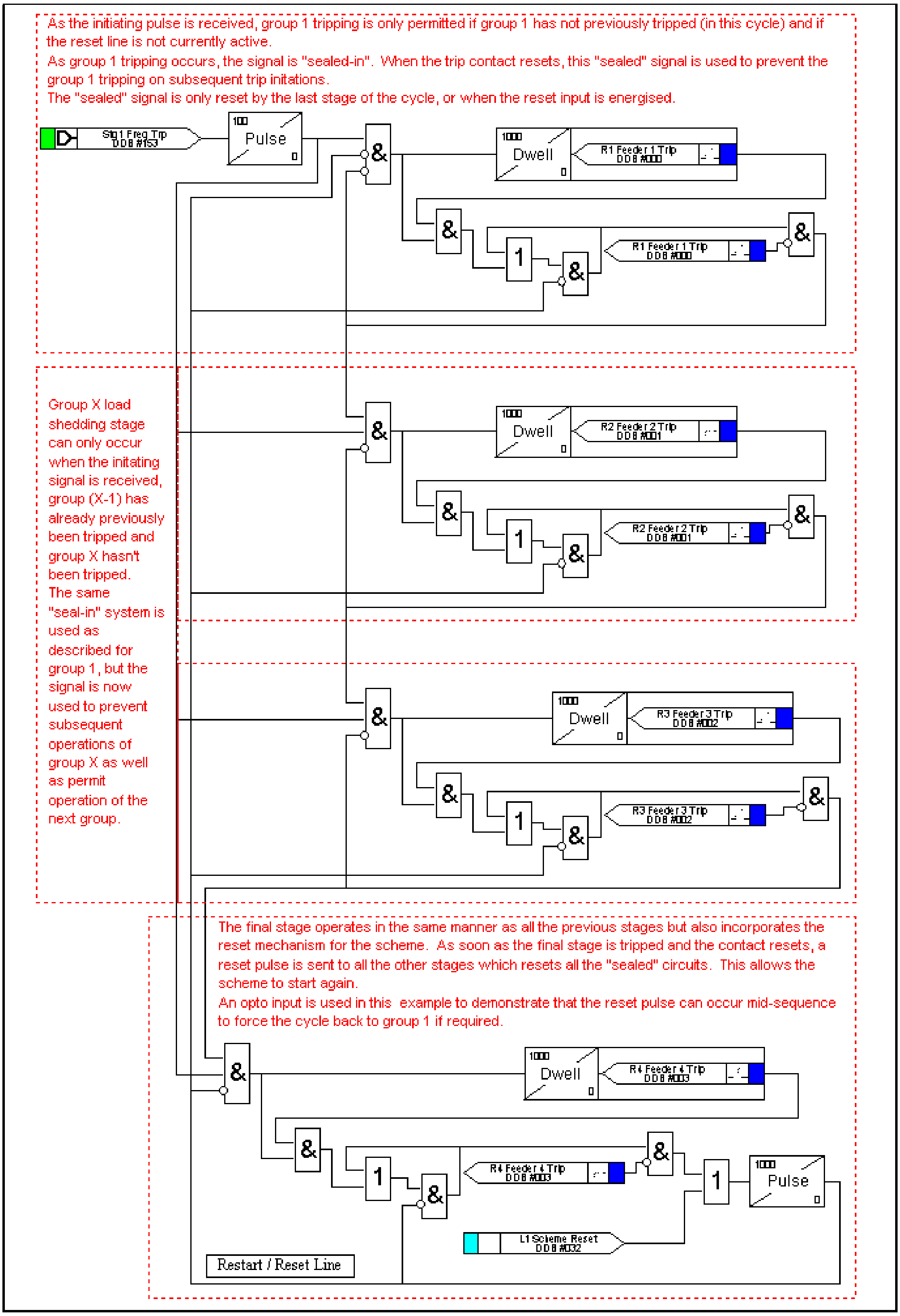

Figure 16: Cyclic (rotational) load shedding (4 groups shown)

4.3 Voltage supervised average rate of change of voltage protection

As an alternative to using the rate of change of frequency protection already discussed in section 2, it is possible to configure the voltage protection of the relay to provide up to two stages of rate of change of voltage protection. The logic required for this protection is created within the PSL and is based upon the methodology of the average rate of change of frequency element “f+Df/Dt”. See the Operations section for more detail (P94x/EN OP).

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This PSL will offer the same advantage to the undervoltage protection, as the rate of change of frequency protection elements offer to the under-frequency protection.

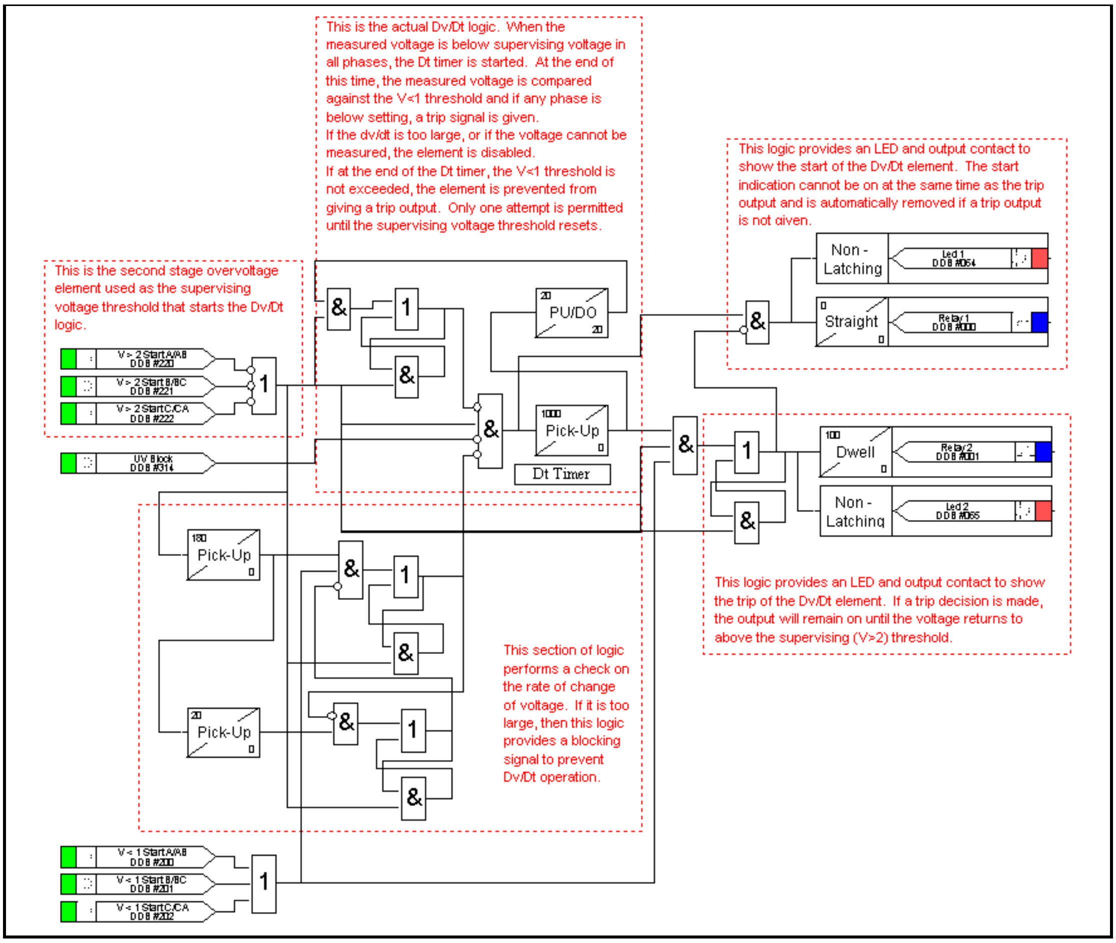

Figure 17: Average rate of change of voltage operating logic (single stage shown)

In this logic, the second overvoltage stage is inverted and used as the voltage supervising threshold for both stages of protection. The undervoltage protection stage is used for the actual rate of change of voltage protection. It should be noted that in all cases the start signals are used which ensures that with suitable timer settings in the PSL, the normal undervoltage protection facilities may be maintained. However, the second stage of overvoltage is "sacrificed" to be used for the supervision threshold.

Using the example logic shown in Figure 17: the following settings were made on the relay:

Supervising Voltage Pick-up Threshold (actual) = 92.5V (Ph-Ph)

Undervoltage Pick-up Threshold (actual) = 83.8V (Ph-Ph), with 5s time delay

Theoretical Rate of Change of Voltage Setting = 8.7V/sec (with 1s timer setting in PSL)

Theoretical Blocking Rate of Change of Voltage threshold = 45V/sec (approx)

With these settings the following test results were obtained:

Applied Ramp Rate (Starting at 100V)	Theoretical Trip Point		Practical Trip Point	
	Undervoltage	**Dv/Dt**	**Undervoltage**	**Dv/Dt**
8.39	41.85V after 6.93 seconds	No Trip (below setting)	41.62V after 6.95 seconds	No Trip (below setting)
8.53	41.15V after 6.9 seconds	No Trip (below setting)	40.69V after 6.92 seconds	83.55V after 1.92 seconds
8.65	40.55V after 6.87 seconds	No Trip (below setting)	40.25V after 6.9 seconds	83.55V after 1.91 seconds
10.39	31.85V after 6.56 seconds	82.11V after 1.72 seconds	31.63V after 6.59 seconds	81.93V after 1.74 seconds
17.31	0V after 5.94 seconds	75.19V after 1.43 seconds	0V after 5.98 seconds	74.72V after 1.46 seconds
46.56	0V after 5.35 seconds	No Trip (Blocking)	0V after 5.39 seconds	44.83V after 1.19 seconds
47.94	0V after 5.34 seconds	No Trip (Blocking)	0V after 5.37 seconds	No Trip (Blocking)
51.63	0V after 5.31 seconds	No Trip (Blocking)	0V after 5.36 seconds	No Trip (Blocking)

As can viewed from this table, the logic operates as anticipated (allowing for accuracies) and with suitable settings applied for the voltage thresholds and timers, the element could be made suitable for any application requiring a rate of change of voltage function. Considerable reduction of the time to load shedding can be achieved, with checks in place to guard against operation during short-circuit fault conditions.

5. VT REQUIREMENTS

In choosing the VT for use with the P940 range of relays, it is only necessary to consider the accuracy requirements and whether the output burden of the VT is sufficient to supply the relay demands. Protection classes 3P or 6P are usually adequate in terms of accuracy but care should be taken that the VT is not over-sized as this may lead to resonance problems. Typically, the output burden of the VT could be 10% higher than the total connected burden of all connected devices.

5.1 VT connections

5.1.1 Open delta (vee connected) VT's

The P940 range can be used with vee connected VTs by connecting the VT secondaries to C19, C20 and C21 input terminals, with the C22 input left unconnected.

This type of VT arrangement cannot pass zero-sequence (residual) voltage to the relay, or provide any phase to neutral voltage quantities. Therefore any protection that is dependent upon phase to neutral voltage measurements should be disabled. The under and over voltage protection can be set as phase-to-phase measurement with vee connected VTs.

The accuracy of the single phase voltage measurements can be impaired when using vee connected VT's because the relay attempts to derive the phase to neutral voltages from the phase to phase voltage vectors. If the impedance of the voltage inputs were perfectly matched the phase to neutral voltage measurements would be correct, provided the phase to phase voltage vectors were balanced. However, in practice there are small differences in the impedance of the voltage inputs, which can cause small errors in the phase to neutral voltage measurements.

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The phase to neutral voltage measurement accuracy can be improved by connecting 3, well matched, load resistors between the phase voltage inputs (C19, C20, C21) and neutral C22, thus creating a 'virtual' neutral point. The load resistor values must be chosen so that their power consumption is within the limits of the VT. It is recommended that 10kΩ ±1% (6W) resistors are used for the 110V (Vn) rated relay, assuming the VT can supply this burden.

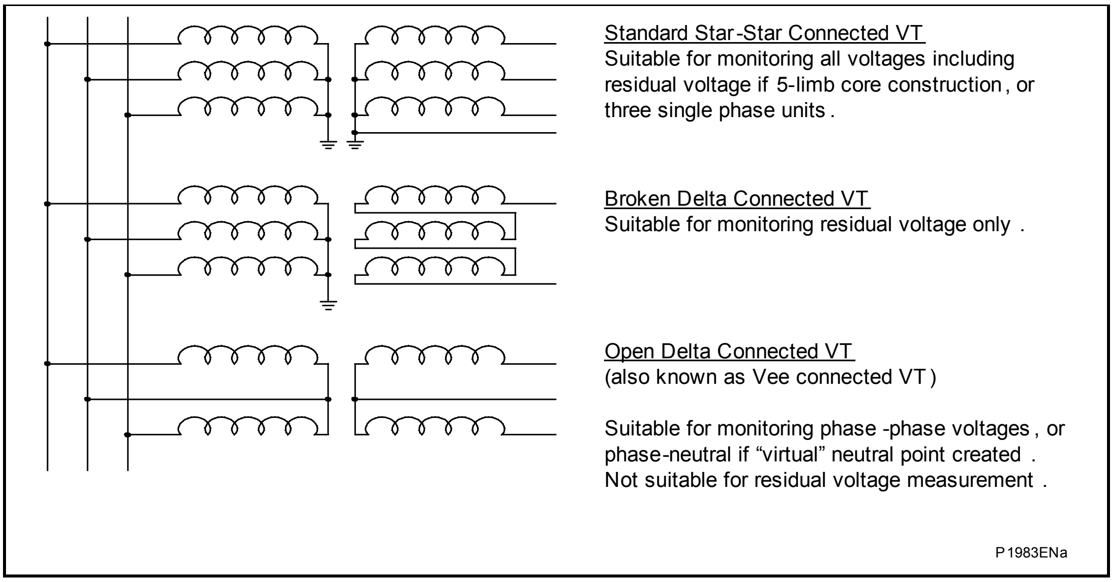

Figure 18: VT conventions

5.1.2 VT single point earthing

The P940 range will function correctly with conventional 3 phase VT's earthed at any one point on the VT secondary circuit. Typical earthing examples being neutral earthing or yellow (B) phase earthing.

6. AUXILIARY SUPPLY FUSE RATING

In the Safety section of this manual, the maximum allowable fuse rating of 16A is quoted. To allow time grading with fuses upstream, a lower fuselink current rating is often preferable. Use of standard ratings of between 6A and 16A is recommended. Low voltage fuselinks, rated at 250V minimum and compliant with IEC60269-2 general application type gG are acceptable, with high rupturing capacity. This gives equivalent characteristics to HRC "red spot" fuses type NIT/TIA often specified historically.

The table below recommends advisory limits on relays connected per fused spur. This applies to MiCOM Px40 series devices with hardware **suffix C and higher,** as these have inrush current limitation on switch-on, to conserve the fuse-link.

Maximum Number of MiCOM Px40 Relays Recommended Per Fuse				
Battery Nominal Voltage	**6A**	**10A Fuse**	**15 or 16A Fuse**	**Fuse Rating > 16A**
24 to 54V	2	4	6	Not permitted
60 to 125V	4	8	12	Not permitted
138 to 250V	6	10	16	Not permitted

Alternatively, miniature circuit breakers (MCB) may be used to protect the auxiliary supply circuits.

PROGRAMMABLE LOGIC

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Date:	**2008**
Hardware Suffix:	**A or C**
Software Version:	**12**
Connection Diagrams:	**10P94yxx (y = 1 or 3) (x = 01 to 06)**

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CONTENTS

1. PROGRAMMABLE LOGIC

1.1 Overview

The purpose of the programmable scheme logic (PSL) is to allow the relay user to configure an individual protection scheme to suit their own particular application. This is achieved through the use of programmable logic gates and delay timers.

The input to the PSL is any combination of the status of opto inputs. It is also used to assign the mapping of functions to the opto inputs and output contacts, the outputs of the protection elements, e.g. protection starts and trips, and the outputs of the fixed protection scheme logic. The fixed scheme logic provides the relay's standard protection schemes. The PSL itself consists of software logic gates and timers. The logic gates can be programmed to perform a range of different logic functions and can accept any number of inputs. The timers are used either to create a programmable delay, and/or to condition the logic outputs, e.g. to create a pulse of fixed duration on the output regardless of the length of the pulse on the input. The outputs of the PSL are the LEDs on the front panel of the relay and the output contacts at the rear.

The execution of the PSL logic is event driven; the logic is processed whenever any of its inputs change, for example as a result of a change in one of the digital input signals or a trip output from a protection element. Also, only the part of the PSL logic that is affected by the particular input change that has occurred is processed. This reduces the amount of processing time that is used by the PSL; even with large, complex PSL schemes the relay trip time will not lengthen.

This system provides flexibility for the user to create their own scheme logic design. However, it also means that the PSL can be configured into a very complex system, hence setting of the PSL is implemented through the PC support package MiCOM S1.

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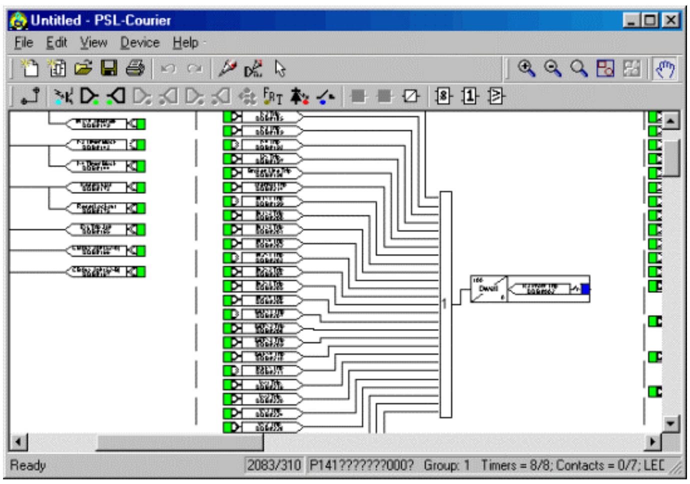
Note: Each setting group has its own PSL. Once a PSL has been designed it can be sent to any one of 4 setting groups within the relay. When downloading a PSL to the relay the user will be prompted to enter the desired setting group to which it will be sent. If the user fails to download the required PSL to any setting group that may be brought into service, then factory default PSL will still be resident and this may have severe operational and safety consequences.

1.2 MiCOM S1 Px40 PSL editor

To access the Px40 PSL Editor menu click on

The PSL Editor module enables you to connect to any MiCOM device front port, retrieve and edit its Programmable Scheme Logic files and send the modified file back to a MiCOM Px40 device.



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1.3 How to use MiCOM Px40 PSL editor

With the MiCOM Px40 PSL Module you can:

- Start a new PSL diagram
- Extract a PSL file from a MiCOM Px40 IED
- Open a diagram from a PSL file
- Add logic components to a PSL file
- Move components in a PSL file
- Edit link of a PSL file
- Add link to a PSL file
- Highlight path in a PSL file
- Use a conditioner output to control logic
- Download PSL file to a MiCOM Px40 IED
- Print PSL files

For a detailed discussion on how to use these functions, please refer to MiCOM S1 Users Manual.

1.4 Warnings

Before the scheme is sent to the relay, checks are done and various warning messages may be displayed as a result of these checks.

The Editor first reads in the model number of the connected relay, and then compares it with the stored model number. A "wildcard" comparison is employed. If a model mismatch occurs then a warning will be generated before sending commences. Both the stored model number and that read-in from the relay are displayed along with the warning; the onus is on you to decide if the settings to be sent are compatible with the connected relay. Wrongly ignoring the warning could lead to undesired behavior in the relay.

If there are any potential problems of an obvious nature then a list will be generated. The types of potential problems that the program attempts to detect are:

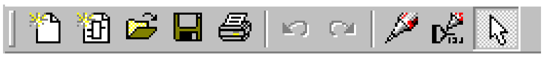
- One or more gates, LED signals, contact signals, and/or timers have their outputs linked directly back to their inputs. An erroneous link of this sort could lock up the relay, or cause other more subtle problems to arise.
- Inputs To Trigger (ITT) exceeds the number of inputs. A programmable gate has its ITT value set to greater than the number of actual inputs; the gate can never activate. Note that there is no lower ITT value check. A 0-value does not generate a warning.
- Too many gates. There is a theoretical upper limit of 256 gates in a scheme, but the practical limit is determined by the complexity of the logic. In practice the scheme would have to be very complex, and this error is unlikely to occur.
- Too many links. There is no fixed upper limit to the number of links in a scheme. However, as with the maximum number of gates, the practical limit is determined by the complexity of the logic. In practice the scheme would have to be very complex, and this error is unlikely to occur.

1.5 Toolbar and commands

There are a number of toolbars available for easy navigation and editing of PSL.

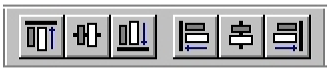
1.5.1 Standard tools

- For file management and printing.



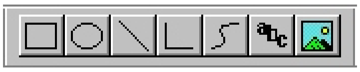
1.5.2 Alignment tools

- To snap logic elements into horizontally or vertically aligned groupings.



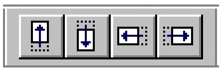
1.5.3 Drawing tools

- To add text comments and other annotations, for easier reading of PSL schemes.



1.5.4 Nudge tools

- To move logic elements.



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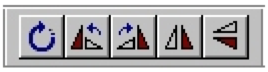
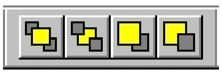
1.5.5 Rotation tools

- Tools to spin, mirror and flip.



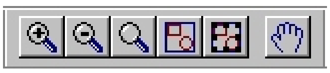
1.5.6 Structure tools

- To change the stacking order of logic components.



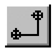
1.5.7 Zoom and pan tools

- For scaling the displayed screen size, viewing the entire PSL, or zooming to a selection.

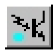


1.5.8 Logic symbols

- The logic symbols are all available in the toolbar below:

Link 

Create a link between two logic symbols.

Opto Signal 

Assign an opto (binary input).

Input 

Use internal fixed logic result as an input to PSL.

Output 

Use an output from PSL to drive a fixed logic scheme.

Control In 

Create an input signal to logic that can be operated from an external command.

Fault Record Trigger 

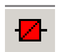
Create a fault record trigger.

LED Signal 

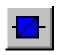
To create a logic input which repeats the status of an LED.

Contact Signal 

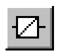
To create a logic input which repeats the status of a relay contact.

LED Conditioner 

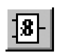
Assign the condition to illuminate LED indicators.

Contact Conditioner 

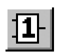
To drive an output contact, with timer conditioning if required.

Timer 

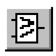
Create a timer.

AND Gate 

Create an AND Gate.

OR Gate 

Create an OR Gate.

Programmable Gate 

Create a programmable gate.

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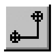
1.6 PSL logic signals properties

The logic signal toolbar is used for the selection of logic signals.

Performing a right-mouse click on any logic signal will open a context sensitive menu and one of the options for certain logic elements is the **Properties…** command. Selecting the Properties option will open a Component Properties window, the format of which will vary according to the logic signal selected.

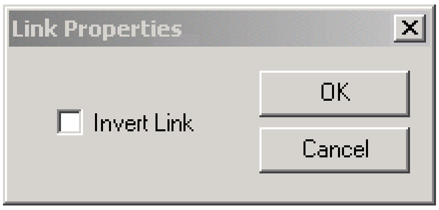
Properties of each logic signal, including the Component Properties windows, are shown in the following sub-sections:

1.6.1 Link properties



Links form the logical link between the output of a signal, gate or condition and the input to any element.

Any link that is connected to the input of a gate can be inverted via its properties window. An inverted link is indicated with a “bubble” on the input to the gate. It is not possible to invert a link that is not connected to the input of a gate.



Rules for Linking Symbols

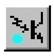
Links can only be started from the output of a signal, gate, or conditioner, and can only be ended on an input to any element.

Since signals can only be either an input or an output then the concept is somewhat different. In order to follow the convention adopted for gates and conditioners, input signals are connected from the left and output signals to the right. The Editor will automatically enforce this convention.

A link attempt will be refused where one or more rules would otherwise be broken. A link will be refused for the following reasons:

- An attempt to connect to a signal that is already driven. The cause of the refusal may not be obvious, since the signal symbol may appear elsewhere in the diagram. Use “Highlight a Path” to find the other signal.
- An attempt is made to repeat a link between two symbols. The cause of the refusal may not be obvious, since the existing link may be represented elsewhere in the diagram.

1.6.2 Opto signal properties



Each opto input can be selected and used for programming in PSL. Activation of the opto input will drive an associated DDB signal.

For example activating opto input L1 will assert DDB 032 in the PSL.

1.6.3 Input signal properties

Relay logic functions provide logic output signals that can be used for programming in PSL. Depending on the relay functionality, operation of an active relay function will drive an associated DDB signal in PSL.

For example DDB 146 will be asserted in the PSL should the active under/'over frequency [81U/O], stage 1 protection operate/trip.

1.6.4 Output signal properties

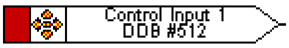
Relay logic functions provide logic input signals that can be used for programming in PSL. Depending on the relay functionality, activation of the output signal will drive an associated DDB signal in PSL and cause an associated response to the relay function

For example, if DDB 264 is asserted in the PSL, it will block the undervoltage stage 1 timer.

1.6.5 Control in signal properties

There are 32 control inputs which can be activated via the relay menu or rear communications. When the control input is activated an associated DDB within the PSL will be asserted high.

For example, if Control Input 1 is activated, DDB 512 is asserted in the PSL.



1.6.6 Fault recorder trigger properties

The fault recording facility can be activated, by driving the fault recorder trigger DDB signal.

For example assert DDB 144 to activate the fault recording in the PSL.

1.6.7 LED signal properties

All programmable LEDs will drive an associated DDB signal when the LED is activated.

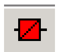
For example DDB 64 will be asserted when LED 1 is activated.

1.6.8 Contact signal properties

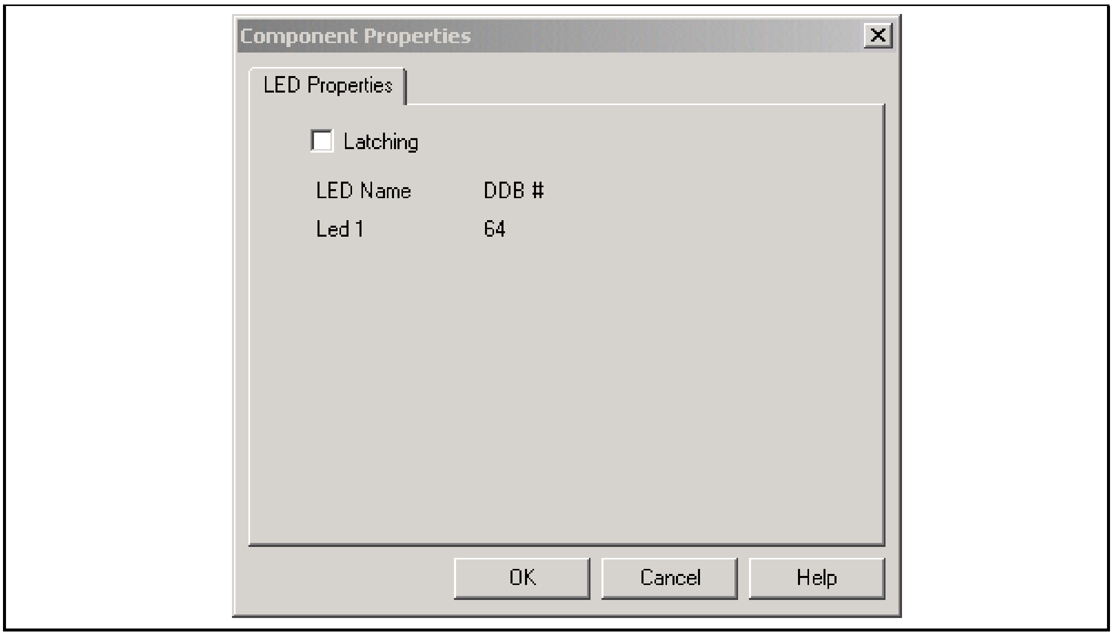
All relay output contacts will drive an associated DDB signal when the output contact is activated.

For example DDB 009 will be asserted when output R10 is activated.

1.6.9 LED conditioner properties



Each LED can be conditioned to be latching or non-latching.



1. Select the LED name from the LED Name list (only shown when inserting a new symbol).
2. Select if the LED should be latching using the Latching check box.

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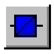
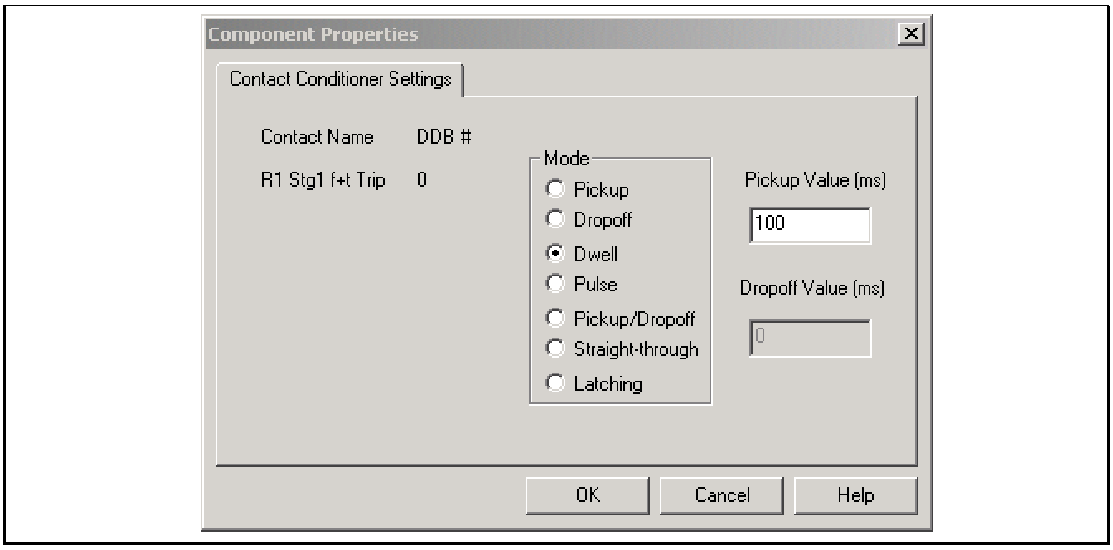
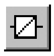
1.6.10 Contact conditioner properties



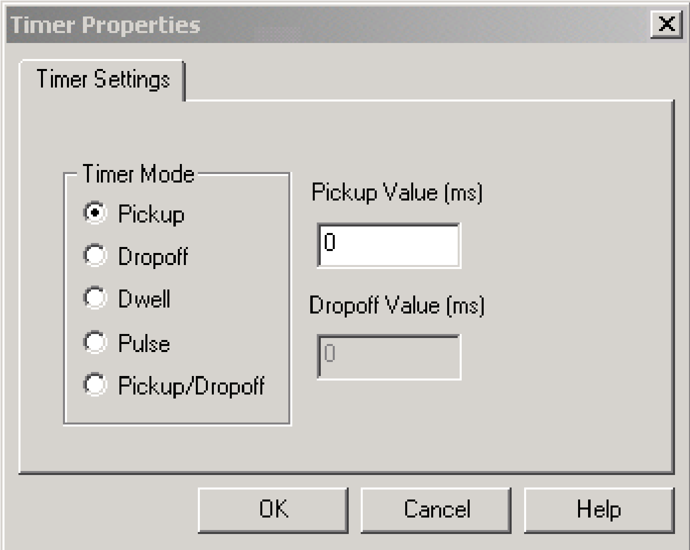
Each contact can be conditioned with an associated timer that can be selected for pick up, drop off, dwell, pulse, pick-up/drop-off, straight-through, or latching operation. "Straight-through" means it is not conditioned in any way whereas "latching" is used to create a sealed-in or lockout type function.



1. Select the contact **name** from the **Contact Name** list (only shown when inserting a new symbol).
2. Choose the conditioner type required in the **Mode** tick list.
3. Set the **Pickup Time** (in milliseconds), if required.
4. Set the **Dropoff Time** (in milliseconds), if required.

1.6.11 Timer properties 

Each timer can be selected for pick up, drop off, dwell, pulse or pick-up/drop-off operation.



1. Choose the operation mode from the **Timer Mode** tick list.
2. Set the **Pick-up Time** (in milliseconds) if required.
3. Set the **Drop-off Time** (in milliseconds) if required.

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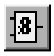
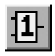
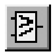
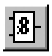
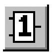
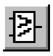
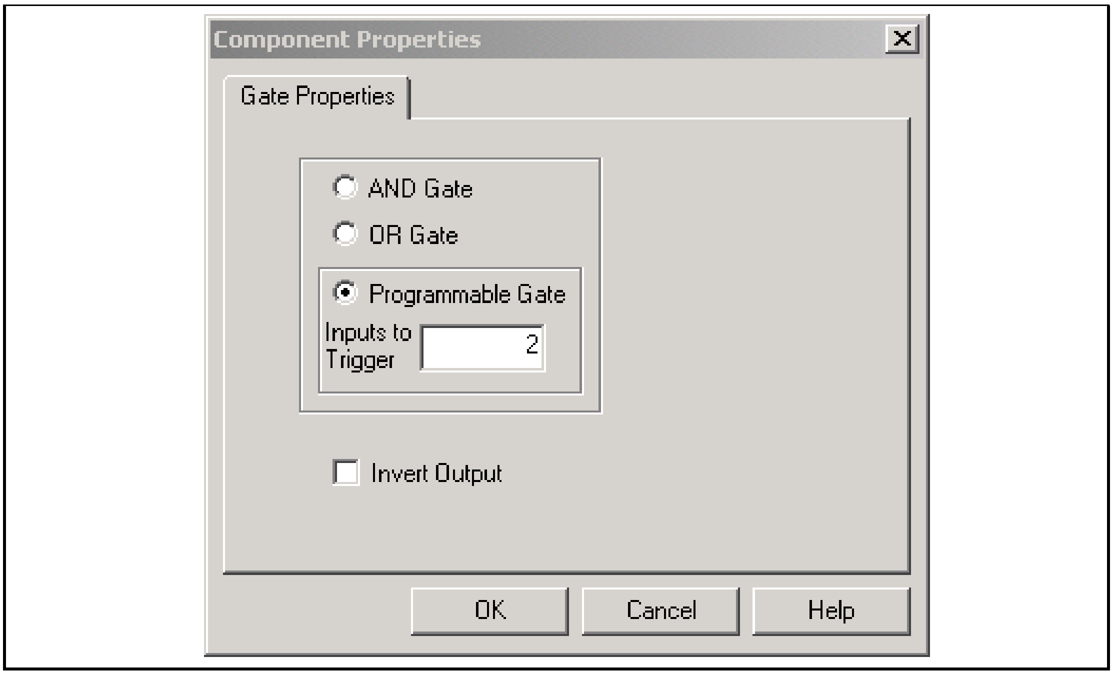
1.6.12 Gate properties  or  or 

A Gate may be an AND, OR, or programmable gate.

An **AND** gate  requires that all inputs are TRUE for the output to be TRUE.

An **OR** gate  requires that one or more input is TRUE for the output to be TRUE.

A **Programmable** gate  requires that the number of inputs that are TRUE is equal to or greater than its ‘Inputs to Trigger’ setting for the output to be TRUE.



1. Select the Gate type AND, OR, or Programmable.
2. Set the number of inputs to trigger when Programmable is selected.
3. Select if the output of the gate should be inverted using the **Invert Output** check box. An inverted output is indicated with a "bubble" on the gate output.

1.7 Description of logic nodes

DDB No.	English Text	Source	Description
0	Output Label 1 *(settable)*	Output Conditioner	Signal which shows the state of output relay 1 (0 = de-energised, 1 = energised).
1 - 31	Output Label 2 … 32 *(settable)*	Output Conditioner	Signal which shows the state of output relay 2 to 32 (0 = de-energised, 1 = energised).
32	Opto Label 1 *(settable)*	Opto Input	Signal which shows the state of opto input 1 (0 = de-energised, 1 = energised).
33 - 63	Opto Label 2 … 31 *(settable)*	Opto Input	Signal which shows the state of opto input 2 to 32 (0 = de-energised, 1 = energised).
64	LED 1	Output Conditioner	Signal which shows the state of programmable LED 1 (0 = Off, 1 = On).
65 - 71	LED 2 … 8	Output Conditioner	Signal which shows the state of programmable LED 2 to 8. (0 = Off; 1 = On).
72	Relay Cond 1	PSL	Input to Relay Output conditioner 1.
73 - 103	Relay Cond 2 … 32	PSL	Input to Relay Output conditioner 2 to 32.
104	LED Cond IN 1	PSL	Input to programmable LED conditioner 1.
105 - 111	LED Cond IN 2 … 8	PSL	Input to programmable LED conditioner 2 to 8.
112	Timer in 1	PSL	Input to Auxiliary Timer 1.
113 - 127	Timer in 2 … 16	PSL	Input to Auxiliary Timer 2 to 16.
128	Timer out 1	Auxiliary Timer	Output from Auxiliary Timer 1.
129 - 143	Timer out 2 … 16	Auxiliary Timer	Output from Auxiliary Timer 2 to 16.
144	Fault REC TRIG	PSL	Input Trigger for Fault Recorder.
145	Stg1 f+t Sta	F+T	1st Stage under/over frequency element [81U/O] start indication.*
146	Stg1 f+t Trp	F+T	1st Stage under/over frequency element [81U/O trip indication.
147	Stg1 f+df/dt Trp	F+df/dt	1st Stage frequency supervised rate of change of frequency element [81RF] trip indication.
148	Stg1 df/dt+t Sta	df/dt+T	1st Stage rate of change of frequency element [81R] start indication.*
149	Stg1 df/dt+t Trp	df/dt+T	1st Stage rate of change of frequency element [81R] trip indication.
150	Stg1 f+Df/Dt Sta	F+DelF/DelT	1st Stage frequency supervised, average rate of change of frequency element [81RAV] start indication.*
151	Stg1 f+Df/Dt Trp	F+DelF/DelT	1st Stage frequency supervised, average rate of change of frequency element [81R] trip indication.
152	Stg1 Freq Sta	Fixed Logic	Any 1st stage frequency protection element start indication.
153	Stg1 Freq Trp	Fixed Logic	Any 1st stage frequency protection element trip indication.
154	Stg2 f+t Sta	F+T	2nd Stage under/over frequency element [81U/O] start indication.*
155	Stg2 f+t Trp	F+T	2nd Stage under/over frequency element [81U/O trip indication.

* The start signal will automatically reset when the initiating condition is no longer present OR if the timer operation has completed and a trip signal given. The start signal will not remain active if the element is in the trip state.

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DDB No.	English Text	Source	Description
156	Stg2 f+df/dt Trp	F+df/dt	2nd Stage frequency supervised rate of change of frequency element [81RF] trip indication.
157	Stg2 df/dt+t Sta	df/dt+T	2nd Stage rate of change of frequency element [81R] start indication.*
158	Stg2 df/dt+t Trp	df/dt+T	2nd Stage rate of change of frequency element [81R] trip indication.
159	Stg2 f+Df/Dt Sta	F+DelF/DelT	2nd Stage frequency supervised, average rate of change of frequency element [81RAV] start indication.*
160	Stg2 f+Df/Dt Trp	F+DelF/DelT	2nd Stage frequency supervised, average rate of change of frequency element [81R] trip indication.
160	Man CB Cls. Fail	CB Control	Circuit Breaker Failed to Close (after a manual/operator or auto-reclose close command).
161	Stg2 Freq Sta	Fixed Logic	Any 2nd stage frequency protection element start indication.
162	Stg2 Freq Trp	Fixed Logic	Any 2nd stage frequency protection element trip indication.
163	Stg3 f+t Sta	F+T	3rd Stage under/over frequency element [81U/O] start indication.*
164	Stg3 f+t Trp	F+T	3rd Stage under/over frequency element [81U/O trip indication.
165	Stg3 f+df/dt Trp	F+df/dt	3rd Stage frequency supervised rate of change of frequency element [81RF] trip indication.
166	Stg3 df/dt+t Sta	df/dt+T	3rd Stage rate of change of frequency element [81R] start indication.*
167	Stg3 df/dt+t Trp	df/dt+T	3rd Stage rate of change of frequency element [81R] trip indication.
168	Stg3 f+Df/Dt Sta	F+DelF/DelT	3rd Stage frequency supervised, average rate of change of frequency element [81RAV] start indication.*
169	Stg3 f+Df/Dt Trp	F+DelF/DelT	3rd Stage frequency supervised, average rate of change of frequency element [81R] trip indication.
170	Stg3 Freq Sta	Fixed Logic	Any 3rd stage frequency protection element start indication.
171	Stg3 Freq Trp	Fixed Logic	Any 3rd stage frequency protection element trip indication.
172	Stg4 f+t Sta	F+T	4th Stage under/over frequency element [81U/O] start indication.*
173	Stg4 f+t Trp	F+T	4th Stage under/over frequency element [81U/O trip indication.
174	Stg4 f+df/dt Trp	F+df/dt	4th Stage frequency supervised rate of change of frequency element [81RF] trip indication.
175	Stg4 df/dt+t Sta	df/dt+T	4th Stage rate of change of frequency element [81R] start indication.*
176	Stg4 df/dt+t Trp	df/dt+T	4th Stage rate of change of frequency element [81R] trip indication.
177	Stg4 f+Df/Dt Sta	F+DelF/DelT	4th Stage frequency supervised, average rate of change of frequency element [81RAV] start indication.*
178	Stg4 f+Df/Dt Trp	F+DelF/DelT	4th Stage frequency supervised, average rate of change of frequency element [81R] trip indication.
179	Stg4 Freq Sta	Fixed Logic	Any 4th stage frequency protection element start indication.

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* The start signal will automatically reset when the initiating condition is no longer present OR if the timer operation has completed and a trip signal given. The start signal will not remain active if the element is in the trip state.

DDB No.	English Text	Source	Description
180	Stg4 Freq Trp	Fixed Logic	Any 4th stage frequency protection element trip indication.
181	Stg5 f+t Sta	F+T	5th Stage under/over frequency element [81U/O] start indication.*
182	Stg5 f+t Trp	F+T	5th Stage under/over frequency element [81U/O trip indication.
183	Stg5 f+df/dt Trp	F+df/dt	5th Stage frequency supervised rate of change of frequency element [81RF] trip indication.
184	Stg5 df/dt+t Sta	df/dt+T	5th Stage rate of change of frequency element [81R] start indication.*
185	Stg5 df/dt+t Trp	df/dt+T	5th Stage rate of change of frequency element [81R] trip indication.
186	Stg5 f+Df/Dt Sta	F+DelF/DelT	5th Stage frequency supervised, average rate of change of frequency element [81RAV] start indication.*
187	Stg5 f+Df/Dt Trp	F+DelF/DelT	5th Stage frequency supervised, average rate of change of frequency element [81R] trip indication.
188	Stg5 Freq Sta	Fixed Logic	Any 5th stage frequency protection element start indication.
189	Stg5 Freq Trp	Fixed Logic	Any 5th stage frequency protection element trip indication.
190	Stg6 f+t Sta	F+T	6th Stage under/over frequency element [81U/O] start indication.*
191	Stg6 f+t Trp	F+T	6th Stage under/over frequency element [81U/O trip indication.
192	Stg6 f+df/dt Trp	F+df/dt	6th Stage frequency supervised rate of change of frequency element [81RF] trip indication.
193	Stg6 df/dt+t Sta	df/dt+T	6th Stage rate of change of frequency element [81R] start indication.*
194	Stg6 df/dt+t Trp	df/dt+T	6th Stage rate of change of frequency element [81R] trip indication.
195	Stg6 f+Df/Dt Sta	F+DelF/DelT	6th Stage frequency supervised, average rate of change of frequency element [81RAV] start indication.*
196	Stg6 f+Df/Dt Trp	F+DelF/DelT	6th Stage frequency supervised, average rate of change of frequency element [81R] trip indication.
197	Stg6 Freq Sta	Fixed Logic	Any 6th stage frequency protection element start indication.
198	Stg6 Freq Trp	Fixed Logic	Any 6th stage frequency protection element trip indication.
199	V<1 Start	Undervoltage	1st Stage Undervoltage Start 3ph.
200	V<1 Start A/AB	Undervoltage	1st Stage Undervoltage Start A/AB.
201	V<1 Start B/BC	Undervoltage	1st Stage Undervoltage Start B/BC.
202	V<1 Start C/CA	Undervoltage	1st Stage Undervoltage Start C/CA.
203	V<2 Start	Undervoltage	2nd Stage Undervoltage Start 3ph.
204	V<2 Start A/AB	Undervoltage	2nd Stage Undervoltage Start A/AB.
205	V<2 Start B/BC	Undervoltage	2nd Stage Undervoltage Start B/BC.
206	V<2 Start C/CA	Undervoltage	2nd Stage Undervoltage Start C/CA.

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* The start signal will automatically reset when the initiating condition is no longer present OR if the timer operation has completed and a trip signal given. The start signal will not remain active if the element is in the trip state.

DDB No.	English Text	Source	Description
207	V<1 Trip	Undervoltage	1st Stage Undervoltage Trip 3ph.
208	V<1 Trip A/AB	Undervoltage	1st Stage Undervoltage Trip A/AB.
209	V<1 Trip B/BC	Undervoltage	1st Stage Undervoltage Trip B/BC.
210	V<1 Trip C/CA	Undervoltage	1st Stage Undervoltage Trip C/CA.
211	V<2 Trip	Undervoltage	2nd Stage Undervoltage Trip 3ph.
212	V<2 Trip A/AB	Undervoltage	2nd Stage Undervoltage Trip A/AB.
213	V<2 Trip B/BC	Undervoltage	2nd Stage Undervoltage Trip B/BC.
214	V<2 Trip C/CA	Undervoltage	2nd Stage Undervoltage Trip C/CA.
215	V>1 Start	Overvoltage	1st Stage Overvoltage Start 3ph.
216	V>1 Start A/AB	Overvoltage	1st Stage Overvoltage Start A/AB.
217	V>1 Start B/BC	Overvoltage	1st Stage Overvoltage Start B/BC.
218	V>1 Start C/CA	Overvoltage	1st Stage Overvoltage Start C/CA.
219	V>2 Start	Overvoltage	2nd Stage Overvoltage Start 3ph.
220	V>2 Start A/AB	Overvoltage	2nd Stage Overvoltage Start A/AB.
221	V>2 Start B/BC	Overvoltage	2nd Stage Overvoltage Start B/BC.
222	V>2 Start C/CA	Overvoltage	2nd Stage Overvoltage Start C/CA.
223	V>1 Trip	Overvoltage	1st Stage Overvoltage Trip 3ph.
224	V>1 Trip A/AB	Overvoltage	1st Stage Overvoltage Trip A/AB.
225	V>1 Trip B/BC	Overvoltage	1st Stage Overvoltage Trip B/BC.
226	V>1 Trip C/CA	Overvoltage	1st Stage Overvoltage Trip C/CA.
227	V>2 Trip	Overvoltage	2nd Stage Overvoltage Trip 3ph.
228	V>2 Trip A/AB	Overvoltage	2nd Stage Overvoltage Trip A/AB.
229	V>2 Trip B/BC	Overvoltage	2nd Stage Overvoltage Trip B/BC.
230	V>2 Trip C/CA	Overvoltage	2nd Stage Overvoltage Trip C/CA.
231	Gen Band1 Sta	Generator Abnormal	Indication that the measured frequency is currently within the limits set in the 1st band of generator abnormal frequency protection.
232	Gen Band1 Trp	Generator Abnormal	Indicates that the measured frequency has been within the 1st band frequency limits for a cumulative period greater than the 1st band timer setting.
233	Gen Band2 Sta	Generator Abnormal	Indication that the measured frequency is currently within the limits set in the 2nd band of generator abnormal frequency protection.
234	Gen Band2 Trp	Generator Abnormal	Indicates that the measured frequency has been within the 2nd band frequency limits for a cumulative period greater than the 2nd band timer setting.
235	Gen Band3 Sta	Generator Abnormal	Indication that the measured frequency is currently within the limits set in the 3rd band of generator abnormal frequency protection.
236	Gen Band3 Trp	Generator Abnormal	Indicates that the measured frequency has been within the 3rd band frequency limits for a cumulative period greater than the 3rd band timer setting.
237	Gen Band4 Sta	Generator Abnormal	Indication that the measured frequency is currently within the limits set in the 4th band of generator abnormal frequency protection.

DDB No.	English Text	Source	Description
238	Gen Band4 Trp	Generator Abnormal	Indicates that the measured frequency has been within the 4th band frequency limits for a cumulative period greater than the 4th band timer setting.
239	Gen Abn Start	Generator Abnormal (Fixed Logic)	Indication that the measured frequency is currently within the limits of one or more of the set frequency bands.
240	Gen Abn Trip	Generator Abnormal (Fixed Logic)	Indicates that one or more of the cumulative timers within the generator abnormal protection has exceeded setting.
241	Stg1 Restore Sta	Load Restoration	Indication that the measured frequency is greater than the 1st stage restoration frequency.*
242	Stg1 Restore Ena	Load Restoration	1st stage load restoration signal. (100ms pulse)
243	Stg2 Restore Sta	Load Restoration	Indication that the measured frequency is greater than the 2nd stage restoration frequency.*
244	Stg2 Restore Ena	Load Restoration	2nd stage load restoration signal. (100ms pulse)
245	Stg3 Restore Sta	Load Restoration	Indication that the measured frequency is greater than the 2nd stage restoration frequency.*
246	Stg3 Restore Ena	Load Restoration	3rd stage load restoration signal. (100ms pulse)
247	Stg4 Restore Sta	Load Restoration	Indication that the measured frequency is greater than the 3rd stage restoration frequency.*
248	Stg4 Restore Ena	Load Restoration	4th stage load restoration signal. (100ms pulse)
249	Stg5 Restore Sta	Load Restoration	Indication that the measured frequency is greater than the 4th stage restoration frequency.*
250	Stg5 Restore Ena	Load Restoration	5th stage load restoration signal. (100ms pulse)
251	Stg6 Restore Sta	Load Restoration	Indication that the measured frequency is greater than the 6th stage restoration frequency.*
252	Stg6 Restore Ena	Load Restoration	6th stage load restoration signal. (100ms pulse)
253	Any Protn Start	Fixed Logic	Any start from any protection element.
254	Any Protn Trip	Fixed Logic	Any trip from any protection element.
255	Any f+t Sta	Fixed Logic	Any under/over frequency element [81U/O] start indication.
256	Any df/dt+t Sta	Fixed Logic	Any rate of change of frequency element [81R] start indication.
257	Any f+Df/Dt Sta	Fixed Logic	Any frequency supervised, average rate of change of frequency element [81RAV] start indication.
258	Any f+t Trp	Fixed Logic	Any under/over frequency element [81U/O trip indication.
259	Any f+df/dt Trp	Fixed Logic	Any frequency supervised, rate of change of frequency element [81RF] trip indication.
260	Any df/dt+t Trp	Fixed Logic	Any rate of change of frequency element [81R] trip indication.
261	Any f+Df/Dt Trp	Fixed Logic	Any frequency supervised, average rate of change of frequency element [81RAV] trip indication.
262	Field Volts Fail	Field Voltage Monitor	48V Field Voltage Failure.
263	Reset Relays/LED	PSL	Reset Latched Relays & LEDs (manual reset of any lockout trip contacts and LEDs).
264	V<1 Timer Block	PSL	Block Undervoltage Stage 1 Time Delay.

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* The reset of the restoration start signal is delayed for the ‘Holding Timer’ setting unless the restoration timer for the stage has completed. On completion of the restoration timer, the restoration start signal has an instantaneous reset.

DDB No.	English Text	Source	Description
265	V<2 Timer Block	PSL	Block Undervoltage Stage 2 Time Delay.
266	V>1 Timer Block	PSL	Block Overvoltage Stage 1 Time Delay.
267	V>2 Timer Block	PSL	Block Overvoltage Stage 2 Time Delay.
268	Freq Invalid	Frequency Tracking	Frequency tracking detects frequency above or below the allowed range.
269	Stop Freq. Track	Frequency Tracking	Stop Frequency Tracking signal - indicates under legitimate conditions when the relay suspends frequency tracking on the instruction of the protection elements.
270	Stats Cleared	PSL	Indicates that the Stage Statistics have been reset.
271	Timers Cleared	PSL	Indicates that the Generator Abnormal cumulative timers have been reset.
272	Wrong Setting 01	F+T Configuration	Indicates that the 1st stage frequency setting [81U/O] is equal to the system nominal frequency.
273	Wrong Setting 02	F+T Configuration	Indicates that the 2nd stage frequency setting [81U/O] is equal to the system nominal frequency.
274	Wrong Setting 03	F+T Configuration	Indicates that the 3rd stage frequency setting [81U/O] is equal to the system nominal frequency.
275	Wrong Setting 04	F+T Configuration	Indicates that the 4th stage frequency setting [81U/O] is equal to the system nominal frequency.
276	Wrong Setting 05	F+T Configuration	Indicates that the 5th stage frequency setting [81U/O] is equal to the system nominal frequency.
277	Wrong Setting 06	F+T Configuration	Indicates that the 6th stage frequency setting [81U/O] is equal to the system nominal frequency.
278	Wrong Setting 07	F+df/dt Configuration	Indicates that the 1st stage frequency setting [81RF] is equal to the system nominal frequency.
279	Wrong Setting 08	F+df/dt Configuration	Indicates that the 2nd stage frequency setting [81RF] is equal to the system nominal frequency.
280	Wrong Setting 09	F+df/dt Configuration	Indicates that the 3rd stage frequency setting [81RF] is equal to the system nominal frequency.
281	Wrong Setting 10	F+df/dt Configuration	Indicates that the 4th stage frequency setting [81RF] is equal to the system nominal frequency.
282	Wrong Setting 11	F+df/dt Configuration	Indicates that the 5th stage frequency setting [81RF] is equal to the system nominal frequency.
283	Wrong Setting 12	F+df/dt Configuration	Indicates that the 6th stage frequency setting [81RF] is equal to the system nominal frequency.
284	Wrong Setting 13	df/dt+T Configuration	Indicates that the 1st stage rate of change of frequency setting [81R] is equal to 0Hz/s.*
285	Wrong Setting 14	df/dt+T Configuration	Indicates that the 2nd stage rate of change of frequency setting [81R] is equal to 0Hz/s.*
286	Wrong Setting 15	df/dt+T Configuration	Indicates that the 3rd stage rate of change of frequency setting [81R] is equal to 0Hz/s.*
287	Wrong Setting 16	df/dt+T Configuration	Indicates that the 4th stage rate of change of frequency setting [81R] is equal to 0Hz/s.*
288	Wrong Setting 17	df/dt+T Configuration	Indicates that the 5th stage rate of change of frequency setting [81R] is equal to 0Hz/s.*
289	Wrong Setting 18	df/dt+T Configuration	Indicates that the 6th stage rate of change of frequency setting [81R] is equal to 0Hz/s.*
290	Wrong Setting 19	F+DelF/DelT Configuration	Indicates that the 1st stage frequency setting [81RAV] is equal to the system nominal frequency.

* Only available on software version v10. Software version v11 does not allow the df/dt setting to be set to zero.

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DDB No.	English Text	Source	Description
291	Wrong Setting 20	F+DelF/DelT Configuration	Indicates that the 2nd stage frequency setting [81RAV] is equal to the system nominal frequency.
292	Wrong Setting 21	F+DelF/DelT Configuration	Indicates that the 3rd stage frequency setting [81RAV] is equal to the system nominal frequency.
293	Wrong Setting 22	F+DelF/DelT Configuration	Indicates that the 4th stage frequency setting [81RAV] is equal to the system nominal frequency.
294	Wrong Setting 23	F+DelF/DelT Configuration	Indicates that the 5th stage frequency setting [81RAV] is equal to the system nominal frequency.
295	Wrong Setting 24	F+DelF/DelT Configuration	Indicates that the 6th stage frequency setting [81RAV] is equal to the system nominal frequency.
296	Wrong Setting 25	Generator Abnormal Configuration	Indicates that the 1st band low frequency setting is greater than the high frequency setting [81AB].
297	Wrong Setting 26	Generator Abnormal Configuration	Indicates that the 2nd band low frequency setting is greater than the high frequency setting [81AB].
298	Wrong Setting 27	Generator Abnormal Configuration	Indicates that the 3rd band low frequency setting is greater than the high frequency setting [81AB].
299	Wrong Setting 28	Generator Abnormal Configuration	Indicates that the 4th band low frequency setting is greater than the high frequency setting [81AB].
300	Wrong Setting 29	Load Restoration Configuration	Indicates that any of the 1st stage frequency settings are greater than system nominal frequency, or that any 1st stage rate of change of frequency setting is greater than 0Hz/s, or that the highest 1st stage frequency setting is less than 0.015Hz below the stage 1 restoration frequency.
301	Wrong Setting 30	Load Restoration Configuration	Indicates that any of the 2nd stage frequency settings are greater than system nominal frequency, or that any 2nd stage rate of change of frequency setting is greater than 0Hz/s, or that the highest 2nd stage frequency setting is less than 0.015Hz below the stage 2 restoration frequency.
302	Wrong Setting 31	Load Restoration Configuration	Indicates that any of the 3rd stage frequency settings are greater than system nominal frequency, or that any 3rd stage rate of change of frequency setting is greater than 0Hz/s, or that the highest 3rd stage frequency setting is less than 0.015Hz below the stage 3 restoration frequency.
303	Wrong Setting 32	Load Restoration Configuration	Indicates that any of the 4th stage frequency settings are greater than system nominal frequency, or that any 4th stage rate of change of frequency setting is greater than 0Hz/s, or that the highest 4th stage frequency setting is less than 0.015Hz below the stage 4 restoration frequency.
304	Wrong Setting 33	Load Restoration Configuration	Indicates that any of the 5th stage frequency settings are greater than system nominal frequency, or that any 5th stage rate of change of frequency setting is greater than 0Hz/s, or that the highest 5th stage frequency setting is less than 0.015Hz below the stage 5 restoration frequency.
305	Wrong Setting 34	Load Restoration Configuration	Indicates that any of the 6th stage frequency settings are greater than system nominal frequency, or that any 6th stage rate of change of frequency setting is greater than 0Hz/s, or that the highest 6th stage frequency setting is less than 0.015Hz below the stage 6 restoration frequency.
306	SG-opto Invalid	Group Selection	Setting group selection opto inputs have detected an invalid (disabled) settings group.
307	Prot’n Disabled	Commission Test	Protection disabled - typically out of service due to test mode.
308	Freq. High	Frequency Tracking	Frequency tracking detects frequency above the allowed range.
309	Freq. Low	Frequency Tracking	Frequency tracking detects frequency below the allowed range.
310	Freq. Not Found	Frequency Tracking	Frequency Not Found by the frequency tracking.

DDB No.	English Text	Source	Description
311	Wrong Setting	Configuration	Indicates that a Wrong Setting event has occurred.
312	Stats Corrupt	Statistics	Indicates that an invalid checksum has been found for the Stage Statistics. All statistics are then reset.
313	Gen Timers Bad	Generator Abnormal	Indicates that an invalid checksum has been found for the Generator Abnormal cumulative timers. All timers are then reset.
314	UV Block	Undervoltage	Indication that the undervoltage blocking of the frequency protection elements is currently active and preventing frequency element operation.
315	Trip LED Enabled	PSL	Input to trigger the Trip LED. It must be permitted to reset to allow completion of the fault record therefore any initiating signal must be self-resetting, or pulsed.
316	SR User Alarm 1	PSL	Triggers the User Alarm 1 message to be alarmed on the LCD display (self-resetting).
317 - 339	SR User Alarm 2 … 24	PSL	Triggers the User Alarm 2 to 24 message to be alarmed on the LCD display (self-resetting).
340	MR User Alarm 25	PSL	Triggers the User Alarm 25 message to be alarmed on the LCD display (manual-resetting).
341 - 363	MR User Alarm 26 … 48	PSL	Triggers the User Alarm 26 to 48 message to be alarmed on the LCD display (manual-resetting).
364	Test Mode	PSL	Energising this signal causes the relay to switch into ‘Test Mode’, taking the relay out of service and illuminating the ‘Out of Service’ LED.
365	Monitor Blocked	PSL	Indicates that the monitor direction is blocked. *
366	Command Blocked	PSL	Indicates that the command direction blocked *
367	Battery Fail	Undervoltage	Indicates a front panel Battery Failure *
368 - 371	Unused		
372	UI AccessLevel1	Access Levels	Indicates if password level 1 is currently active on the relay HMI (front user interface).
373	UI AccessLevel2	Access Levels	Indicates if password level 2 is currently active on the relay HMI (front user interface).
374	F AccessLevel1	Access Levels	Indicates if password level 1 is currently active on the front 9-pin communication port.
375	F AccessLevel2	Access Levels	Indicates if password level 2 is currently active on the front 9-pin communication port.
376	R AccessLevel1	Access Levels	Indicates if password level 1 is currently active on the rear communication port.
377	R AccessLevel2	Access Levels	Indicates if password level 2 is currently active on the rear communication port.
378 - 383	Unused		
384	Stg7 f+t Sta	F+T	7th Stage under/over frequency element [81 U/O] start indication *
385	Stg7 f+t Trp	F+T	7th Stage under/over frequency element [81 U/O] trip indication *
386 - 392	Unused		
393	Stg7 Restore Sta	F+T	Indication that the measured frequency is greater than the 7th stage restoration frequency.*

* Only available on software version v12.

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DDB No.	English Text	Source	Description
394	Stg7 Restore Ena	F+T	6th stage load restoration signal. (100ms pulse) .*
395	Wrong Setting 35	F+T Configuration	Indicates that the 7th stage frequency setting [81U/O] is equal to the system nominal frequency. *
396	Wrong Setting 36	Load Restoration Configuration	Indicates that any of the 7th stage frequency settings are greater than system nominal frequency, or that any 7th stage rate of change of frequency setting is greater than 0Hz/s, or that the highest 7th stage frequency setting is less than 0.015Hz below the stage 7 restoration frequency. *
397	Stg8 f+t Sta	F+T	8th Stage under/over frequency element [81 U/O] start indication *
398	Stg8 f+t Trp	F+T	8th Stage under/over frequency element [81 U/O] trip indication *
399 - 405	Unused		
406	Stg8 Restore Sta	F+T	Indication that the measured frequency is greater than the 8th stage restoration frequency.*
407	Stg8 Restore Ena	F+T	8th stage load restoration signal. (100ms pulse) .*
408	Wrong Setting 37	F+T Configuration	Indicates that the 8th stage frequency setting [81U/O] is equal to the system nominal frequency. *
409	Wrong Setting 38	Load Restoration Configuration	Indicates that any of the 8th stage frequency settings are greater than system nominal frequency, or that any 8th stage rate of change of frequency setting is greater than 0Hz/s, or that the highest 8th stage frequency setting is less than 0.015Hz below the stage 8 restoration frequency.
410	Stg9 f+t Sta	F+T	9th Stage under/over frequency element [91 U/O] start indication *
411	Stg9 f+t Trp	F+T	9th Stage under/over frequency element [91 U/O] trip indication *
412 – 418	Unused		
419	Stg9 Restore Sta	F+T	Indication that the measured frequency is greater than the 9th stage restoration frequency.*
420	Stg9 Restore Ena	F+T	9th stage load restoration signal. (100ms pulse) .*
421	Wrong Setting 39	F+T Configuration	Indicates that the 9th stage frequency setting [91U/O] is equal to the system nominal frequency. *
422	Wrong Setting 40	Load Restoration Configuration	Indicates that any of the 9th stage frequency settings are greater than system nominal frequency, or that any 9th stage rate of change of frequency setting is greater than 0Hz/s, or that the highest 9th stage frequency setting is less than 0.015Hz below the stage 9 restoration frequency.
423 – 511	Unused		
512	Control Input 1	Control Input Command	Control Input 1 - for SCADA and menu commands into PSL.
513 - 543	Control Input 2 … 32	Control Input Command	Control Input 2 to 32 - for SCADA and menu commands into PSL.
544 - 922	Unused		
923	PSL Internal 000	PSL	PSL Internal Node 1. (Used within PSL where no other DDB signal can be attributed, for example for links between logic gates).
924 - 1022	PSL Internal 001 … 100	PSL	PSL Internal Node 2 to 100. (Used within PSL where no other DDB signal can be attributed, for example for links between logic gates).

* Only available on software version v12.

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1.8 Factory default programmable scheme logic

The following section details the default settings of the PSL.

The P94x model options are as follows:

Model	Logic Inputs	Relay Outputs
P941xxxAxxxxxxx	8	7
P941xxxBxxxxxxC	12	11
P941xxxCxxxxxxC	16	7
P941xxxDxxxxxxC	8	15
P943xxxAxxxxxxx	16	14
P943xxxCxxxxxxC	24	14
P943xxxDxxxxxxC	16	22
P943xxxExxxxxxC	24	22
P943xxxFxxxxxxC	32	14
P943xxxGxxxxxxC	16	30

1.9 Logic input mapping

The default mappings for each of the opto-isolated inputs are as shown in the following table:

Opto-Input Number	P94x Relay Text		Function
	Software Version 10	Software Versions 11 / 12	
1	L1 Setting Group	Opto Input 1	Setting Group selection
2	L2 Setting Group	Opto Input 2	Setting Group selection
3	L3 Stg1 f+t Block	Opto Input 3	Block frequency protection [81U/O] stage 1
4	L4 Stg2 f+t Block	Opto Input 4	Block frequency protection [81U/O] stage 2
5	L5 Stg3 f+t Block	Opto Input 5	Block frequency protection [81U/O] stage 3
6	L6 Stg4 f+t Block	Opto Input 6	Block frequency protection [81U/O] stage 4
7	L7 Stg6 f+t Block	Opto Input 7	Block frequency protection [81U/O] stage 6
8	L8 Voltage Block	Opto Input 8	Block under & over voltage protection stages 1 and 2
9	L9 Not Used	Opto Input 9	Not used in Default PSL
10	L10 Not Used	Opto Input 10	Not used in Default PSL
11	L11 Not Used	Opto Input 11	Not used in Default PSL
12	L12 Not Used	Opto Input 12	Not used in Default PSL
13	L13 Not Used	Opto Input 13	Not used in Default PSL
14	L14 Not Used	Opto Input 14	Not used in Default PSL
15	L15 Not Used	Opto Input 15	Not used in Default PSL
16	L16 Not Used	Opto Input 16	Not used in Default PSL

Opto-Input Number	P94x Relay Text		Function
	Software Version 10	Software Versions 11 / 12	
17	L17 Not Used	Opto Input 17	Not used in Default PSL
18	L18 Not Used	Opto Input 18	Not used in Default PSL
19	L19 Not Used	Opto Input 19	Not used in Default PSL
20	L20 Not Used	Opto Input 20	Not used in Default PSL
21	L21 Not Used	Opto Input 21	Not used in Default PSL
22	L22 Not Used	Opto Input 22	Not used in Default PSL
23	L23 Not Used	Opto Input 23	Not used in Default PSL
24	L24 Not Used	Opto Input 24	Not used in Default PSL
25	L25 Not Used	Opto Input 25	Not used in Default PSL
26	L26 Not Used	Opto Input 26	Not used in Default PSL
27	L27 Not Used	Opto Input 27	Not used in Default PSL
28	L28 Not Used	Opto Input 28	Not used in Default PSL
29	L29 Not Used	Opto Input 29	Not used in Default PSL
30	L30 Not Used	Opto Input 30	Not used in Default PSL
31	L31 Not Used	Opto Input 31	Not used in Default PSL
32	L32 Not Used	Opto Input 32	Not used in Default PSL

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Note: If the "Setting Group" cell in the "CONFIGURATION" column is set to "Select via Opto", the opto's that are used for changing setting groups are always opto's 1 and 2. This mapping is effectively hardwired and does not therefore need to be mapped within the PSL.

1.10 Relay output contact mapping

1.10.1 Relay output contact mapping for P941

The default mappings for each of the relay output contacts are as shown in the following table:

Relay Contact Number	P941 Relay Text		Function
	Software Version 10	Software Versions 11/12	
1	R1 Stg1 f+t Trip	Relay 1	Stage 1 under/over frequency protection [81U/O] trip
2	R2 Stg2 f+t Trip	Relay 2	Stage 2 under/over frequency protection [81U/O] trip
3	R3 Stg3 f+t Trip	Relay 3	Stage 3 under/over frequency protection [81U/O] trip
4	R4 Stg4 f+t Trip	Relay 4	Stage 4 under/over frequency protection [81U/O] trip
5	R5 Stg6 f+t Trip	Relay 5	Stage 6 under/over frequency protection [81U/O] trip
6	R6 Voltage Start	Relay 6	Stage 1 & 2, under or over voltage protection start

Relay Contact Number	P941 Relay Text		Function
	Software Version 10	Software Versions 11/12	
7	R7 Voltage Trips	Relay 7	Stage 1 & 2, under or over voltage protection trip
8	R8 Not Used	Relay 8	Not used in Default PSL
9	R9 Not Used	Relay 9	Not used in Default PSL
10	R10 Not Used	Relay 10	Not used in Default PSL
11	R11 Not Used	Relay 11	Not used in Default PSL
12	R12 Not Used	Relay 12	Not used in Default PSL
13	R13 Not Used	Relay 13	Not used in Default PSL
14	R14 Not Used	Relay 14	Not used in Default PSL
15	R15 Not Used	Relay 15	Not used in Default PSL

1.10.2 Relay output contact mapping for P943

The default mappings for each of the relay output contacts are as shown in the following table:

Relay Contact Number	P943 Relay Text		Function
	Software Version 10	Software Versions 11/12	
1	R1 Stg1 f+t Trip	Relay 1	Stage 1 under/over frequency protection [81U/O] trip
2	R2 Stg2 f+t Trip	Relay 2	Stage 2 under/over frequency protection [81U/O] trip
3	R3 Stg3 f+t Trip	Relay 3	Stage 3 under/over frequency protection [81U/O] trip
4	R4 Stg4 f+t Trip	Relay 4	Stage 4 under/over frequency protection [81U/O] trip
5	R5 Stg6 f+t Trip	Relay 5	Stage 6 under/over frequency protection [81U/O] trip
6	R6 Stg1f+Df/Dt T	Relay 6	Stage 1 frequency supervised, average rate of change of frequency protection [81RAV] trip
7	R7 Stg2f+df/dt T	Relay 7	Stage 2 frequency supervised, rate of change of frequency protection [81RF] trip
8	R8 Stg3f+df/dt T	Relay 8	Stage 3 frequency supervised, rate of change of frequency protection [81RF] trip
9	R9 Stg4f+df/dt T	Relay 9	Stage 4 frequency supervised, rate of change of frequency protection [81RF] trip
10	R10 Voltage Strt	Relay 10	Stage 1 & 2, under or over voltage protection start
11	R11 Voltage Trip	Relay 11	Stage 1 & 2, under or over voltage protection trip
12	R12 Gen. Abn. Trip	Relay 12	Generator Abnormal protection [81AB] trip in any frequency band

Relay Contact Number	P943 Relay Text		Function
	Software Version 10	Software Versions 11/12	
13	R13 Stg1 Restore	Relay 13	Stage 1 Load Restoration pulse
14	R14 Stg2 Restore	Relay 14	Stage 2 Load Restoration pulse
15	R15 Not Used	Relay 15	Not used in Default PSL
16	R16 Not Used	Relay 16	Not used in Default PSL
17	R17 Not Used	Relay 17	Not used in Default PSL
18	R18 Not Used	Relay 18	Not used in Default PSL
19	R19 Not Used	Relay 19	Not used in Default PSL
20	R20 Not Used	Relay 20	Not used in Default PSL
21	R21 Not Used	Relay 21	Not used in Default PSL
22	R22 Not Used	Relay 22	Not used in Default PSL
23	R23 Not Used	Relay 23	Not used in Default PSL
24	R24 Not Used	Relay 24	Not used in Default PSL
25	R25 Not Used	Relay 25	Not used in Default PSL
26	R26 Not Used	Relay 26	Not used in Default PSL
27	R27 Not Used	Relay 27	Not used in Default PSL
28	R28 Not Used	Relay 28	Not used in Default PSL
29	R29 Not Used	Relay 29	Not used in Default PSL
30	R30 Not Used	Relay 30	Not used in Default PSL

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1.10.3 Relay output contact conditioning

Each relay output has its own timer to condition the relay contact. The default settings for each of the contacts used in the default PSL are as shown in the following table:

Relay Contact Number	P941 Relay	P943 Relay
1	Dwell (100ms)	Dwell (100ms)
2	Dwell (100ms)	Dwell (100ms)
3	Dwell (100ms)	Dwell (100ms)
4	Dwell (100ms)	Dwell (100ms)
5	Dwell (100ms)	Dwell (100ms)
6	Straight	Dwell (100ms)
7	Dwell (100ms)	Dwell (100ms)
8		Dwell (100ms)
9		Dwell (100ms)
10		Straight
11		Dwell (100ms)
12		Dwell (100ms)
13		Dwell (100ms)
14		Dwell (100ms)

1.11 Programmable LED output mapping

The default mappings for each of the programmable LEDs are as shown in the following table:

LED Number	P941 Relay		P943 Relay	
	LED Function	Latched	LED Function	Latched
1	Stage 1 Frequency Start	No	Stage 1 Frequency Start	No
2	Stage 2 Frequency Start	No	Stage 2 Frequency Start	No
3	Stage 3 Frequency Start	No	Stage 3 Frequency Start	No
4	Stage 4 Frequency Start	No	Stage 4 Frequency Start	No
5	Stage 5 Frequency Start	No	Stage 5 Frequency Start	No
6	Any Voltage Start	No	Any Voltage Start	No
7	Any Voltage Trip	No	Load Restoration initiated	No
8	Undervoltage Block active	No	Undervoltage Block active	No

1.12 Fault recorder start mapping

The default mapping for the signal that initiates a fault record is shown in the following table:

P941 Relay		P943 Relay	
Software Version 10	Software Versions 11/12	Software Version 10	Software Versions 11/12
R1 Stg1 f+t Trip	Relay 1	R1 Stg1 f+t Trip	Relay 1
R2 Stg2 f+t Trip	Relay 2	R2 Stg2 f+t Trip	Relay 2
R3 Stg3 f+t Trip	Relay 3	R3 Stg3 f+t Trip	Relay 3
R4 Stg4 f+t Trip	Relay 4	R4 Stg4 f+t Trip	Relay 4
R5 Stg6 f+t Trip	Relay 5	R5 Stg6 f+t Trip	Relay 5
R7 Voltage Trips	Relay 7	R6 Stg1f+Df/Dt T	Relay 6
		R7 Stg2 f+df/dt T	Relay 7
		R8 Stg3 f+df/dt T	Relay 8
		R9 Stg4 f+df/dt T	Relay 9
		R11 Voltage Trip	Relay 11
		R12 Gen. Abn. Trip	Relay 12

The fault record trigger (DDB 128) requires a rising edge for operation. In other words, the input to the FRT signal must go from a low (de-energized) to a high (energized) state. When the rising edge occurs, a fault record is generated and the amber Alarm LED is illuminated (flashing). When a fault record is generated, the data can be viewed on the LCD using the ⓘ key, and reset by the ⓒ key if the correct password level is active. Any subsequent fault record will only be generated on a new rising edge of the fault recorder trigger DDB signal. It is therefore recommended that all the initiating signals to the fault recorder trigger are self-resetting.

Note: Since the data is captured on the rising edge, it is possible to clear the record on the default display even though the initiating signals are still active. However, the information may still be viewed in the "VIEW RECORDS" column of the menu.

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1.13 Trip LED Illumination mapping

The default mapping for the signal which illuminates the trip LED is shown in the following table:

P941 Relay		P943 Relay	
Software Version 10	**Software Versions 11/12**	**Software Version 10**	**Software Versions 11/12**
R1 Stg1 f+t Trip	Relay 1	R1 Stg1 f+t Trip	Relay 1
R2 Stg2 f+t Trip	Relay 2	R2 Stg2 f+t Trip	Relay 2
R3 Stg3 f+t Trip	Relay 3	R3 Stg3 f+t Trip	Relay 3
R4 Stg4 f+t Trip	Relay 4	R4 Stg4 f+t Trip	Relay 4
R5 Stg6 f+t Trip	Relay 5	R5 Stg6 f+t Trip	Relay 5
R7 Voltage Trips	Relay 7	R6 Stg1f+Df/Dt T	Relay 6
		R7 Stg2 f+df/dt T	Relay 7
		R8 Stg3 f+df/dt T	Relay 8
		R9 Stg4 f+df/dt T	Relay 9
		R11 Voltage Trip	Relay 11
		R12 Gen. Abn. Trip	Relay 12

As soon as the Trip LED Enabled signal (DDB 302) is energized the red Trip LED and the amber Alarm LED will be illuminated. These LED's can only be reset when the initiating condition has been removed which implies that all the initiating signals to the Trip LED Enabled DDB must be self-resetting. After the initiating signal has been removed, the Trip LED will remain lit until reset using the Ⓒ key.

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1.14 PSL DATA column

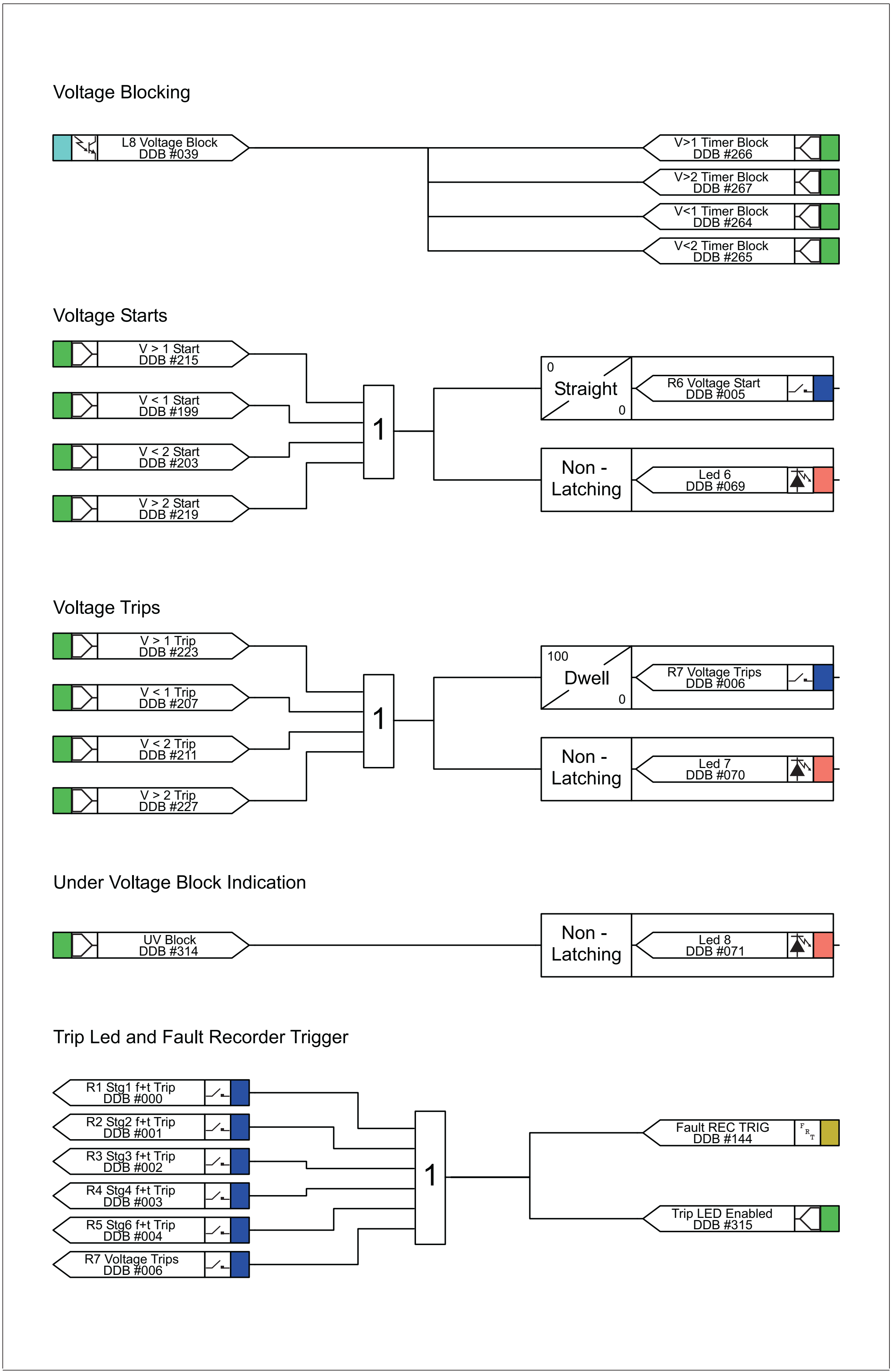
The MiCOM P94x relays contain information to assist in the tracking of changes to the application specific PSL. In conjunction with the password control of the relay, it will provide security against changes to protection scheme operation caused by PSL modification by unauthorised personnel.

Tracking information is stored in the PSL Data relay menu column and is shown in the following table:

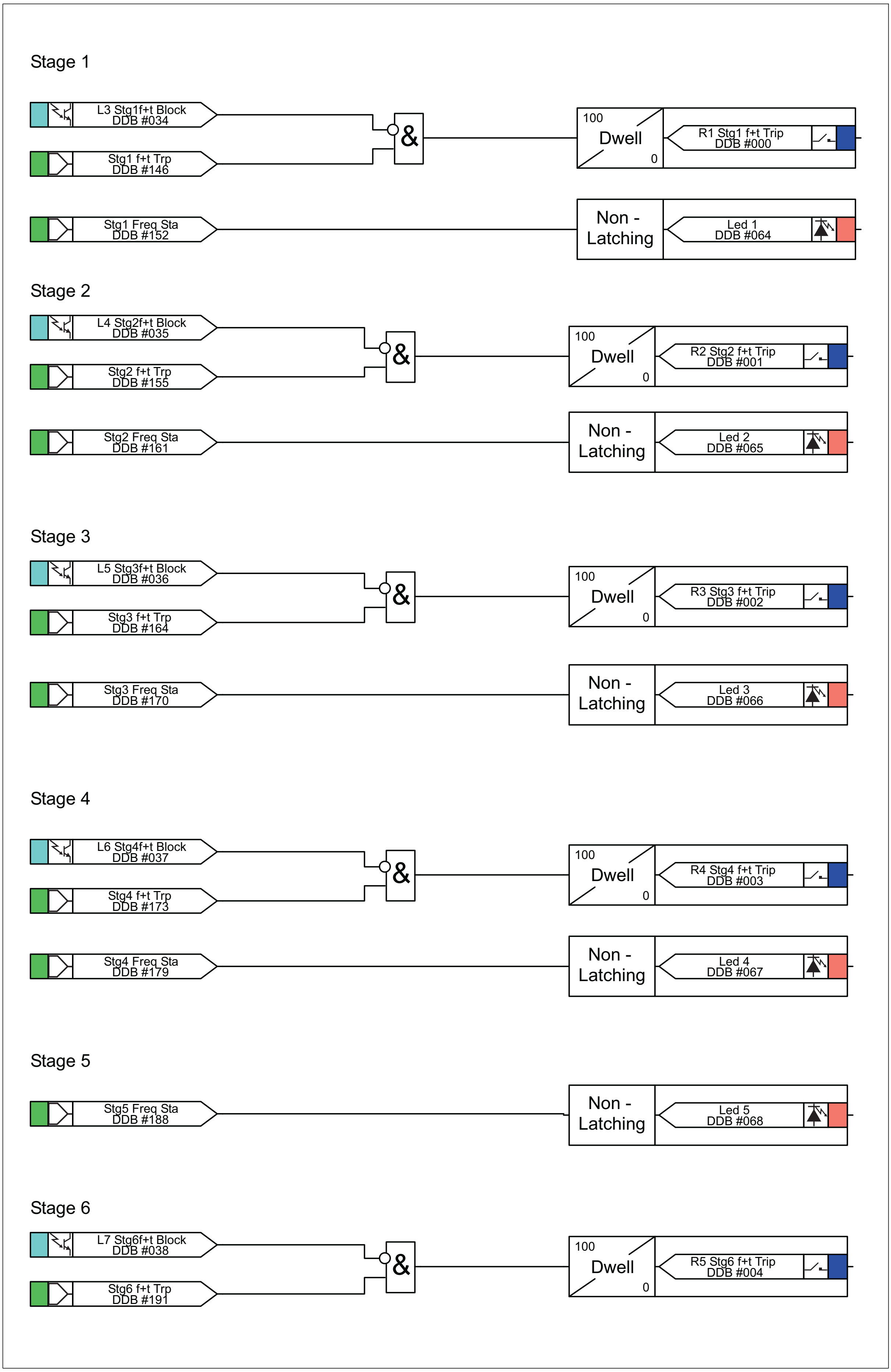
Grp. PSL Ref.	When downloading a PSL to the relay, the user will be prompted to enter which group the PSL is for and a reference identifier. The first 32 characters of the reference ID will be displayed in this cell. The ⇦ and ⇨ keys can be used to scroll through 32 characters as only 16 can be displayed at any one time.
18 Nov 2002 08:59:32.047	This cell displays the date and time when the PSL was down loaded to the relay.
Grp. 1 PSL ID - 2062813232	This is a unique number for the PSL that has been downloaded to the relay. The number is based upon the PSL content and date/time of download so every change will result in a different number being displayed.

Note: The above cells are repeated for each setting group.

MiCOM P941 PROGRAMMABLE SCHEME LOGIC (VERSION 10)

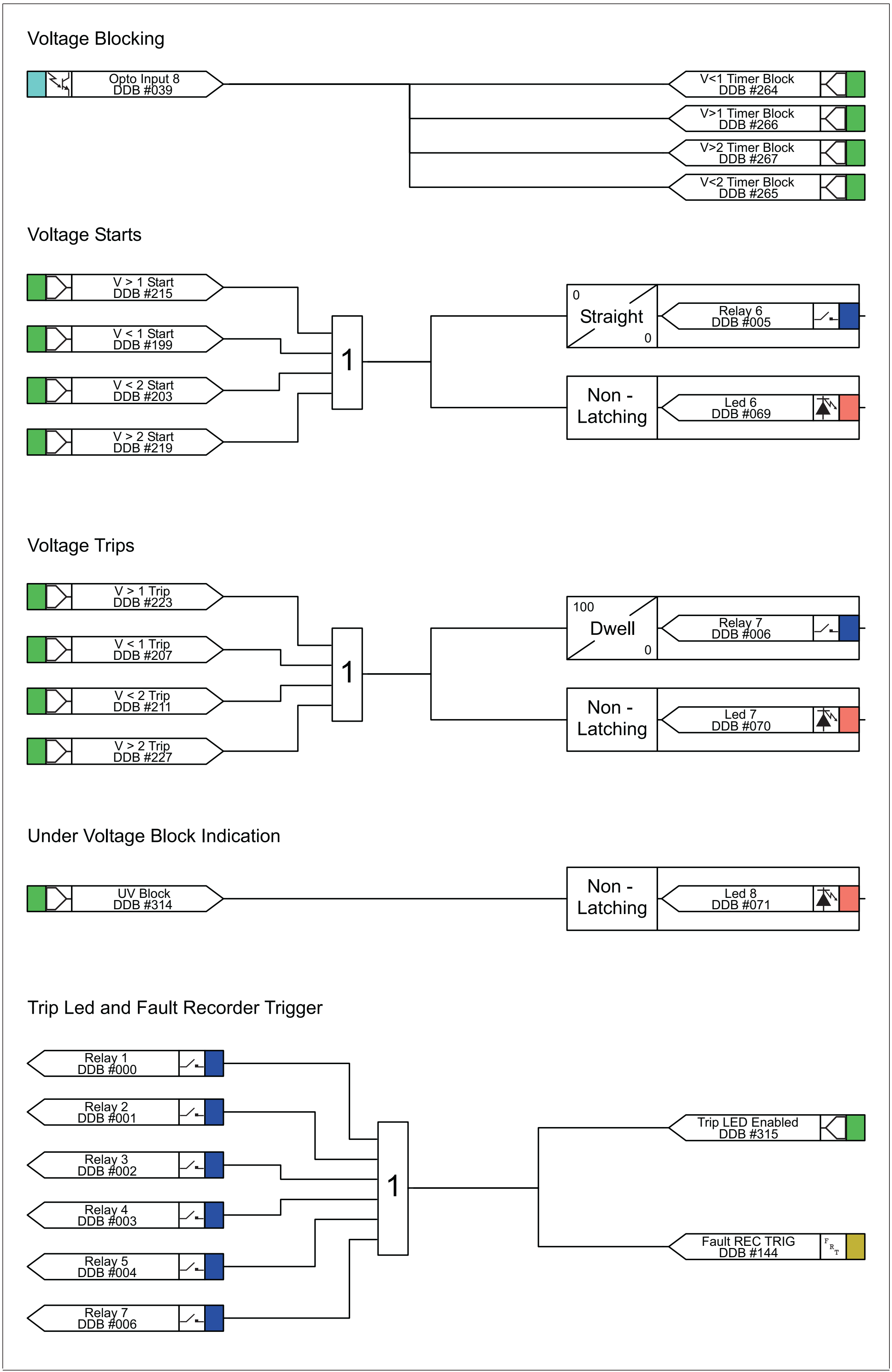


MiCOM P941 PROGRAMMABLE SCHEME LOGIC (VERSION 10)

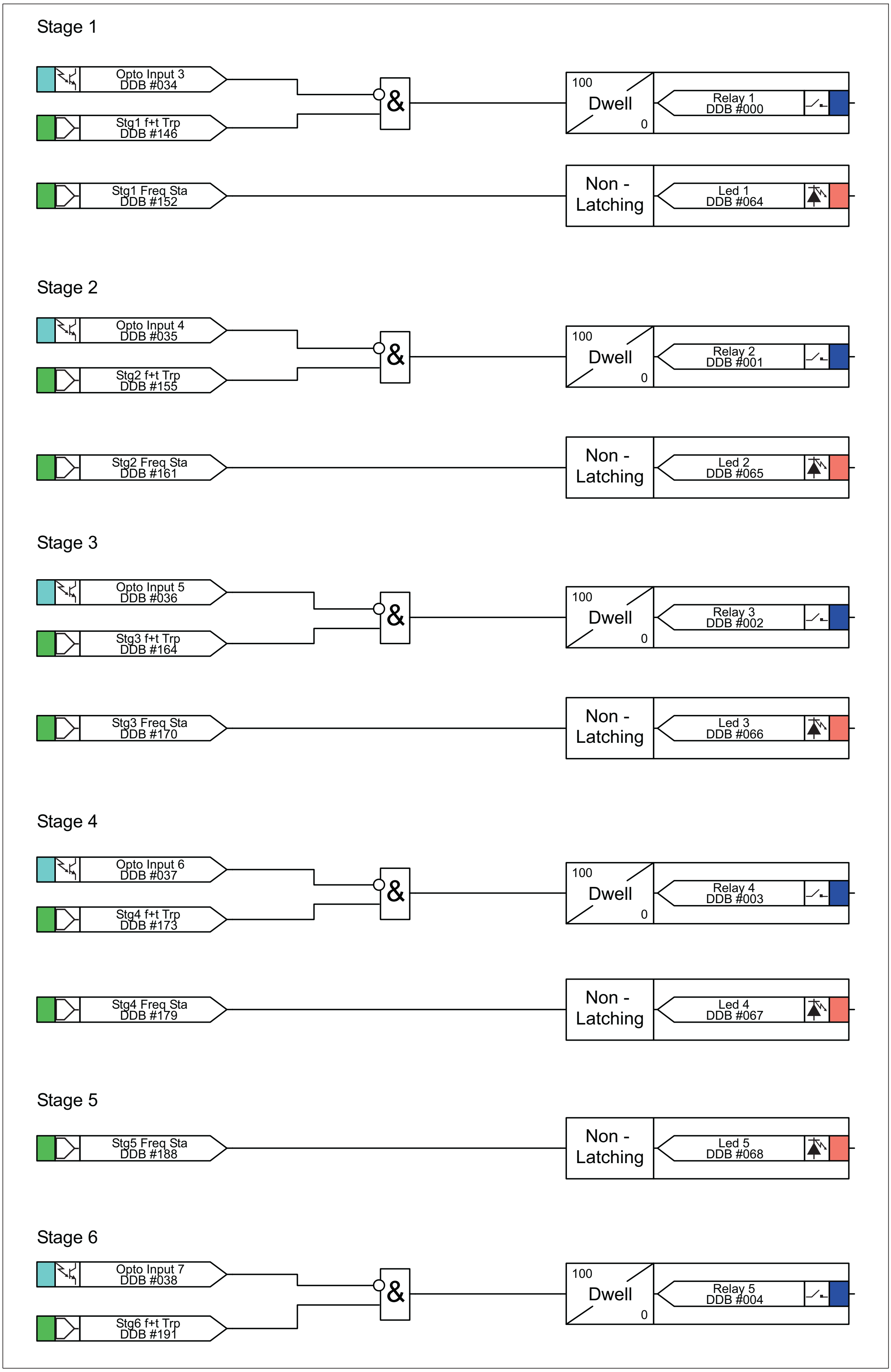


PL

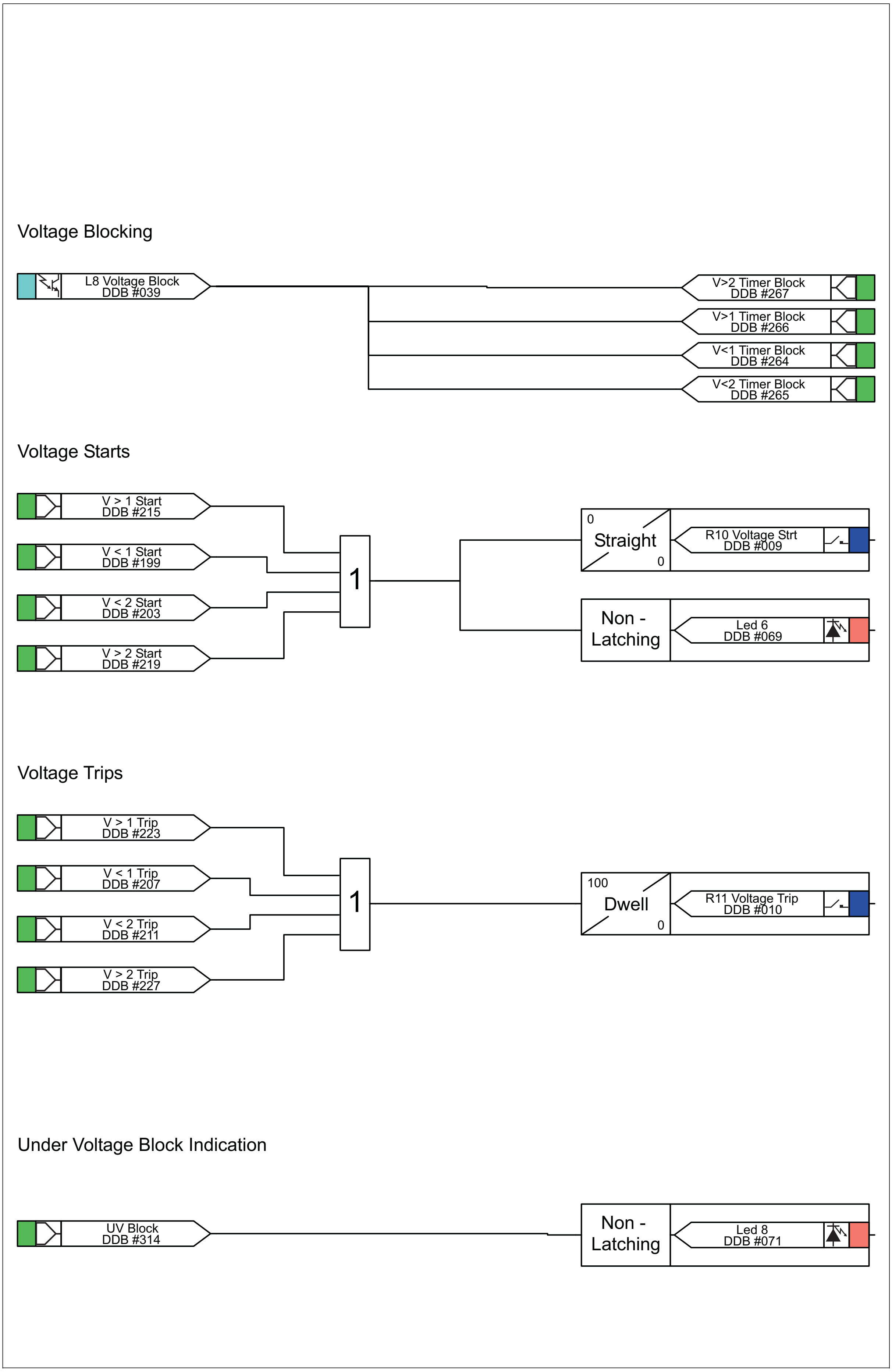
MiCOM P941 PROGRAMMABLE SCHEME LOGIC (VERSIONS 11 & 12)



MiCOM P941 PROGRAMMABLE SCHEME LOGIC (VERSIONS 11 & 12)

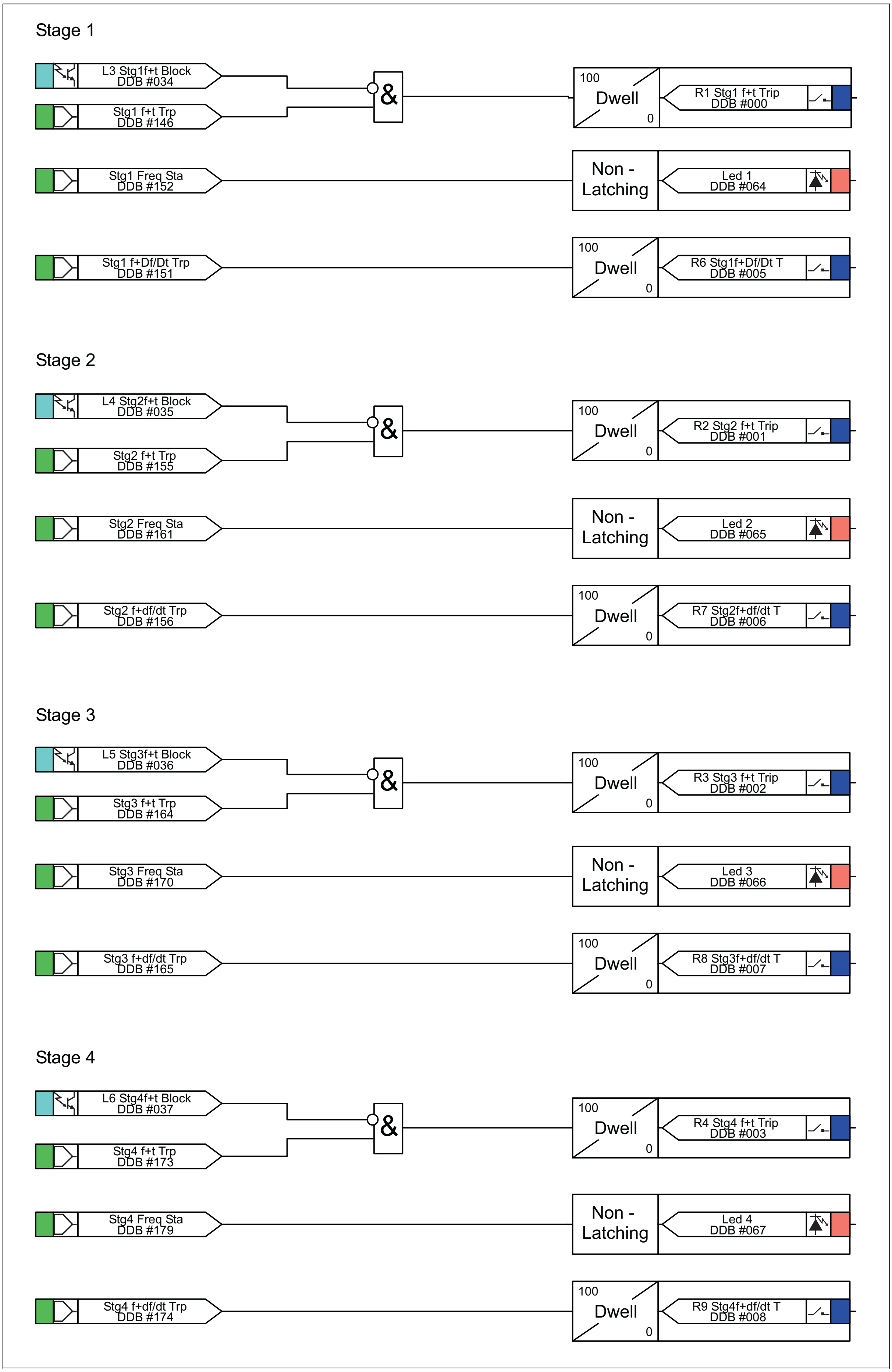


MiCOM P943 PROGRAMMABLE SCHEME LOGIC (VERSION 10)



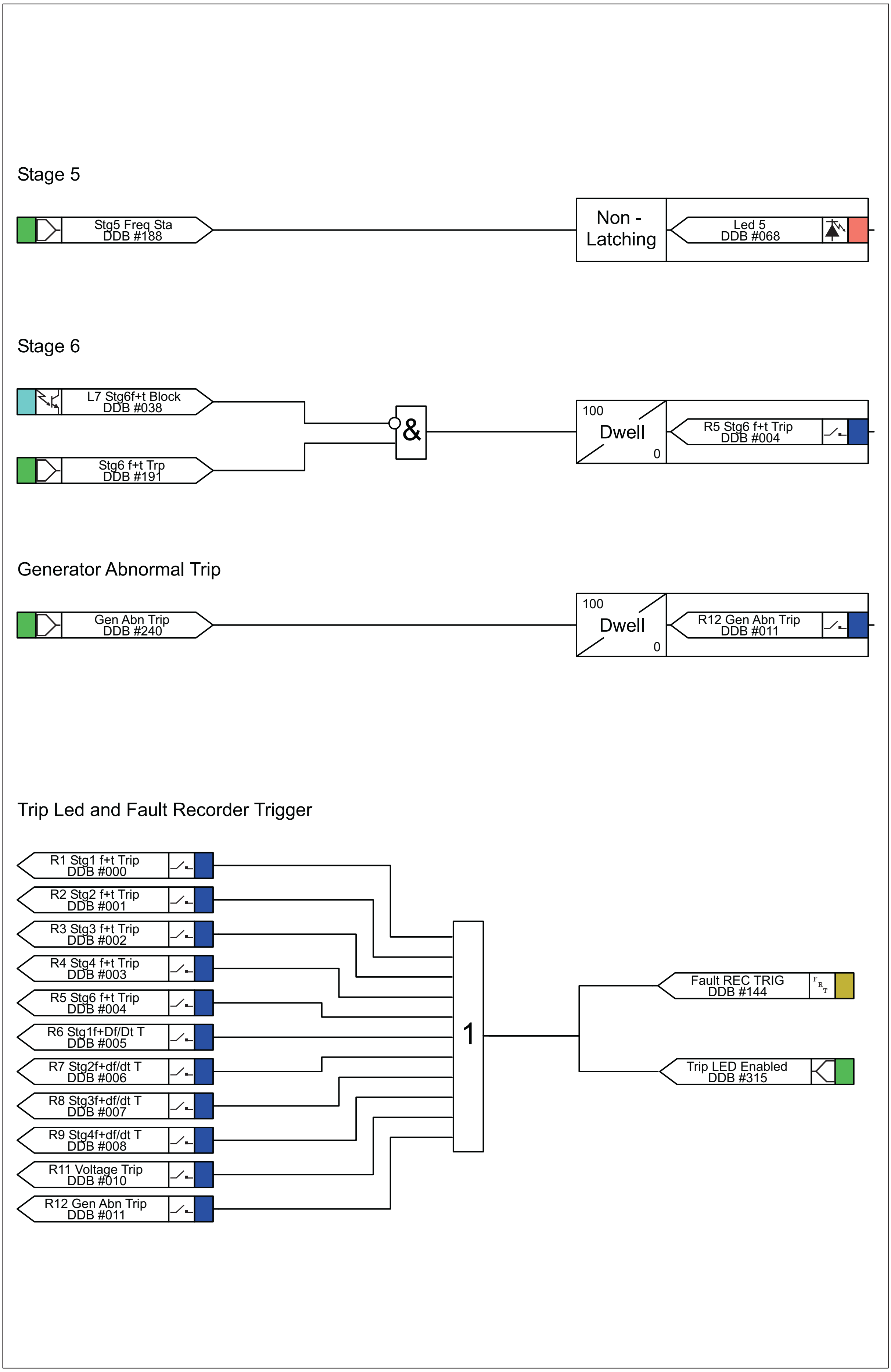
PL

MiCOM P943 PROGRAMMABLE SCHEME LOGIC (VERSION 10)

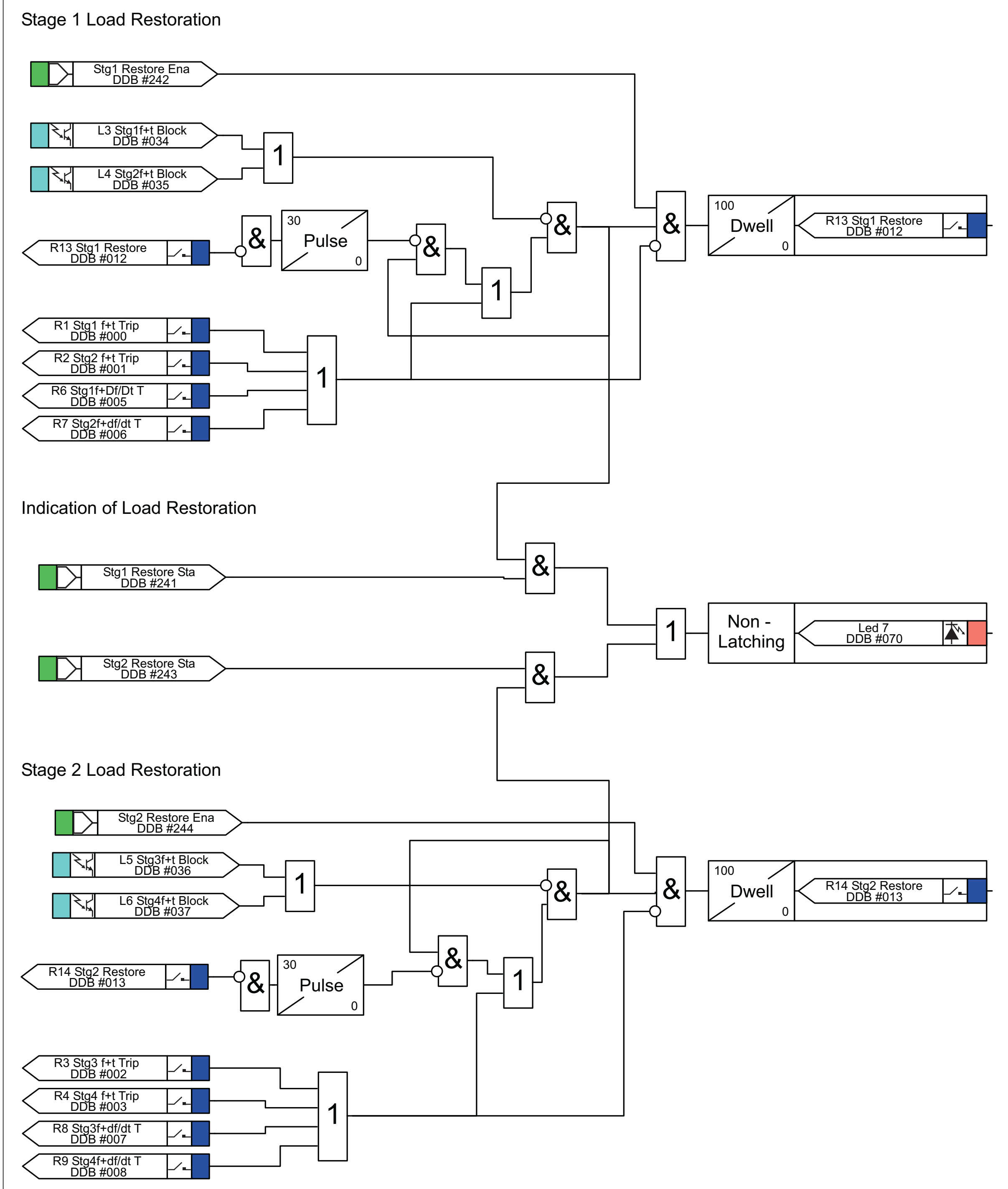


PL

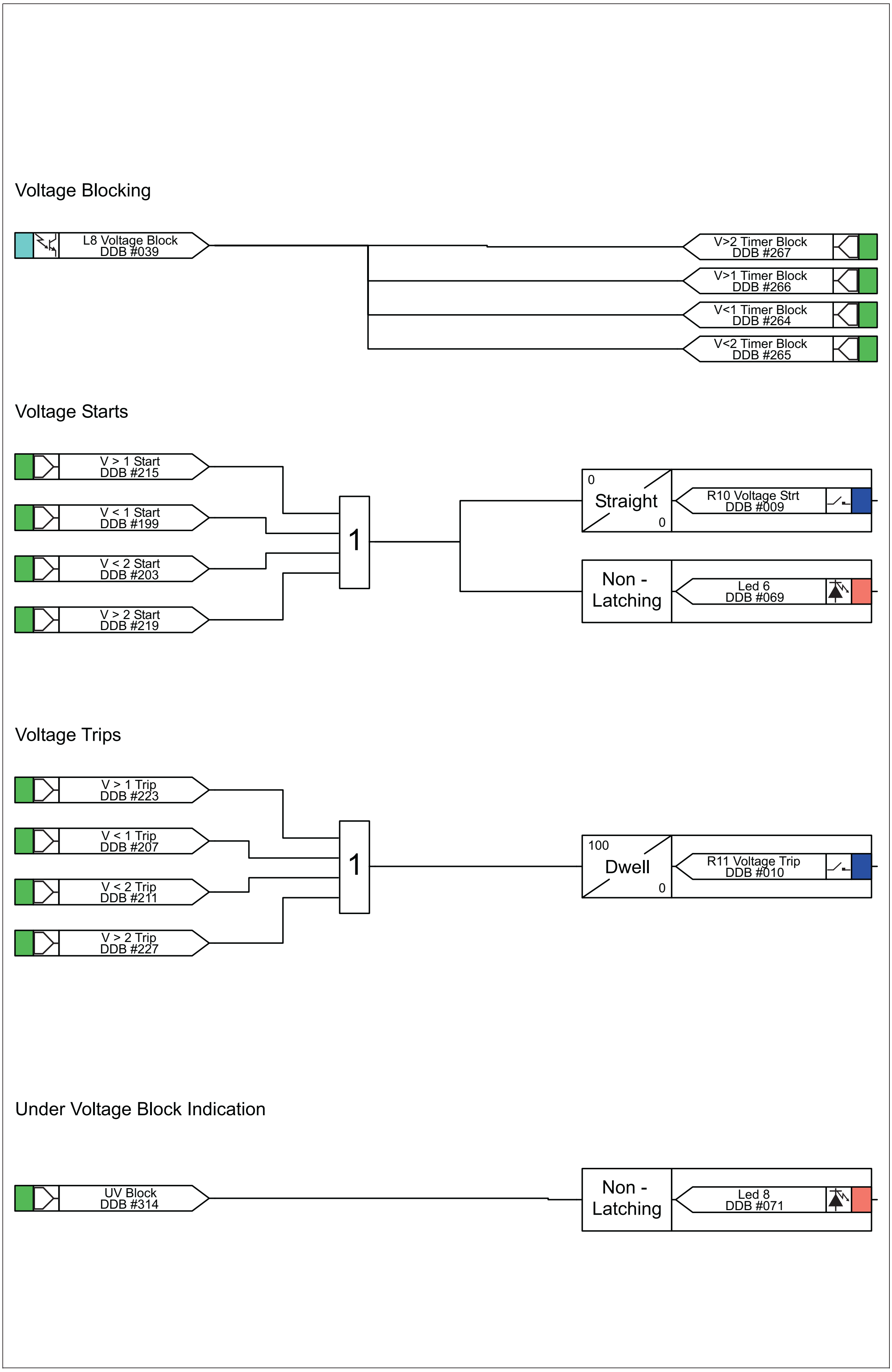
MiCOM P943 PROGRAMMABLE SCHEME LOGIC (version 10)



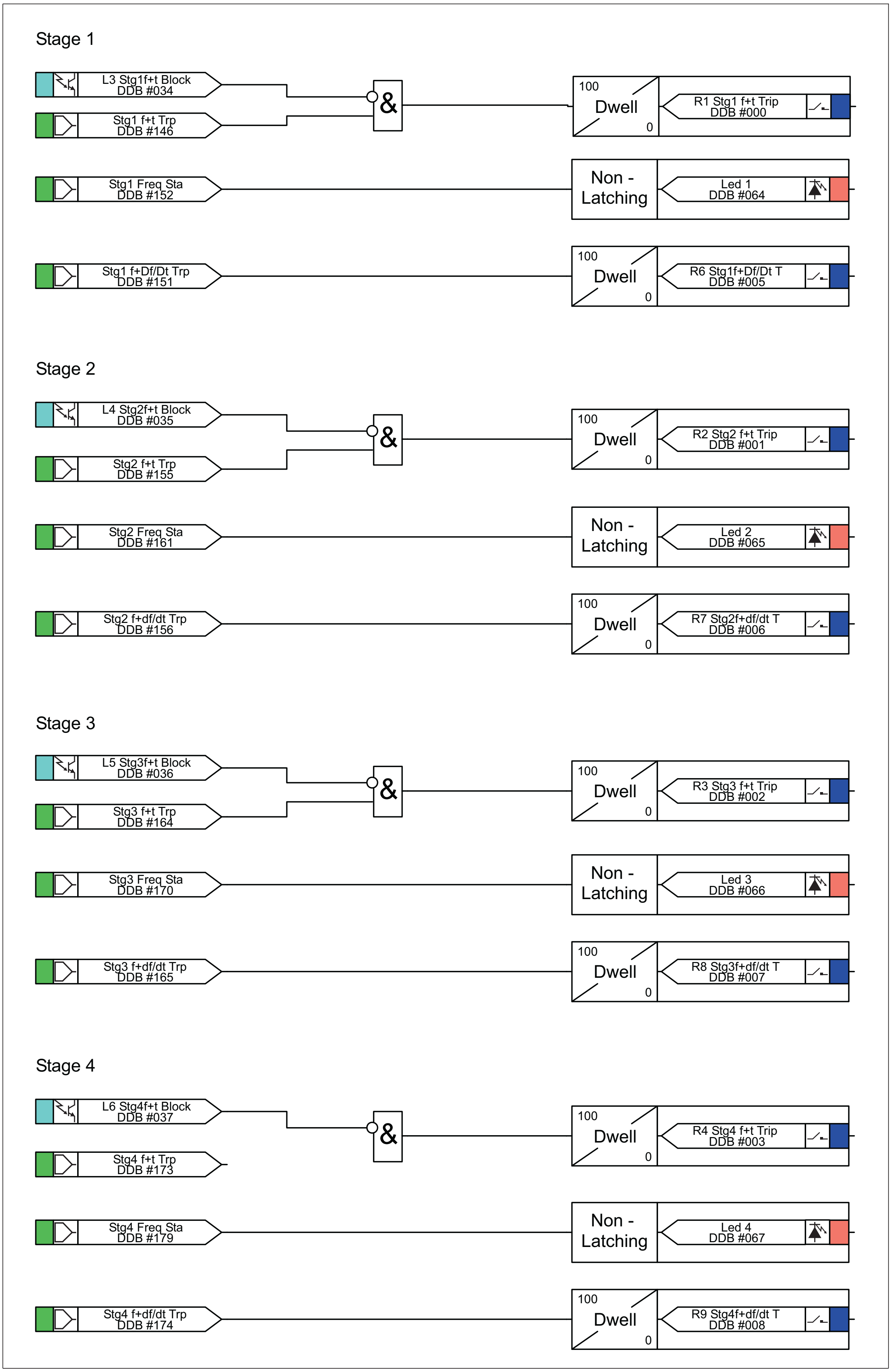
MiCOM P943 PROGRAMMABLE SCHEME LOGIC (VERSION 10)



MiCOM P943 PROGRAMMABLE SCHEME LOGIC (VERSIONS 11 & 12)

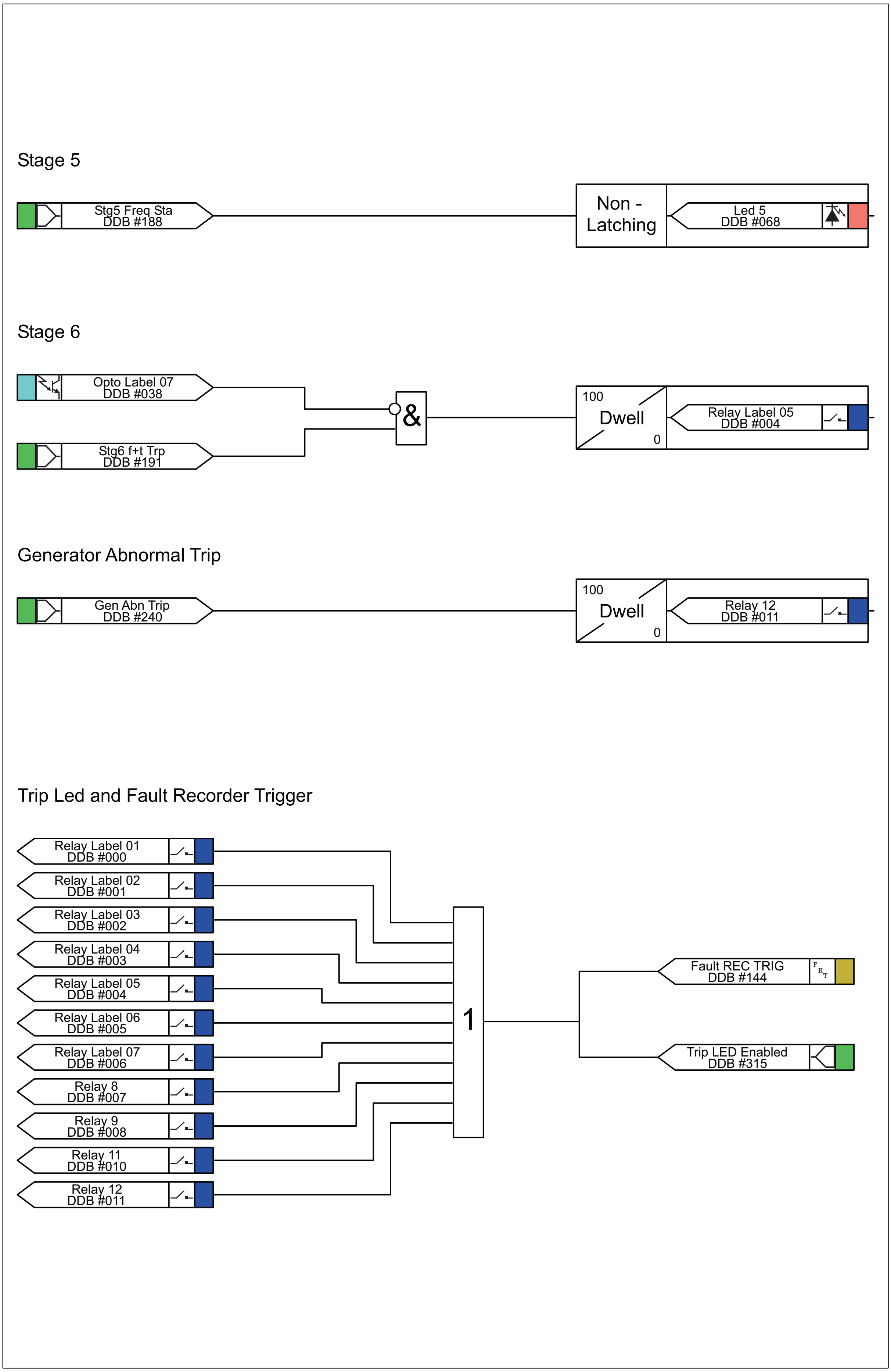


MiCOM P943 PROGRAMMABLE SCHEME LOGIC (VERSIONS 11 & 12)



PL

MiCOM P943 PROGRAMMABLE SCHEME LOGIC (VERSIONS 11 & 12)



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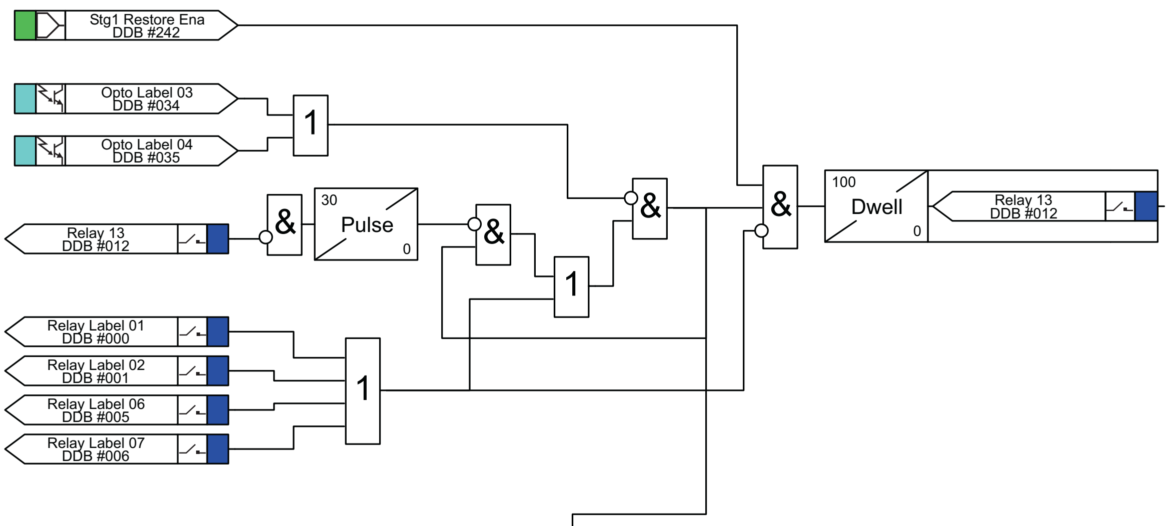
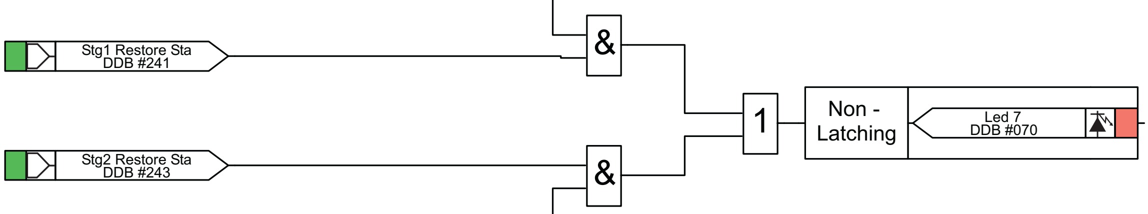
MiCOM P943 PROGRAMMABLE SCHEME LOGIC (VERSIONS 11 & 12)

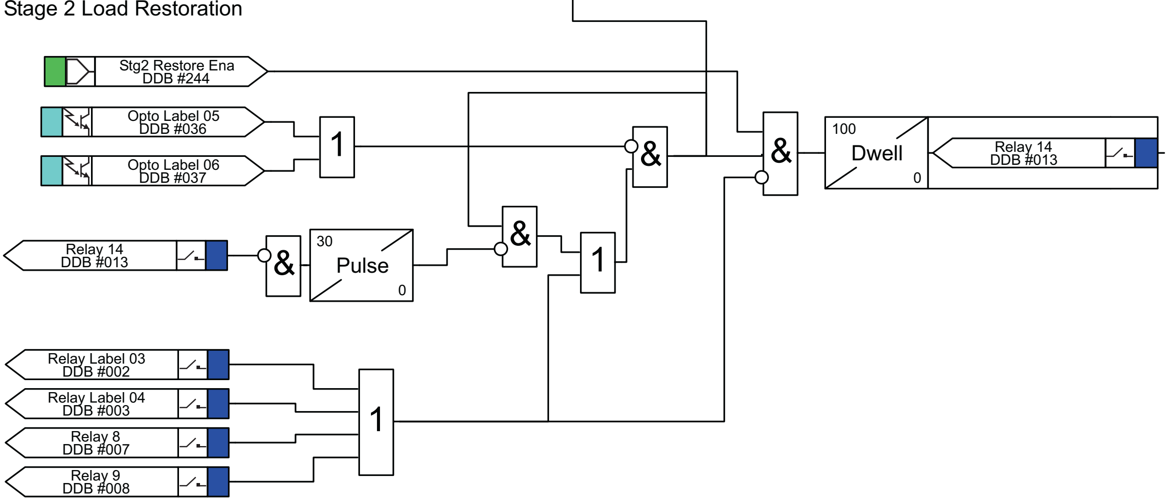
Stage 1 Load Restoration



Indication of Load Restoration



Stage 2 Load Restoration



MEASUREMENTS AND RECORDING

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Date:	**2008**
Hardware Suffix:	**A or C**
Software Version:	**12**
Connection Diagrams:	**10P94yxx (y = 1 or 3) (x = 01 to 06)**

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CONTENTS

1. MEASUREMENTS AND RECORDING

1.1 Introduction

The P94x is equipped with integral measurements, event, fault and disturbance recording facilities suitable for analysis of complex system disturbances.

The relay is flexible enough to allow for the programming of these facilities to specific user application requirements and is discussed below.

1.2 Event & fault records

The relay records and time tags up to 250 events and stores them in non-volatile (battery backed up) memory. This enables the system operator to establish the sequence of events that occurred within the relay following a particular power system condition, switching sequence etc. When the available space is exhausted, the oldest event is automatically overwritten by the new one.

The real time clock within the relay provides the time tag to each event, to a resolution of 1ms.

The event records are available for viewing either via the frontplate LCD or remotely, via the communications ports (Courier, MODBUS and IEC60870-5-103 versions only).

Local viewing on the LCD is achieved in the menu column entitled "VIEW RECORDS". This column allows viewing of event, fault and maintenance records and is shown in the following table:

LCD Reference	Description
VIEW RECORDS	
Select Event	Setting range from 0 to 249. This selects the required event record from the possible 250 that may be stored. A value of 0 corresponds to the latest event and so on.
Time & Date	Time & Date Stamp for the event given by the internal Real Time Clock.
Event Text	Up to 16 Character description of the Event refer to following sections).
Event Value	Up to 32 Bit Binary Flag or integer representative of the Event (refer to following sections).
Select Fault	Setting range from 0 to 4. This selects the required fault record from the possible 5 that may be stored. A value of 0 corresponds to the latest fault and so on.
	The following cells show all the fault flags, protection starts, protection trips, fault location, measurements etc. associated with the fault, i.e. the complete fault record.
Select Maint.	Setting range from 0 to 4. This selects the required maintenance report from the possible 10 that may be stored. A value of 0 corresponds to the latest report and so on.
Maint. Text	Up to 16 Character description of the occurrence (refer to following sections).
Maint. Type/Main Data	These cells are numbers representative of the occurrence. They form a specific error code which should be quoted in any related correspondence.
Reset Indication	Either Yes or No. This serves to reset the trip LED indications provided that the relevant protection element and the ‘Trip LED Enabled’ DDB signal (DDB 302) has reset.

For extraction from a remote source via communications, refer to the SCADA Communications section (P94x/EN CT), where the procedure is fully explained.

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1.2.1 Types of event

An event may be a change of state of a control input or output relay, an alarm condition, setting change etc. The following sections show the various items that constitute an event:

1.2.1.1 Change of state of opto-isolated inputs

If one or more of the opto (logic) inputs has changed state since the last time that the protection algorithm ran, the new status is logged as an event. When this event is selected to be viewed on the LCD, three applicable cells will become visible as shown below:

Time & Date of Event
“LOGIC INPUTS #”
“Event Value 0101010101010101”

The Event Value is an 8, 12, 16, 24 or 32 bit word showing the status of the opto inputs, where the least significant bit (extreme right) corresponds to opto input 1 etc. The same information is present if the event is extracted and viewed via PC.

1.2.1.2 Change of state of one or more output relay contacts

If one or more of the output relay contacts have changed state since the last time that the protection algorithm ran, then the new status is logged as an event. When this event is selected to be viewed on the LCD, three applicable cells will become visible as shown below:

Time & Date of Event
“OUTPUT CONTACTS #”
“Event Value 010101010101010101010”

The Event Value is a 7, 11, 14, 15, 22 or 30 bit word showing the status of the output contacts, where the least significant bit (extreme right) corresponds to output contact 1 etc. The same information is present if the event is extracted and viewed via PC.

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1.2.1.3 Relay alarm conditions

Any alarm conditions generated by the relays will also be logged as individual events. The following table shows examples of some of the alarm conditions and how they appear in the event list:

Alarm Condition	**Resulting Event**	
	Event Text	**Event Value**
Battery Fail	Battery Fail ON/OFF	Bit position 0 in 32 bit field
Field Voltage Fail	Field Volt Fail ON/OFF	Bit position 1 in 32 bit field
Setting Group via Opto Invalid	SG-opto Invalid ON/OFF	Bit position 2 in 32 bit field
Protection Disabled	Prot’n. Disabled ON/OFF	Bit position 3 in 32 bit field
Frequency Above 70Hz	Freq. High ON/OFF	Bit position 4 in 32 bit field
Frequency Below 40Hz	Freq. Low ON/OFF	Bit position 5 in 32 bit field
Frequency Out of Range	Freq. Not Found ON/OFF	Bit position 4 in 32 bit field
Invalid Setting	Wrong Setting ON/OFF	Bit position 7 in 32 bit field
Statistics Checksum Incorrect	Stats. Corrupt ON/OFF	Bit position 8 in 32 bit field

Alarm Condition	Resulting Event	
	Event Text	**Event Value**
Generator Abnormal Timers Checksum Incorrect	Gen. Timers Bad ON/OFF	Bit position 9 in 32 bit field
Undervoltage Block	UV Block ON/OFF	Bit position 10 in 32 bit field
Trip LED Illuminated	Trip LED Enabled ON/OFF	Bit position 11 in 32 bit field
Generator Abnormal Timers Checksum Incorrect	Gen. Timers Bad ON/OFF	Bit position 9 in 32 bit field

The previous table shows the abbreviated description that is given to the various alarm conditions and also a corresponding value between 0 and 31. This value is appended to each alarm event in a similar way as for the input and output events previously described. It is used by the event extraction software, such as MiCOM S1, to identify the alarm and is therefore invisible if the event is viewed on the LCD. Either ON or OFF is shown after the description to signify whether the particular condition has become operated or has reset.

A complete list of the 'Relay Alarm Events' is given in the Relay Menu Database (P94x/EN MD), which is a separate document, available for download from our website.

1.2.1.4 Protection element starts and trips

Any operation of protection elements, (either a start or a trip condition) will be logged as an event record, consisting of a text string indicating the operated element and an event value. Again, this value is intended for use by the event extraction software, such as MiCOM S1, rather than for the user, and is therefore invisible when the event is viewed on the LCD.

A complete list of the 'Protection Events' is given in the Relay Menu Database (P94x/EN MD), which is a separate document, available for download from our website.

1.2.1.5 General events

A number of events come under the heading of 'General Events' - an example is shown below:

Nature of Event	Displayed Text in Event Record	Displayed Value
Level 1 password modified, either from user interface, front or rear port.	PW1 modified UI, F or R	Bit position 6 (UI), 11 (F) or 16 (R)

A complete list of the 'General Events' is given in the Relay Menu Database (P94x/EN MD), which is a separate document, available for downloaded from our website.

1.2.1.6 Fault records

Each time a fault record is generated, an event is also created. The event simply states that a fault record was generated, with a corresponding time stamp.

Note that viewing of the actual fault record is carried out in the "Select Fault'" cell further down the "VIEW RECORDS" column, which is selectable from up to 5 records. These records consist of fault flags, fault measurements etc. Also note that the time stamp given in the fault record itself will be more accurate than the corresponding stamp given in the event record as the event is logged some time after the actual fault record is generated.

The fault record is triggered from the 'Fault REC. TRIG.' signal assigned in the programmable scheme logic (PSL). Note the fault measurements in the fault record are given at the time the 'Fault REC. TRIG.' signal is asserted high and that before any new data or record can be stored, 'Fault REC. TRIG.' signal must be allowed to reset. It is therefore recommended that all signals connected to the 'Fault REC. TRIG' signal are self-resetting.

It is recommended that the triggering contact (relay 3 for example) be 'self reset' and not latching. If a latching contact were chosen the fault record would not be generated until the contact had fully reset.

1.2.1.7 Maintenance reports

Internal failures detected by the self-monitoring circuitry, such as watchdog failure, field voltage failure etc. are logged into a maintenance report. The maintenance report holds up to 5 such 'events' and is accessed from the "Select Report" cell at the bottom of the "VIEW RECORDS" column.

Each entry consists of a self explanatory text string and a 'Type' and 'Data' cell, which are explained in the menu extract at the beginning of this section.

Each time a Maintenance Report is generated, an event is also created. The event simply states that a report was generated, with a corresponding time stamp.

1.2.1.8 Setting changes and "wrong settings"

Changes to any setting within the relay are logged as an event. Two examples are shown in the following table:

Type of Setting Change	Displayed Text in Event Record	Displayed Value
Control/Support Setting	C & S Changed	22
Group 1 Change	Group 1 Changed	24

Note: Control/Support settings are communications, measurement, CT/VT ratio settings etc, which are not duplicated within the four setting groups. When any of these settings are changed, the event record is created simultaneously. However, changes to protection or disturbance recorder settings will only generate an event once the settings have been confirmed at the 'setting trap'.

As part of the setting change event type on the P940, there is the ability to identify certain setting errors. These 'wrong settings' are labeled according to the setting that is considered incorrect, are notified by a text alarm "Wrong Setting" on the LCD and accompanied by operation of the amber Alarm LED. The actual alarm doesn't state which setting is incorrect, but within the event records of the relay each wrong setting is given a number that can be examined to identify its cause.

The complete list of causes of wrong setting alarms is given below:

Wrong Setting Number	Effected Element	Cause
Wrong Setting 01	Stage 1 f+t	Frequency setting = system nominal frequency
Wrong Setting 02	Stage 2 f+t	Frequency setting = system nominal frequency
Wrong Setting 03	Stage 3 f+t	Frequency setting = system nominal frequency
Wrong Setting 04	Stage 4 f+t	Frequency setting = system nominal frequency
Wrong Setting 05	Stage 5 f+t	Frequency setting = system nominal frequency
Wrong Setting 06	Stage 6 f+t	Frequency setting = system nominal frequency
Wrong Setting 07	Stage 1 f+df/dt	Frequency setting = system nominal frequency
Wrong Setting 08	Stage 2 f+df/dt	Frequency setting = system nominal frequency
Wrong Setting 09	Stage 3 f+df/dt	Frequency setting = system nominal frequency
Wrong Setting 10	Stage 4 f+df/dt	Frequency setting = system nominal frequency
Wrong Setting 11	Stage 5 f+df/dt	Frequency setting = system nominal frequency
Wrong Setting 12	Stage 6 f+df/dt	Frequency setting = system nominal frequency
Wrong Setting 13*	Stage 1 df/dt+t	Rate of change of frequency setting = 0 Hz/s

* Only available on software version v10. Software version v11 does not allow the df/dt setting to be set to zero.

Wrong Setting Number	**Effected Element**	**Cause**
Wrong Setting 14*	Stage 2 df/dt+t	Rate of change of frequency setting = 0 Hz/s
Wrong Setting 15*	Stage 3 df/dt+t	Rate of change of frequency setting = 0 Hz/s
Wrong Setting 16*	Stage 4 df/dt+t	Rate of change of frequency setting = 0 Hz/s
Wrong Setting 17*	Stage 5 df/dt+t	Rate of change of frequency setting = 0 Hz/s
Wrong Setting 18*	Stage 6 df/dt+t	Rate of change of frequency setting = 0 Hz/s
Wrong Setting 19	Stage 1 f+Df/Dt	Frequency setting = system nominal frequency
Wrong Setting 20	Stage 2 f+Df/Dt	Frequency setting = system nominal frequency
Wrong Setting 21	Stage 3 f+Df/Dt	Frequency setting = system nominal frequency
Wrong Setting 22	Stage 4 f+Df/Dt	Frequency setting = system nominal frequency
Wrong Setting 23	Stage 5 f+Df/Dt	Frequency setting = system nominal frequency
Wrong Setting 24	Stage 6 f+Df/Dt	Frequency setting = system nominal frequency
Wrong Setting 25	Band1 Generator Abnormal Protn	Low frequency setting > High frequency setting
Wrong Setting 26	Band2 Generator Abnormal Protn	Low frequency setting > High frequency setting
Wrong Setting 27	Band3 Generator Abnormal Protn	Low frequency setting > High frequency setting
Wrong Setting 28	Band4 Generator Abnormal Protn	Low frequency setting > High frequency setting
Wrong Setting 29	Stage 1 Load Restoration	Any of the following conditions; ➢ Stage 1 df/dt+t df/dt setting is greater than 0Hz/s ➢ Stage 1 f+t, f+df/dt or f+Df/Dt is configured for overfrequency protection ➢ Stage 1 restoration frequency is less than 0.015Hz above the stage 1 f+t or stage 1 f+Df/Dt setting
Wrong Setting 30	Stage 2 Load Restoration	Any of the following conditions; ➢ Stage 2 df/dt+t df/dt setting is greater than 0Hz/s ➢ Stage 2 f+t, f+df/dt or f+Df/Dt is configured for overfrequency protection ➢ Stage 2 restoration frequency is less than 0.015Hz above the stage 1 f+t or stage 1 f+Df/Dt setting

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Wrong Setting Number	Effected Element	Cause
Wrong Setting 31	Stage 3 Load Restoration	Any of the following conditions; ➢ Stage 3 df/dt+t df/dt setting is greater than 0Hz/s ➢ Stage 3 f+t, f+df/dt or f+Df/Dt is configured for overfrequency protection ➢ Stage 3 restoration frequency is less than 0.015Hz above the stage 1 f+t or stage 1 f+Df/Dt setting
Wrong Setting 32	Stage 4 Load Restoration	Any of the following conditions; ➢ Stage 4 df/dt+t df/dt setting is greater than 0Hz/s ➢ Stage 4 f+t, f+df/dt or f+Df/Dt is configured for overfrequency protection ➢ Stage 4 restoration frequency is less than 0.015Hz above the stage 1 f+t or stage 1 f+Df/Dt setting
Wrong Setting 33	Stage 5 Load Restoration	Any of the following conditions; ➢ Stage 5 df/dt+t df/dt setting is greater than 0Hz/s ➢ Stage 5 f+t, f+df/dt or f+Df/Dt is configured for overfrequency protection ➢ Stage 5 restoration frequency is less than 0.015Hz above the stage 1 f+t or stage 1 f+Df/Dt setting
Wrong Setting 34	Stage 6 Load Restoration	Any of the following conditions; ➢ Stage 6 df/dt+t df/dt setting is greater than 0Hz/s ➢ Stage 6 f+t, f+df/dt or f+Df/Dt is configured for overfrequency protection ➢ Stage 6 restoration frequency is less than 0.015Hz above the stage 1 f+t or stage 1 f+Df/Dt setting
Wrong Setting 35	Stage 7 f+Df/Dt	Frequency setting = system nominal frequency
Wrong Setting 36	Stage 7 Load Restoration	Any of the following conditions; ➢ Stage 7 df/dt+t df/dt setting is greater than 0Hz/s ➢ Stage 7 f+t, f+df/dt or f+Df/Dt is configured for overfrequency protection Stage 7 restoration frequency is less than 0.015Hz above the stage 1 f+t or stage 1 f+Df/Dt setting
Wrong Setting 37	Stage 8 f+Df/Dt	Frequency setting = system nominal frequency

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Wrong Setting Number	Effected Element	Cause
Wrong Setting 38	Stage 8 Load Restoration	Any of the following conditions; ➢ Stage 8 df/dt+t df/dt setting is greater than 0Hz/s ➢ Stage 8 f+t, f+df/dt or f+Df/Dt is configured for overfrequency protection Stage 8 restoration frequency is less than 0.015Hz above the stage 1 f+t or stage 1 f+Df/Dt setting
Wrong Setting 39	Stage 9 f+Df/Dt	Frequency setting = system nominal frequency
Wrong Setting 40	Stage 9 Load Restoration	Any of the following conditions; ➢ Stage 9 df/dt+t df/dt setting is greater than 0Hz/s ➢ Stage 9 f+t, f+df/dt or f+Df/Dt is configured for overfrequency protection Stage 9 restoration frequency is less than 0.015Hz above the stage 1 f+t or stage 1 f+Df/Dt setting

Note: When an incorrect setting is identified by the relay, the appropriate stage is automatically prevented from operating.

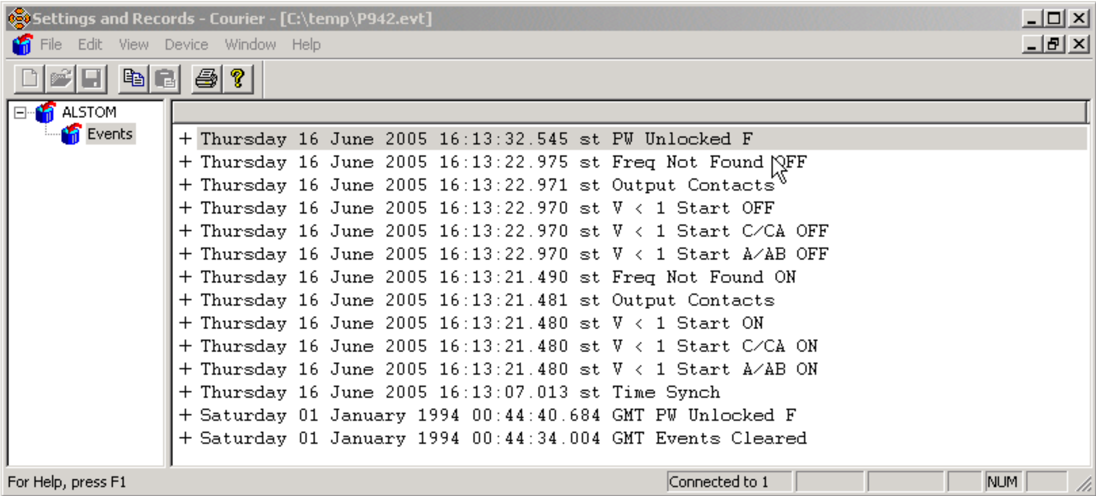
1.2.2 Resetting of event/fault records

If it is required to delete either the event, fault or maintenance reports, this may be done from within the "RECORD CONTROL" column.

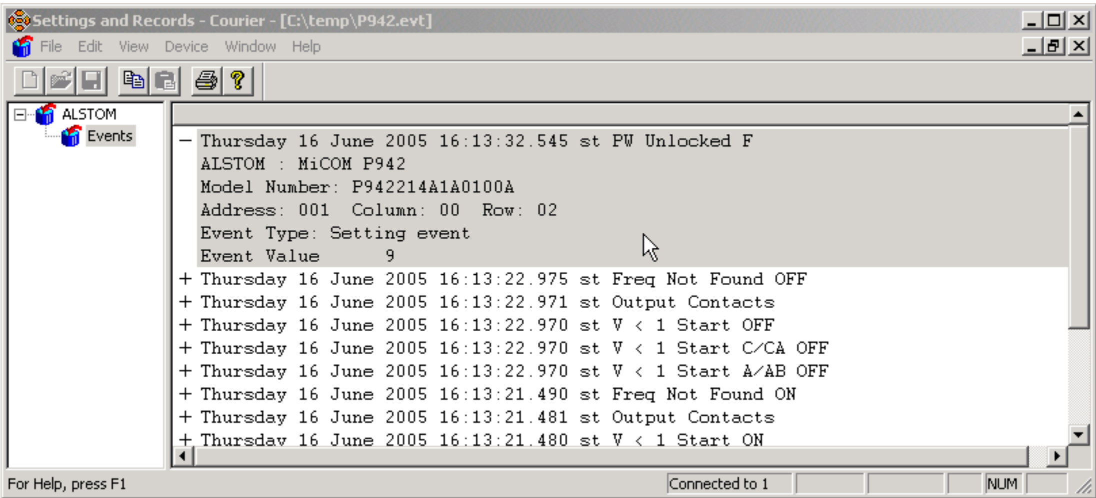
1.2.3 Viewing event records via MiCOM S1 support software

When the event records are extracted and viewed on a PC they look slightly different than when viewed on the LCD. The following shows an example of how various events appear when displayed using MiCOM S1:

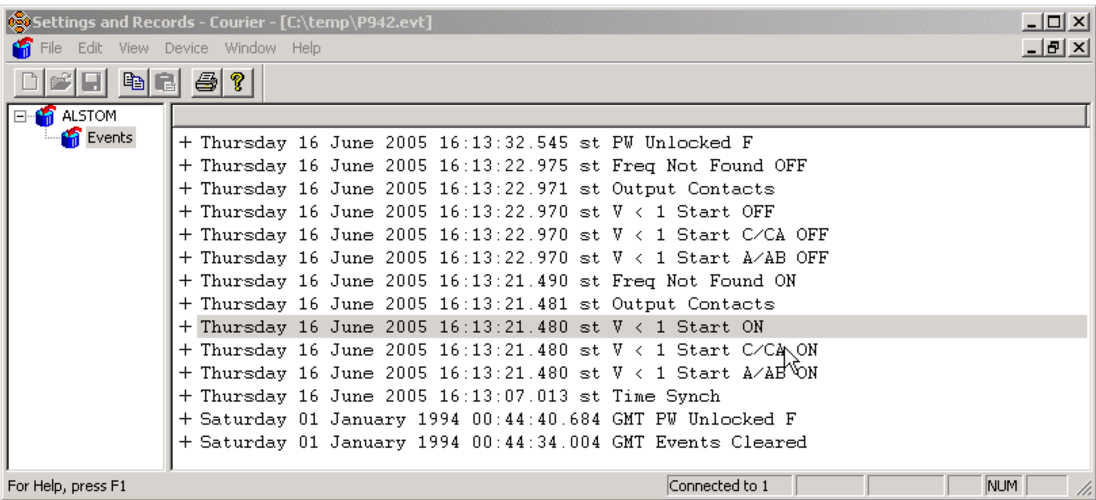
Example 1: Setting Change Event



When the event is “double-clicked” it will expand to:



Example 2: Protection Event



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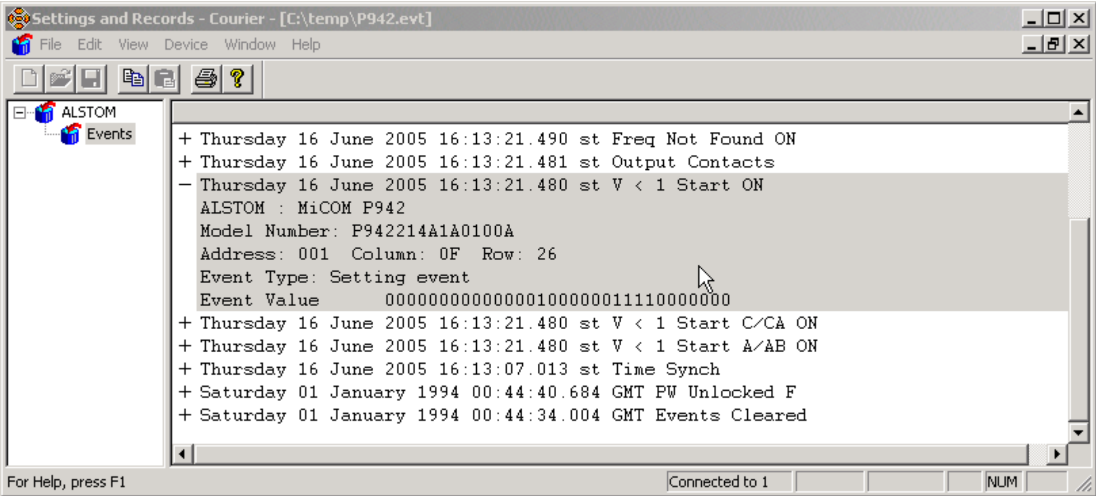
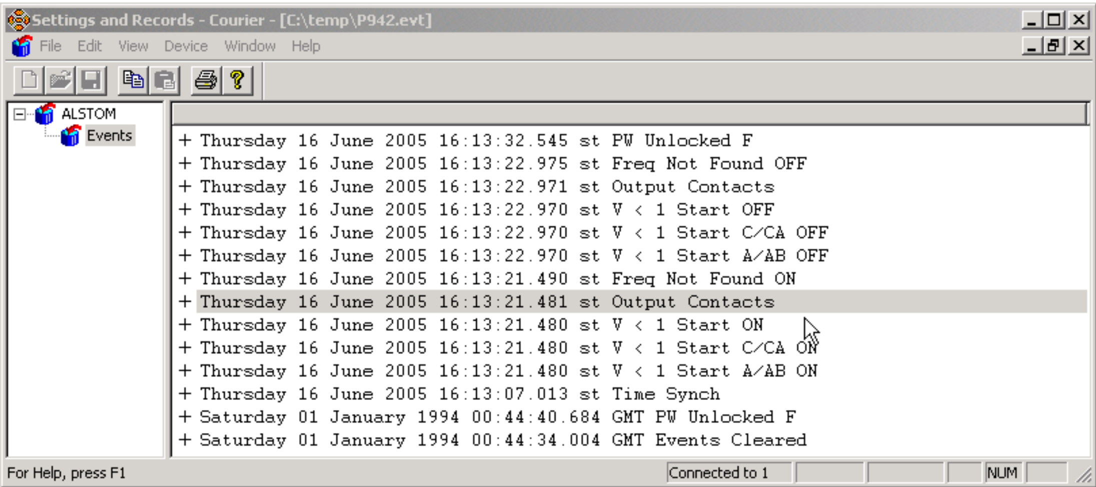
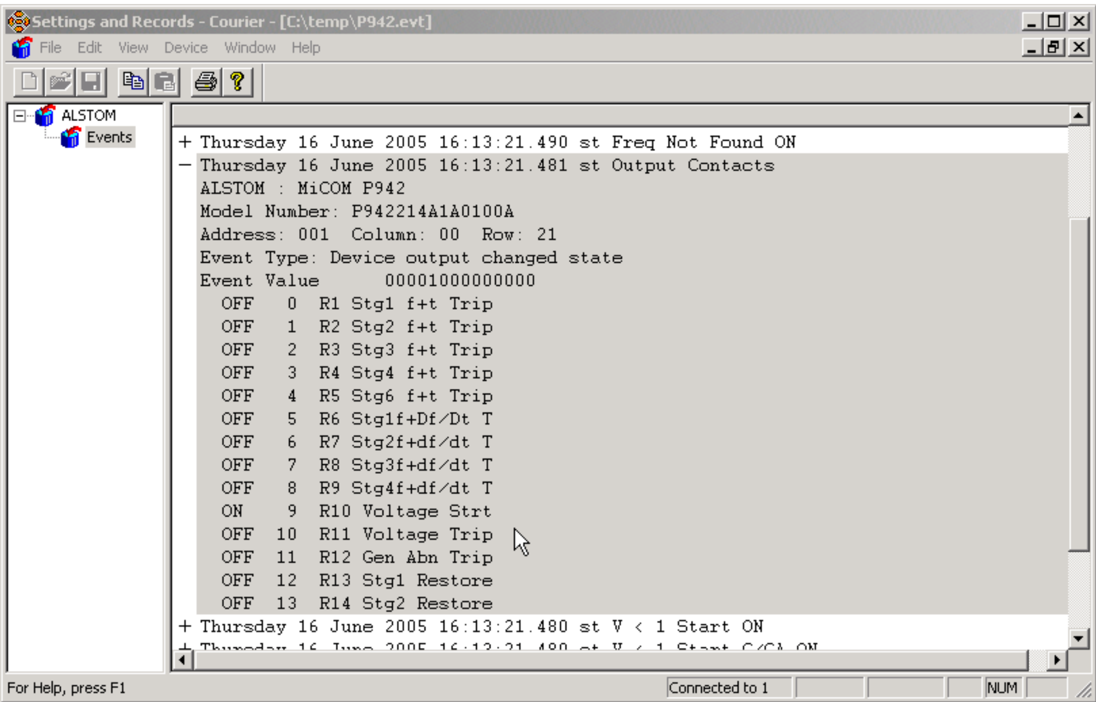
When the event is “double-clicked” it will expand to:



Example 3: Output Relay Change Event



When the event is “double-clicked” it will expand to:



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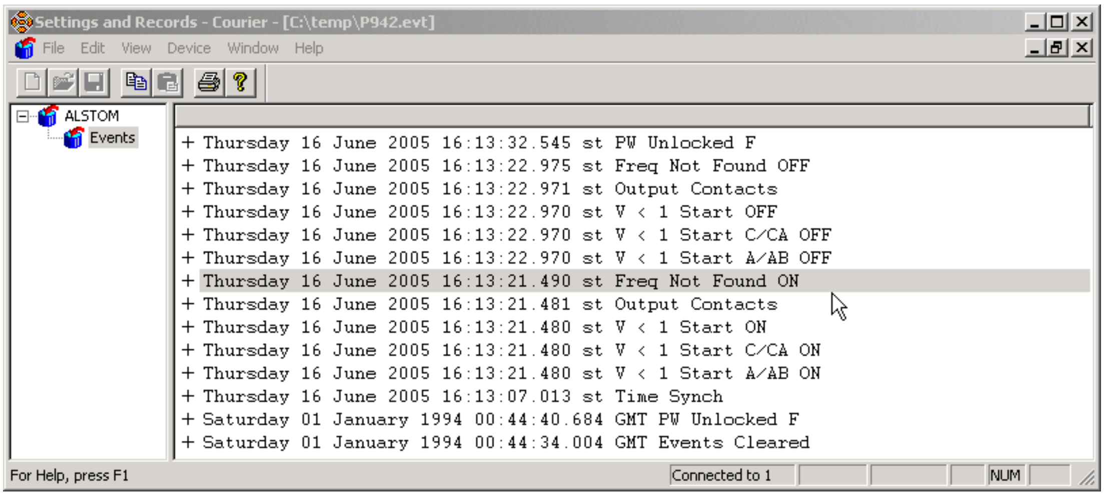
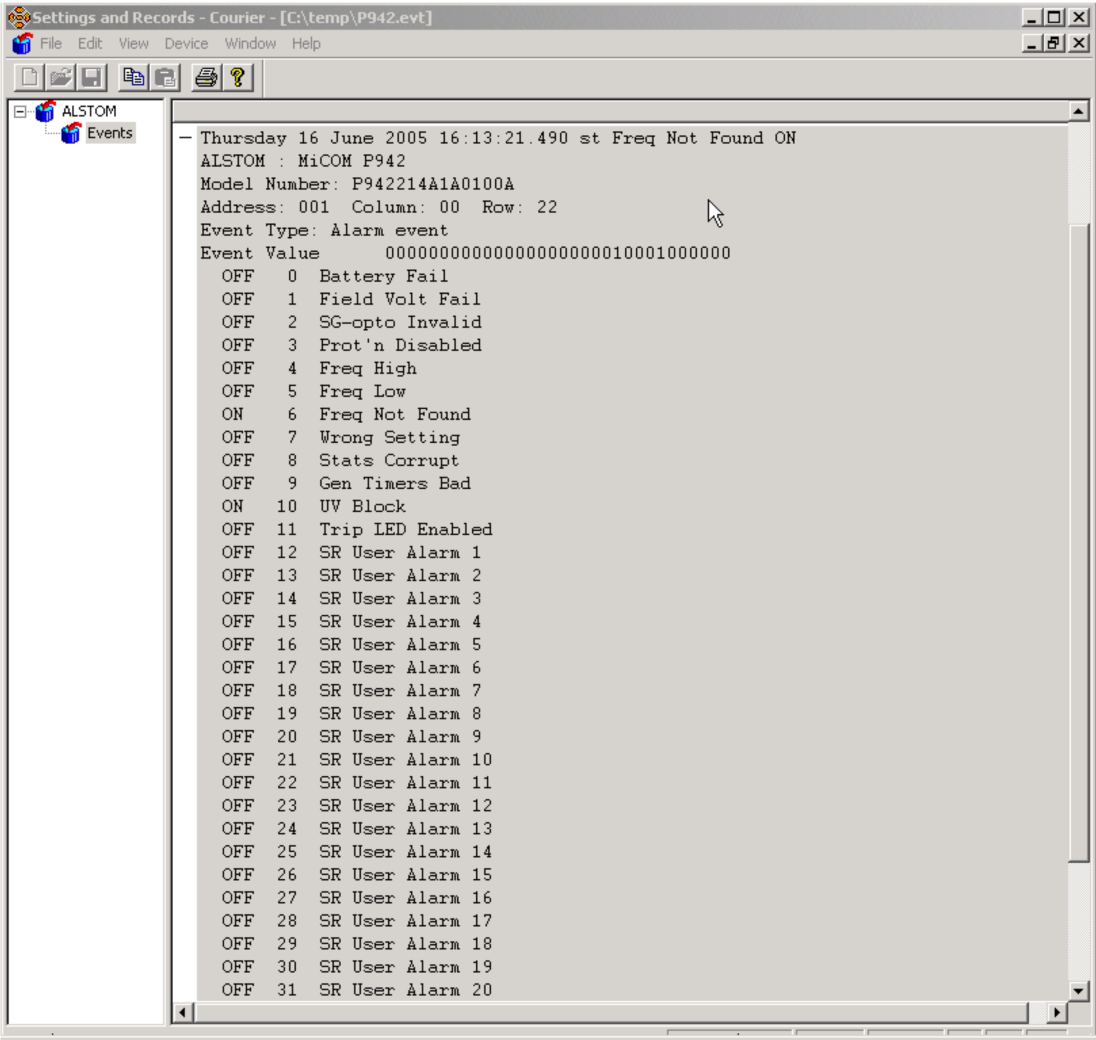
Example 4: Alarm Event



When the event is “double-clicked” it will expand to:



As can be seen, the first line gives the description and time stamp for the event, whilst the additional information that is displayed below may be collapsed via the +/– symbol.

For further information regarding events and their specific meaning, refer to the Relay Menu Database document (P94x/EN MD).

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1.2.4 Event filtering

It is possible to disable the reporting of events from all interfaces that supports setting changes. The settings that control the various types of events are in the Record Control column. The effect of setting each to disabled is as follows:

Menu Text	Default Setting	Available Settings
RECORD CONTROL		
Clear Events	No	No or Yes
Selecting “Yes” will cause the existing event log to be cleared and an event will be generated indicating that the events have been erased.		
Clear Faults	No	No or Yes
Selecting “Yes” will cause the existing fault records to be erased from the relay.		
Clear Maint.	No	No or Yes
Selecting “Yes” will cause the existing maintenance records to be erased from the relay.		
Alarm Event	Enabled	Enabled or Disabled
Disabling this setting means that all the occurrences that produce an alarm will result in no event being generated.		
Relay O/P Event	Enabled	Enabled or Disabled
Disabling this setting means that no event will be generated for any change in relay output state.		
Opto Input Event	Enabled	Enabled or Disabled
Disabling this setting means that no event will be generated for any change in logic input state.		
General Event	Enabled	Enabled or Disabled
Disabling this setting means that no General Events will be generated.		
Fault Rec. Event	Enabled	Enabled or Disabled
Disabling this setting means that any operation of protection elements will not be logged as an event.		
Maint. Rec. Event	Enabled	Enabled or Disabled
Disabling this setting means that no event will be generated for any occurrence that produces a maintenance record.		
Protection Event	Enabled	Enabled or Disabled
Disabling this setting means that any operation of protection elements will not be logged as an event.		
DDB 31 - 0	11111111111111111111111111111111	
Allows the user to individually select whether DDB signals 0 to 31 create an event or not. Setting a ‘1’ will allow an event to be generated; setting a ’0’ will prevent an event being generated.		
DDB 1022 - 992	11111111111111111111111111111111	
As above, for DDB signals 992 to 1022.		

Note that some occurrences will result in more than one type of event, e.g. a battery failure will produce an alarm event and a maintenance record event.

For further information regarding events and their specific meaning, refer to Relay Menu Database document (P94x/EN MD).

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1.3 Disturbance recorder

The integral disturbance recorder has an area of memory specifically set aside for record storage. In the software version 12, the compressed disturbance recorder is replaced by the uncompressed version, based on a data acquisition of 24 samples per cycle and to permit extraction via the rear port interface for Courier, Modbus, DNP3 and IEC60870-5-103 protocols (IEC60870-5-103 available in software version v12B).

The number of records that may be stored by the relay is dependent upon the selected recording duration. The relay can typically store up to 8 disturbance records (version 12). Tthe maximum record duration is 10.5 seconds.

Disturbance records continue to be recorded until the available memory is exhausted, at which time the oldest record(s) are overwritten to make space for the newest one.

The recorder stores actual samples that are taken at a rate of 24 samples per cycle.

Each disturbance record consists of eight analog data channels and thirty-two digital data channels. The relevant VT ratios for the analog channels are also extracted to enable scaling to primary quantities.

The "DISTURBANCE RECORDER" menu column is shown in the following table:

<table>
<tr><th rowspan="2">Menu Text</th><th rowspan="2">Default Setting</th><th colspan="2">Setting Range</th><th rowspan="2">Step Size</th></tr>
<tr><th>Min.</th><th>Max.</th></tr>
<tr><td colspan="5">DISTURB. RECORDER</td></tr>
<tr><td>Duration</td><td>10s</td><td>0.1s</td><td>10.5s</td><td>0.01s</td></tr>
<tr><td colspan="5">This sets the overall recording time.</td></tr>
<tr><td>Trigger Position</td><td>70.0%</td><td>0</td><td>100%</td><td>0.1%</td></tr>
<tr><td colspan="5">This sets the trigger point as a percentage of the duration. For example, the default settings show that the overall recording time is set to 10s with the trigger point being at 70% of this, giving 7s pre-fault and 1s post fault recording times.</td></tr>
<tr><td>Trigger Mode</td><td>Single</td><td colspan="3">Single or Extended</td></tr>
<tr><td colspan="5">If set to single mode, if a further trigger occurs whilst a recording is taking place, the recorder will ignore the trigger. However, if this has been set to "Extended", the post trigger timer will be reset to zero, thereby extending the recording time.</td></tr>
<tr><td>Analog. Channel 1</td><td>Frequency</td><td colspan="3">Frequency</td></tr>
<tr><td colspan="5">This channel is fixed as the frequency channel in the disturbance recorder.</td></tr>
<tr><td>Analog. Channel 2</td><td>VAN</td><td colspan="3">VAN, VBN or VCN</td></tr>
<tr><td colspan="5">Selects any available analog input to be assigned to this channel.</td></tr>
<tr><td>Analog. Channel 3</td><td>VBN</td><td colspan="3">As above</td></tr>
<tr><td>Analog. Channel 4</td><td>VCN</td><td colspan="3">As above</td></tr>
<tr><td>Digital Input 1</td><td>Stg1 Freq Sta</td><td colspan="3">Any of the opto input, relay output or Internal Digital Signals relating to trip or start conditions or inability to measure frequency.</td></tr>
<tr><td colspan="5">The digital channels may be mapped to any of the opto isolated inputs or output contacts, in addition to a number of internal relay digital signals, such as protection starts, trips etc.</td></tr>
<tr><td>Digital Input 2</td><td>Stg2 Freq Sta</td><td colspan="3">As above</td></tr>
<tr><td>Digital Input 3</td><td>Stg3 Freq Sta</td><td colspan="3">As above</td></tr>
<tr><td>Digital Input 4</td><td>Stg4 Freq Sta</td><td colspan="3">As above</td></tr>
<tr><td>Digital Input 5</td><td>Stg5 Freq Sta</td><td colspan="3">As above</td></tr>
<tr><td>Digital Input 6</td><td>Stg6 Freq Sta</td><td colspan="3">As above</td></tr>
</table>

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
Digital Input 7	Stg1 Freq Trp	As above		
Digital Input 8	Stg2 Freq Trp	As above		
Digital Input 9	Stg3 Freq Trp	As above		
Digital Input 10	Stg4 Freq Trp	As above		
Digital Input 11	Stg5 Freq Trp	As above		
Digital Input 12	Stg6 Freq Trp	As above		
Digital Input 13	V<1 Start	As above		
Digital Input 14	V<2 Start	As above		
Digital Input 15	V>1 Start	As above		
Digital Input 16	V>2 Start	As above		
Digital Input 17	V<1 Trip	As above		
Digital Input 18	V<2 Trip	As above		
Digital Input 19	V>1 Trip	As above		
Digital Input 20	V>2 Trip	As above		
Digital Input 21	Freq High	As above		
Digital Input 22	Freq Low	As above		
Digital Input 23	Freq Not Found	As above		
Digital Input 24 to 32	Not Used	As above		
Inputs 1 to 32 Trigger	Trigger L/H	No Trigger, Trigger L/H, Trigger H/L		
Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition.				

The pre and post fault recording times are set by a combination of the "Duration" and "Trigger Position" cells. "Duration" sets the overall recording time and the "Trigger Position" sets the trigger point as a percentage of the duration. For example, the default settings show that the overall recording time is set to 10s with the trigger point being at 70% of this, giving 7s pre-fault and 3s post fault recording times.

If a further trigger occurs whilst a recording is taking place, the recorder will ignore the trigger if the "Trigger Mode" has been set to "Single". However, if this has been set to "Extended", the post trigger timer will be reset to zero, thereby extending the recording time.

As can be seen from the menu, each of the analog channels is selectable from the available analog inputs to the relay. The digital channels may be mapped to any of the opto isolated inputs or output contacts, in addition to a number of internal relay digital signals, such as protection starts, LEDs etc. The complete list of these signals may be found by viewing the available settings in the relay menu or via a setting file in MiCOM S1. Any of the digital channels may be selected to trigger the disturbance recorder on either a low to high or a high to low transition, via the "Input Trigger" cell.

It is not possible to view the disturbance records locally via the LCD; they must be extracted using suitable software such as MiCOM S1. This process is fully explained in the SCADA Communications section (P94x/EN SC).

1.4 Measurements

The relay produces a variety of both directly measured and calculated power system quantities. These measurement values are updated on a per second basis and can be viewed in the “Measurements” columns (up to three) of the relay or via MiCOM S1 Measurement viewer. The P94x relays are able to measure and display the following quantities as summarized below:

– Phase Voltages

– Phase to Phase Voltage

– Frequency

– Sequence Voltages

– Rms. Voltages

There are also measured values from the protection functions, which are also displayed under the measurement columns of the menu; these are described in the section on the relevant protection function.

1.4.1 Measured voltages

The relay produces both phase to ground and phase to phase voltage values. They are produced directly from the DFT (Discrete Fourier Transform) used by the relay protection functions and present both magnitude and phase angle measurement.

1.4.2 Sequence voltages

Sequence quantities are produced by the relay from the measured Fourier values; these are displayed as magnitude and phase angle values.

1.4.3 Rms. voltages

Rms. phase voltage values are calculated by the relay using the sum of the samples squared over a cycle of sampled data.

1.4.4 Settings

The following settings under the heading measurement set-up can be used to configure the relay measurement function.

Menu Text	Default Settings	Available settings
MEASUREMENT SETUP		
Default Display	Date and Time	Date and Time, Description, Plant Reference, Frequency, 3Ph Voltage, or Access Level
This setting is used to select the default display from a range of options, noting that it is also possible to view the other default displays whilst at the default level using the and keys. However once the 15 minute timeout elapses the default display will revert to that selected by this setting.		
Local Values	Primary	Primary/Secondary
This cell defines whether measurements are displayed in primary or secondary terms on the front-panel user interface and front communication port.		
Remote Values	Primary	Primary/Secondary
This cell defines whether measurements are displayed in primary or secondary terms on the rear communication port.		
Measurement Ref.	VA	VA, VB or VC
This cell defines the phase reference for all angular measurements that the relay displays.		

1.4.5 Measurement display quantities

There is one “Measurement” column available in the relay for viewing of measurement quantities. This can also be viewed with MiCOM S1 (see MiCOM Px40 - Monitoring section of the MiCOM S1 User Manual) and is shown below:

MEASUREMENTS 1	
VAB Magnitude	0V
VAB Phase Angle	0 °
VBC Magnitude	0V
VBC Phase Angle	0 °
VCA Magnitude	0V
VCA Phase Angle	0 °
VAN Magnitude	0V
VAN Phase Angle	0 °
VBN Magnitude	0V

VBN Phase Angle	0 °
VCN Magnitude	0V
VCN Phase Angle	0 °
V1 Magnitude	0V
V2 Magnitude	0V
V0 Magnitude	0V
VAN RMS	0V
VBN RMS	0V
VCN RMS	0V

Frequency	
V1 Magnitude	0V
V1 Phase Angle	0 °
V2 Magnitude	0V
V2 Phase Angle	0 °
V0 Magnitude	0V
V0 Phase Angle	0 °

1.4.6 Stage statistics

In addition to the measurements column, the “STAGE STATISTICS” menu column of the relay provides information on the number of starts and trips that have occurred for each stage of each of the frequency protection elements. A revision date is also given for each stage of frequency protection that records the date and time that the last change of setting was made in any of the frequency protection elements. For example, the “Stg1 Revn Date” cell will record the date and time that the most recent setting change took place in stage 1 of any of the “f+t”, “df/dt+t”, “f+df/dt” or “f+Df/Dt” protection elements.

Each of the counters in the stage statistics simply accumulates until they are reset back to zero using the “Reset Statistics” cell located at the end of the column. When the statistics are reset, all the revision dates will also be reset to the current date and time.

This can also be viewed with MiCOM S1 (see MiCOM Px40 - Monitoring section of the MiCOM S1 User Manual) and is shown below:

STAGE STATISTICS	
Stg1 f+t Sta	0
Stg1 f+t Trp	0
Stg1 f+df/dt Trp	0
Stg1 df/dt+t Sta	0
Stg1 df/dt+t Trp	0
Stg1 f+Df/Dt Sta	0
Stg1 f+Df/Dt Trp	0
Stg1 Revn Date	
Stg2 f+t Sta	0
Stg2 f+t Trp	0
Stg2 f+df/dt Trp	0
Stg2 df/dt+t Sta	0
Stg2 df/dt+t Trp	0
Stg2 f+Df/Dt Sta	0
Stg2 f+Df/Dt Trp	0
Stg2 Revn Date	
Stg3 f+t Sta	0
Stg3 f+t Trp	0
Stg3 f+df/dt Trp	0
Stg3 df/dt+t Sta	0
Stg3 df/dt+t Trp	0
Stg3 f+Df/Dt Sta	0
Stg3 f+Df/Dt Trp	0
Stg3 Revn Date	
Stg4 f+t Sta	0
Stg4 f+t Trp	0
Stg4 f+df/dt Trp	0
Stg4 df/dt+t Sta	0
Stg4 df/dt+t Trp	0
Stg4 f+Df/Dt Sta	0
Stg4 f+Df/Dt Trp	0
Stg4 Revn Date	
Stg5 f+t Sta	0
Stg5 f+t Trp	0
Stg5 f+df/dt Trp	0
Stg5 df/dt+t Sta	0
Stg5 df/dt+t Trp	0
Stg5 f+Df/Dt Sta	0
Stg5 f+Df/Dt Trp	0
Stg5 Revn Date	
Stg6 f+t Sta	0
Stg6 f+t Trp	0
Stg6 f+df/dt Trp	0
Stg6 df/dt+t Sta	0
Stg6 df/dt+t Trp	0
Stg6 f+Df/Dt Sta	0
Stg6 f+Df/Dt Trp	0
Stg6 Revn Date	
Reset Statistics	No
Stg7 f+t Sta	0
Stg7 f+t Trp	0
Stg7 Revn Date	
Stg8 f+t Sta	0
Stg8 f+t Trp	0
Stg8 Revn Date	
Stg9 f+t Sta	0
Stg9 f+t Trp	0
Stg9 Revn Date	

MR

1.4.7 Generator abnormal timers

When the generator abnormal protection is enabled within the "CONFIGURATION" column of the relay, an additional "GENR ABN TIMERS" column will appear in the relay menu, to display the time spent in each of the generator abnormal frequency bands. It is also possible to reset the generator abnormal timers back to zero using the "Reset Timers" cell within this column.

GENR ABN TIMERS	
Freq Band1 Timer	h:mm:ss
Freq Band2 Timer	0
Freq Band3 Timer	0
Freq Band4 Timer	0
Reset Timers	No

FIRMWARE DESIGN

FD

Date:	**2008**
Hardware Suffix:	**A or C**
Software Version:	**12**
Connection Diagrams:	**10P94yxx (y = 1 or 3) (x = 01 to 06)**

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CONTENTS

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FIGURES

1. FIRMWARE DESIGN

1.1 Relay system overview

1.1.1 Hardware overview

The relay hardware is based on a modular design whereby the relay is made up of an assemblage of several modules that are drawn from a standard range. Some modules are essential while others are optional depending on the user's requirements.

The different modules that can be present in the relay are as follows:

1.1.1.1 Processor board

The processor board performs all calculations for the relay and controls the operation of all other modules within the relay. The processor board also contains and controls the user interfaces (LCD, LEDs, keypad, function keys and communication interfaces).

1.1.1.2 Input module

The input module converts the information contained in the analog and digital input signals into a format suitable for processing by the processor board. The standard input module consists of two boards; a transformer board to provide electrical isolation and a main input board which provides analog to digital conversion and the isolated digital inputs.

1.1.1.3 Power supply module

The power supply module provides a power supply to all of the other modules in the relay, at three different voltage levels. The power supply board also provides the EIA(RS)485 electrical connection for the rear communication port and a 48V external field supply that may be used to drive the opto isolated digital inputs. A second board within the power supply module also contains the first seven relay output contacts.

1.1.1.4 IRIG-B board

This board, which is optional, can be used where an IRIG-B signal is available to provide an accurate time reference for the relay. There is also an option on this board to specify a fiber optic rear communication port, for use with IEC60870-5-103 communication only.

All modules are connected by a parallel data and address bus that allows the processor board to send and receive information to and from the other modules as required. There is also a separate serial data bus for conveying sample data from the input module to the processor. Figure 1 shows the modules of the relay and the flow of information between them.

1.1.2 Software overview

The software for the relay can be conceptually split into four elements; the real-time operating system, the system services software, the platform software and the protection and control software. These four elements are not distinguishable to the user, and are all processed by the same processor board. The distinction between the four parts of the software is made purely for the purpose of explanation here:

1.1.2.1 Real-time operating system

The real time operating system is used to provide a framework for the different parts of the relay's software to operate within. To this end the software is split into tasks.

The real-time operating system is responsible for scheduling the processing of these tasks such that they are carried out in the time available and in the desired order of priority. The operating system is also responsible for the exchange of information between tasks, in the form of messages.

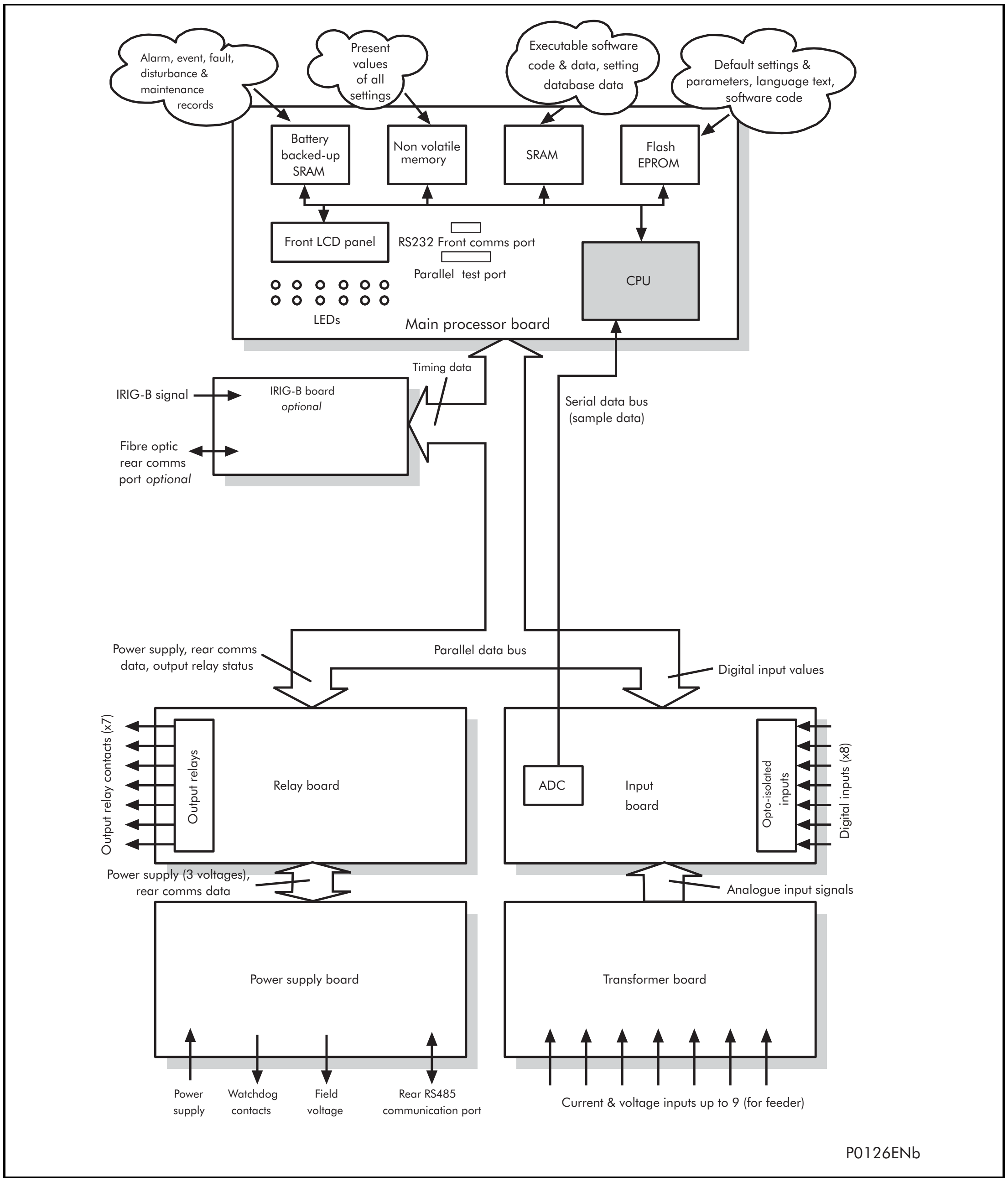

Figure 1: Relay modules and information flow

1.1.2.2 System services software

The system services software provides the low-level control of the relay hardware. For example, the system services software controls the boot of the relay's software from the non-volatile flash EPROM memory at power-on, and provides driver software for the user interface via the LCD and keypad, and via the serial communication ports. The system services software provides an interface layer between the control of the relay's hardware and the rest of the relay software.

1.1.2.3 Platform software

The platform software deals with the management of the relay settings, the user interfaces and logging of event, alarm, fault and maintenance records. All of the relay settings are stored in a database within the relay that provides direct compatibility with Courier communications. For all other interfaces (i.e. the front panel keypad and LCD interface, MODBUS, IEC60870-5-103 and DNP3.0) the platform software converts the information from the database into the format required. The platform software notifies the protection & control software of all settings changes and logs data as specified by the protection & control software.

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1.1.2.4 Protection & control software

The protection and control software performs the calculations for all of the protection algorithms of the relay. This includes digital signal processing such as Fourier filtering and ancillary tasks such as the measurements. The protection & control software interfaces with the platform software for settings changes and logging of records, and with the system services software for acquisition of sample data and access to output relays and digital opto-isolated inputs.

1.1.2.5 Disturbance recorder

The analog values and logic signals are routed from the protection and control software to the disturbance recorder software which compresses the data to allow a greater number of records to be stored. The platform software interfaces to the disturbance recorder to allow extraction of the stored records.

1.2 Hardware modules

The relay is based on a modular hardware design where each module performs a separate function within the relay operation. This section describes the functional operation of the various hardware modules.

1.2.1 Processor board

The relay is based around a TMS320C32 floating point, 32-bit digital signal processor (DSP) operating at a clock frequency of 20MHz. This processor performs all of the calculations for the relay, including the protection functions, control of the data communication and user interfaces including the operation of the LCD, keypad and LEDs.

The processor board is located directly behind the relay's front panel which allows the LCD and LEDs to be mounted on the processor board along with the front panel communication ports. These comprise the 9-pin D-connector for EIA(RS)232 serial communications (e.g. using MiCOM S1 and Courier communications) and the 25-pin D-connector relay test port for parallel communication. All serial communication is handled using a two-channel 85C30 serial communications controller (SCC).

The memory provided on the main processor board is split into two categories, volatile and non-volatile; the volatile memory is fast access (zero wait state) SRAM which is used for the storage and execution of the processor software, and data storage as required during the processor's calculations. The non-volatile memory is sub-divided into 3 groups; 2MB of flash memory for non-volatile storage of software code and text together with default settings, 256kB of battery backed-up SRAM for the storage of disturbance, event, fault and maintenance record data, and 32kB of non-volatile memory for the storage of configuration data, including the present setting values.

1.2.2 Internal communication buses

The relay has two internal buses for the communication of data between different modules. The main bus is a parallel link that is part of a 64-way ribbon cable. The ribbon cable carries the data and address bus signals in addition to control signals and all power supply lines. Operation of the bus is driven by the main processor board that operates as a master while all other modules within the relay are slaves.

The second bus is a serial link that is used exclusively for communicating the digital sample values from the input module to the main processor board. The DSP processor has a built-in serial port that is used to read the sample data from the serial bus. The serial bus is also carried on the 64-way ribbon cable.

1.2.3 Input module

The input module provides the interface between the relay processor board and the analog and digital signals coming into the relay. The input module consists of two PCBs; the main input board and a transformer board. The P941 and P943 are both fitted with three voltage inputs.

1.2.3.1 Transformer board

The transformer board holds three voltage transformers (VTs) and can be specified for either 110V or 440V nominal voltage (order option). The transformers are used both to step-down the voltages to levels appropriate to the relay's electronic circuitry and to provide effective isolation between the relay and the power system. The connection arrangements of voltage transformer secondaries provide differential input signals to the main input board to reduce noise.

1.2.3.2 Input board

The main input board is shown as a block diagram in Figure 2. It provides the circuitry for the digital input signals and the analog-to-digital conversion for the analog signals. Hence it takes the differential analog signals from the VTs on the transformer board, converts these to digital samples and transmits the samples to the processor board via the serial data bus. On the input board the analog signals are passed through an anti-alias filter before being multiplexed into a single analog to digital converter chip. The A - D converter provides 16-bit resolution and a serial data stream output. The digital input signals are opto isolated on this board to prevent excessive voltages on these inputs causing damage to the relay's internal circuitry.

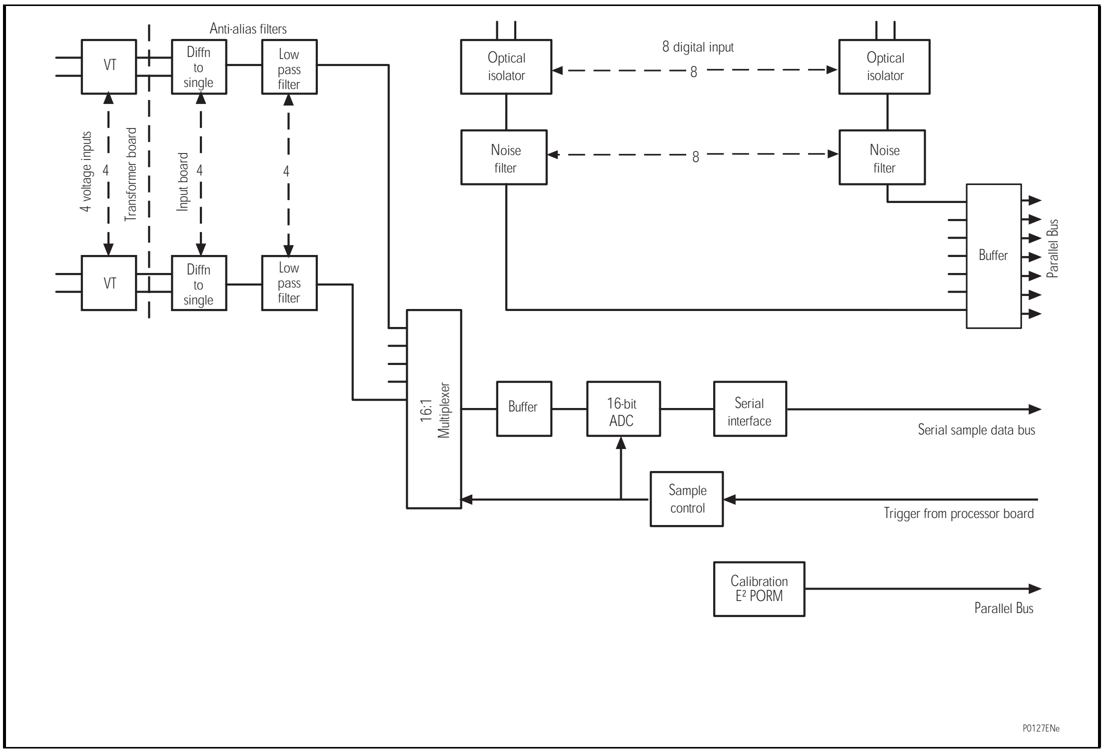

Figure 2: Main input board

The signal multiplexing arrangement provides for 16 analog channels to be sampled. The P941 and P943 relays provide 3 voltage inputs. 3 spare channels are used to sample 3 different reference voltages for the purpose of continually checking the operation of the multiplexer and the accuracy of the A - D converter. The sample rate is maintained at 24 samples per cycle of the power waveform by a logic control circuit that is driven by the frequency tracking function on the main processor board. The calibration E^2PROM holds the calibration coefficients that are used by the processor board to correct for any amplitude or phase errors introduced by the transformers and analog circuitry.

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The other function of the input board is to read the state of the signals present on the digital inputs and present this to the parallel data bus for processing. The input board holds 8 optical isolators for the connection of up to eight digital input signals. The opto-isolators are used with the digital signals for the same reason as the transformers with the analog signals; to isolate the relay's electronics from the power system environment. The input board provides some hardware filtering of the digital signals to remove unwanted noise before buffering the signals for reading on the parallel data bus. Depending on the relay model, more than 8 digital input signals can be accepted by the relay. This is achieved by the use of an additional input board which contains the same provision for 8 isolated digital inputs as the main input board, but does not contain any of the circuits for analog signals which are provided on the main input board. The basic compliment of digital inputs for the P941 is 8 whilst the P943 has 16.

For the P940 frequency relays, the protection task is executed twice per cycle, i.e. after every 12 samples for the sample rate of 24 samples per power cycle used by the relay. Therefore, the time taken to register a change in the state of an opto input can vary between a half to one cycle. The time to register the change of state will depend on whether the opto input changes state at the start or end of a protection task cycle with the additional half cycle filtering time.

1.2.3.3 Opto isolated logic inputs (relay hardware suffix A)

If the last digit of the relay model number is 'A', the relay is fitted with opto isolated logic inputs that are intended for a 48V DC supply. These inputs nominally provide a logical 1 or 'On' value for voltages ≥25V and a logical 0 or 'Off' value for voltages ≤12V. Each input also has a pre-set filter of ½ cycle which renders the input immune to induced noise on the wiring: although this method is secure it can be slow, particularly for intertripping.

1.2.3.4 Universal opto isolated logic inputs (relay hardware suffix C or greater)

If the last digit of the relay model number is 'C' or greater, the relay is fitted with universal opto isolated logic inputs that can be programmed for the nominal battery voltage of the circuit of which it is a part. These inputs nominally provide a logical 1 or 'On' value for voltages ≥80% of the set lower nominal voltage and a logical 0 or 'Off' value for voltages ≤60% of the set higher nominal voltage. The lower value eliminates fleeting pickups that may occur during a battery earth fault, when stray capacitance may present up to 50% of battery voltage across the input. Each input also has a pre-set filter of ½ cycle which renders the input immune to induced noise on the wiring: although this method is secure it can be slow, particularly for intertripping.

FD

Menu Text	Default Setting	Setting Range		Step Size
		Min.	Max.	
OPTO CONFIG.				
Global Nominal V	48/54V	24/27V, 30/34V, 48/54V, 110/125V, 220/250V or Custom		
Sets the nominal battery voltage for all opto inputs by selecting one of the five standard ratings in the Global Nominal V settings. If 'Custom' is selected then each opto input can individually be set to a nominal voltage value.				
Opto Input 1	48/54V	24/27V, 30/34V, 48/54V, 110/125V or 220/250V		
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting.				
Opto Input 2 - 32	48/54V	24/27V, 30/34V, 48/54V, 110/125V or 220/250V		
Each opto input can individually be set to a nominal voltage value if custom is selected for the global setting.				

Table 1: Opto isolated input configuration settings

In addition to the standard compliment of digital inputs, the P941 and P943 have additional expansion slots that can be used for additional hardware. The P941 has one expansion slot that can be fitted with an 8 digital input card, an 8 relay output card or a combination card with 4 inputs and 4 relay outputs. The P943 has two expansion slots with each slot capable of accepting an 8 digital input card or an 8 relay output card. The expansion slots on the P943 will not accept the combination card.

1.2.4 Power supply module (including output relays)

The power supply module contains two PCBs, one for the power supply unit itself and the other for the output relays. The power supply board also contains the input and output hardware for the rear communication port which provides an EIA(RS)485 communication interface.

1.2.4.1 Power supply board (including EIA(RS)485 communication interface)

One of three different configurations of the power supply board can be fitted to the relay. This will be specified at the time of order and depends on the nature of the supply voltage that will be connected to the relay. The three options are shown in table 1 below:

Nominal dc Range	Nominal ac Range
24/54 V	DC only
48/125 V	30/100 Vrms
110/250 V	100/240 Vrms

Table 2: Power supply options

The output from all versions of the power supply module are used to provide isolated power supply rails to all of the other modules within the relay. Three voltage levels are used within the relay, 5.1V for all of the digital circuits, ±16V for the analog electronics, e.g. on the input board, and 22V for driving the output relay coils. All power supply voltages including the 0V earth line are distributed around the relay via the 64-way ribbon cable. The power supply board provides one further voltage level that is the field voltage of 48V. This is brought out to terminals on the back of the relay so that it can be used to drive the optically isolated digital inputs.

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The two other functions provided by the power supply board are the EIA(RS)485 communications interface and the watchdog contacts for the relay. The EIA(RS)485 interface is used with the relay's rear communication port to provide communication using one of either Courier, MODBUS, IEC60870-5-103 or DNP3.0 protocols. The EIA(RS)485 hardware supports half-duplex communication and provides optical isolation of the serial data being transmitted and received. All internal communication of data from the power supply board is conducted via the output relay board that is connected to the parallel bus.

The watchdog facility provides two output relay contacts, one normally open and one normally closed that are driven by the processor board. These are provided to give an indication that the relay is in a healthy state.

The power supply board on relays with hardware suffix C or greater, incorporates inrush current limiting. This limits the peak inrush current during energization to approximately 10A.

1.2.4.2 Output relay board

Three versions of the output relay board are used within the P940 relays; two with 7 relays and one with 8 relays. In all cases the relays are driven from the 22V power supply line and the relays' state is written to or read from using the parallel data bus. The number of each type of board depends upon the relay model but can allow for between 7 and 30 output relay contacts.

1.2.4.2.1 7 Output relay board (relay hardware suffix A)

This board contains 3 normally open (make) and 4 changeover contacts, each with 5A continuous current carrying capacity (see section P94x/EN TD). On relays with hardware suffix A, this is the only output board available resulting in 7 outputs on the P941 and 14 outputs on the P943.

1.2.4.2.2 7 Output relay board (relay hardware suffix C or greater)

This board contains 3 normally open (make) and 4 changeover contacts, each with 10A continuous current carrying capacity (see section P94x/EN TD). On relays with hardware suffix C or greater, this board forms the base compliment of output relays to maintain compatibility between relay versions; relays 1 to 7 on all models and relays 8 to 14 on the P943.

1.2.4.2.3 8 Output relay board (relay hardware suffix C or greater)

This board contains 6 normally open (make) and 2 changeover contacts and is only used in the expansion slots on the P941 and P943. The P941 can have one optional expansion card that will increase the number of relay outputs to 15, whilst the P943 can have two optional expansion cards to increase the relay outputs to 30.

1.2.4.3 Input/output (4 + 4) relay board

The input/output relay board holds four isolated digital inputs and four output relays (10A rating), two with normally open contacts and two with changeover contacts. The output relays are driven from the 22V power supply line. The relays’ state is written to or read from using the parallel data bus.

This is used with the B model variant of the P941 relay that has 12 opto inputs and 11 output contacts.

1.2.4.4 IRIG-B board

The IRIG-B board is an order option that can be fitted to provide an accurate timing reference for the relay. This can be used wherever an IRIG-B signal is available. The IRIG-B signal is connected to the board via a BNC connector on the back of the relay. The timing information is used to synchronize the relay’s internal real-time clock to an accuracy of 1ms. The internal clock is then used for the time tagging of the event, fault maintenance and disturbance records.

The IRIG-B board can also be specified with a fiber optic transmitter/receiver that can be used for the rear communication port instead of the EIA(RS)485 electrical connection (IEC60870-5-103 only).

1.2.5 Mechanical layout

The case materials of the relay are constructed from pre-finished steel that has a conductive covering of aluminum and zinc. This provides good earthing at all joints giving a low impedance path to earth that is essential for performance in the presence of external noise. The boards and modules use a multi-point earthing strategy to improve the immunity to external noise and minimize the effect of circuit noise. Ground planes are used on boards to reduce impedance paths and spring clips are used to ground the module metalwork.

Heavy duty terminal blocks are used at the rear of the relay for the current and voltage signal connections. Medium duty terminal blocks are used for the digital logic input signals, the output relay contacts, the power supply and the rear communication port. A BNC connector is used for the optional IRIG-B signal. 9-pin and 25-pin female D-connectors are used at the front of the relay for data communication.

Inside the relay the PCBs plug into the connector blocks at the rear, and can be removed from the front of the relay only.

The front panel consists of a membrane keypad with tactile dome keys, an LCD and 12 LEDs mounted on an aluminum backing plate.

1.3 Relay software

The relay software was introduced in the overview of the relay at the start of this manual (P94x/EN FD). The software can be considered to be made up of four sections:

- The real-time operating system
- The system services software
- The platform software
- The protection & control software

This section describes in detail the latter two of these, the platform software and the protection & control software, which between them control the functional behavior of the relay. Figure 3 shows the structure of the relay software.

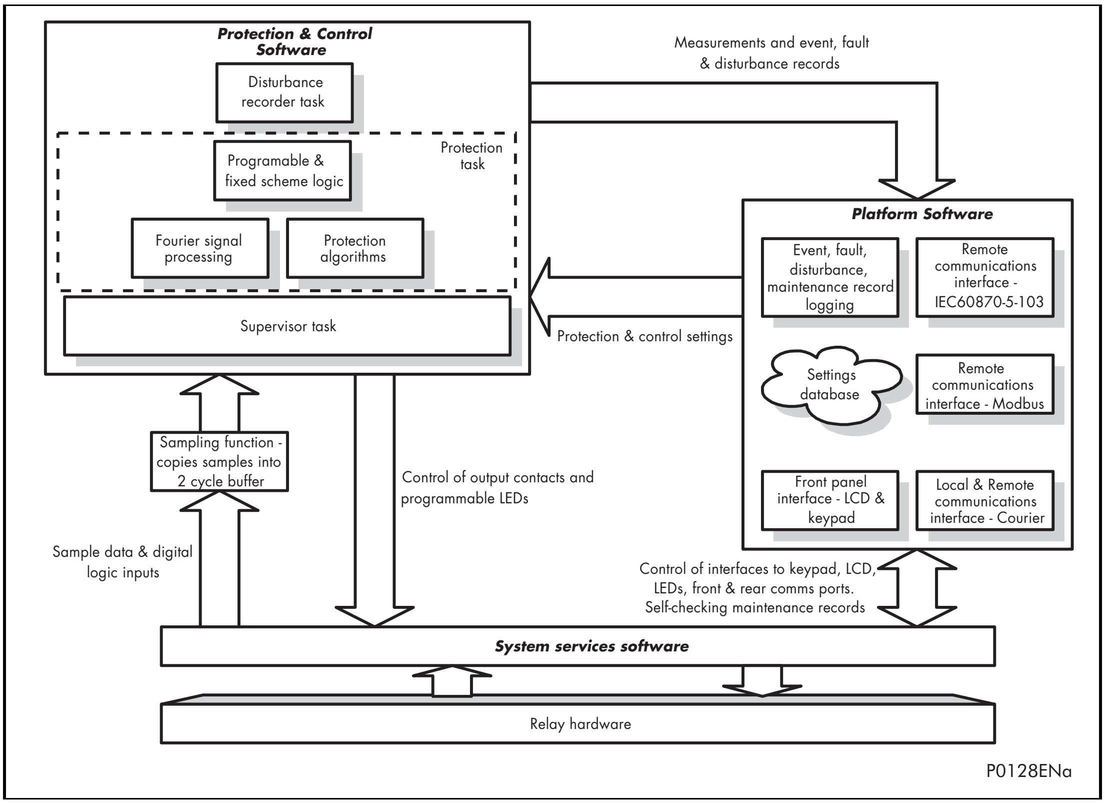

Figure 3: Relay software structure

1.3.1 Real-time operating system

The software is split into tasks; the real-time operating system is used to schedule the processing of the tasks to ensure that they are processed in the time available and in the desired order of priority. The operating system is also responsible in part for controlling the communication between the software tasks through the use of operating system messages.

1.3.2 System services software

As shown in Figure 3, the system services software provides the interface between the relay's hardware and the higher-level functionality of the platform software and the protection & control software. For example, the system services software provides drivers for items such as the LCD display, the keypad and the remote communication ports, and controls the boot of the processor and downloading of the processor code into SRAM from flash EPROM at power up.

1.3.3 Platform software

The platform software has three main functions:

- To control the logging of records that are generated by the protection software, including alarms and event, fault, and maintenance records.
- To store and maintain a database of all of the relay's settings in non-volatile memory.
- To provide the internal interface between the settings database and each of the relay's user interfaces, i.e. the front panel interface and the front and rear communication ports, using whichever communication protocol has been specified (Courier, MODBUS, IEC 60870-5-103 or DNP3.0).

1.3.3.1 Record logging

The logging function is provided to store all alarms, events, faults and maintenance records. The records for all of these incidents are logged in battery backed-up SRAM in order to provide a non-volatile log of what has happened. The relay maintains four logs: one each for up to 32 alarms, 250 event records, 5 fault records and 5 maintenance records. The logs are maintained such that the oldest record is overwritten with the newest record. The logging function can be initiated from the protection software or the platform software is responsible for logging of a maintenance record in the event of a relay failure. This includes errors that have been detected by the platform software itself or error that are detected by either the system services or the protection software function. See also the section on supervision and diagnostics later in this document (P94x/EN FD).

1.3.3.2 Settings database

The settings database contains all of the settings and data for the relay, including the protection, disturbance recorder and control & support settings. The settings are maintained in non-volatile memory. The platform software's management of the settings database includes the responsibility of ensuring that only one user interface modifies the settings of the database at any one time. This feature is employed to avoid conflict between different parts of the software during a setting change. For changes to protection settings and disturbance recorder settings, the platform software operates a 'scratchpad' in SRAM memory. This allows a number of setting changes to be applied to the protection elements, disturbance recorder and saved in the database in non-volatile memory. (See also the Introduction to this manual (P94x/EN IT) on the user interface). If a setting change affects the protection & control task, the database advises it of the new values.

1.3.3.3 Database interface

The other function of the platform software is to implement the relay's internal interface between the database and each of the relay's user interfaces. The database of settings and measurements must be accessible from all of the relay's user interfaces to allow read and modify operations. The platform software presents the data in the appropriate format for each user interface.

1.3.4 Protection and control software

The protection and control software task is responsible for processing all of the protection elements and measurement functions of the relay. To achieve this it has to communicate with both the system services software and the platform software as well as organize its own operations. The protection software has the highest priority of any of the software tasks in the relay in order to provide the fastest possible protection response. The protection & control software has a supervisor task that controls the start-up of the task and deals with the exchange of messages between the task and the platform software.

1.3.4.1 Overview - protection and control scheduling

After initialization at start-up, the protection and control task is suspended until there are sufficient samples available for it to process. The acquisition of samples is controlled by a 'sampling function' which is called by the system services software and takes each set of new samples from the input module and stores them in a two-cycle buffer. The protection and control software resumes execution when the number of unprocessed samples in the buffer reaches a certain number. For the P940 frequency protection relay, the protection task is executed twice per cycle, i.e. after every 12 samples for the sample rate of 24 samples per power cycle used by the relay. The protection and control software is suspended again when all of its processing on a set of samples is complete. This allows operations by other software tasks to take place.

1.3.4.2 Signal processing

The sampling function provides filtering of the digital input signals from the opto-isolators and frequency tracking of the analog signals. The digital inputs are checked against their previous value over a period of half a cycle. Hence a change in the state of one of the inputs must be maintained over at least half a cycle before it is registered with the protection and control software.

The frequency tracking of the analog input signals is achieved by a recursive Fourier algorithm which is applied to one of the input signals, and works by detecting a change in the measured signal's phase angle. The calculated value of the frequency is used to modify the sample rate being used by the input module so as to achieve a constant sample rate of 24 samples per cycle of the power waveform. The value of the frequency is also stored for use by the protection and control task.

1.3.4.3 Fourier filtering

When the protection and control task is re-started by the sampling function, it calculates the Fourier components for the analog signals. With the exception of the RMS measurements all other measurements and protection functions are based on the Fourier derived fundamental component. The Fourier components are calculated using a one-cycle, 24-sample Discrete Fourier Transform (DFT). The DFT is always calculated using the last cycle of samples from the 2-cycle buffer, i.e. the most recent data is used. The DFT used in this way extracts the power frequency fundamental component from the signal and produces the magnitude and phase angle of the fundamental in rectangular component format. This gives good harmonic rejection for frequencies up to the 23rd harmonic. The 23rd is the first predominant harmonic that is not attenuated by the Fourier filter and this is known as 'Alias'. However, the Alias is attenuated by approximately 85% by an additional, analog, 'anti-aliasing' filter (low pass filter). The combined affect of the anti-aliasing and Fourier filters is shown below:

FD

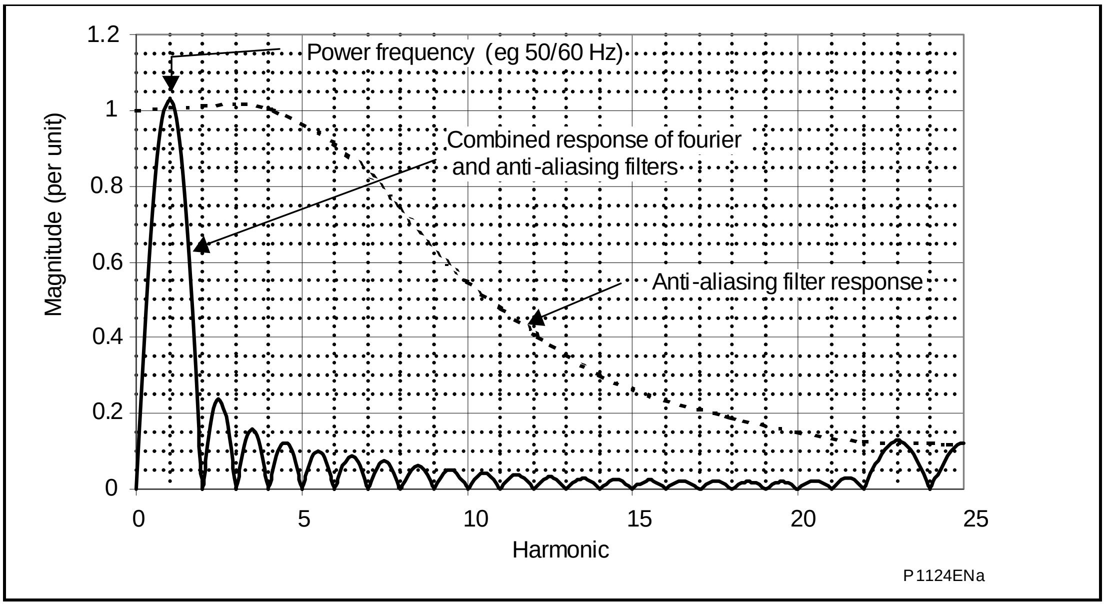

Figure 4: Frequency response

The Fourier components of the input voltage signals are stored in memory so that they can be accessed by all of the protection elements' algorithms. The samples from the input module are also used in an unprocessed form by the disturbance recorder for waveform recording and to calculate true rms. values of voltage for metering purposes.

1.3.4.4 Programmable scheme logic

The purpose of the programmable scheme logic (PSL) is to allow the relay user to configure an individual protection scheme to suit their own particular application. This is achieved through the use of programmable logic gates and delay timers.

The input to the PSL is any combination of the status of the digital input signals from the opto-isolators on the input board, the outputs of the protection elements, e.g. protection starts and trips, control inputs and the outputs of the fixed protection scheme logic. The fixed scheme logic provides the relay's standard protection schemes. The PSL itself consists of software logic gates and timers. The logic gates can be programmed to perform a range of different logic functions and can accept any number of inputs. The timers are used either to create a programmable delay, and/or to condition the logic outputs, e.g. to create a pulse of fixed duration on the output regardless of the length of the pulse on the input. The outputs of the PSL are the LEDs on the front panel of the relay and the output contacts at the rear.

The execution of the PSL logic is event driven; the logic is processed whenever any of its inputs change, for example as a result of a change in one of the digital input signals or a trip output from a protection element. Also, only the part of the PSL logic that is affected by the particular input change that has occurred is processed. This reduces the amount of processing time that is used by the PSL. The protection and control software updates the logic delay timers and checks for a change in the PSL input signals every time it runs.

This system provides flexibility for the user to create their own scheme logic design. However, it also means that the PSL can be configured into a very complex system, and because of this setting of the PSL is implemented through the PC support package MiCOM S1.

Note: Each setting group has its own PSL. Once a PSL has been designed it can be sent to any one of 4 setting groups within the relay. When downloading a PSL to the relay the user will be prompted to enter the desired setting group to which it will be sent. If the user fails to download the required PSL to any setting group that may be brought into service, then factory default PSL will still be resident and this may have severe operational and safety consequences.

1.3.4.5 Event and fault recording

A change in any digital input signal or protection element output signal causes an event record to be created. When this happens, the protection and control task sends a message to the supervisor task to indicate that an event is available to be processed and writes the event data to a fast buffer in SRAM which is controlled by the supervisor task. When the supervisor task receives either an event or fault record message, it instructs the platform software to create the appropriate log in battery backed-up SRAM. The operation of the record logging to battery backed-up SRAM is slower than the supervisor's buffer. This means that the protection software is not delayed waiting for the records to be logged by the platform software. However, in the rare case when a large number of records to be logged are created in a short period of time, it is possible that some will be lost if the supervisor's buffer is full before the platform software is able to create a new log in battery backed-up SRAM. If this occurs then an event is logged to indicate this loss of information.

1.3.4.6 Disturbance recorder

The disturbance recorder operates as a separate task from the protection and control task. It can record the waveforms for up to 4 analogue channels and the values of up to 32 digital signals. The recording time is user selectable up to a maximum of 10 seconds. The disturbance recorder is supplied with data by the protection and control task once per cycle. The disturbance recorder collates the data that it receives into the required length disturbance record. It attempts to limit the demands it places on memory space by saving the analogue data in compressed format whenever possible. This is done by detecting changes in the analogue input signals and compressing the recording of the waveform when it is in a steady-state condition. The compressed disturbance records can be decompressed by MiCOM S1 which can also store the data in COMTRADE format, thus allowing the use of other packages to view the recorded data.

1.4 Self testing & diagnostics

The relay includes a number of self-monitoring functions to check the operation of its hardware and software when it is in service. These are included so that if an error or fault occurs within the relay's hardware or software, the relay is able to detect and report the problem and attempt to resolve it by performing a re-boot. This involves the relay being out of service for a short period of time which is indicated by the 'Healthy' LED on the front of the relay being extinguished and the watchdog contact at the rear operating. If the restart fails to resolve the problem, then the relay will take itself permanently out of service. Again this will be indicated by the LED and watchdog contact.

If a problem is detected by the self-monitoring functions, the relay attempts to store a maintenance record in battery backed-up SRAM to allow the nature of the problem to be notified to the user.

The self-monitoring is implemented in two stages: firstly a thorough diagnostic check which is performed when the relay is booted-up, e.g. at power-on, and secondly a continuous self-checking operation which checks the operation of the relay's critical functions whilst it is in service.

1.4.1 Start-up self-testing

The self-testing which is carried out when the relay is started takes a few seconds to complete, during which time the relay's protection is unavailable. This is signaled by the 'Healthy' LED on the front of the relay which will illuminate when the relay has passed all of the tests and entered operation. If the testing detects a problem, the relay will remain out of service until it is manually restored to working order.

The operations that are performed at start-up are as follows:

1.4.1.1 System boot

The integrity of the flash memory is verified using a checksum before the program code and data stored in it is copied into SRAM to be used for execution by the processor. When the copy has been completed the data then held in SRAM is compared to that in the flash to ensure that the two are the same and that no errors have occurred in the transfer of data from flash to SRAM. The entry point of the software code in SRAM is then called which is the relay initialization code.

1.4.1.2 Initialization software

The initialization process includes the operations of initializing the processor registers and interrupts, starting the watchdog timers (used by the hardware to determine whether the software is still running), starting the real-time operating system and creating and starting the supervisor task. In the course of the initialization process the relay checks:

- The status of the battery
- The integrity of the battery backed-up SRAM that is used to store event, fault and disturbance records
- The voltage level of the field voltage supply which is used to drive the opto-isolated inputs
- The operation of the LCD controller
- The watchdog operation

At the conclusion of the initialization software the supervisor task begins the process of starting the platform software.

1.4.1.3 Platform software initialization & monitoring

In starting the platform software, the relay checks the integrity of the data held in non-volatile memory with a checksum, the operation of the real-time clock, and the IRIG-B board if fitted. The final test that is made concerns the input and output of data; the presence and healthy condition of the input board is checked and the analog data acquisition system is checked through sampling the reference voltage.

At the successful conclusion of all of these tests the relay is entered into service and the protection started-up.

1.4.2 Continuous self-testing

When the relay is in service, it continually checks the operation of the critical parts of its hardware and software. The checking is carried out by the system services software (see section on relay software earlier in this document (P94x/EN FD)) and the results reported to the platform software. The functions that are checked are as follows:

- The flash containing all program code setting values and language text is verified by a checksum
- The code and constant data held in SRAM is checked against the corresponding data in flash to check for data corruption
- The SRAM containing all data other than the code and constant data is verified with a checksum
- The battery status
- The level of the field voltage
- The integrity of the digital signal I/O data from the opto-isolated inputs and the relay contacts is checked by the data acquisition function every time it is executed. The operation of the analog data acquisition system is continuously checked by the acquisition function every time it is executed, by means of sampling the reference voltages
- The operation of the IRIG-B board is checked, where it is fitted, by the software that reads the time and date from the board

In the unlikely event that one of the checks detects an error within the relay's subsystems, the platform software is notified and it will attempt to log a maintenance record in battery backed-up SRAM. If the problem is with the battery status or the IRIG-B board, the relay will continue in operation. However, for problems detected in any other area the relay will initiate a shutdown and re-boot. This will result in a period of up to 5 seconds when the protection is unavailable, but the complete restart of the relay including all initializations should clear most problems that could occur. As described above, an integral part of the start-up procedure is a thorough diagnostic self-check. If this detects the same problem that caused the relay to restart, i.e. the restart has not cleared the problem, then the relay will take itself permanently out of service. This is indicated by the 'Healthy' LED on the front of the relay, which will extinguish, and the watchdog contact that will operate.

Watchdog (self-monitoring) contacts are provided in numerical relays to indicate the health of the device. Schneider Electric strongly recommends that these contacts are hardwired into the substation's automation system, for alarm purposes.

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COMMISSIONING

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Date:	**2008**
Hardware Suffix:	**A or C**
Software Version:	**12**
Connection Diagrams:	**10P94yxx (y = 1 or 3) (x = 01 to 06)**

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CONTENTS

TABLES

1. INTRODUCTION

The MiCOM P940 frequency protection relays are fully numerical in their design, implementing all protection and non-protection functions in software. The relays employ a high degree of self-checking and, in the unlikely event of a failure, will give an alarm. As a result of this, the commissioning tests do not need to be as extensive as with non-numeric electronic or electro-mechanical relays.

To commission numeric relays, it is only necessary to verify that the hardware is functioning correctly and the application-specific software settings have been applied to the relay. It is considered unnecessary to test every function of the relay if the settings have been verified by one of the following methods:

- Extracting the settings applied to the relay using appropriate setting software (preferred method)
- Via the operator interface

Unless previously agreed to the contrary, the customer will be responsible for determining the application-specific settings to be applied to the relay and for testing of any scheme logic applied by external wiring and/or configuration of the relay's internal programmable scheme logic.

Blank commissioning test and setting records are provided at the end of this chapter for completion as required.

As the relay's menu language is user-selectable, it is acceptable for the Commissioning Engineer to change it to allow accurate testing as long as the menu is restored to the customer's preferred language on completion.

To simplify the specifying of menu cell locations in these Commissioning Instructions, they will be given in the form [courier reference: COLUMN HEADING, Cell Text]. For example, the cell for selecting the menu language (first cell under the column heading) is located in the System Data column (column 00) so it would be given as [0001: SYSTEM DATA, Language].

Before carrying out any work on the equipment, the user should be familiar with the contents of the Safety Guide (SFTY/4L M/C11) or later issue, or the Safety and Technical Data sections of this Technical Manual and also the ratings on the equipment's rating label.

The MiCOM P94x relay must not be disassembled in any way during commissioning.

2. RELAY COMMISSIONING TOOLS

To help minimize the time required to test MiCOM relays the relay provides several test facilities under the 'COMMISSION TESTS' menu heading. There are menu cells which allow the status of the opto-isolated inputs, output relay contacts, internal digital data bus (DDB) signals and user-programmable LEDs to be monitored. Additionally there are cells to test the operation of the output contacts and user-programmable LEDs.

The following table shows the relay menu of commissioning tests, including the available setting ranges and factory defaults:

Menu Text	Default Setting	Settings
COMMISSION TESTS		
Opto I/P Status	–	–
Relay O/P Status	–	–
Test Port Status	–	–
LED Status	–	–
Monitor Bit 1	64 (LED 1)	0 to 1022 See section P94x/EN PL for details of Digital Data Bus signals
Monitor Bit 2	65 (LED 2)	0 to 1022
Monitor Bit 3	66 (LED 3)	0 to 1022
Monitor Bit 4	67 (LED 4)	0 to 1022
Monitor Bit 5	68 (LED 5)	0 to 1022
Monitor Bit 6	69 (LED 6)	0 to 1022
Monitor Bit 7	70 (LED 7)	0 to 1022
Monitor Bit 8	71 (LED 8)	0 to 1022
Test Mode	Disabled	Disabled Test Mode Contacts Blocked
Test Pattern	All bits set to 0	0 = Not Operated 1 = Operated
Contact Test	No Operation	No Operation Apply Test Remove Test
Test LEDs	No Operation	No Operation Apply Test

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2.1 Opto I/P status

This menu cell displays the status of the relay's opto-isolated inputs as a binary string, a '1' indicating an energized opto-isolated input and a '0' a de-energized one. If the cursor is moved along the binary numbers the corresponding label text will be displayed for each logic input.

It can be used during commissioning or routine testing to monitor the status of the opto-isolated inputs whilst they are sequentially energized with a suitable dc voltage.

2.2 Relay O/P status

This menu cell displays the status of the digital data bus (DDB) signals that result in energization of the output relays as a binary string, a '1' indicating an operated state and '0' a non-operated state. If the cursor is moved along the binary numbers the corresponding label text will be displayed for each relay output.

The information displayed can be used during commissioning or routine testing to indicate the status of the output relays when the relay is 'in service'. Additionally fault finding for output relay damage can be performed by comparing the status of the output contact under investigation with its associated bit.

Note: When the 'Test Mode' cell is set to 'Contacts Blocked' this cell will continue to indicate which contacts would operate if the relay was in-service, it does not show the actual status of the output relays.

2.3 Test port status

This menu cell displays the status of the eight digital data bus (DDB) signals that have been allocated in the 'Monitor Bit' cells. If the cursor is moved along the binary numbers the corresponding DDB signal text string will be displayed for each monitor bit.

By using this cell with suitable monitor bit settings, the state of the DDB signals can be displayed as various operating conditions or sequences are applied to the relay. Thus the programmable scheme logic can be tested.

As an alternative to using this cell, the optional monitor/download port test box can be plugged into the monitor/download port located behind the bottom access cover. Details of the monitor/download port test box can be found in section 2.10 of this section (P94x/EN CM).

2.4 LED status

The 'LED Status' cell is an eight bit binary string that indicates which of the user-programmable LEDS on the relay are illuminated, a '1' indicating a particular LED is lit and a '0' not lit.

2.5 Monitor bits 1 to 8

The eight 'Monitor Bit' cells allow the user to select the status of which digital data bus signals can be observed in the 'Test Port Status' cell or via the monitor/download port.

Each 'Monitor Bit' is set by entering the required digital data bus (DDB) signal number (0 - 1022) from the list of available DDB signals in section P94x/EN PL. The pins of the monitor/download port used for monitor bits are given in the table below. The signal ground is available on pins 18, 19, 22 and 25.

Monitor bit	1	2	3	4	5	6	7	8
Monitor/download port pin	11	12	15	13	20	21	23	24

THE MONITOR/DOWNLOAD PORT IS NOT ELECTRICALLY ISOLATED AGAINST INDUCED VOLTAGES ON THE COMMUNICATIONS CHANNEL. IT SHOULD THEREFORE ONLY BE USED FOR LOCAL COMMUNICATIONS.

2.6 Test mode

The Test Mode menu cell is used to allow secondary injection testing to be performed on the relay and also enables a facility to directly test the output contacts by applying menu controlled test signals. To select test mode the Test Mode menu cell should be set to 'Test Mode'. This takes the relay out of service causing an alarm condition to be recorded and the yellow 'Out of Service' LED to illuminate and an alarm message 'Prot'n. Disabled' is given. In relays using IEC60870-5-103 protocol this will change the Cause of Transmission, COT, to Test Mode. (Test mode can also be selected by energizing an opto input mapped to the Test mode signal in the programmable scheme logic).

To enable testing of output contacts the Test Mode cell should be set to Contacts Blocked. This blocks the protection from operating the contacts and enables the test pattern and contact test functions which can be used to manually operate the output contacts.

Once testing is complete the cell must be set back to 'Disabled' to restore the relay back to service.

2.7 Test pattern

The ‘Test Pattern’ cell is used to select the output relay contacts that will be tested when the ‘Contact Test’ cell is set to ‘Apply Test’. The cell has a binary string with one bit for each user-configurable output contact which can be set to ‘1’ to operate the output under test conditions and ‘0’ to not operate it.

2.8 Contact test

When the ‘Apply Test’ command in this cell is issued the contacts set for operation (set to ‘1’) in the ‘Test Pattern’ cell change state. After the test has been applied the command text on the LCD will change to ‘No Operation’ and the contacts will remain in the Test State until reset issuing the ‘Remove Test’ command. The command text on the LCD will again revert to ‘No Operation’ after the ‘Remove Test’ command has been issued.

Note: When the ‘Test Mode’ cell is set to ‘Enabled’ the ‘Relay O/P Status’ cell does not show the current status of the output relays and hence can not be used to confirm operation of the output relays. Therefore it will be necessary to monitor the state of each contact in turn.

2.9 Test LEDs

When the ‘Apply Test’ command in this cell is issued the eight user-programmable LEDs will illuminate for approximately 2 seconds before they extinguish and the command text on the LCD reverts to ‘No Operation’.

2.10 Using a monitor/download port test box

A monitor/download port test box (part no. ZG1094 001) containing 8 LEDs and a switchable audible indicator is available from Schneider Electric, or one of their regional sales offices. It is housed in a small plastic box with a 25-pin male D-connector that plugs directly into the relay’s monitor/download port. There is also a 25-pin female D-connector which allows other connections to be made to the monitor/download port whilst the monitor/download port test box is in place.

Each LED corresponds to one of the monitor bit pins on the monitor/download port with ‘Monitor Bit 1’ being on the left hand side when viewing from the front of the relay. The audible indicator can either be selected to sound if a voltage appears on any of the eight monitor pins or remain silent so that indication of state is by LED alone.

3. SETTING FAMILIARIZATION

When commissioning a MiCOM P94x relay for the first time, sufficient time should be allowed to become familiar with the method by which the settings are applied.

The Getting Started section (P94x/EN GS) contains a detailed description of the menu structure of P94x relays.

With the secondary front cover (optional) in place all keys except the key are accessible. All menu cells can be read. LEDs and alarms can be reset. However, no protection or configuration settings can be changed, or fault and event records cleared.

Removing the secondary front cover allows access to all keys so that settings can be changed, LEDs and alarms reset, and fault and event records cleared. However, menu cells that have access levels higher than the default level will require the appropriate password to be entered before changes can be made.

Alternatively, if a portable PC is available together with suitable setting software (such as MiCOM S1), the menu can be viewed a page at a time to display a full column of data and text. This PC software also allows settings to be entered more easily, saved to a file on disk for future reference or printed to produce a setting record. Refer to the PC software user manual for details. If the software is being used for the first time, allow sufficient time to become familiar with its operation.

4. EQUIPMENT REQUIRED FOR COMMISSIONING

4.1 Minimum equipment required

Multifunctional dynamic current and voltage injection test set.

Multimeter with suitable ac and dc voltage ranges of 0 - 440V and 0 - 250V respectively.

Continuity tester (if not included in multimeter).

Phase rotation meter.

Note: Modern test equipment may contain many of the above features in one unit.

4.2 Optional equipment

Multi-finger test plug type P992 (if test block type P991 installed) or MMLB (if using MMLG blocks).

An electronic or brushless insulation tester with a dc output not exceeding 500V (for insulation resistance testing when required).

A portable PC, with appropriate software (this enables the rear communications port to be tested, if this is to be used, and will also save considerable time during commissioning).

KITZ K-Bus to EIA(RS)232 protocol converter (if EIA(RS)485 K-Bus port is being tested and one is not already installed).

EIA(RS)485 to EIA(RS)232 converter (if EIA(RS)485 MODBUS/IEC60870/DNP3.0 port is being tested).

A printer (for printing a setting record from the portable PC).

5. PRODUCT CHECKS

These product checks cover all aspects of the relay which should be checked to ensure that it has not been physically damaged prior to commissioning, is functioning correctly and all input quantity measurements are within the stated tolerances.

If the application-specific settings have been applied to the relay prior to commissioning, it is advisable to make a copy of the settings so as to allow their restoration later. This could be done by:

- Obtaining a setting file on a diskette from the customer (this requires a portable PC with appropriate setting software for transferring the settings from the PC to the relay)
- Extracting the settings from the relay itself (this again requires a portable PC with appropriate setting software)
- Manually creating a setting record. This could be done using a copy of the setting record located at the end of this chapter to record the settings as the relay's menu is sequentially stepped through via the front panel user interface

If password protection is enabled and the customer has changed password 2 that prevents unauthorized changes to some of the settings, either the revised password 2 should be provided, or the customer should restore the original password prior to commencement of testing.

Note: In the event that the password has been lost, a recovery password can be obtained from Schneider Electric by quoting the serial number of the relay. The recovery password is unique to that relay and is unlikely to work on any other relay.

5.1 With the relay de-energized

The following group of tests should be carried out without the auxiliary supply being applied to the relay and with the trip circuit isolated.

The voltage transformer connections must be isolated from the relay for these checks. If a P991 test block is provided, the required isolation can easily be achieved by inserting test plug type P992 that effectively open-circuits all wiring routed through the test block.

Before inserting the test plug, reference should be made to the scheme (wiring) diagram to ensure that this will not potentially cause damage or a safety hazard. For example, the test block may be associated with protection current transformer circuits. It is essential that the sockets in the test plug, which correspond to the current transformer secondary windings, are linked before the test plug is inserted into the test block.

DANGER: Never open circuit the secondary circuit of a current transformer since the high voltage produced may be lethal and could damage insulation.

If a test block is not provided, the voltage transformer supply to the relay should be isolated by means of the panel links or connecting blocks. Where means of isolating the auxiliary supply and trip circuit (e.g. isolation links, fuses, MCB, etc.) are provided, these should be used. If this is not possible, the wiring to these circuits will have to be disconnected and the exposed ends suitably terminated to prevent them from being a safety hazard.

5.1.1 Visual inspection

The rating information given under the top access cover on the front of the relay should be checked. Check that the relay being tested is correct for the protected line/circuit. Ensure that the circuit reference and system details are entered onto the setting record sheet.

Carefully examine the relay to see that no physical damage has occurred since installation.

Ensure that the case earthing connections, bottom left-hand corner at the rear of the relay case, are used to connect the relay to a local earth bar using an adequate conductor.

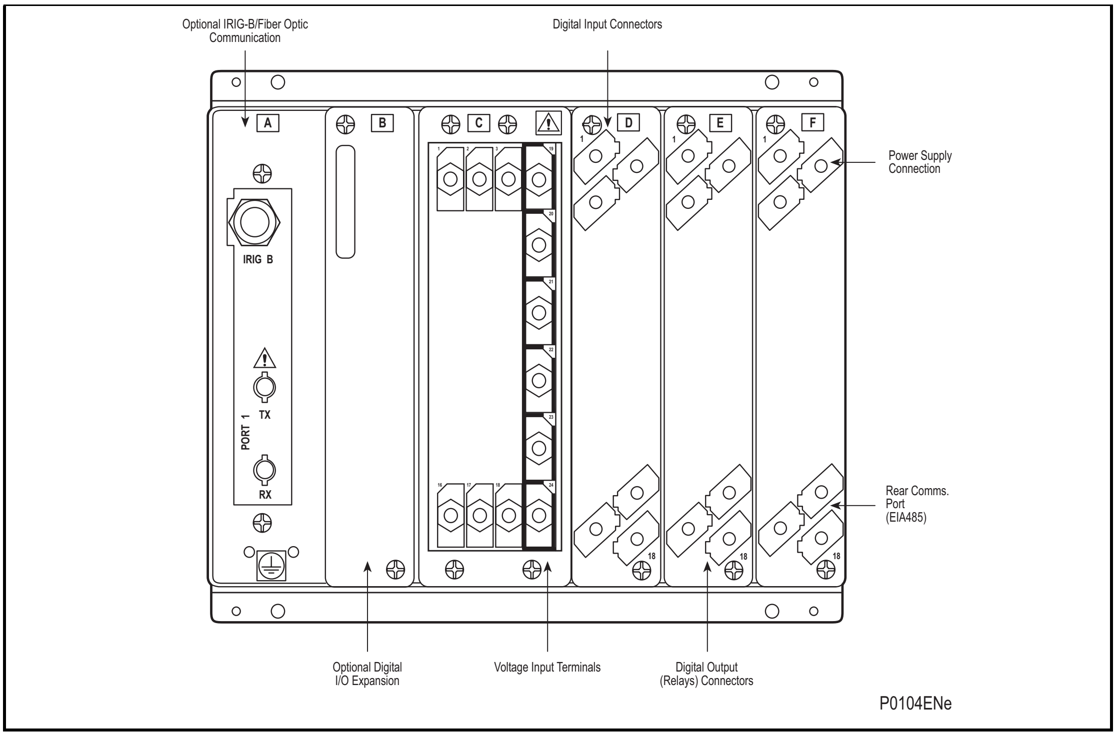

Figure 1: P941 Rear View (40TE) with hardware expansion and optional IRIG-B & fiber optic interface

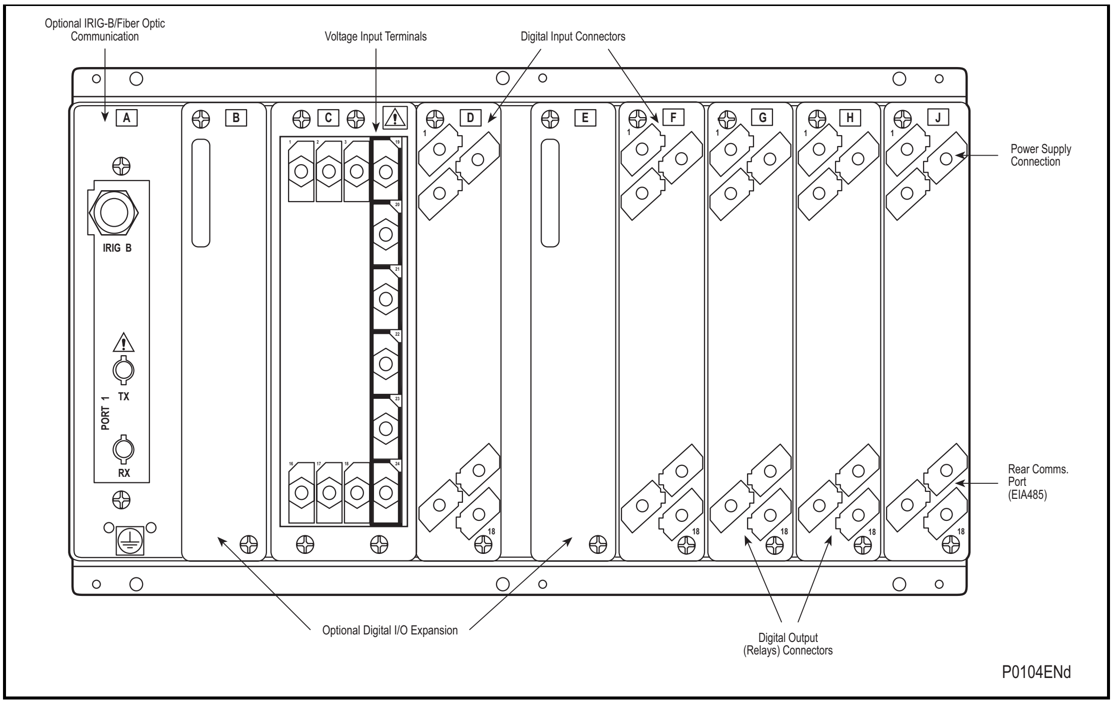

Figure 2: P943 Rear View (60TE) with hardware expansion and optional IRIG-B & fiber optic interface

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5.1.2 Insulation

Insulation resistance tests are only necessary during commissioning if it is required for them to be done and they have not been performed during installation.

Isolate all wiring from the earth and test the insulation with an electronic or brushless insulation tester at a dc voltage not exceeding 500V. Terminals of the same circuits should be temporarily connected together.

The main groups of relay terminals are:

Voltage transformer circuits

Auxiliary voltage supply

Field voltage output and opto-isolated control inputs

Relay contacts

EIA(RS)485 communication port

Case earth

The insulation resistance should be greater than 100MΩ at 500V.

On completion of the insulation resistance tests, ensure all external wiring is correctly reconnected to the relay.

5.1.3 External wiring

Check that the external wiring is correct to the relevant relay diagram and scheme diagram. Ensure as far as practical that phasing/phase rotation appears to be as expected. The relay diagram number appears on the rating label under the top access cover on the front of the relay.

If a P991 test block is provided, the connections should be checked against the scheme (wiring) diagram. It is recommended that the supply connections are to the live side of the test block colored orange with the odd numbered terminals (1, 3, 5, 7 etc.). The auxiliary supply is normally routed via terminals 13 (supply positive) and 15 (supply negative), with terminals 14 and 16 connected to the relay's positive and negative auxiliary supply terminals respectively. However, check the wiring against the schematic diagram for the installation to ensure compliance with the customer's normal practice.

5.1.4 Watchdog contacts

Using a continuity tester, check that the watchdog contacts are in the states given in Table 1 for a de-energized relay.

Terminals		Contact State	
		Relay De-energized	Relay Energized
F11 - F12 J11 - J12	P941 P943	Closed	Open
F13 - F14 J13 - J14	P941 P943	Open	Closed

Table 1: Watchdog contact status

Watchdog (self-monitoring) contacts are provided in numerical relays to indicate the health of the device. Schneider Electric strongly recommends that these contacts are hardwired into the substation's automation system, for alarm purposes.

5.1.5 Auxiliary supply

The relay can be operated from either a dc only or AC/DC auxiliary supply depending on the relay's nominal supply rating. The incoming voltage must be within the operating range specified in Table 2.

Without energizing the relay measure the auxiliary supply to ensure it is within the operating range.

Nominal Supply Rating DC [AC rms]		DC Operating Range	AC Operating Range
24 - 48V	[-]	19 to 65V	-
48 - 110V	[30 - 100V]	37 to 150V	24 - 110V
125 - 250V	[100 - 240V]	87 to 300V	80 to 265V

Table 2: Operational range of auxiliary supply Vx

It should be noted that the relay can withstand an ac ripple of up to 12% of the upper rated voltage on the dc auxiliary supply.

Do not energize the relay or interface unit using the battery charger with the battery disconnected as this can irreparably damage the relay’s power supply circuitry.

Energize the relay only if the auxiliary supply is within the specified operating ranges. If a test block is provided, it may be necessary to link across the front of the test plug to connect the auxiliary supply to the relay.

5.2 With the relay energized

The following group of tests verify that the relay hardware and software is functioning correctly and should be carried out with the auxiliary supply applied to the relay.

The voltage transformer connections must remain isolated from the relay for these checks. The trip circuit should also remain isolated to prevent accidental operation of the associated circuit breaker.

5.2.1 Watchdog contacts

Using a continuity tester, check the watchdog contacts are in the states given in Table 1 for an energized relay.

5.2.2 Date and time

Before setting the date and time, ensure that the factory-fitted battery isolation strip, that prevents battery drain during transportation and storage, has been removed. With the lower access cover open, presence of the battery isolation strip can be checked by a red tab protruding from the positive side of the battery compartment. Whilst lightly pressing the battery, to prevent it from falling out of the battery compartment, pull the red tab to remove the isolation strip.

The date and time should now be set to the correct values. The method of setting will depend on whether accuracy is being maintained via the optional Inter-Range Instrumentation Group standard B (IRIG-B) port on the rear of the relay.

5.2.2.1 With an IRIG-B signal

If a satellite time clock signal conforming to IRIG-B is provided and the relay has the optional IRIG-B port fitted, the satellite clock equipment should be energized.

To allow the relay’s time and date to be maintained from an external IRIG-B source cell [0804: DATE and TIME, IRIG-B Sync.] must be set to ‘Enabled’.

Ensure the relay is receiving the IRIG-B signal by checking that cell [0805: DATE and TIME, IRIG-B Status] reads ‘Active’.

Once the IRIG-B signal is active, adjust the time offset of the universal co-ordinated time (satellite clock time) on the satellite clock equipment so that local time is displayed.

Check the time, date and month are correct in cell [0801: DATE and TIME, Date/Time]. The IRIG-B signal does not contain the current year so it will need to be set manually in this cell.

In the event of the auxiliary supply failing, with a battery fitted in the compartment behind the bottom access cover, the time and date will be maintained. Therefore, when the auxiliary supply is restored, the time and date will be correct and not need to be set again.

To test this, remove the IRIG-B signal, and then remove the auxiliary supply from the relay. Leave the relay de-energized for approximately 30 seconds. On re-energization, the time in cell [0801: DATE and TIME, Date/Time] should be correct.

Reconnect the IRIG-B signal.

5.2.2.2 Without an IRIG-B signal

If the time and date is not being maintained by an IRIG-B signal, ensure that cell [0804: DATE and TIME, IRIG-B Sync.] is set to ‘Disabled’.

Set the date and time to the correct local time and date using cell [0801: DATE and TIME, Date/Time].

In the event of the auxiliary supply failing, with a battery fitted in the compartment behind the bottom access cover, the time and date will be maintained. Therefore when the auxiliary supply is restored the time and date will be correct and not need to be set again.

To test this, remove the auxiliary supply from the relay for approximately 30 seconds. On re-energization, the time in cell [0801: DATE and TIME, Date/Time] should be correct.

5.2.3 Light emitting diodes (LEDs)

On power up the green LED should have illuminated and stayed on indicating that the relay is healthy. The relay has non-volatile memory which remembers the state (on or off) of the alarm, trip and, if configured to latch, user-programmable LED indicators when the relay was last energized from an auxiliary supply. Therefore these indicators may also illuminate when the auxiliary supply is applied.

If any of these LEDs are on then they should be reset before proceeding with further testing. If the LEDs successfully reset (the LED goes out), there is no testing required for that LED because it is known to be operational.

Note: It is likely that alarms related to the communications channels will not reset at this stage.

5.2.3.1 Testing the alarm and out of service LEDs

The alarm and out of service LEDs can be tested using the COMMISSION TESTS menu column. Set cell [0F0D: COMMISSION TESTS, Test Mode] to ‘Contacts Blocked’. Check that the out of service LED illuminates continuously and the alarm LED flashes.

It is not necessary to return cell [0F0D: COMMISSION TESTS, Test Mode] to ‘Disabled’ at this stage because the test mode will be required for later tests.

CM

5.2.3.2 Testing the trip LED

The trip LED will operate during the setting checks performed later. Therefore no further testing of the trip LED is required at this stage.

5.2.3.3 Testing the user-programmable LEDs

To test the user-programmable LEDs set cell [0F10: COMMISSION TESTS, Test LEDs] to ‘Apply Test’. Check that all 8 programmable LEDs on the relay illuminate.

5.2.4 Field voltage supply

The relay generates a field voltage of nominally 48V that can be used to energize the opto-isolated inputs (alternatively the substation battery may be used).

Measure the field voltage across the terminals 7 and 9 on the terminal block given in Table 3. Check that the field voltage is within the range 40V to 60V when no load is connected and that the polarity is correct.

Repeat for terminals 8 and 10.

Supply Rail	Terminals	
	MiCOM P941	**MiCOM P943**
+ve	F7 and F8	J7 and J8
–ve	F9 and F10	J9 and J10

Table 3: Field voltage terminals

5.2.5 Input opto-isolators

This test checks that all the opto-isolated inputs on the relay are functioning correctly.

- The P941 with I/O option “A” (model no. begins: P941xxxA..) has 8 opto inputs
- The P941 with I/O option “B” (model no. begins: P941xxxB..) has 12 opto inputs
- The P941 with I/O option “C” (model no. begins: P941xxxC..) has 16 opto inputs
- The P941 with I/O option “D” (model no. begins: P941xxxD..) has 8 opto inputs
- The P943 with I/O option “A” (model no. begins: P943xxxA..) has 16 opto inputs
- The P943 with I/O option “C” (model no. begins: P943xxxC..) has 24 opto inputs
- The P943 with I/O option “D” (model no. begins: P943xxxD..) has 16 opto inputs
- The P943 with I/O option “E” (model no. begins: P943xxxE..) has 24 opto inputs
- The P943 with I/O option “F” (model no. begins: P943xxxF..) has 32 opto inputs
- The P943 with I/O option “G” (model no. begins: P943xxxG..) has 16 opto inputs

The opto-isolated inputs should be energized one at a time, see external connection diagrams (P94x/EN IN) for terminal numbers.

Ensuring that the correct opto input nominal voltage is set in the ‘Opto Config.’ menu and correct polarity, connect the field supply voltage to the appropriate terminals for the input being tested. Each opto input also has selectable filtering. This allows use of a pre-set filter of ½ a cycle that renders the input immune to induced noise on the wiring.

Note: The opto-isolated inputs may be energized from an eternal dc auxiliary supply (e.g. the station battery) in some installations. Check that this is not the case before connecting the field voltage otherwise damage to the relay may result. If an external 24/27V, 30/34V, 48/54V, 110/125V, 220/250V supply is being used it will be connected to the relays optically isolated inputs directly. If an external supply is being used than it must be energized for this test but only if it has been confirmed that it is suitably rated with less than 12% ac ripple.

CM

The status of each opto-isolated input can be viewed using either cell [0020: SYSTEM DATA, Opto I/P Status] or [0F01: COMMISSION TESTS, Opto I/P Status], a ‘1’ indicating an energized input and a ‘0’ indicating a de-energized input. When each opto-isolated input is energized one of the characters on the bottom line of the display will change to indicate the new state of the inputs.

5.2.6 Output relays

This test checks that all the output relays are functioning correctly.

- The P941 with I/O option “A” (model no. begins: P941xxxA..) has 7 relay outputs
- The P941 with I/O option “B” (model no. begins: P941xxxB..) has 11 relay outputs
- The P941 with I/O option “C” (model no. begins: P941xxxC..) has 7 relay outputs
- The P941 with I/O option “D” (model no. begins: P941xxxD..) has 15 relay outputs
- The P943 with I/O option “A” (model no. begins: P943xxxA..) has 14 relay outputs
- The P943 with I/O option “C” (model no. begins: P943xxxC..) has 14 relay outputs

- The P943 with I/O option “D” (model no. begins: P943xxxD..) has 22 relay outputs
- The P943 with I/O option “E” (model no. begins: P943xxxE..) has 22 relay outputs
- The P943 with I/O option “F” (model no. begins: P943xxxF..) has 14 relay outputs
- The P943 with I/O option “G” (model no. begins: P943xxxG..) has 30 relay outputs

Ensure that the relay is still in test mode by viewing cell [0F0D: COMMISSION TESTS, Test Mode] to ensure that it is set to ‘Blocked’.

The output relays should be energized one at a time. To select output relay 1 for testing, set cell [0F0E: COMMISSION TESTS, Test Pattern] as appropriate.

Connect a continuity tester across the terminals corresponding to output relay 1 as given in external connection diagram (P94x/EN IN).

To operate the output relay set cell [0F0F: COMMISSION TESTS, Contact Test] to ‘Apply Test’. Operation will be confirmed by the continuity tester operating for a normally open contact and ceasing to operate for a normally closed contact. Measure the resistance of the contacts in the closed state.

Reset the output relay by setting cell [0F0F: COMMISSION TESTS, Contact Test] to ‘Remove Test’.

Note: It should be ensured that thermal ratings of anything connected to the output relays during the contact test procedure are not exceeded by the associated output relay being operated for too long. It is therefore advised that the time between application and removal of the contact test is kept to the minimum.

Repeat the test for all the relay outputs of the particular hardware model.

Return the relay to service by setting cell [0F0D: COMMISSION TESTS, Test Mode] to ‘Disabled’.

5.2.7 Rear communications port

This test should only be performed where the relay is to be accessed from a remote location and will vary depending on the communications standard being adopted.

It is not the intention of the test to verify the operation of the complete system from the relay to the remote location, just the relay’s rear communications port and any protocol converter necessary.

5.2.7.1 Courier communications

If a K-Bus to EIA(RS)232 KITZ protocol converter is installed, connect a portable PC running the appropriate software to the incoming (remote from relay) side of the protocol converter. The terminal numbers for the relay’s K-Bus port are given in Table 4.

Connection		**Terminal**	
K-Bus	**MODBUS, IEC60870-5-103 or DNP3.0**	**P941**	**P943**
Screen	Screen	F16	J16
1	+ve	F17	J17
2	–ve	F18	J18

Table 4: EIA(RS)485 terminals

Ensure that the communications baud rate and parity settings in the application software are set the same as those on the protocol converter (usually a KITZ but could be a SCADA RTU). The relays courier address in cell [0E02: COMMUNICATIONS, Remote Access] must be set to a value between 1 and 254.

Check that communications can be established with this relay using the portable PC.

CM

5.2.7.2 MODBUS communications

Connect a portable PC running the appropriate MODBUS Master Station software to the relays rear EIA(RS)485 port via an EIA(RS)485 to EIA(RS)232 interface converter. The terminal numbers for the relays EIA(RS)485 port are given in Table 4.

Ensure that the relay address, baud rate and parity settings in the application software are set the same as those in cells [0E02: COMMUNICATIONS, Remote Address], [0E04: COMMUNICATIONS, Baud Rate] and [0E05: COMMUNICATIONS, Parity] of the relay.

Check that communications with this relay can be established.

5.2.7.3 IEC60870-5-103 (VDEW) communications

If the relay has the optional fiber optic communications port fitted, the port to be used should be selected by setting cell [0E07: COMMUNICATIONS, Physical Link] to 'Fiber Optic'. Otherwise the terminal numbers for the relays EIA(RS)485 port are given in Table 4.

IEC60870-5-103/VDEW communication systems are designed to have a local Master Station and this should be used to verify that the relay's fiber optic or EIA(RS)485 port, as appropriate, is working.

Ensure that the relay address and baud rate settings in the application software are set the same as those in cell [0E04: COMMUNICATIONS, Baud Rate] of the relay.

Check that, using the Master Station, communications with the relay can be established.

5.2.7.4 DNP3.0 interface

Connect a portable PC running the appropriate DNP3.0 software to the relay's EIA(RS)485 port via an EIA(RS)232 interface converter. The terminal numbers for the relay's EIA(RS)485 port are given in Table 4. Ensure that the relay address, baud rate and parity are set the same as those in cells [0E04: COMMUNICATIONS, Baud Rate] and [0E05: COMMUNICATIONS, Parity] of the relay.

Check that, using the Master Station, communications with the relay can be established.

5.2.8 Voltage inputs

This test verifies that the accuracy of voltage measurement is within the acceptable tolerances.

CM

All relays will leave the factory set for operation at a system frequency of 50Hz. If operation at 60Hz is required then this must be set in cell [0009: SYSTEM DATA, Frequency].

Apply rated voltage to each voltage transformer input in turn, checking its magnitude using a multimeter/test set readout. Refer to Table 5 for the corresponding reading in the relay's MEASUREMENTS 1 column and record the value displayed.

	Voltage Applied To
Cell in MEASUREMENTS 1 Column	**MiCOM P941 or P943**
[021A: VAN Magnitude]	C19 - C22
[021C: VBN Magnitude]	C20 - C22
[021E: VCN Magnitude]	C21 - C22

Table 5: Voltage input terminals

The measured voltage values on the relay LCD or a portable PC connected to the front communication port will either be in primary or secondary volts. If cell [0D02: MEASURE'T SETUP, Local Values] is set to 'Primary', the values displayed should be equal to the applied voltage multiplied by the corresponding voltage transformer ratio set in the 'VT and CT RATIOS' menu column (see Table 6). If cell [0D02: MEASURE'T SETUP, Local Values] is set to 'Secondary', the value displayed should be equal to the applied voltage.

Note: If a PC connected to the relay via the rear communications port is being used to display the measured voltage, the process will be similar. However, the setting of cell [0D03: MEASURE'T SETUP, Remote Values] will determine whether the displayed values are in primary or secondary Volts.

The measurement accuracy of the relay is ±1%. However, an additional allowance must be made for the accuracy of the test equipment being used.

Cell in MEASUREMENTS 1 Column (02)	Corresponding CT Ratio in 'CT and VT RATIO' Column(0A) of Menu)
[021A: VAN Magnitude] [021C: VBN Magnitude] [021E: VCN Magnitude]	$\frac{[0A01: MainVTPrimary]}{[0A02: MainVTSecondary]}$

Table 6: VT ratio settings

6. SETTING CHECKS

The setting checks ensure that all of the application-specific relay settings (i.e. both the relay's function and programmable scheme logic settings), for the particular installation, have been correctly applied to the relay.

If the application-specific settings are not available, ignore sections 6.1 and 6.2.

Note: The trip circuit should remain isolated during these checks to prevent accidental operation of the associated circuit breaker.

6.1 Apply application-specific settings

There are two methods of applying the settings to the relay:

- Transferring them from a pre-prepared setting file to the relay using a portable PC running the appropriate software via the relay's front EIA(RS)232 port, located under the bottom access cover, or rear communications port (with a KITZ protocol converter connected). This method is preferred for transferring function settings as it is much faster and there is less margin for error. If programmable scheme logic other than the default settings with which the relay is supplied are to be used then this is the only way of changing the settings.

  If a setting file has been created for the particular application and provided on a diskette, this will further reduce the commissioning time and should always be the case where application-specific programmable scheme logic is to be applied to the relay.

- Enter them manually via the relay's operator interface. This method is not suitable for changing the programmable scheme logic.

Note: It is essential that where the installation needs application-specific Programmable Scheme Logic, that the appropriate .psl file is downloaded (sent) to the relay, for each and every setting group that will be used. If the user fails to download the required .psl file to any setting group that may be brought into service, then factory default PSL will still be resident. This may have severe operational and safety consequences.

6.2 Demonstrate correct relay operation

Test 5.2.8 has already demonstrated that the relay is within calibration, thus the purpose of these tests is as follows:

- To determine that the primary protection functions of the relay (frequency, voltage etc. can trip according to the correct application settings

- To verify correct assignment of the trip contacts, by monitoring the response to a selection of fault injections

6.2.1 Undervoltage protection testing (optional)

This test, performed on stage 1 of the undervoltage protection function in setting group 1, demonstrates that the relay is operating correctly at the application-specific settings.

6.2.1.1 Connection and preliminaries

Determine which output relay has been selected to operate when a V<1 trip occurs by viewing the relay's programmable scheme logic.

The programmable scheme logic can only be changed using the appropriate software. If this software has not been available then the default output relay allocations will still be applicable.

If the trip outputs are phase-segregated (i.e. a different output relay allocated for each phase), the relay assigned for tripping on 'A' phase faults should be used.

To perform this test, the undervoltage trip output must be directly mapped to an output contact in the programmable scheme logic and should also be mapped to the Trip LED and Fault Recorder Trigger signals.

The associated terminal numbers for the relay output being used can be found from the external connection diagram (P94x/EN IN).

Connect the output relay so that its operation stops the timer and restore voltage above setting.

Connect the ac voltage output of the test set to each of the voltage transformer inputs of the relay (terminals C19, C20, C21 and C22).

As the undervoltage protection functions is being tested, the relay must see a voltage greater than the setting in cell [4205: GROUP 1 VOLT PROT [27/59], V<1 Voltage Set] when not being tested and less than this setting during the test. To reset the undervoltage element and allow record clearance, the applied voltage must be increased above the setting.

Ensure that the timer will start when the voltage applied to the relay is reduced.

6.2.1.2 Check the set-point

Apply voltage at least 10% above setting and reset any alarms that may be present by pressing the key until the prompt ‘Press clear to reset alarms’ is viewed. With this message on the LCD, press the key.

Slowly decrease the applied voltage allowing sufficient time between each change in voltage for the time delayed trip output to operate. (If an undervoltage start indication is available this will ease testing). Check that the pick-up voltage when the relay operates is within ±2% of the setting.

Check that the red trip LED has illuminated. The display will show Alarms/Faults present and the Alarm and Trip LEDs will illuminate. To view the alarm message press the read key , repeat presses of this key should be used to verify that phase A was the “Start Element”. Keep pressing the key until the yellow alarm LED changes from flashing to being steadily on. At the prompt ‘Press clear to reset alarms’, press the key. This will clear the fault record from the display.

6.2.1.3 Check the operating time

Apply an undervoltage condition and check that the operating time recorded by the timer is within the range shown in Table 7.

Note: Except for the definite time characteristic, the operating times given in Table 7 are for a time multiplier setting of 1. Therefore, to obtain the operating time at other time multiplier or time dial settings, the time given in Table 7 must be multiplied by the setting of cell [4207: GROUP 1 VOLT PROT [27/59], V<1 TMS].

In addition, there is an additional delay of up to 0.06 second that may need to be added to the relay’s acceptable range of operating times.

For all characteristics, allowance must be made for the accuracy of the test equipment being used.

Definite Time Characteristic		
Applied Undervoltage	**Nominal Operating Time (Seconds)**	**Range (Seconds)**
Any voltage < 0.9x setting	[4206: V<1 Time Delay] setting	Setting ±5%
Inverse Time Characteristic (with TMS setting = 1.0)		
Applied Undervoltage	**Nominal Operating Time (Seconds)**	**Range (Seconds)**
0.9x setting	10.00	9.50 - 10.50
0.8x setting	5.00	4.75 - 5.25
0.7x setting	3.33	3.16 - 3.50
0.6x setting	2.50	2.37 - 2.63
0.5x setting	2.00	1.90 - 2.10
0.4x setting	1.67	1.58 - 1.75
0.3x setting	1.43	1.35 - 1.50
0.2x setting	1.25	1.18 - 1.32

Table 7: Operating times for V<1

Reconfigure to test a B phase fault. Repeat the test in sections 6.2.1.2 and 6.2.1.3, this time ensuring that the breaker trip contacts relative to B phase operation close correctly. Record the phase B trip time. Repeat for C phase fault. Switch OFF the ac supply and reset the alarms (where possible).

6.2.2 Underfrequency protection testing (optional)

This test, performed on stage 1 of the frequency protection function in setting group 1, demonstrates that the relay is operating correctly at the application-specific settings.

6.2.2.1 Connection and preliminaries

Determine which output relay has been selected to operate when a Stage 1 (f+t) trip occurs by viewing the relay's programmable scheme logic.

The programmable scheme logic can only be changed using the appropriate software. If this software has not been available then the default output relay allocations will still be applicable.

To perform this test, the underfrequency trip output must be directly mapped to an output contact in the programmable scheme logic and should also be mapped to the Trip LED and Fault Recorder Trigger signals.

The associated terminal numbers for the relay output being used can be found from the external connection diagram (P94x/EN IN).

Connect the output relay so that its operation stops the timer.

Connect the ac voltage output of the test set to each of the voltage transformer inputs of the relay (terminals C19, C20, C21 and C22).

As the underfrequency protection functions is being tested, the relay must see a frequency greater than the setting in cell [3102: f+t [81U/81O], 1(f+t) f] when not being tested and less than this setting during the test. To reset the underfrequency element, the applied frequency must be increased above the setting, or the AC supply removed.

Ensure that the timer will start when the frequency applied to the relay is reduced to a value equal to (for ramps) or lower than setting.

Note: It is preferred that the underfrequency protection is tested by applying a falling frequency ramp as this is more realistic to power system operation. For realism, the frequency steps that are used in creating the ramp should be as small as permitted by the test set. However, the element may be tested using step changes in frequency, although this will effect the operating time depending upon the step change conditions.

6.2.2.2 Check the set-point

Apply rated AC voltage and reset any alarms that may be present by pressing the key until the prompt 'Press clear to reset alarms' is viewed. With this message on the LCD, press the key.

Slowly decrease the applied frequency allowing sufficient time between each step for the time delayed trip output to operate. (If an underfrequency start indication is available this will ease testing). Check that the pick-up frequency when the relay operates is within ±20mHz of the setting.

Check that the red trip LED has illuminated. The display will show Alarms/Faults present and the Alarm and Trip LEDs will illuminate. To view the alarm message press the read key, repeat presses of this key should be used to verify that underfrequency stage 1 was the "Start Element". Keep pressing the key until the yellow alarm LED changes from flashing to being steadily on. At the prompt 'Press clear to reset alarms', press the key. This will clear the fault record from the display.

6.2.2.3 Check the operating time

Apply an underfrequency condition and check that the operating time recorded by the timer is within ±5% of the setting in cell [3103: f+t [81U/81O], 1(f+t) t].

If the underfrequency operating time is being tested using a ramp, the timer should be started when the frequency applied to the relay is equal to the setting in cell [3102: f+t [81U/81O], 1(f+t) f]. An additional time of up to 100ms may need to be added in the acceptable range of operating times.

If the underfrequency operating time is being tested using a step change in frequency, it is suggested that the frequency is stepped from 0.5Hz above setting to 0.5Hz below setting. With this test condition, an additional time of up to 100ms may need to be added in the acceptable range of operating times. For other step conditions, the additional time that may need to be added will depend upon the ratio of start frequency to setting to end frequency, Fs/Ff:

If (Start frequency - Setting)/(Setting - End frequency) is less than 2, the additional time will be up to 100ms.
If (Start frequency - Setting)/(Setting - End frequency) is less than 6, the additional time will be up to 160ms.
If (Start frequency - Setting)/(Setting - End frequency) is greater than 6, the additional time will be up to 230ms.

For all cases, the above times are based upon a setting of 0 averaging cycles in cell [3005: COMMON SETTINGS, Freq. Av. Cycles]. For higher settings, additional time delays will need to be accounted. For the default setting of 5 averaging cycles, an additional time of up to 55ms will need to be added during a ramp test. However, when using a step test procedure, the additional time (in ms) is given by $6.4\mathrm{Log}_e\left(Fs/Ff\right) + 55$ where Fs/Ff is the ratio of start frequency to setting to end frequency. Please refer to P94x/EN AP.

Note: For all cases, allowance must be made for the accuracy of the test equipment being used.

Switch OFF the ac supply and reset the alarms (where possible).

6.3 Disable all commissioning testing options

Ensure that all Test Mode, and Static Test options have been **disabled**. Clear, then re-read any alarms present to be certain that no alarms relating to these test options remain.

6.4 Check application settings

The settings applied should be carefully checked against the required application-specific settings to ensure that they are correct, and have not been mistakenly altered during the injection test.

There are two methods of checking the settings:

- Extract the settings from the relay using a portable PC running the appropriate software via the front EIA(RS)232 port, located under the bottom access cover, or rear communications port (with a KITZ protocol converter connected). Compare the settings transferred from the relay with the original written application-specific setting record. (For cases where the customer has only provided a printed copy of the required settings but a portable PC is available).
- Step through the settings using the relay's operator interface and compare them with the original application-specific setting record. Ensure that all protection elements required have been ENABLED in the CONFIGURATION column.

Unless previously agreed to the contrary, the application-specific programmable scheme logic will not be checked as part of the commissioning tests.

7. ON-LOAD CHECKS

The objectives of the on-load checks are to:

- Confirm the external wiring to the voltage inputs are correct.

However, these checks can only be carried out if there are no restrictions preventing the energization of the plant being protected and the other relays in the group have been commissioned.

Remove all test leads, temporary shorting leads, etc. and replace any external wiring that has been removed to allow testing.

If it has been necessary to disconnect any of the external wiring from the relay in order to perform any of the foregoing tests, it should be ensured that all connections are replaced in accordance with the relevant external connection or scheme diagram.

7.1 Confirm voltage transformer wiring

Using a multimeter measure the voltage transformer secondary voltages to ensure they are correctly rated. Check that the system phase rotation is correct using a phase rotation meter.

Compare the values of the secondary phase voltages with the relay's measured values, which can be found in the MEASUREMENTS 1 menu column.

<table>
<tr><th>Voltage</th><th>Cell in MEASUREMENTS 1 Column (02)</th><th>Corresponding VT Ratio in 'VT and CT RATIO' Column (0A) of Menu)</th></tr>
<tr><td>VAB</td><td>[0214: VAB Magnitude]</td><td rowspan="6">$\frac{[0A01: Main VT Primary]}{[0A02: Main VT Secondary]}$</td></tr>
<tr><td>VBC</td><td>[0216: VBC Magnitude]</td></tr>
<tr><td>VCA</td><td>[0218: VCA Magnitude]</td></tr>
<tr><td>VAN</td><td>[021A: VAN Magnitude]</td></tr>
<tr><td>VBN</td><td>[021C: VBN Magnitude]</td></tr>
<tr><td>VCN</td><td>[021E: VCN Magnitude]</td></tr>
</table>

Table 8: Measure voltages and VT ratio settings

If cell [0D02: MEASURE'T. SETUP, Local Values] is set to 'Secondary', the values displayed on the relay LCD or a portable PC connected to the front EIA(RS)232 communication port should be equal to the applied secondary voltage. The values should be within 1% of the applied secondary voltages. However, an additional allowance must be made for the accuracy of the test equipment being used.

If cell [0D02: MEASURE'T. SETUP, Local Values] is set to 'Primary', the values displayed should be equal to the applied secondary voltage multiplied the corresponding voltage transformer ratio set in the 'CT & VT RATIOS' menu column (see Table 8). Again the values should be within 1% of the expected value, plus an additional allowance for the accuracy of the test equipment being used.

8. FINAL CHECKS

The tests are now complete.

Remove all test or temporary shorting leads, etc. If it has been necessary to disconnect any of the external wiring from the relay in order to perform the wiring verification tests, it should be ensured that all connections (wiring, fuses and links) are replaced in accordance with the relevant external connection or scheme diagram.

Ensure that the relay has been restored to service by checking that cell [0F0D: COMMISSION TESTS, Test Mode] is set to ‘Disabled’.

If the menu language has been changed to allow accurate testing it should be restored to the customer’s preferred language.

If a P991/MMLG test block is installed, remove the P992/MMLB test plug and replace the cover so that the protection is put into service.

Ensure that all event records, fault records, disturbance records, alarms and LEDs have been reset before leaving the relay.

If applicable, replace the secondary front cover on the relay.

9. COMMISSIONING TEST RECORD

Date:		Engineer:	
Station:		Circuit:	
		System Frequency:	Hz
VT Ratio:	/ V		

Front Plate Information

Frequency protection relay	**MiCOM P941** ☐ **MiCOM P943** ☐
Model number	
Serial number	
Rated voltage Vn	
Auxiliary voltage Vx	

Test Equipment Used

This section should be completed to allow future identification of protective devices that have been commissioned using equipment that is later found to be defective or incompatible but may not be detected during the commissioning procedure.

Injection test set	Model: Serial No:	
Phase angle meter	Model: Serial No:	
Phase rotation meter	Model: Serial No:	
Insulation tester	Model: Serial No:	
Setting software:	Type: Version:	

Have all relevant safety instructions been followed?	Yes ☐ No ☐

5. Product Checks

5.1 With the relay de-energized

5.1.1 Visual inspection

Relay damaged?	Yes ☐ No ☐
Rating information correct for installation?	Yes ☐ No ☐
Case earth installed?	Yes ☐ No ☐

5.1.2	Insulation resistance >100MΩ at 500V dc	Yes ☐ No ☐ Not tested ☐

5.1.3 External wiring

Wiring checked against diagram?	Yes ☐ No ☐
Test block connections checked?	Yes ☐ No ☐ N/A ☐

5.1.4 Watchdog contacts (auxiliary supply off)

Terminals 11 and 12	Contact closed?	Yes ☐ No ☐
Terminals 13 and 14	Contact open?	Yes ☐ No ☐

5.1.5	Measured auxiliary supply	_____ V ac/dc

5.2 With the relay energized

5.2.1 Watchdog contacts (auxiliary supply on)

Terminals 11 and 12	Contact open?	Yes ☐ No ☐
Terminals 13 and 14	Contact closed?	Yes ☐ No ☐

CM

5.2.2 Date and time

Clock set to local time?	Yes ☐ No ☐
Time maintained when auxiliary supply removed?	Yes ☐ No ☐

5.2.3 Light emitting diodes

Alarm (yellow) LED working?	Yes ☐ No ☐
Out of service (yellow) LED working?	Yes ☐ No ☐

5.2.3.3	All programmable LEDs working?	Yes ☐ No ☐

5.2.4 Field supply voltage

Value measured between terminals 8 and 9	_____ V dc

5.2.5 Input opto-isolators

Opto input 1 working?	Yes ☐ No ☐
Opto input 2 working?	Yes ☐ No ☐
Opto input 3 working?	Yes ☐ No ☐
Opto input 4 working?	Yes ☐ No ☐
Opto input 5 working?	Yes ☐ No ☐
Opto input 6 working?	Yes ☐ No ☐
Opto input 7 working?	Yes ☐ No ☐
Opto input 8 working?	Yes ☐ No ☐
Opto input 9 working?	Yes ☐ No ☐ N/A ☐
Opto input 10 working?	Yes ☐ No ☐ N/A ☐
Opto input 11 working?	Yes ☐ No ☐ N/A ☐
Opto input 12 working?	Yes ☐ No ☐ N/A ☐
Opto input 13 working?	Yes ☐ No ☐ N/A ☐
Opto input 14 working?	Yes ☐ No ☐ N/A ☐
Opto input 15 working?	Yes ☐ No ☐ N/A ☐
Opto input 16 working?	Yes ☐ No ☐ N/A ☐
Opto input 17 working?	Yes ☐ No ☐ N/A ☐
Opto input 18 working?	Yes ☐ No ☐ N/A ☐
Opto input 19 working?	Yes ☐ No ☐ N/A ☐
Opto input 20 working?	Yes ☐ No ☐ N/A ☐
Opto input 21 working?	Yes ☐ No ☐ N/A ☐
Opto input 22 working?	Yes ☐ No ☐ N/A ☐
Opto input 23 working?	Yes ☐ No ☐ N/A ☐
Opto input 24 working?	Yes ☐ No ☐ N/A ☐

Opto input 25	working?	Yes ☐ No ☐ N/A ☐
Opto input 26	working?	Yes ☐ No ☐ N/A ☐
Opto input 27	working?	Yes ☐ No ☐ N/A ☐
Opto input 28	working?	Yes ☐ No ☐ N/A ☐
Opto input 29	working?	Yes ☐ No ☐ N/A ☐
Opto input 30	working?	Yes ☐ No ☐ N/A ☐
Opto input 31	working?	Yes ☐ No ☐ N/A ☐
Opto input 32	working?	Yes ☐ No ☐ N/A ☐

5.2.6 Output relays

Relay 1	working?	Yes ☐ No ☐
Relay 2	working?	Yes ☐ No ☐
Relay 3	working?	Yes ☐ No ☐
Relay 4	working?	Yes ☐ No ☐
Relay 5	working?	Yes ☐ No ☐
Relay 6	working?	Yes ☐ No ☐
Relay 7	working?	Yes ☐ No ☐
Relay 8	working?	Yes ☐ No ☐ N/A ☐
Relay 9	working?	Yes ☐ No ☐ N/A ☐
Relay 10	working?	Yes ☐ No ☐ N/A ☐
Relay 11	working?	Yes ☐ No ☐ N/A ☐
Relay 12	working?	Yes ☐ No ☐ N/A ☐
Relay 13	working?	Yes ☐ No ☐ N/A ☐
Relay 14	working?	Yes ☐ No ☐ N/A ☐
Relay 15	working?	Yes ☐ No ☐ N/A ☐

Relay 16	working?	Yes ☐ No ☐ N/A ☐
Relay 17	working?	Yes ☐ No ☐ N/A ☐
Relay 18	working?	Yes ☐ No ☐ N/A ☐
Relay 19	working?	Yes ☐ No ☐ N/A ☐
Relay 20	working?	Yes ☐ No ☐ N/A ☐
Relay 21	working?	Yes ☐ No ☐ N/A ☐
Relay 22	working?	Yes ☐ No ☐ N/A ☐
Relay 23	working?	Yes ☐ No ☐ N/A ☐
Relay 24	working?	Yes ☐ No ☐ N/A ☐
Relay 25	working?	Yes ☐ No ☐ N/A ☐
Relay 26	working?	Yes ☐ No ☐ N/A ☐
Relay 27	working?	Yes ☐ No ☐ N/A ☐
Relay 28	working?	Yes ☐ No ☐ N/A ☐
Relay 29	working?	Yes ☐ No ☐ N/A ☐
Relay 30	working?	Yes ☐ No ☐ N/A ☐

5.2.7	Communication standard	Courier/MODBUS/ IEC60870-5-103/DNP3.0
	Communications established?	Yes ☐ No ☐
	Protocol converter tested?	Yes ☐ No ☐ N/A ☐

5.2.9	Voltage inputs	
	Displayed voltage	Primary ☐ Secondary ☐
	Main VT ratio	_____ N/A ☐

CM

Input VT	Applied Value	Displayed value
VAN	_____ V	_____ V
VBN	_____ V	_____ V
VCN	_____ V	_____ V

6.	Setting Checks	
6.1	Application-specific function settings applied?	Yes ☐ No ☐
	Application-specific programmable scheme logic settings applied?	Yes ☐ No ☐ N/A ☐
6.2	Protection function tested?	Yes ☐ No ☐
6.2.1	Undervoltage tested?	Yes ☐ No ☐
6.2.1.2	Undervoltage pick-up setting	_____ V
	Measured pick-up voltage	_____ V
6.2.1.3	Voltage applied for test	_____ V
	Expected operating time	_____ s
	Measured operating time	_____ s
6.2.2	Underfrequency tested?	Yes ☐ No ☐
6.2.2.2	Underfrequency pick-up setting	_____ Hz
	Measured pick-up frequency	_____ Hz
6.2.2.3	Frequency applied at start of test	_____ Hz
	Frequency applied at end of test	_____ Hz
	Expected operating time	_____ s
	Measured operating time	_____ s
6.3	All commissioning test options disabled?	Yes ☐ No ☐
6.4	Application-specific function settings verified?	Yes ☐ No ☐ N/A ☐
	Application-specific programmable scheme logic tested?	Yes ☐ No ☐ N/A ☐
7.	On-load checks	
	Test wiring removed?	Yes ☐ No ☐
7.1	Voltage inputs and phase rotation OK?	Yes ☐ No ☐
8.	Final Checks	
	All test equipment, leads, shorts and test blocks removed safely?	Yes ☐ No ☐
	Disturbed customer wiring re-checked?	Yes ☐ No ☐ N/A ☐
	All commissioning tests disabled?	Yes ☐ No ☐

Event records reset?	Yes	☐	No	☐
Fault records reset?	Yes	☐	No	☐
Disturbance records reset?	Yes	☐	No	☐
Alarms reset?	Yes	☐	No	☐
LEDs reset?	Yes	☐	No	☐
Secondary front cover replaced?	Yes	☐	No	☐
	N/A	☐		

COMMENTS #
(# Optional, for site observations or utility-specific notes).

Commissioning Engineer

Date:

Customer Witness

Date:

10. SETTING RECORD

Date: ____________ Engineer: ____________

Station: Circuit: ____________

System Frequency: ____________ Hz

VT Ratio: ____________ / V

Front Plate Information

Frequency protection relay	**MiCOM P941** ☐ **MiCOM P943** ☐
Model number	
Serial number	
Rated voltage Vn	
Auxiliary voltage Vx	

Setting Groups Used

Group 1	Yes ☐ No ☐
Group 2	Yes ☐ No ☐
Group 3	Yes ☐ No ☐
Group 4	Yes ☐ No ☐

0000 SYSTEM DATA

0001	Language	English ☐ Francais ☐ Deutsche ☐ Espanol ☐
0002	Password	
0003	Sync. Fn. Links	
0004	Description	
0005	Plant Reference	
0006	Model Number	
0008	Serial Number	
0009	Frequency	
000B	Relay Address	
0011	Software Ref. 1	
00D1	Password Control	Level 0 ☐ Level 1 ☐ Level 2 ☐
00D2	Password Level 1	
00D3	Password Level 2	

0800 DATE AND TIME

0804	IRIG-B Sync.	Disabled ☐ Enabled ☐
0807	Battery Alarm	Disabled ☐ Enabled ☐

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0900 CONFIGURATION

0902	Setting Group	Select via Menu	☐	Select via Optos	☐
0903	Active Settings	Group 1 ☐ Group 2 ☐ Group 3 ☐ Group 4 ☐			
0907	Setting Group 1	Disabled	☐	Enabled	☐
0908	Setting Group 2	Disabled	☐	Enabled	☐
0909	Setting Group 3	Disabled	☐	Enabled	☐
090A	Setting Group 4	Disabled	☐	Enabled	☐
090B	Load Restoration	Disabled	☐	Enabled	☐
090C	Genr Abn Protn	Disabled	☐	Enabled	☐
091D	Volt Protection	Disabled	☐	Enabled	☐
0925	Input Labels	Invisible	☐	Visible	☐
0926	Output Labels	Invisible	☐	Visible	☐
0928	CT & VT Ratios	Invisible	☐	Visible	☐
0929	Event Recorder	Invisible	☐	Visible	☐
092A	Disturb Recorder	Invisible	☐	Visible	☐
092B	Measure’t. Setup	Invisible	☐	Visible	☐
092C	Comms. Settings	Invisible	☐	Visible	☐
092D	Commissioning Tests	Invisible	☐	Visible	☐
092E	Setting Values	Primary	☐	Secondary	☐
092F	Control Inputs	Invisible	☐	Visible	☐
0935	Control I/P Config	Invisible	☐	Visible	☐

0A00 CT AND VT RATIOS

0A01	Main VT Primary	
0A02	Main VT Sec'y.	

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0B00 RECORD CONTROL

0B04	Alarm Event	Disabled	☐	Enabled	☐
0B05	Relay O/P Event	Disabled	☐	Enabled	☐
0B06	Opto Input Event	Disabled	☐	Enabled	☐
0B07	General Event	Disabled	☐	Enabled	☐
0B08	Fault Rec. Event	Disabled	☐	Enabled	☐
0B09	Maint. Rec. Event	Disabled	☐	Enabled	☐
0B0A	Protection Event	Disabled	☐	Enabled	☐

0C00	DISTURB. RECORDER				
0C01	Duration				
0C02	Trigger Position				
0C03	Trigger Mode	Single	☐	Extended	☐
0C04	Analog Channel 1				
0C05	Analog Channel 2				
0C06	Analog Channel 3				
0C07	Analog Channel 4				
0C0C	Digital Input 1				
0C0D	Input 1 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C0E	Digital Input 2				
0C0F	Input 2 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C10	Digital Input 3				
0C11	Input 3 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C12	Digital Input 4				
0C13	Input 4 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C14	Digital Input 5				
0C15	Input 5 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C16	Digital Input 6				
0C17	Input 6 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C18	Digital Input 7				
0C19	Input 7 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C1A	Digital Input 8				
0C1B	Input 8 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C1C	Digital Input 9				
0C1D	Input 9 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C1E	Digital Input 10				
0C1F	Input 10 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C20	Digital Input 11				
0C21	Input 11 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐

0C00	DISTURB. RECORDER				
0C22	Digital Input 12				
0C23	Input 12 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C24	Digital Input 13				
0C25	Input 13 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C26	Digital Input 14				
0C27	Input 14 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C28	Digital Input 15				
0C29	Input 15 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C2A	Digital Input 16				
0C2B	Input 16 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C2C	Digital Input 17				
0C2D	Input 17 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C2E	Digital Input 18				
0C2F	Input 18 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C30	Digital Input 19				
0C31	Input 19 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C32	Digital Input 20				
0C33	Input 20 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C34	Digital Input 21				
0C35	Input 21 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C36	Digital Input 22				
0C37	Input 22 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C38	Digital Input 23				
0C39	Input 23 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C3A	Digital Input 24				
0C3B	Input 24 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C3C	Digital Input 25				

0C00 DISTURB. RECORDER

0C3D	Input 25 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C3E	Digital Input 26				
0C3F	Input 26 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C40	Digital Input 27				
0C41	Input 27 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C42	Digital Input 28				
0C43	Input 28 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C44	Digital Input 29				
0C45	Input 29 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C46	Digital Input 30				
0C47	Input 30 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C48	Digital Input 31				
0C49	Input 31 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐
0C4A	Digital Input 32				
0C4B	Input 32 Trigger	No Trigger Trigger H - L	☐ ☐	Trigger L - H	☐

0D00 MEASURE'T. SETUP

0D01	Default Display	Date & Time		☐	Description		☐
0D02	Local Values	Primary		☐	Secondary		☐
0D03	Remote Values	Primary		☐	Secondary		☐
0D04	Measurement Ref.	VA	☐	VB	☐	VC	☐

0E00 COMMUNICATIONS

0E01	Rear Protocol	Courier		☐	IEC870-5-103		☐
0E02	Remote Address						
0E03	Inactivity Timer						
0E04	Baud Rate	1200 9600	☐ ☐	2400 19200	☐ ☐	4800 38400	☐ ☐
0E05	Parity	Odd	☐	Even	☐	None	☐

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0E00 COMMUNICATIONS

0E06	Measure’t Period				
0E07	Physical Link	EIA(RS)485	☐	Fiber Optic	☐
0E08	Time Sync.	Disabled	☐	Enabled	☐
0E09	Function Type				
0E09	MODBUS IEC Time	Standard	☐	Reverse	☐

0F00 COMMISSION TESTS

0F05	Monitor Bit 1				
0F06	Monitor Bit 2				
0F07	Monitor Bit 3				
0F08	Monitor Bit 4				
0F09	Monitor Bit 5				
0F0A	Monitor Bit 6				
0F0B	Monitor Bit 7				
0F0C	Monitor Bit 8				
0F0D	Test Mode	Disabled	☐	Test Mode	☐

1100 OPTO CONFIG.

1101	Global Nominal V	
1102	Opto Input 1	
1103	Opto Input 2	
1104	Opto Input 3	
1105	Opto Input 4	
1106	Opto Input 5	
1107	Opto Input 6	
1108	Opto Input 7	
1109	Opto Input 8	
110A	Opto Input 9	
110B	Opto Input 10	
110C	Opto Input 11	
110D	Opto Input 12	
110E	Opto Input 13	
110F	Opto Input 14	
1110	Opto Input 15	
1111	Opto Input 16	
1112	Opto Input 17	
1113	Opto Input 18	
1114	Opto Input 19	
1115	Opto Input 20	

1100 OPTO CONFIG.

1116	Opto Input 21	
1117	Opto Input 22	
1118	Opto Input 23	
1119	Opto Input 24	
111A	Opto Input 25	
111B	Opto Input 26	
111C	Opto Input 27	
111D	Opto Input 28	
111E	Opto Input 29	
111F	Opto Input 30	
1120	Opto Input 31	
1121	Opto Input 32	

x000 COMMON SETTINGS

		Group 1 Settings *(x = 3)*	Group 1 Settings *(x = 5)*	Group 1 Settings *(x = 7)*	Group 1 Settings *(x = 9)*
x001	V<B Status				
x002	V<B Voltage Set				
x003	V<B Measur Mode*				
x004	V<B Operate Mode*				
x005	Freq. Av. Cycles				
x006	df/dt Av. Cycles				
x007	Holding Timer				

x100 f+t [81U/81O]

		Group 1 Settings *(x = 3)*	Group 1 Settings *(x = 5)*	Group 1 Settings *(x = 7)*	Group 1 Settings *(x = 9)*
x101	Stage1 f+t				
x102	1(f+t) f				
x103	1(f+t) t				
x104	Stage2 f+t				
x105	2(f+t) f				
x106	2(f+t) t				
x107	Stage3 f+t				
x108	3(f+t) f				
x109	3(f+t) t				
x10A	Stage4 f+t				

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* Only available on software version v11.

x100 f+t [81U/81O]

		Group 1 Settings *(x = 3)*	Group 1 Settings *(x = 5)*	Group 1 Settings *(x = 7)*	Group 1 Settings *(x = 9)*
x10B	4(f+t) f				
x10C	4(f+t) t				
x10D	Stage5 f+t				
x10E	5(f+t) f				
x10F	5(f+t) t				
x110	Stage6 f+t				
x111	6(f+t) f				
x112	6(f+t) t				
x113	Stage7 f+t				
x114	7(f+t) f				
x115	7(f+t) t				
x116	Stage8 f+t				
x117	8(f+t) f				
x118	8(f+t) t				
x119	Stage9 f+t				
x11A	9(f+t) f				
x11B	9(f+t) t				

x200 f+df/dt [81RF]

		Group 1 Settings *(x = 3)*	Group 1 Settings *(x = 5)*	Group 1 Settings *(x = 7)*	Group 1 Settings *(x = 9)*
x201	Stage1 f+df/dt				
x202	1(f+df/dt) f				
x203	1(f+df/dt) df/dt				
x204	Stage2 f+df/dt				
x205	2(f+df/dt) f				
x206	2(f+df/dt) df/dt				
x207	Stage3 f+df/dt				
x208	3(f+df/dt) f				
x209	3(f+df/dt) df/dt				
x20A	Stage4 f+df/dt				
x20B	4(f+df/dt) f				
x20C	4(f+df/dt) df/dt				
x20D	Stage5 f+df/dt				
x20E	5(f+df/dt) f				
x20F	5(f+df/dt) df/dt				
x210	Stage6 f+df/dt				

x200 f+df/dt [81RF]

		Group 1 Settings *(x = 3)*	Group 1 Settings *(x = 5)*	Group 1 Settings *(x = 7)*	Group 1 Settings *(x = 9)*
x211	6(f+df/dt) f				
x212	6(f+df/dt) df/dt				

x300 df/dt+t [81R]

		Group 1 Settings *(x = 3)*	Group 1 Settings *(x = 5)*	Group 1 Settings *(x = 7)*	Group 1 Settings *(x = 9)*
x301	Stage1 df/dt+t				
x302	1(df/dt+t) df/dt				
x303	1(df/dt+t) t				
x304	Stage2 df/dt+t				
x305	2(df/dt+t) df/dt				
x306	2(df/dt+t) t				
x307	Stage3 df/dt+t				
x308	3(df/dt+t) df/dt				
x309	3(df/dt+t) t				
x30A	Stage4 df/dt+t				
x30B	4(df/dt+t) df/dt				
x30C	4(df/dt+t) t				
x30D	Stage5 df/dt+t				
x30E	5(df/dt+t) df/dt				
x30F	5(df/dt+t) t				
x310	Stage6 df/dt+t				
x311	6(df/dt+t) df/dt				
x312	6(df/dt+t) t				

CM

x400 f+Df/Dt [81RAV]

		Group 1 Settings *(x = 3)*	Group 1 Settings *(x = 5)*	Group 1 Settings *(x = 7)*	Group 1 Settings *(x = 9)*
x401	Stage1 f+Df/Dt				
x402	1(f+Df/Dt) f				
x403	1(f+Df/Dt) Df				
x404	1(f+Df/Dt) Dt				
x405	Stage2 f+Df/Dt				
x406	2(f+Df/Dt) f				
x407	2(f+Df/Dt) Df				
x408	2(f+Df/Dt) Dt				
x409	Stage3 f+Df/Dt				

x400 f+Df/Dt [81RAV]

		Group 1 Settings *(x = 3)*	Group 1 Settings *(x = 5)*	Group 1 Settings *(x = 7)*	Group 1 Settings *(x = 9)*
x40A	3(f+Df/Dt) f				
x40B	3(f+Df/Dt) Df				
x40C	3(f+Df/Dt) Dt				
x40D	Stage4 f+Df/Dt				
x40E	4(f+Df/Dt) f				
x40F	4(f+Df/Dt) Df				
x410	4(f+Df/Dt) Dt				
x411	Stage5 f+Df/Dt				
x412	5(f+Df/Dt) f				
x413	5(f+Df/Dt) Df				
x414	5(f+Df/Dt) Dt				
x415	Stage6 f+Df/Dt				
x416	6(f+Df/Dt) f				
x417	6(f+Df/Dt) Df				
x418	6(f+Df/Dt) Dt				

x900 GENR ABN [81AB]

		Group 1 Settings *(x = 3)*	Group 1 Settings *(x = 5)*	Group 1 Settings *(x = 7)*	Group 1 Settings *(x = 9)*
x901	Band1 Freq Low				
x902	Band1 Freq High				
x903	Band1 Delay				
x904	Band2 Freq Low				
x905	Band2 Freq High				
x906	Band2 Delay				
x907	Band3 Freq Low				
x908	Band3 Freq High				
x909	Band3 Delay				
x90A	Band4 Freq Low				
x90B	Band4 Freq High				
x90C	Band4 Delay				
x90D	Time Units				

xC00 LOAD RESTORATION

		Group 1 Settings *(x = 3)*	Group 1 Settings *(x = 5)*	Group 1 Settings *(x = 7)*	Group 1 Settings *(x = 9)*
xC01	Restore1 Status				

xC00 LOAD RESTORATION

		Group 1 Settings *(x = 3)*	Group 1 Settings *(x = 5)*	Group 1 Settings *(x = 7)*	Group 1 Settings *(x = 9)*
xC02	Restore1 Freq				
xC03	Restore1 Time				
xC04	Restore2 Status				
xC05	Restore2 Freq				
xC06	Restore2 Time				
xC07	Restore3 Status				
xC08	Restore3 Freq				
xC09	Restore3 Time				
xC0A	Restore4 Status				
xC0B	Restore4 Freq				
xC0C	Restore4 Time				
xC0D	Restore5 Status				
xC0E	Restore5 Freq				
xC0F	Restore5 Time				
xC10	Restore6 Status				
xC11	Restore6 Freq				
xC12	Restore6 Time				
xC13	Restore7 Status				
xC14	Restore7 Freq				
xC15	Restore7 Time				
xC16	Restore8 Status				
xC17	Restore8 Freq				
xC18	Restore8 Time				
xC19	Restore9 Status				
xC1A	Restore9 Freq				
xC1B	Restore9 Time				

x200 VOLT PROT [27/59]

		Group 1 Settings *(x = 4)*	Group 1 Settings *(x = 6)*	Group 1 Settings *(x = 8)*	Group 1 Settings *(x = A)*
x202	V< Measur't. Mode				
x203	V< Operate Mode				
x204	V<1 Function				
x205	V<1 Voltage Set				
x206	V<1 Time Delay				
x207	V<1 TMS				
x209	V<2 Status				

x200 VOLT PROT [27/59]

x20A	V<2 Voltage Set				
x20B	V<2 Time Delay				
x20E	V> Measur't. Mode				
x20F	V> Operate Mode				
x210	V>1 Function				
x211	V>1 Voltage Set				
x212	V>1 Time Delay				
x213	V>1 TMS				
x214	V>2 Status				
x215	V>2 Voltage Set				
x216	V>2 Time Delay				

xA00 INPUT LABELS

		Group 1 Settings *(x = 4)*	Group 1 Settings *(x = 6)*	Group 1 Settings *(x = 8)*	Group 1 Settings *(x = A)*
xA01	Opto Input 1				
xA02	Opto Input 2				
xA03	Opto Input 3				
xA04	Opto Input 4				
xA05	Opto Input 5				
xA06	Opto Input 6				
xA07	Opto Input 7				
xA08	Opto Input 8				
xA09	Opto Input 9				
xA0A	Opto Input 10				
xA0B	Opto Input 11				
xA0C	Opto Input 12				
xA0D	Opto Input 13				
xA0E	Opto Input 14				
xA0F	Opto Input 11				
xA10	Opto Input 16				
xA11	Opto Input 17				
xA12	Opto Input 18				
xA13	Opto Input 19				
xA14	Opto Input 20				
xA15	Opto Input 21				
xA16	Opto Input 22				
xA17	Opto Input 23				
xA18	Opto Input 24				

xA00 INPUT LABELS

xA19	Opto Input 25				
xA1A	Opto Input 26				
xA1B	Opto Input 27				
xA1C	Opto Input 28				
xA1D	Opto Input 29				
xA1E	Opto Input 30				
xA1F	Opto Input 31				
xA20	Opto Input 32				

xB00 OUTPUT LABELS

		Group 1 Settings *(x = 4)*	Group 1 Settings *(x = 6)*	Group 1 Settings *(x = 8)*	Group 1 Settings *(x = A)*
xB01	Relay 1				
xB02	Relay 2				
xB03	Relay 3				
xB04	Relay 4				
xB05	Relay 5				
xB06	Relay 6				
xB07	Relay 7				
xB08	Relay 8				
xB09	Relay 9				
xB0A	Relay 10				
xB0B	Relay 11				
xB0C	Relay 12				
xB0D	Relay 13				
xB0E	Relay 14				
xB0F	Relay 15				
xB10	Relay 16				
xB11	Relay 17				
xB12	Relay 18				
xB13	Relay 19				
xB14	Relay 20				
xB15	Relay 21				
xB16	Relay 22				
xB17	Relay 23				
xB18	Relay 24				
xB19	Relay 25				
xB1A	Relay 26				
xB1B	Relay 27				
xB1C	Relay 28				
xB1D	Relay 29				
xB1E	Relay 30				

CM

Commissioning Engineer Customer Witness

Date: Date:

MAINTENANCE

Date:	**2008**
Hardware Suffix:	**A or C**
Software Version:	**12**
Connection Diagrams:	**10P94yxx (y = 1 or 3) (x = 01 to 06)**

MT

CONTENTS

MT

1. MAINTENANCE

1.1 Maintenance period

It is recommended that products supplied by Schneider Electric receive periodic monitoring after installation. In view of the critical nature of protective relays and their infrequent operation, it is desirable to confirm that they are operating correctly at regular intervals.

Schneider Electric protective relays are designed for a life in excess of 20 years.

MiCOM relays are self-supervising and so require less maintenance than earlier designs of relay. Most problems will result in an alarm so that remedial action can be taken. However, some periodic tests should be done to ensure that the relay is functioning correctly and the external wiring is intact.

1.2 Maintenance checks

Although some functionality checks can be performed from a remote location by utilizing the communications ability of the relays, these are predominantly restricted to checking that the relay is measuring the applied currents and voltages accurately, and checking the circuit breaker maintenance counters. Therefore it is recommended that maintenance checks are performed locally (i.e. at the substation itself).

Before carrying out any work on the equipment, the user should be familiar with the contents of the Safety Guide (SFTY/4L M/C11) or later issue, or the Safety and Technical Data sections of this Technical Manual and also the ratings on the equipment's rating label.

1.2.1 Alarms

The alarm status LED should first be checked to identify if any alarm conditions exist. If so, press the read key [ ] repeatedly to step through the alarms.

Clear the alarms to extinguish the LED.

1.2.2 Opto-isolators

The opto-isolated inputs can be checked to ensure that the relay responds to their energization by repeating the commissioning test detailed in section 5.2.5 of the Commissioning section (P94x/EN CM).

1.2.3 Output relays

The output relays can be checked to ensure that they operate by repeating the commissioning test detailed in section 5.2.6 of the Commissioning section (P94x/EN CM).

1.2.4 Measurement accuracy

If the power system is energized, the values measured by the relay can be compared with known system values to check that they are in the approximate range that is expected. If they are then the analog/digital conversion and calculations are being performed correctly by the relay. Suitable test methods can be found in section 7.1 of the Commissioning section (P94x/EN CM).

Alternatively, the values measured by the relay can be checked against known values injected into the relay via the test block, if fitted, or injected directly into the relay terminals. Suitable test methods can be found in section 5.2.8 of the Commissioning section (P94x/EN CM). This test will prove the calibration accuracy is being maintained.

1.3 Method of repair

1.3.1 MiCOM P940 relays

If the relay should develop a fault whilst in service, depending on the nature of the fault, the watchdog contacts will change state and an alarm condition will be flagged. Due to the extensive use of surface-mount components faulty PCBs should be replaced, as it is not possible to perform repairs on damaged circuits. Thus either the complete relay or just the faulty PCB, identified by the in-built diagnostic software, can be replaced. Advice about identifying the faulty PCB can be found in the Troubleshooting section (P94x/EN TS).

The preferred method is to replace the complete relay as it ensures that the internal circuitry is protected against electrostatic discharge and physical damage at all times and overcomes the possibility of incompatibility between replacement PCBs. However, it may be difficult to remove an installed relay due to limited access in the back of the cubicle and rigidity of the scheme wiring.

Replacing PCBs can reduce transport costs but requires clean, dry conditions on site and higher skills from the person performing the repair. However, if the repair is not performed by an approved service center, the warranty will be invalidated.

Before carrying out any work on the equipment, the user should be familiar with the contents of the Safety and Technical Data sections and the ratings on the equipment's rating label. This should ensure that no damage is caused by incorrect handling of the electronic components.

1.3.1.1 Replacing the complete relay

The case and rear terminal blocks have been designed to facilitate removal of the complete relay should replacement or repair become necessary without having to disconnect the scheme wiring.

Before working at the rear of the relay, isolate all voltage supplies to the relay.

Disconnect the relay earth, IRIG-B and fiber optic connections, as appropriate, from the rear of the relay.

There are two types of terminal block used on the relay, medium and heavy duty, which are fastened to the rear panel using crosshead screws.

Note: The use of a magnetic bladed screwdriver is recommended to minimize the risk of the screws being left in the terminal block or lost.

Without exerting excessive force or damaging the scheme wiring, pull the terminal blocks away from their internal connectors.

Remove the screws used to fasten the relay to the panel, rack, etc. These are the screws with the larger diameter heads that are accessible when the access covers are fitted and open.

If the top and bottom access covers have been removed, do not remove the screws with the smaller diameter heads which are accessible. These screws secure the front panel to the relay.

Withdraw the relay carefully from the panel, rack, etc. because it will be heavy due to the internal transformers.

To reinstall the repaired or replacement relay, follow the above instructions in reverse, ensuring that each terminal block is relocated in the correct position and the case earth, IRIG-B and fiber optic connections are replaced. To facilitate easy identification of each terminal block, they are labeled alphabetically with 'A' on the left hand side when viewed from the rear.

Once reinstallation is complete the relay should be re-commissioned using the instructions in sections 1 to 8 of the Commissioning section (P94x/EN CM).

1.3.1.2 Replacing a PCB

Replacing printed circuit boards and other internal components of protective relays must be undertaken only by Service Centers approved by Schneider Electric. Failure to obtain the authorization of Schneider Electric After Sales Engineers prior to commencing work may invalidate the product warranty.

Before removing the front panel to replace a PCB the auxiliary supply must be removed, and wait 5s for capacitors to discharge. It is also strongly recommended that the voltage transformer connections and trip circuit are isolated.

Schneider Electric Support teams are available world-wide, and it is strongly recommended that any repairs be entrusted to those trained personnel. For this reason, details on product disassembly and re-assembly are not included here.

1.4 Re-calibration

1.4.1 P940 relay

Re-calibration is not required when a PCB is replaced **unless it happens to be one of the boards in the input module;** the replacement of either directly affects the calibration.

Although it is possible to carry out re-calibration on site, this requires test equipment with suitable accuracy and a special calibration program to run on a PC. It is therefore recommended that the work be carried out by the manufacturer, or entrusted to an approved service center.

1.5 Changing the relay battery

Each relay has a battery to maintain status data and the correct time when the auxiliary supply voltage fails. The data maintained includes event and disturbance records, stage statistics, generator abnormal cumulative timers and the status of the trip LED.

This battery will periodically need changing, although an alarm will be given as part of the relay’s continuous self-monitoring in the event of a low battery condition.

If the battery-backed facilities are not required to be maintained during an interruption of the auxiliary supply, the steps below can be followed to remove the battery, but do not replace with a new battery.

Before carrying out any work on the equipment, the user should be familiar with the contents of the safety and technical data sections and the ratings on the equipment's rating label.

1.5.1 Instructions for replacing the battery

Open the bottom access cover on the front of the relay.

Gently extract the battery from its socket. If necessary, use a small, insulated screwdriver to prize the battery free.

Ensure that the metal terminals in the battery socket are free from corrosion, grease and dust.

The replacement battery should be removed from its packaging and placed into the battery holder, taking care to ensure that the polarity markings on the battery agree with those adjacent to the socket.

Note: Only use a type ½AA Lithium battery with a nominal voltage of 3.6V and safety approvals such as UL (Underwriters Laboratory), CSA (Canadian Standards Association) or VDE (Vereinigung Deutscher Elektrizitätswerke).

Ensure that the battery is securely held in its socket and that the battery terminals are making good contact with the metal terminals of the socket.

Close the bottom access cover.

1.5.2 Post modification tests

To ensure that the replacement battery will maintain the time and status data if the auxiliary supply fails, check cell [0806: DATE and TIME, Battery Status] reads ‘Healthy’.

Additionally, if further confirmation that the replacement battery is installed correctly is required, the commissioning test described in section 5.2.2 of the Commissioning section (P94x/EN CM), ‘Date and Time’, can be performed.

1.5.3 Battery disposal

The battery that has been removed should be disposed of in accordance with the disposal procedure for Lithium batteries in the country in which the relay is installed.

1.6 Cleaning

Before cleaning the equipment ensure that all ac and dc supplies, and voltage transformer connections are isolated to prevent any chance of an electric shock whilst cleaning.

The equipment may be cleaned using a lint-free cloth moistened with clean water. The use of detergents, solvents or abrasive cleaners is not recommended as they may damage the relay’s surface and leave a conductive residue.

TROUBLESHOOTING

TS

Date:	**2008**
Hardware Suffix:	**A or C**
Software Version:	**12**
Connection Diagrams:	**10P94yxx (y = 1 or 3) (x = 01 to 06)**

CONTENTS

TS

1. INTRODUCTION

Before carrying out any work on the equipment, the user should be familiar with the contents of the Safety Guide (SFTY/4L M/C11) or later issue, or the Safety and Technical Data sections of this Technical Manual and also the ratings on the equipment's rating label.

The purpose of this section of the service manual is to allow an error condition on the relay to be identified so that appropriate corrective action can be taken.

Should the relay have developed a fault, it should be possible in most cases to identify which relay module requires attention. The Maintenance section (P94x/EN MT), advises on the recommended method of repair where faulty modules need replacing. It is not possible to perform an on-site repair to a faulted module.

In cases where a faulty relay/module is being returned to the manufacturer or one of their approved service centers, completed copy of the Repair/Modification Return Authorization Form located at the end of this section should be included.

2. INITIAL PROBLEM IDENTIFICATION

Consult the table below to find the description that best matches the problem experienced, then consult the section referenced to perform a more detailed analysis of the problem.

Symptom	Refer To
Relay fails to power up	Section 4
Relay powers up - but indicates error and halts during power-up sequence	Section 5
Relay Powers up but Out of Service LED is illuminated	Section 6
Error during normal operation	Section 7
Mal-operation of the relay during testing	Section 8

Table 1: Problem identification

3. POWER UP ERRORS

If the relay does not appear to power up then the following procedure can be used to determine whether the fault is in the external wiring, auxiliary fuse, power supply module of the relay or the relay front panel.

Test	Check	Action
1	Measure auxiliary voltage on terminals 1 and 2; verify voltage level and polarity against rating the label on front. Terminal 1 is –dc, 2 is +dc	If auxiliary voltage is present and correct, then proceed to test 2. Otherwise the wiring/fuses in auxiliary supply should be checked.
2	Do LEDs/and LCD backlight illuminate on power-up, also check the N/O watchdog contact for closing.	If they illuminate or the contact closes and no error code is displayed then error is probably in the main processor board (front panel). If they do not illuminate and the contact does not close then proceed to test 3.
3	Check Field voltage output (nominally 48V DC)	If field voltage is not present then the fault is probably in the relay power supply module.

Table 2: Failure of relay to power up

4. ERROR MESSAGE/CODE ON POWER-UP

During the power-up sequence of the relay self-testing is performed as indicated by the messages displayed on the LCD. If an error is detected by the relay during these self-tests then an error message will be displayed and the power-up sequence will be halted. If the error occurs when the relay application software is executing then a maintenance record will be created and the relay will reboot.

Test	Check	Action
1	Is an error message or code permanently displayed during power up?	If relay locks up and displays an error code permanently then proceed to test 2. If the relay prompts for input by the user proceed to test 4. If the relay re-boots automatically then proceed to test 5
2	Record displayed error, then remove and re-apply relay auxiliary supply.	Record whether the same error code is displayed when the relay is rebooted. If no error code is displayed then contact the local service center stating the error code and relay information. If the same code is displayed proceed to test 3.
3	Error code Identification Following text messages (in English) will be displayed if a fundamental problem is detected preventing the system from booting: Bus Fail – address lines SRAM Fail – data lines FLASH Fail format error FLASH Fail checksum Code Verify Fail The following hex error codes relate to errors detected in specific relay modules:	These messages indicate that a problem has been detected on the main processor board of the relay (located in the front panel).
	0c140005/0c0d0000	Input Module (inc. Opto-isolated inputs)
	0c140006/0c0e0000	Output Relay Cards
	Last 4 digits provide details on the actual error.	Other error codes relate to problems within the main processor board hardware or software. It will be necessary to contact Schneider Electric with details of the problem for a full analysis.
4	Relay displays message for corrupt settings and prompts for restoration of defaults to the affected settings.	The power up tests have detected corrupted relay settings, it is possible to restore defaults to allow the power-up to be completed. It will then be necessary to re-apply the application-specific settings.

TS

Test	Check	Action
5	Relay resets on completion of power up - record error code displayed	Error 0x0E080000, programmable scheme logic error due to excessive execution time. Restore default settings by performing a power up with and keys depressed, confirm restoration of defaults at prompt using key. If relay powers up successfully, check programmable logic for feedback paths. Other error codes will relate to software errors on the main processor board, contact Schneider Electric.

Table 3: Power-up self-test error

5. OUT OF SERVICE LED ILLUMINATED ON POWER UP

Test	Check	Action
1	Using the relay menu confirm whether the Commission Test/Test Mode setting is Enabled. Otherwise proceed to test 2.	If the setting is Enabled then disable the test mode and, verify that the Out of Service LED is extinguished.
2	Select and view the last maintenance record from the menu (in the View Records).	Check for H/W Verify Fail this indicates a discrepancy between the relay model number and the hardware; examine the “Maint. Data”, this indicates the causes of the failure using bit fields: Bit Meaning 0 The application type field in the model number does not match the software ID 1 The application field in the model number does not match the software ID 2 The variant 1 field in the model number does not match the software ID 3 The variant 2 field in the model number does not match the software ID 4 The protocol field in the model number does not match the software ID 5 The language field in the model number does not match the software ID 6 The VT type field in the model number is incorrect (110V VTs fitted) 7 The VT type field in the model number is incorrect (440V VTs fitted) 8 The VT type field in the model number is incorrect (no VTs fitted)

Table 4: Out of service LED illuminated

TS

6. ERROR CODE DURING OPERATION

The relay performs continuous self-checking, if an error is detected then an error message will be displayed, a maintenance record will be logged and the relay will reset (after a 1.6 second delay). A permanent problem (for example due to a hardware fault) will generally be detected on the power up sequence, following which the relay will display an error code and halt. If the problem was transient in nature then the relay should reboot correctly and continue in operation. The nature of the detected fault can be determined by examination of the maintenance record logged.

There are also two cases where a maintenance record will be logged due to a detected error where the relay will not reset. These are detection of a failure of either the field voltage or the lithium battery, in these cases the failure is indicated by an alarm message, however the relay will continue to operate.

If the field voltage is detected to have failed (the voltage level has dropped below threshold), then a scheme logic signal is also set. This allows the scheme logic to be adapted in the case of this failure (for example if a blocking scheme is being used).

In the case of a battery failure it is possible to prevent the relay from issuing an alarm using the setting under the Date and Time section of the menu. This setting ‘Battery Alarm’ can be set to 'Disabled' to allow the relay to be used without a battery, without an alarm message being displayed.

7. MAL-OPERATION OF THE RELAY DURING TESTING

7.1 Failure of output contacts

An apparent failure of the relay output contacts may be caused by the relay configuration; the following tests should be performed to identify the real cause of the failure. Note that the relay self-tests verify that the coil of the contact has been energized, an error will be displayed if there is a fault in the output relay board.

Test	Check	Action
1	Is the Out of Service LED illuminated?	Illumination of this LED may indicate that the relay is in test mode or that the protection has been disabled due to a hardware verify error (see Table 4).
2	Examine the Contact status in the Commissioning section of the menu.	If the relevant bits of the contact status are operated then proceed to test 4, if not proceed to test 3.
3	Verify by examination of the fault record or by using the test port whether the protection element is operating correctly.	If the protection element does not operate verify whether the test is being correctly applied. If the protection element does operate then it will be necessary to check the programmable logic, to ensure that the mapping of the protection element to the contacts is correct.
4	Using the Commissioning/Test mode function apply a test pattern to the relevant relay output contacts and verify whether they operate (note the correct external connection diagram should be consulted). A continuity tester can be used at the rear of the relay for this purpose.	If the output relay does operate then the problem must be in the external wiring to the relay. If the output relay does not operate this could indicate a failure of the output relay contacts (note that the self-tests verify that the relay coil is being energized). Ensure that the closed resistance is not too high for the continuity tester to detect.

Table 5: Failure of output contacts

7.2 Failure of opto-isolated inputs

The opto-isolated inputs are mapped onto the relay internal signals using the programmable scheme logic. If an input does not appear to be recognized by the relay scheme logic the Commission Tests/Opto Status menu option can be used to verify whether the problem is in the opto-isolated input itself or the mapping of its signal to the scheme logic functions. If the opto-isolated input does appear to be read correctly then it will be necessary to examine its mapping within the programmable logic.

Ensure the voltage rating for the opto inputs has been configured correctly with applied voltage. If the opto-isolated input state is not being correctly read by the relay the applied signal should be tested. Verify the connections to the opto-isolated input using the correct wiring diagram. Next, using a voltmeter verify that 80% opto setting voltage is present on the terminals of the opto-isolated input in the energized state. If the signal is being correctly applied to the relay then the failure may be on the input card itself. Depending on which opto-isolated input has failed this may require replacement of either the complete analog input module (the board within this module cannot be individually replaced without re-calibration of the relay) or a separate opto board.

7.3 Incorrect analog signals

The measurements may be configured in primary or secondary to assist. If it is suspected that the analog quantities being measured by the relay are not correct then the measurement function of the relay can be used to verify the nature of the problem. The measured values displayed by the relay should be compared with the actual magnitudes at the relay terminals. Verify that the correct terminals are being used (in particular the dual rated CT inputs) and that the CT and VT ratios set on the relay are correct. The correct 120 degree displacement of the phase measurements should be used to confirm that the inputs have been correctly connected.

7.4 PSL editor troubleshooting

A failure to open a connection could be because of one or more of the following:

- The relay address is not valid (note: this address is always 1 for the front port).
- Password in not valid
- Communication Set-up - COM port, Baud rate, or Framing - is not correct
- Transaction values are not suitable for the relay and/or the type of connection
- Modem configuration is not valid. Changes may be necessary when using a modem
- The connection cable is not wired correctly or broken. See MiCOM S1 connection configurations
- The option switches on any KITZ101/102 this is in use may be incorrectly set

7.4.1 Diagram reconstruction after recover from relay

Although the extraction of a scheme from a relay is supported, the facility is provided as a way of recovering a scheme in the event that the original file is unobtainable.

The recovered scheme will be logically correct, but much of the original graphical information is lost. Many signals will be drawn in a vertical line down the left side of the canvas. Links are drawn orthogonally using the shortest path from A to B.

Any annotation added to the original diagram (titles, notes, etc.) are lost.

Sometimes a gate type may not be what was expected, e.g. a 1-input AND gate in the original scheme will appear as an OR gate when uploaded. Programmable gates with an inputs-to-trigger value of 1 will also appear as OR gates.

7.4.2 PSL version check

The PSL is saved with a version reference, time stamp and CRC check. This gives a visual check whether the default PSL is in place or whether a new application has been downloaded.

8. REPAIR AND MODIFICATION PROCEDURE

Please follow these 5 steps to return an Automation product to us:

1. **Get the Repair and Modification Authorization Form (RMA)**

   Find a copy of the RMA form at the end of this section.

   - To obtain an electronic version of the RMA form for e-mailing, please contact your local Schneider Electric service.

2. **Fill**

   Fill in only the white part of the form.

   Please ensure that all fields marked **(M)** are completed such as:

   - Equipment model
   - Model No. and Serial No.
   - Description of failure or modification required (please be specific)
   - Value for customs (in case the product requires export)
   - Delivery and invoice addresses
   - Contact details

3. **Send RMA form to your local Schneider Electric contact**

4. **Receive from local service contact, the information required to ship the product**

   Your local service contact will provide you with all the information:

   - Pricing details
   - RMA n°
   - Repair centre address

   If required, an acceptance of the quote must be delivered before going to next stage.

5. **Send the product to the repair centre**

   - Address the shipment to the repair centre specified by your local contact
   - Ensure all items are protected by appropriate packaging: anti-static bag and foam protection
   - Ensure a copy of the import invoice is attached with the unit being returned
   - Ensure a copy of the RMA form is attached with the unit being returned

   E-mail or fax a copy of the import invoice and airway bill document to your local contact.

Schneider Electric

REPAIR/MODIFICATION RETURN AUTHORIZATION FORM

FIELDS IN GREY TO BE FILLED IN BY SCHNEIDER ELECTRIC PERSONNEL ONLY

Reference **RMA:** ______		Date:
Repair Center Address (for shipping)	**Service Type** ☐ Retrofit ☐ Warranty ☐ Paid service ☐ Under repair contract ☐ Wrong supply	LSC PO No.:
Schneider Electric - Local Contact Details Name: Telephone No.: Fax No.: E-mail:		

IDENTIFICATION OF UNIT

Fields marked (M) are mandatory, delays in return will occur if not completed.

Model No./Part No.: **(M)**	Site Name/Project:
Manufacturer Reference: **(M)**	Commissioning Date:
Serial No.: **(M)**	Under Warranty: ☐ Yes ☐ No
Software Version:	Additional Information:
Quantity:	Customer P.O (if paid):

FAULT INFORMATION

Type of Failure	**Found Defective**
Hardware fail ☐	During FAT/inspection ☐
Mechanical fail/visible defect ☐	On receipt ☐
Software fail ☐	During installation/commissioning ☐
Other:	During operation ☐
	Other:
Fault Reproducibility	
Fault persists after removing, checking on test bench ☐	
Fault persists after re-energization ☐	
Intermittent fault ☐	

Description of Failure Observed or Modification Required - *Please be specific* **(M)**

FOR REPAIRS ONLY

Would you like us to install an updated firmware version after repair? ☐ Yes ☐ No

CUSTOMS & INVOICING INFORMATION

Required to allow return of repaired items

Value for Customs (M)	
Customer Invoice Address ((M) if paid)	**Customer Return Delivery Address (full street address) (M)** Part shipment accepted ☐ Yes ☐ No **OR** Full shipment required ☐ Yes ☐ No
Contact Name: Telephone No.: Fax No.: E-mail:	Contact Name: Telephone No.: Fax No.: E-mail:

REPAIR TERMS

1. **Please ensure that a copy of the import invoice is attached with the returned unit, together with the airway bill document.** Please fax/e-mail a copy of the appropriate documentation (M).
2. Please ensure the Purchase Order is released, for paid service, to allow the unit to be shipped.
3. Submission of equipment to Schneider Electric is deemed as authorization to repair and acceptance of quote.
4. Please ensure all items returned are marked as Returned for ‘Repair/Modification’ and **protected by appropriate packaging** (anti-static bag for each board and foam protection).

SCADA COMMUNICATIONS

SC

Date:	**2008**
Hardware Suffix:	**A or C**
Software Version:	**12**
Connection Diagrams:	**10P94yxx (y = 1 or 3) (x = 01 to 06)**

CONTENTS

SC

FIGURES

1. SCADA COMMUNICATIONS

1.1 Introduction

This section outlines the remote communications interfaces of the MiCOM relay. The relay supports a choice of one of four protocols via the rear communication interface, selected via the model number when ordering. This is in addition to the front serial interface which supports the Courier protocol only.

The rear EIA(RS)485 interface is isolated and is suitable for permanent connection whichever protocol is selected. The advantage of this type of connection is that up to 32 relays can be 'daisy chained' together using a simple twisted pair electrical connection.

It should be noted that the descriptions contained within this section do not aim to fully detail the protocol itself. The relevant documentation for the protocol should be referred to for this information. This section serves to describe the specific implementation of the protocol in the relay.

1.2 Rear port information and connection advice - EIA(RS)485 protocols

1.2.1 Rear communication port EIA(RS)485 interface

The rear EIA(RS)485 communication port is provided by a 3-terminal screw connector located on the back of the relay. See section P94x/EN IN for details of the connection terminals. The rear port provides K-Bus/EIA(RS)485 serial data communication and is intended for use with a permanently wired connection to a remote control center. Of the three connections, two are for the signal connection, and the other is for the earth shield of the cable. When the K-Bus option is selected for the rear port, the two signal connections are not polarity conscious, however for MODBUS, IEC60870-5-103 and DNP3.0 care must be taken to observe the correct polarity.

The protocol provided by the relay is indicated in the relay menu in the 'Communications' column. Using the keypad and LCD, firstly check that the 'Comms. settings' cell in the 'Configuration' column is set to 'Visible', then move to the 'Communications' column. The first cell down the column shows the communication protocol being used by the rear port.

1.2.1.1 EIA(RS)485 bus

The EIA(RS)485 two-wire connection provides a half-duplex fully isolated serial connection to the product. The connection is polarized and whilst the product's connection diagrams indicate the polarization of the connection terminals it should be borne in mind that there is no agreed definition of which terminal is which. If the master is unable to communicate with the product, and the communication parameters match, then it is possible that the two-wire connection is reversed.

1.2.1.2 Bus termination

The EIA(RS)485 bus must have 120Ω (Ohm) ½ Watt terminating resistors fitted at either end across the signal wires - see Figure 1. Some devices may be able to provide the bus terminating resistors by different connection or configuration arrangements, in which case separate external components will not be required. However, this product does not provide such a facility, so if it is located at the bus terminus then an external termination resistor will be required.

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1.2.1.3 Bus connections & topologies

The EIA(RS)485 standard requires that each device be directly connected to the physical cable that is the communications bus. Stubs and tees are expressly forbidden, as are star topologies. Loop bus topologies are not part of the EIA(RS)485 standard and are forbidden by it.

Two-core screened cable is recommended. The specification of the cable will be dependent on the application, although a multi-strand 0.5mm^2 per core is normally adequate. Total cable length must not exceed 1000m. The screen must be continuous and connected to ground at one end, normally at the master connection point; it is important to avoid circulating currents, especially when the cable runs between buildings, for both safety and noise reasons.

This product does not provide a signal ground connection. If a signal ground connection is present in the bus cable then it must be ignored, although it must have continuity for the benefit of other devices connected to the bus. At no stage must the signal ground be connected to the cables screen or to the product's chassis. This is for both safety and noise reasons.

1.2.1.4 Biasing

It may also be necessary to bias the signal wires to prevent jabber. Jabber occurs when the signal level has an indeterminate state because the bus is not being actively driven. This can occur when all the slaves are in receive mode and the master is slow to turn from receive mode to transmit mode. This may be because the master purposefully waits in receive mode, or even in a high impedance state, until it has something to transmit. Jabber causes the receiving device(s) to miss the first bits of the first character in the packet, which results in the slave rejecting the message and consequentially not responding. Symptoms of this are poor response times (due to retries), increasing message error counters, erratic communications, and even a complete failure to communicate.

Biasing requires that the signal lines be weakly pulled to a defined voltage level of about 1V. There should only be one bias point on the bus, which is best situated at the master connection point. The DC source used for the bias must be clean; otherwise noise will be injected. Note that some devices may (optionally) be able to provide the bus bias, in which case external components will not be required.

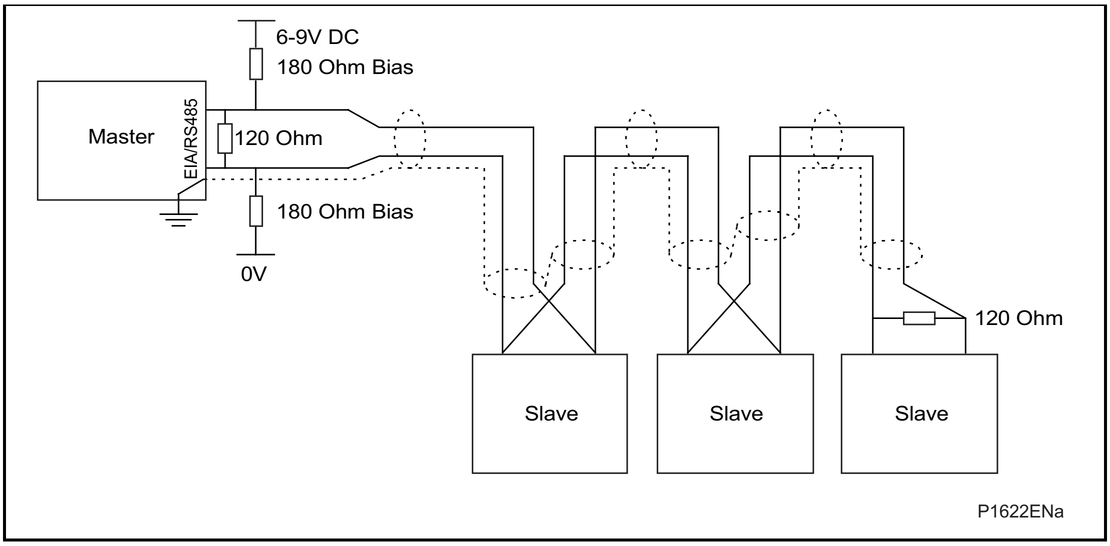

Figure 1: EIA(RS)485 bus connection arrangements

It is possible to use the products field voltage output (48V DC) to bias the bus using values of 2.2kΩ (½W) as bias resistors instead of the 180Ω resistors shown in the above diagram.

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Note the following warnings apply:

- It is extremely important that the 120Ω termination resistors are fitted. Failure to do so will result in an excessive bias voltage that may damage the devices connected to the bus.
- As the field voltage is much higher than that required, Schneider Electric cannot assume responsibility for any damage that may occur to a device connected to the network as a result of incorrect application of this voltage.
- Ensure that the field voltage is not being used for other purposes (i.e. powering logic inputs) as this may cause noise to be passed to the communication network.

1.2.2 Courier communication

Courier works on a master/slave basis where the slave units contain information in the form of a database, and respond with information from the database when it is requested by a master unit.

The relay is a slave unit that is designed to be used with a Courier master unit such as MiCOM S1, MiCOM S10, PAS&T or a SCADA system.

To use the rear port to communicate with a PC-based master station using Courier, a KITZ K-Bus to EIA(RS)232 protocol converter is required. This unit is available from Schneider Electric. A typical connection arrangement is shown in Figure 2. For more detailed information on other possible connection arrangements refer to the manual for the Courier master station software and the manual for the KITZ protocol converter. Each spur of the K-Bus twisted pair wiring can be up to 1000m in length and have up to 32 relays connected to it.

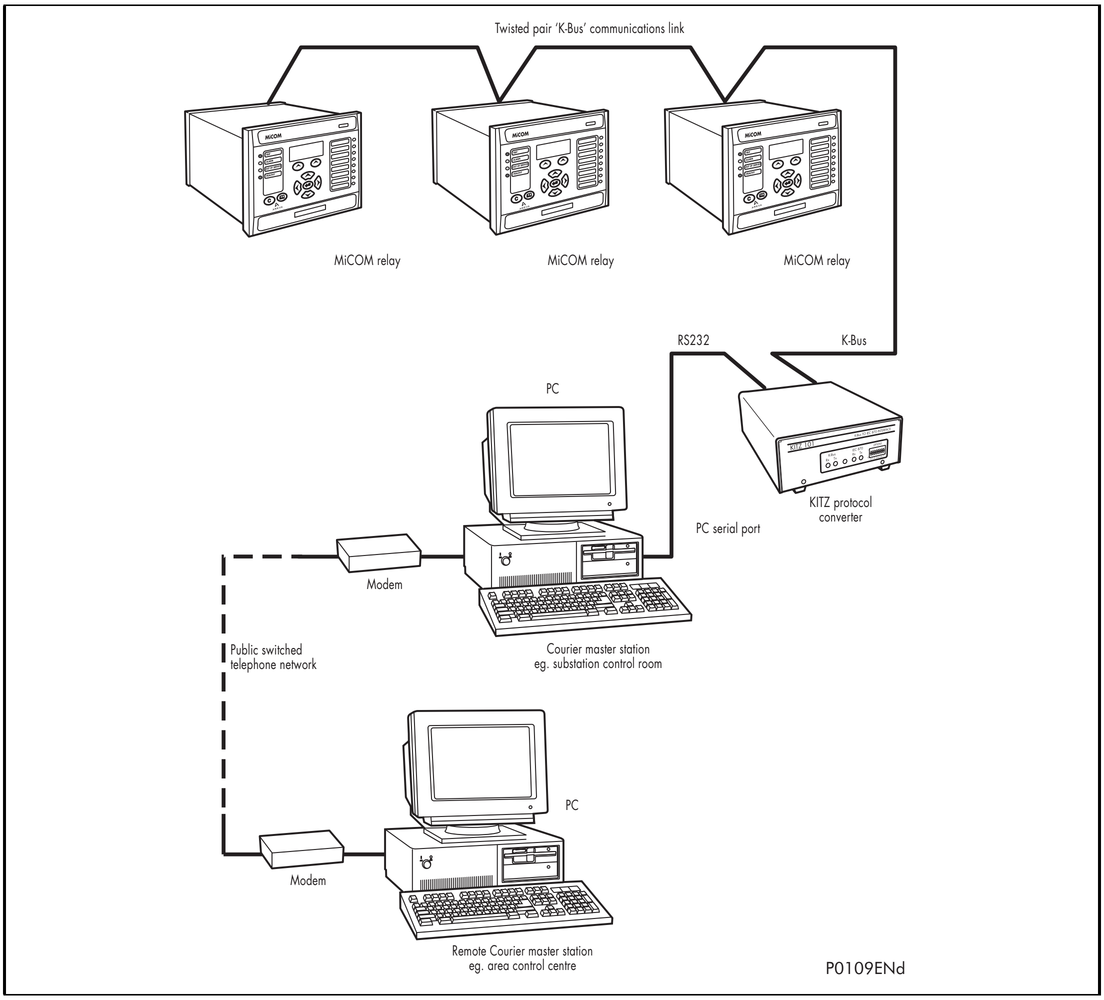

Figure 2: Remote communication connection arrangements

Having made the physical connection to the relay, the relay's communication settings must be configured. To do this use the keypad and LCD user interface. In the relay menu firstly check that the 'Comms. settings' cell in the 'Configuration' column is set to 'Visible', then move to the 'Communications' column. Only two settings apply to the rear port using Courier, the relay's address and the inactivity timer. Synchronous communication is used at a fixed baud rate of 64kbits/s.

Move down the ‘Communications’ column from the column heading to the first cell down which indicates the communication protocol:

Rear Protocol Courier

The next cell down the column controls the address of the relay:

Remote address 1

Since up to 32 relays can be connected to one K-bus spur, as indicated in Figure 2, it is necessary for each relay to have a unique address so that messages from the master control station are accepted by one relay only. Courier uses an integer number between 0 and 254 for the relay address, which is set with this cell. It is important that no two relays have the same Courier address. The Courier address is then used by the master station to communicate with the relay. Default value of remote address is 255 and must be changed to a value in the range of 1 to 254 before use.

The next cell down controls the inactivity timer:

Inactivity timer 10.00 mins.

The inactivity timer controls how long the relay will wait without receiving any messages on the rear port before it reverts to its default state, including revoking any password access that was enabled. For the rear port this can be set between 1 and 30 minutes.

Note that protection and disturbance recorder settings that are modified using an on-line editor such as PAS&T must be confirmed with a write to the ‘Save changes’ cell of the ‘Configuration’ column. Off-line editors such as MiCOM S1 do not require this action for the setting changes to take effect.

1.2.3 MODBUS communication

MODBUS is a master/slave communication protocol, which can be used for network control. In a similar fashion to Courier, the system works by the master device initiating all actions and the slave devices, (the relays), responding to the master by supplying the requested data or by taking the requested action. MODBUS communication is achieved via a twisted pair EIA(RS)485 connection to the rear port and can be used over a distance of 1000m with up to 32 slave devices.

To use the rear port with MODBUS communication, the relay’s communication settings must be configured. To do this use the keypad and LCD user interface. In the relay menu firstly check that the ‘Comms. settings’ cell in the ‘Configuration’ column is set to ‘Visible’, then move to the ‘Communications’ column. Five settings apply to the rear port using MODBUS, which are described below. Move down the ‘Communications’ column from the column heading to the first cell down which indicates the communication protocol:

Rear Protocol MODBUS

The next cell down controls the address of the relay:

Remote address 23

Up to 32 relays can be connected to one MODBUS spur, and therefore it is necessary for each relay to have a unique address so that messages from the master control station are accepted by one relay only. MODBUS uses an integer number between 1 and 247 for the relay address. It is important that no two relays have the same MODBUS address. The MODBUS address is then used by the master station to communicate with the relay.

The next cell down controls the inactivity timer:

Inactivity timer 10.00 mins.

The inactivity timer controls how long the relay will wait without receiving any messages on the rear port before it reverts to its default state, including revoking any password access that was enabled. For the rear port this can be set between 1 and 30 minutes.

The next cell down the column controls the baud rate to be used:

Baud rate 9600 bits/s

MODBUS communication is asynchronous. Three baud rates are supported by the relay, ‘9600 bits/s’, ‘19200 bits/s’ and ‘38400 bits/s’. It is important that whatever baud rate is selected on the relay is the same as that set on the MODBUS master station.

The next cell down controls the parity format used in the data frames:

Parity None

The parity can be set to be one of ‘None’, ‘Odd’ or ‘Even’. It is important that whatever parity format is selected on the relay is the same as that set on the MODBUS master station.

The next cell down controls the IEC time format used in the data frames:

MODBUS IEC time Standard

The MODBUS IEC time can be set to ‘Standard’ or ‘Reverse’. When ‘Standard’ is selected the time format complies with IEC60870-5-4 requirements such that byte 1 of the information is transmitted first, followed by bytes 2 through to 7. If ‘Reverse’ is selected the transmission of information is reversed.

1.2.4 IEC60870-5 CS 103 communication

The IEC specification IEC60870-5-103: Telecontrol Equipment and Systems, Part 5: Transmission Protocols Section 103 defines the use of standards IEC60870-5-1 to IEC60870-5-5 to perform communication with protection equipment. The standard configuration for the IEC60870-5-103 protocol is to use a twisted pair EIA(RS)485 connection over distances up to 1000m. The relay operates as a slave in the system, responding to commands from a master station.

To use the rear port with IEC60870-5-103 communication, the relay’s communication settings must be configured. To do this use the keypad and LCD user interface. In the relay menu firstly check that the ‘Comms. settings’ cell in the ‘Configuration’ column is set to ‘Visible’, then move to the ‘Communications’ column. Six settings apply to the rear port using IEC60870-5-103 that are described below. Move down the ‘Communications’ column from the column heading to the first cell that indicates the communication protocol:

Rear Protocol IEC60870-5-103

The next cell down controls the IEC60870-5-103 address of the relay:

Remote address 162

Up to 32 relays can be connected to one IEC60870-5-103 spur, and therefore it is necessary for each relay to have a unique address so that messages from the master control station are accepted by one relay only. IEC60870-5-103 uses an integer number between 0 and 254 for the relay address. It is important that no two relays have the same IEC60870-5-103 address. The IEC60870-5-103 address is then used by the master station to communicate with the relay.

The next cell down controls the inactivity timer:

Inactivity timer 10.00 mins.

The inactivity timer controls how long the relay will wait without receiving any messages on the rear port before it reverts to its default state, including revoking any password access that was enabled. For the rear port this can be set between 1 and 30 minutes.

The next cell down the column controls the baud rate to be used:

Baud rate 9600 bits/s

IEC60870-5-103 communication is asynchronous. Two baud rates are supported by the relay, ‘9600 bits/s’ and ‘19200 bits/s’. It is important that whatever baud rate is selected on the relay is the same as that set on the IEC60870-5-103 master station.

The next cell down controls the period between IEC60870-5-103 measurements:

Measure’t. period 30.00 s

The IEC60870-5-103 protocol allows the relay to supply measurements at regular intervals. The interval between measurements is controlled by this cell, and can be set between 1 and 60 seconds.

The next cell down controls the period physical media used for the communication:

Physical Link RS485

The default setting is for EIA(RS)485 connection. If the optional fiber optic connectors are fitted to the relay, then this setting can be changed to “Fiber optic”.

The next cell down can be used to define the primary function type for this interface where this is not explicitly defined for the application by the IEC60870-5-103 protocol:

Function Type 226

1.2.5 DNP3.0 communication

The DNP3.0 protocol is defined and administered by the DNP User Group. Information about the user group, DNP3.0 in general and protocol specifications can be found on their website: www.dnp.org

The relay operates as a DNP3.0 slave and supports subset level 2 of the protocol plus some of the features from level 3. DNP3.0 communication is achieved via a twisted pair EIA(RS)485 connection to the rear port and can be used over a distance of 1000m with up to 32 slave devices.

To use the rear port with DNP3.0 communication, the relay's communication settings must be configured. To do this use the keypad and LCD user interface. In the relay menu firstly check that the 'Comms. setting' cell in the 'Configuration' column is set to 'Visible', then move to the 'Communications' column. Four settings apply to the rear port using DNP3.0, which are described below. Move down the 'Communications' column from the column heading to the first cell that indicates the communications protocol:

Rear Protocol DNP3.0

The next cell controls the DNP3.0 address of the relay:

DNP3.0 address 232

Up to 32 relays can be connected to one DNP3.0 spur, and therefore it is necessary for each relay to have a unique address so that messages from the master control station are accepted by only one relay. DNP3.0 uses a decimal number between 1 and 65519 for the relay address. It is important that no two relays have the same DNP3.0 address. The DNP3.0 address is then used by the master station to communicate with the relay.

The next cell down the column controls the baud rate to be used:

Baud rate 9600 bits/s

DNP3.0 communication is asynchronous. Six baud rates are supported by the relay '1200bits/s', '2400bits/s', '4800bits/s', '9600bits/s', '19200bits/s' and '38400bits/s'. It is important that whatever baud rate is selected on the relay is the same as that set on the DNP3.0 master station.

The next cell down the column controls the parity format used in the data frames:

Parity None

The parity can be set to be one of 'None', 'Odd' or 'Even'. It is important that whatever parity format is selected on the relay is the same as that set on the DNP3.0 master station.

The next cell down the column sets the time synchronization request from the master by the relay:

Time Sync. Enabled

The time sync. can be set to either enabled or disabled. If enabled it allows the DNP3.0 master to synchronize the time.

2. COURIER INTERFACE

2.1 Courier protocol

K-Bus is based on EIA(RS)485 voltage levels with HDLC FM0 encoded synchronous signaling and its own frame format. The K-Bus twisted pair connection is unpolarized, whereas the EIA(RS)485 and EIA(RS)232 interfaces are polarized.

The EIA(RS)232 interface uses the IEC60870-5 FT1.2 frame format.

The relay supports an IEC60870-5 FT1.2 connection on the front-port. This is intended for temporary local connection and is not suitable for permanent connection. This interface uses a fixed baud rate, 11-bit frame, and a fixed device address.

The rear interface is used to provide a permanent connection for K-Bus and allows multi-drop connection. It should be noted that although K-Bus is based on EIA(RS)485 voltage levels it is a synchronous HDLC protocol using FM0 encoding. It is not possible to use a standard EIA(RS)232 to EIA(RS)485 converter to convert IEC60870-5 FT1.2 frames to K-Bus. Nor is it possible to connect K-Bus to an EIA(RS)485 computer port. A protocol converter, such as the KITZ101, should be employed for this purpose.

2.2 Supported command set

The following Courier commands are supported by the relay:

Protocol Layer

- Reset Remote Link
- Poll Status
- Poll Buffer*

Low Level Commands

- Send Event*
- Accept Event*
- Send Block
- Store Block Identifier
- Store Block Footer

Menu Browsing

- Get Column Headings
- Get Column Text
- Get Column Values
- Get Strings
- Get Text
- Get Value
- Get Column Setting Limits

Setting Changes

- Enter Setting Mode
- Preload Setting
- Abort Setting
- Execute Setting
- Reset Menu Cell

Set Value

Control Commands

Select Setting Group

Change Device Address*

Set Real Time

Note: Commands indicated with a * are not supported via the front Courier port.

2.3 Relay courier database

The Courier database is a two dimensional structure with each cell in the database being referenced by a row and column address. Both the column and the row can take a range from 0 to 255. Addresses in the database are specified as hexadecimal values; e.g. 0A02 is column 0A (10 decimal) row 02. Associated settings/data will be part of the same column, row zero of the column contains a text string to identify the contents of the column, i.e. a column heading.

P94x/EN GC contains the complete database definition for the relay. For each cell location the following information is stated:

– Cell text

– Cell datatype

– Cell value

– Whether the cell is settable, if so

– Minimum value

– Maximum value

– Step size

– Password level required to allow setting changes

– String information (for Indexed String or Binary flag cells)

2.4 Setting changes

(See R6512, Courier User Guide - Chapter 9)

There are three categories of settings within the relay database:

– Control and support

– Disturbance recorder

– Protection settings group

Setting changes made to the control and support settings are implemented immediately and stored in non-volatile memory. Changes made to either the disturbance recorder settings or the protection settings groups are stored in a 'scratchpad' memory and are not immediately implemented by the relay.

To action setting changes stored in the scratchpad the save changes cell in the configuration column must be written to. This allows the changes to either be confirmed and stored in non-volatile memory, or the setting changes to be aborted.

2.4.1 Setting transfer mode

If it is necessary to transfer all of the relay settings to or from the relay a cell within the communication system data column can be used. This cell (location BF03) when set to 1 makes all of the relay settings visible. Any setting changes made, with the relay set in this mode, are stored in scratchpad memory (including control and support settings). When the value of BF03 is set back to 0 any setting changes are verified and stored in non-volatile memory.

2.5 Event extraction

Events can be extracted either automatically (rear port only) or manually (either Courier port). For automatic extraction all events are extracted in sequential order using the standard Courier event mechanism, this includes fault/maintenance data if appropriate. The manual approach allows the user to select events, faults, or maintenance data at random from the stored records.

2.5.1 Automatic event extraction

(See Chapter 7 Courier User Guide, publication R6512)

This method is intended for continuous extraction of event and fault information as it is produced. It is only supported via the rear Courier port.

When new event information is created the event bit is set within the status byte, this indicates to the master device that event information is available. The oldest, unextracted event can be extracted from the relay using the send event command. The relay will respond with the event data, which will be either a Courier Type 0 or Type 3 event. The Type 3 event is used for fault records and maintenance records.

Once an event has been extracted from the relay, the accept event can be used to confirm that the event has been successfully extracted. If all events have been extracted then the event bit will reset, if there are more events still to be extracted the next event can be accessed using the send event command as before.

2.5.2 Event types

Events will be created by the relay under the following circumstances:

- Change of state of output contact
- Change of state of opto input
- Protection element operation
- Alarm condition
- Setting change
- Password entered/timed-out
- Fault record (Type 3 Courier Event)
- Maintenance record (Type 3 Courier Event)

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2.5.3 Event format

The send event command results in the following fields being returned by the relay:

- Cell reference
- Timestamp
- Cell text
- Cell value

The menu database, P94x/EN GC, contains a table of the events created by the relay and indicates how the contents of the above fields are interpreted. Fault records and maintenance records will return a Courier Type 3 event, which contains the above fields together with two additional fields:

- Event extraction column
- Event number

These events contain additional information that is extracted from the relay using the referenced extraction column. Row 01 of the extraction column contains a setting that allows the fault/maintenance record to be selected. This setting should be set to the event number value returned within the record; the extended data can be extracted from the relay by uploading the text and data from the column.

2.5.4 Manual event record extraction

Column 01 of the database can be used for manual viewing of event, fault, and maintenance records. The contents of this column will depend on the nature of the record selected. It is possible to select events by event number and to directly select a fault record or maintenance record by number.

Event Record Selection (Row 01) - This cell can be set to a value between 0 to 249 to select which of the 250 stored events is selected, 0 will select the most recent record; 249 the oldest stored record. For simple event records, (Type 0) cells 0102 to 0105 contain the event details. A single cell is used to represent each of the event fields. If the event selected is a fault or maintenance record (Type 3) then the remainder of the column will contain the additional information.

Fault Record Selection (Row 05) - This cell can be used to directly select a fault record using a value between 0 and 4 to select one of up to five stored fault records. (0 will be the most recent fault and 4 will be the oldest). The column will then contain the details of the fault record selected.

Maintenance Record Selection (Row F0) - This cell can be used to select a maintenance record using a value between 0 and 4 and operates in a similar way to the fault record selection.

It should be noted that if this column is used to extract event information from the relay the number associated with a particular record will change when a new event or fault occurs.

2.6 Disturbance record extraction

The stored disturbance records within the relay are accessible in a compressed format via the Courier interface and are extracted using column B4. It should be noted that cells required for extraction of uncompressed disturbance records are not supported by the P94x.

Select Record Number (Row 01) - This cell can be used to select the record to be extracted. Record 0 will be the oldest unextracted record, already extracted older records will be assigned positive values, and negative values will be used for more recent records. To facilitate automatic extraction via the rear port the disturbance bit of the status byte is set by the relay whenever there are unextracted disturbance records.

Once a record has been selected, using the above cell, the time and date of the record can be read from cell 02. The disturbance record itself can be extracted using the block transfer mechanism from cell B00B. It should be noted that the file extracted from the relay is in a compressed format and it will be necessary to use MiCOM S1 to de-compress the file and save it in COMTRADE format.

As has been stated, the rear Courier port can be used to automatically extract disturbance records as they occur. This operates using the standard Courier mechanism defined in Chapter 8 of the Courier User Guide. The front Courier port does not support automatic extraction although disturbance record data can be extracted manually from this port.

2.7 Programmable scheme logic settings

The programmable scheme logic (PSL) settings can be uploaded from and downloaded to the relay using the block transfer mechanism defined in Chapter 12 of the Courier User Guide.

The following cells are used to perform the extraction:

- B204 Domain: Used to select either PSL settings (Upload or download) or PSL configuration data (Upload only)
- B208 Sub-Domain: Used to select the Protection Setting Group to be uploaded/downloaded.
- B20C Version: Used on a download to check the compatibility of the file to be downloaded with the relay.
- B21C Transfer Mode: Used to set-up the transfer process.
- B120 Data Transfer Cell: Used to perform upload/download.

The programmable scheme logic settings can be uploaded and downloaded to and from the relay using this mechanism. If it is necessary to edit the settings MiCOM S1 must be used as the data format is compressed. MiCOM S1 also performs checks on the validity of the settings before they are downloaded to the relay.

3. MODBUS INTERFACE

The MODBUS interface is a master/slave protocol and it is defined by MODBUS.org: See

www.modbus.org

MODBUS Serial Protocol Reference Guide: PI-MBUS-300 Rev. E

3.1 Communication link

This interface also uses the rear EIA(RS)485 port (or converted fiber optic port) for communication using 'RTU' mode communication rather than 'ASCII' mode as this provides more efficient use of the communication bandwidth. This mode of communication is defined by the MODBUS standard.

In summary, the character framing is 1 start bit, 8 bit data, either 1 parity bit and 1 stop bit, or two stop bits. This gives 11 bits per character.

The following parameters can be configured for this port using either the front panel interface or the front Courier port:

– Device address

– Inactivity time

– Baud rate

– Parity

– Time format

3.2 MODBUS functions

The following MODBUS function codes are supported by the relay:

01	Read Coil Status
02	Read Input Status
03	Read Holding Registers
04	Read Input Registers
06	Preset Single Register
08	Diagnostics
11	Fetch Communication Event Counter
12	Fetch Communication Event Log
16	Preset Multiple Registers 127 max

These are interpreted by the MiCOM relay in the following way:

01	Read status of output contacts	(0xxxx addresses)
02	Read status of opto inputs	(1xxxx addresses)
03	Read setting values	(4xxxx addresses)
04	Read measured values	(3xxxx addresses
06	Write single setting value	(4xxxx addresses)
16	Write multiple setting values	(4xxxx addresses)

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3.3 Response codes

Code	MODBUS Description	MiCOM Interpretation
01	Illegal Function Code	The function code transmitted is not supported by the slave.
02	Illegal Data Address	The start data address in the request is not an allowable value. If any of the addresses in the range cannot be accessed due to password protection then all changes within the request are discarded and this error response will be returned. Note: If the start address is correct but the range includes non–implemented addresses this response is not produced.
03	Illegal Value	A value referenced in the data field transmitted by the master is not within range. Other values transmitted within the same packet will be executed if inside range.
06	Slave Device Busy	The write command cannot be implemented due to the database being locked by another interface. This response is also produced if the relay software is busy executing a previous request.

3.4 Register mapping

The relay supports the following memory page references:

Memory Page	Interpretation
0xxxx	Read and write access of the output relays
1xxxx	Read only access of the opto inputs
3xxxx	Read only access of data
4xxxx	Read and write access of settings

Where xxxx represents the addresses available in the page (0 to 9999).

Note that the “extended memory file” (6xxxx) is not supported.

A complete map of the MODBUS addresses supported by the relay is contained in menu database, P94x/EN GC, of this service manual.

Note that MODBUS convention is to document register addresses as ordinal values whereas the actual protocol addresses are literal values. The MiCOM relays begin their register addresses at zero. Thus, the first register in a memory page is register address zero. The second register is register address 1 and so on. Note that the page number notation is not part of the address.

3.5 Event extraction

The relay supports two methods of event extraction providing either automatic or manual extraction of the stored event, fault, and maintenance records.

3.5.1 Manual selection

There are three registers available to manually select stored records, there are also three read only registers allowing the number of stored records to be determined.

40100 - Select Event, 0 to 249

40101 - Select Fault, 0 to 4

40102 - Select Maintenance Record, 0 to 4

For each of the above registers a value of 0 represents the most recent stored record. The following registers can be read to indicate the numbers of the various types of record stored.

30100 - Number of stored records

30101 - Number of stored fault records

30102 - Number of stored maintenance records

Each fault or maintenance record logged causes an event record to be created by the relay. If this event record is selected the additional registers allowing the fault or maintenance record details will also become populated.

3.5.2 Automatic extraction

The automatic extraction facilities allow all types of record to be extracted as they occur. Event records are extracted in sequential order including any fault or maintenance data that may be associated with the event.

The MODBUS master can determine whether the relay has any events stored that have not yet been extracted. This is performed by reading the relay status register 30001 (G26 data type). If the event bit of this register is set then the relay has unextracted events available. To select the next event for sequential extraction the master station writes a value of 1 to the record selection register 40400 (G18 data type). The event data together with any fault/maintenance data can be read from the registers specified below. Once the data has been read the event record can be marked as having been read by writing a value of 2 to register 40400.

3.5.3 Record data

The location and format of the registers used to access the record data is the same whether they have been selected using either of the two mechanisms detailed above.

Event Description	MODBUS Address	Length	Comments
Time and Date	30103	4	See G12 data type description in section 3.8.
Event Type	30107	1	See G13 data type. Indicates type of event.
Event Value	30108	2	Nature of value depends on event type. This will contain the status as a binary flag for contact, opto, alarm, and protection events.
MODBUS Address	30110	1	This indicates the MODBUS register address where the change occurred. Alarm 30011 Relays 30723 Optos 30725 Protection events - like the relay and opto addresses this will map onto the MODBUS address of the appropriate DDB status register depending on which bit of the DDB the change occurred. These will range from 30727 to 30785. For platform events, fault events and maintenance events the default is 0.

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Event Description	MODBUS Address	Length	Comments
Event Index	30111	1	This register will contain the DDB ordinal for protection events or the bit number for alarm events. The direction of the change will be indicated by the most significant bit; 1 for 0 - 1 change and 0 for 1 - 0 change.
Additional Data Present	30112	1	0 means that there is no additional data. 1 means fault record data can be read from 30113 to 30199 (number of registers depends on the product). 2 means maintenance record data can be read from 30036 to 30039.

If a fault record or maintenance record is directly selected using the manual mechanism then the data can be read from the register ranges specified above. The event record data in registers 30103 to 30111 will not be available.

It is possible using register 40401(G6 data type) to clear independently the stored relay event/fault and maintenance records. This register also provides an option to reset the relay indications, which has the same effect on the relay as pressing the clear key within the alarm viewer using the front panel menu.

3.6 Disturbance record extraction

The relay provides facilities for both manual and automatic extraction of disturbance records. The two methods differ only in the mechanism for selection of the record but the method of extraction of the data and its format remain the same. The extraction mechanisms are explained below:

3.6.1 Extraction mechanism

The disturbance record data is stored in a compressed format and due to the record size it must be read using a paging system.

Each file is extracted by reading a series of data pages from the relay. The data page is made up of 127 registers, giving a maximum transfer of 254 bytes per page.

3.6.1.1 Interface registers

The following set of registers is presented to the master station to support the extraction of compressed disturbance records:

MODBUS Register	Name	Description
3x00001	Status register	Provides the status of the relay as bit flags: b0 - Out of service b1 - Minor self test failure b2 - Event b3 - Time synchronization b4 - Disturbance b5 - Fault b6 - Trip b7 - Alarm b8 to b15 - Unused A ‘1’ on b4 indicates the presence of a disturbance.

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MODBUS Register	Name	Description
3x00800	N° of stored disturbances	Indicates the total number of disturbance records currently stored in the relay, both extracted and unextracted.
3x00801	Unique identifier of the oldest disturbance record	Indicates the unique identifier value for the oldest disturbance record stored in the relay. This is an integer value used in conjunction with the 'N° of stored disturbances' value to calculate a value for manually selecting records.
4x00250	Manual disturbance record selection register	This register is used to manually select disturbance records. The values written to this cell are an offset of the unique identifier value for the oldest record. The offset value, which ranges from 0 to the N° of stored disturbances - 1, is added to the identifier of the oldest record to generate the identifier of the required record.
4x00400	Record selection command register	This register is used during the extraction process and has a number of commands. These are: b0 - Select next event b1 - Accept event b2 - Select next disturbance record b3 - Accept disturbance record b4 - Select next page of disturbance data b5 - Select data file
3x00930 – 3x00933	Record time stamp	These registers return the timestamp of the disturbance record.
3x00802	N° of registers in data page	This register informs the master station of the number of registers in the data page that are populated.
3x00803 – 3x00929	Data page registers	These 127 registers are used to transfer data from the relay to the master station. They are 16-bit unsigned integers.

Note: Register addresses are provided in reference code + address format. E.g. 4x00001 is reference code 4x, address 1 (which is specified as function code 03, address 0x0000 in the MODBUS specification).

3.6.2 Extraction procedure

The following procedure will be used to extract disturbances from the relay. The procedure is split into three sections:

1. Selection of a disturbance - either manually or automatically
2. Extraction of the data
3. Accepting the extracted record (automatic extraction only)

3.6.2.1 Manual extraction procedure

The procedure used to extract a disturbance manually is shown in Figure 3 below. The manual method of extraction does not allow for the acceptance of disturbance records.

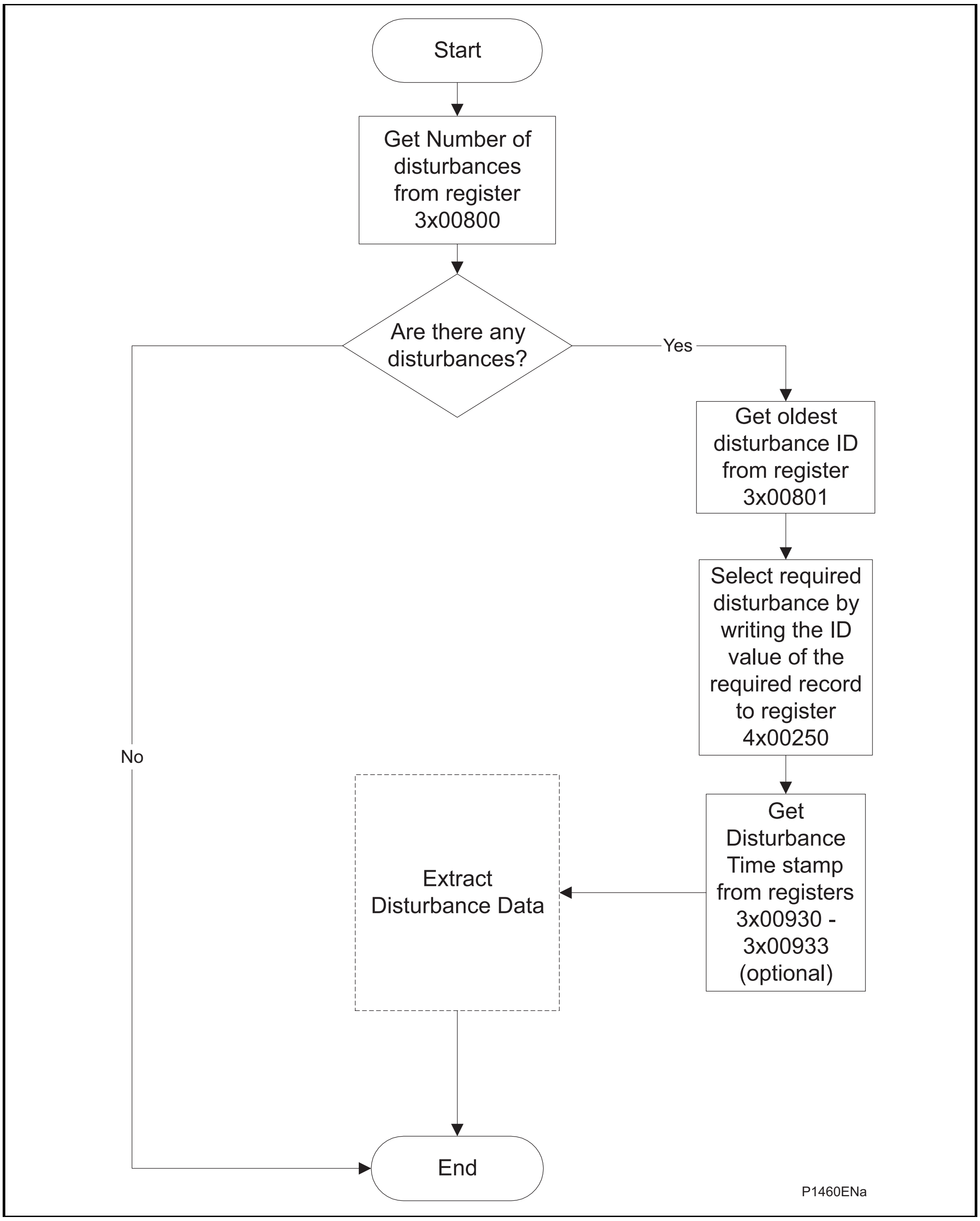

Figure 3: Manual selection of a disturbance record

3.6.2.2 Automatic extraction procedure

There are two methods that can be used for automatically extracting disturbances. Option 1 is simpler and is better at extracting single disturbance records, i.e. when the disturbance recorder is polled regularly. Option 2, however, is more complex to implement but is more efficient at extracting large quantities of disturbance records. This may be useful when the disturbance recorder is polled only occasionally and hence may have many stored records.

3.6.2.3 Automatic extraction procedure - option 1

The procedure for the first method is shown in Figure 4 below. This also shows the acceptance of the disturbance record once the extraction is complete.

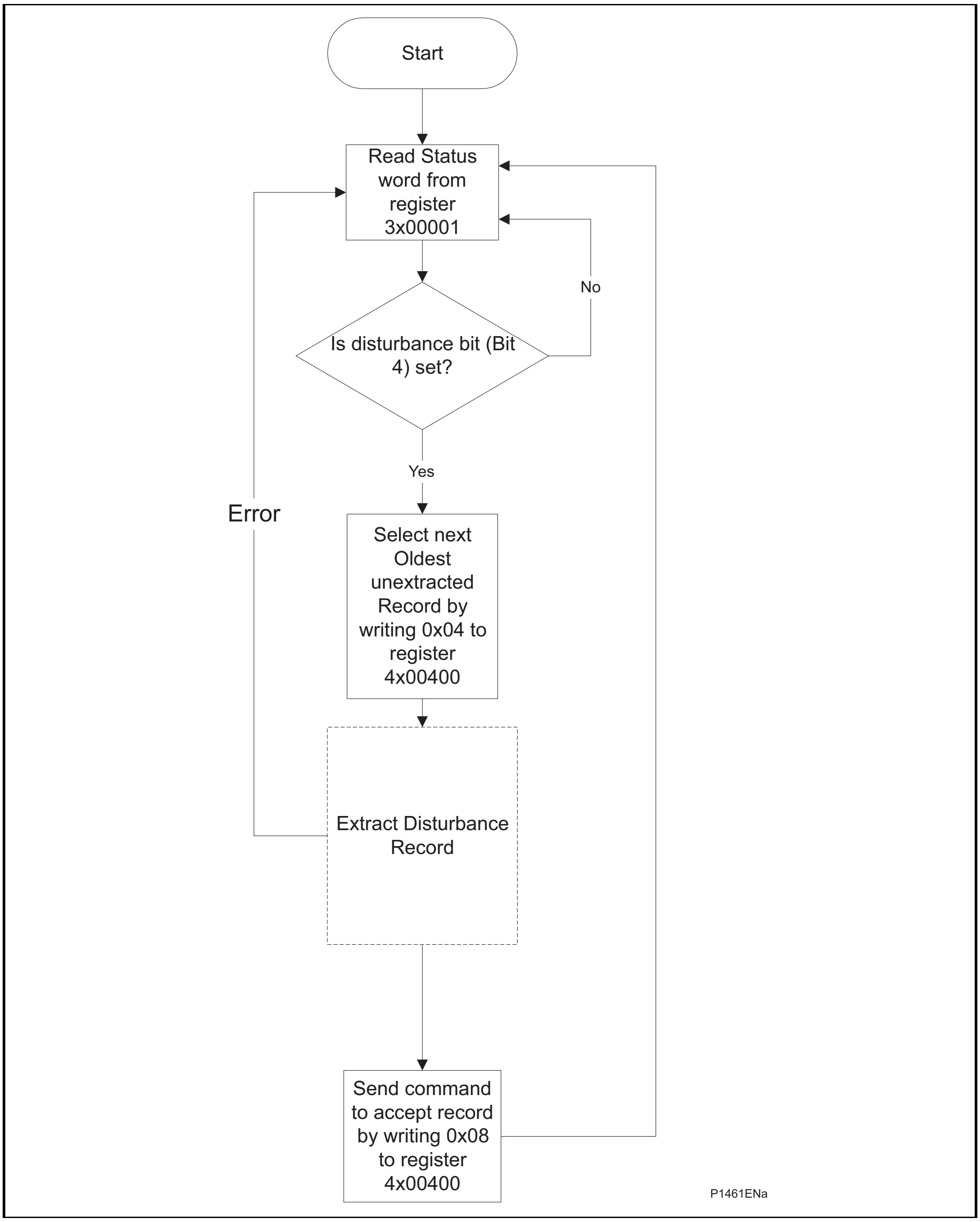

Figure 4: Automatic selection of a disturbance - option 1

3.6.2.4 Automatic extraction procedure - option 2

The second method that can be used for automatic extraction is shown in Figure 5 below. This also shows the acceptance of the disturbance record once the extraction is complete:

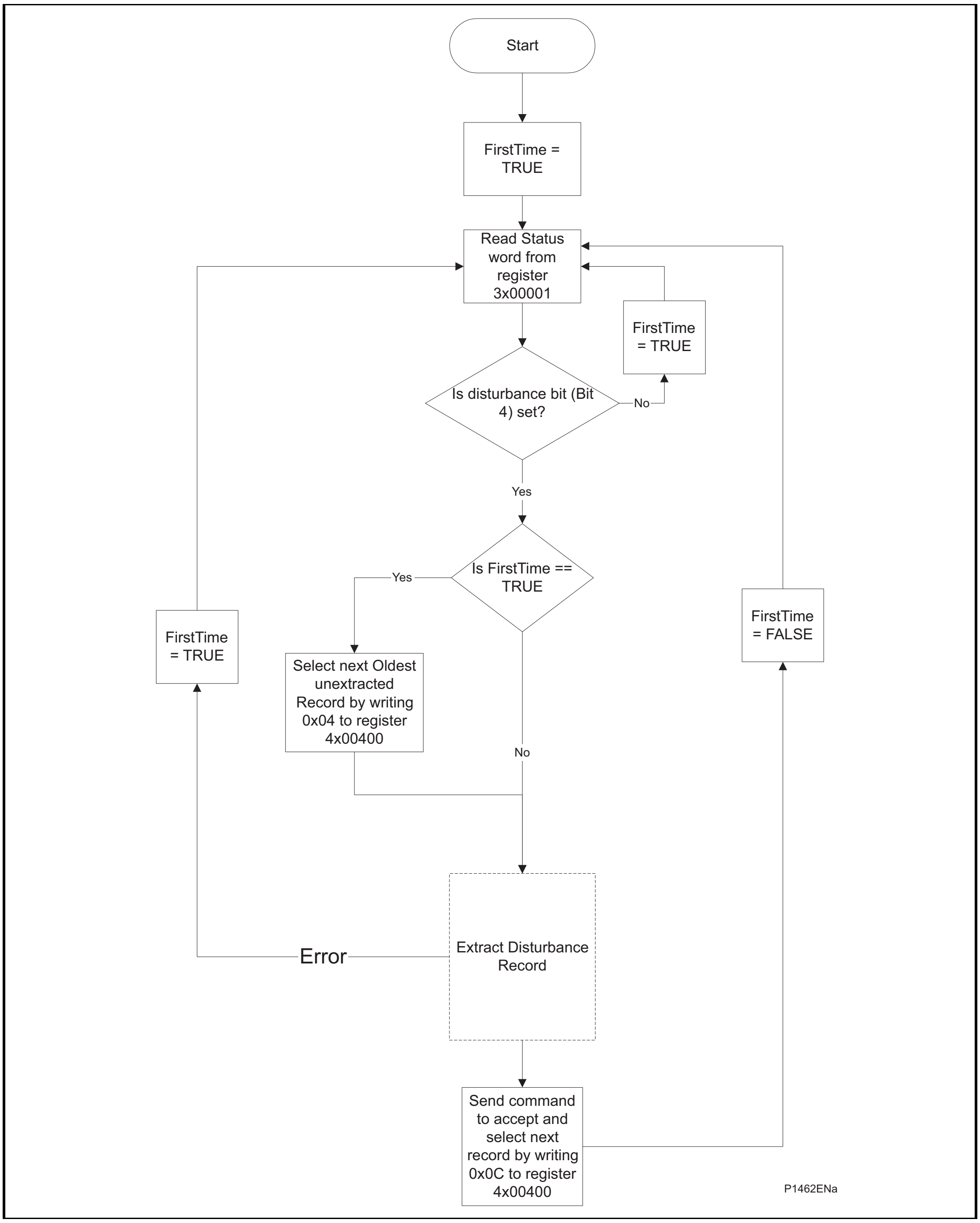

Figure 5: Automatic selection of a disturbance - option 2

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3.6.3 Extracting the disturbance data

The extraction of the disturbance record, as shown in the three previous figures, is shown in Figure 6:

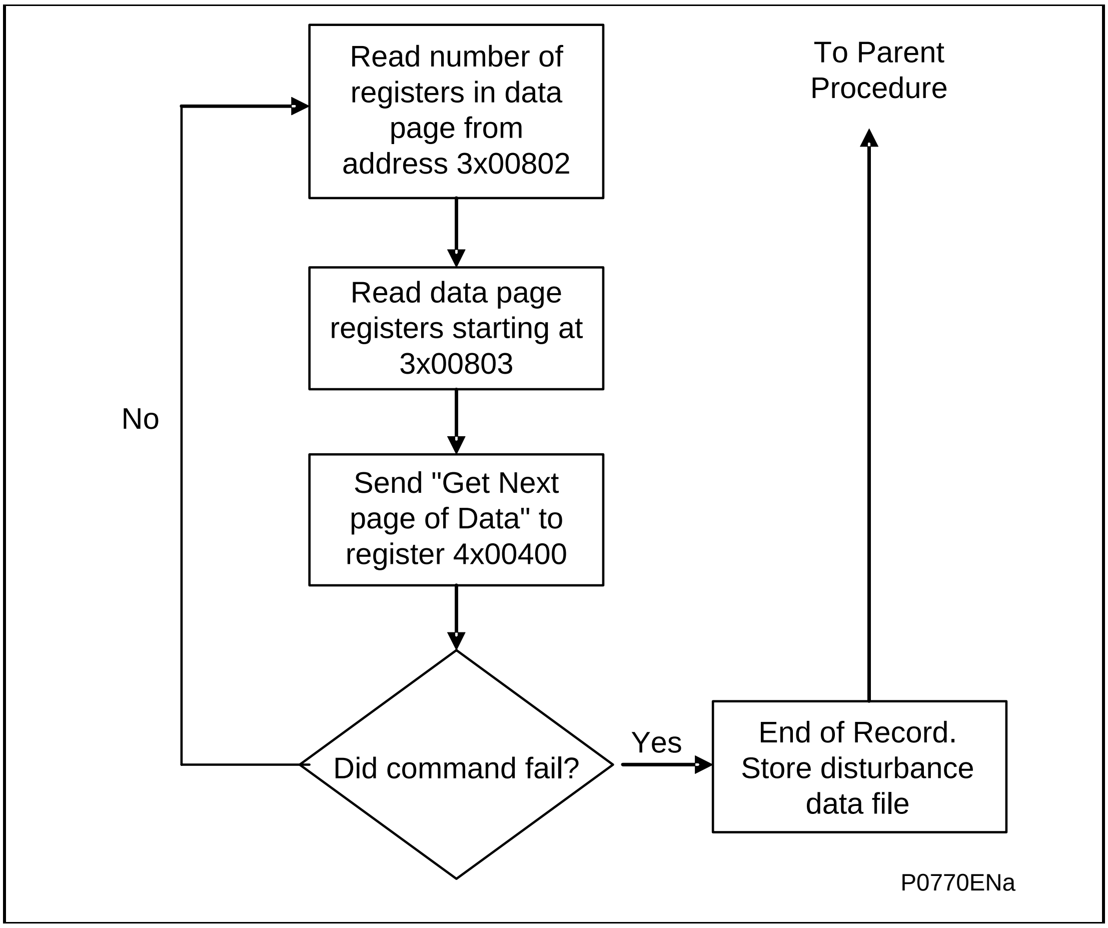

Figure 6: Extracting the disturbance record file

3.6.4 Decompression of Data

Since the disturbance records use compression to maximize the information that can be stored, it is necessary to decompress the record after extraction is completed. A small utility programme is available from Schneider Electric that can be used for this process that will convert the record to COMTRADE format.

3.7 Setting changes

The relay settings can be split into two categories:

– Control and support settings

– Disturbance record settings and protection setting groups

Changes to settings within the control and support area are executed immediately. Changes to the protection setting groups or the disturbance recorder settings are stored in a temporary ‘scratchpad’ area and must be confirmed before they are implemented. All the relay settings are 4xxxx page addresses. The following points should be noted when changing settings:

– Settings implemented using multiple registers must be written to using a multi-register write operation.

– The first address for a multi-register write must be a valid address, if there are unmapped addresses within the range being written to then the data associated with these addresses will be discarded.

- If a write operation is performed with values that are out of range then the illegal data response will be produced. Valid setting values within the same write operation will be executed.
- If a write operation is performed attempting to change registers that require a higher level of password access than is currently enabled then all setting changes in the write operation will be discarded.

3.7.1 Password protection

As described in the introduction to this service manual, the relay settings can be subject to password protection. The level of password protection required to change a setting is indicated in the relay setting database (P94x/EN GC). Level 2 is the highest level of password access, level 0 indicates that no password is required.

The following registers are available to control password protection:

40001 & 40002	Password entry
40022	Default password level
40023 & 40024	Setting to change password level 1
40025 & 40026	Setting to change password level 2
30010	Can be read to indicate current access level

3.7.2 Control and support settings

Control and support settings are executed immediately on the write operation.

3.7.3 Protection and disturbance recorder settings

Setting changes to either of these areas are stored in a scratchpad area and will not be used by the relay unless a confirm or an abort operation is performed. Register 40405 can be used either to confirm or abort the setting changes within the scratchpad area. It should be noted that the relay supports four groups of protection settings. The MODBUS addresses for each of the four groups are repeated within the following address ranges:

Group 1	41000 - 42999
Group 2	43000 - 44999
Group 3	45000 - 46999
Group 4	47000 - 48999

In addition to the basic editing of the protection setting groups, the following functions are provided:

- Default values can be restored to a setting group or to all of the relay settings by writing to register 40402.
- It is possible to copy the contents of one setting group to another by writing the source group to register 40406 and the target group to 40407.

It should be noted that the setting changes performed by either of the two operations defined above are made to the scratchpad area. These changes must be confirmed by writing to register 40405.

The active protection setting groups can be selected by writing to register 40404. An illegal data response will be returned if an attempt is made to set the active group to one that has been disabled.

3.8 Date and time format (data type G12)

The date-time data type G12 allows *real* date and time information to be conveyed down to a resolution of 1ms. The structure of the data type is shown in Table 3-1 and is compliant with the IEC60870-5-4 “Binary Time 2a” format.

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The seven bytes of the structure are packed into four 16-bit registers, such that byte 1 is transmitted first, followed by byte 2 through to byte 7, followed by a null (zero) byte to make eight bytes in total. Since register data is usually transmitted in big-endian format (high order byte followed by low order byte), byte 1 will be in the high-order byte position followed by byte 2 in the low-order position for the first register. The last register will contain just byte 7 in the high order position and the low order byte will have a value of zero.

Byte	**Bit Position**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
1	m^7	m^6	m^5	m^4	m^3	m^2	m^1	m^0
2	m^{15}	m^{14}	m^{13}	m^{12}	m^{11}	m^{10}	m^9	m^8
3	IV	R	I^5	I^4	I^3	I^2	I^1	I^0
4	SU	R	R	H^4	H^3	H^2	H^1	H^0
5	W^2	W^1	W^0	D^4	D^3	D^2	D^1	D^0
6	R	R	R	R	M^3	M^2	M^1	M^0
7	R	Y^6	Y^5	Y^4	Y^3	Y^2	Y^1	Y^0

Where:

– m = 0…59,999ms

– I = 0…59 minutes

– H = 0…23 Hours

– W = 1…7 Day of week; Monday to Sunday, 0 for not calculated

– D = 1…31 Day of Month

– M = 1…12 Month of year; January to December

– Y = 0…99 Years (year of century)

– R = Reserved bit = 0

– SU = summertime: 0 = standard time, 1 = summer time

– IV = invalid value: 0 = valid, 1 = invalid

– range = 0ms…99 years

Table 3-1 G12 date & time data type structure

Since the range of the data type is only 100 years, the century must be deduced. The century is calculated as the one that will produce the nearest time value to the current date. For example: 30-12-99 is 30-12-1999 when received in 1999 & 2000, but is 30-12-2099 when received in 2050. This technique allows 2 digit years to be accurately converted to 4 digits in a ±50 year window around the current datum.

The invalid bit has two applications:

1. It can indicate that the date-time information is considered inaccurate, but is the best information available.

2. Date-time information is not available.

The summertime bit is used to indicate that summertime (day light saving) is being used and, more importantly, to resolve the alias and time discontinuity which occurs when summertime starts and ends. This is important for the correct time correlation of time stamped records.

The day of the week field is optional and if not calculated will be set to zero.

The concept of time zone is not catered for by this data type and hence by the relay. It is up to the end user to determine the time zone utilized by the relay. Normal practice is to use UTC (universal co-ordinated time), which avoids the complications with day light saving time-stamp correlation's.

4. IEC60870-5-103 INTERFACE

The IEC60870-5-103 interface is a master/slave interface with the relay as the slave device. The relay conforms to compatibility level 2; compatibility level 3 is not supported.

The following IEC60870-5-103 facilities are supported by this interface:

- Initialization (reset)
- Time synchronization
- Event record extraction
- General interrogation
- Cyclic measurements
- General commands
- Disturbance record extraction
- Private codes

4.1 Physical connection and link layer

Two connection options are available for IEC60870-5-103, either the rear EIA(RS)485 port or an optional rear fiber optic port. Should the fiber optic port be fitted the selection of the active port can be made via the front panel menu or the front Courier port, however the selection will only be effective following the next relay power up.

For either of the two modes of connection it is possible to select both the relay address and baud rate using the front panel menu/front Courier. Following a change to either of these two settings a reset command is required to re-establish communications, see reset command description below.

4.2 Initialization

Whenever the relay has been powered up, or if the communication parameters have been changed a reset command is required to initialize the communications. The relay will respond to either of the two reset commands (Reset CU or Reset FCB), the difference being that the Reset CU will clear any unsent messages in the relay's transmit buffer.

The relay will respond to the reset command with an identification message ASDU 5, the Cause Of Transmission COT of this response will be either Reset CU or Reset FCB depending on the nature of the reset command. The content of ASDU 5 is described in the IEC60870-5-103 section of the menu database, P94x/EN GC.

In addition to the above identification message, if the relay has been powered up it will also produce a power up event.

4.3 Time synchronization

The relay time and date can be set using the time synchronization feature of the IEC60870-5-103 protocol. The relay will correct for the transmission delay as specified in IEC60870-5-103. If the time synchronization message is sent as a send/confirm message then the relay will respond with a confirm. Whether the time-synchronization message is sent as a send confirm or a broadcast (send/no reply) message, a time synchronization Class 1 event will be generated/produced.

If the relay clock is being synchronized using the IRIG-B input then it will not be possible to set the relay time using the IEC60870-5-103 interface. An attempt to set the time via the interface will cause the relay to create an event with the current date and time taken from the IRIG-B synchronized internal clock.

4.4 Spontaneous events

Events are categorized using the following information:

- Function type
- Information number

The IEC60870-5-103 profile in the menu database, P94x/EN GC, contains a complete listing of all events produced by the relay.

4.5 General interrogation

The GI request can be used to read the status of the relay, the function numbers, and information numbers that will be returned during the GI cycle are indicated in the IEC60870-5-103 profile in the menu database, P94x/EN GC.

4.6 Cyclic measurements

The relay will produce measured values using ASDU 9 on a cyclical basis, this can be read from the relay using a Class 2 poll (note ADSU 3 is not used). The rate at which the relay produces new measured values can be controlled using the measurement period setting. This setting can be edited from the front panel menu/front Courier port and is active immediately following a change.

It should be noted that the measurands transmitted by the relay are sent as a proportion of 2.4 times the rated value of the analog value.

4.7 Commands

A list of the supported commands is contained in the menu database, P94x/EN GC. The relay will respond to other commands with an ASDU 1, with a cause of transmission (COT) indicating ‘negative acknowledgement’.

4.8 Test mode

It is possible using either the front panel menu or the front Courier port to disable the relay output contacts to allow secondary injection testing to be performed. This is interpreted as ‘test mode’ by the IEC60870-5-103 standard. An event will be produced to indicate both entry to and exit from test mode. Spontaneous events and cyclic measured data transmitted whilst the relay is in test mode will have a COT of ‘test mode’.

4.9 Disturbance records

The disturbance records stored by the relay cannot be extracted using the mechanism defined in the IEC60870-5-103 standard. The relay maintains compatibility with the VDEW control system by transmitting an ASDU23 with no disturbance records at the start of every GI cycle.

Any attempt to extract disturbance record data from the relay using ASDU24 will result in the relay responding with ASDU31 end of transmission of disturbance record with a Type of Order of abortion by the protection equipment.

4.10 Blocking of monitor direction

The relay does not support a facility to block messages in the Monitor.

5. DNP3.0 INTERFACE

5.1 DNP3.0 protocol

The DNP3.0 protocol is defined and administered by the DNP User Group. Information about the user group, DNP3.0 in general and protocol specifications can be found on their website: www.dnp.org

The descriptions given here are intended to accompany the device profile document that is included in the menu database, P94x/EN GC. The DNP3.0 protocol is not described here, please refer to the documentation available from the user group. The device profile document specifies the full details of the DNP3.0 implementation for the relay. This is the standard format DNP3.0 document that specifies which objects, variations and qualifiers are supported. The device profile document also specifies what data is available from the relay via DNP3.0. The relay operates as a DNP3.0 slave and supports subset level 2 of the protocol, plus some of the features from level 3.

DNP3.0 communication uses the EIA(RS)485 port at the rear of the relay. The data format is 1 start bit, 8 data bits, an optional parity bit and 1 stop bit.

5.2 Object 1 binary inputs

Object 1, binary inputs, contains information describing the state of signals within the relay which mostly form part of the digital data bus (DDB). In general these include the state of the output contacts and input optos, alarm signals and protection start and trip signals. The 'DDB number' column in the device profile document provides the DDB numbers for the DNP3.0 point data. These can be used to cross-reference to the DDB definition list that is also found in the menu database, P94x/EN GC. The binary input points can also be read as change events via object 2 and object 60 for class 1-3 event data.

5.3 Object 10 binary outputs

Object 10, binary outputs, contains commands that can be operated via DNP3.0. As such the points accept commands of type pulse on [null, trip, close] and latch on/off as detailed in the device profile in the menu database, P94x/EN GC and execute the command once for either command. The other fields are ignored (queue, clear, trip/close, in time and off time).

Due to that fact that many of the relay's functions are configurable, it may be the case that some of the object 10 commands described below are not available for operation. In the case of a read from object 10 this will result in the point being reported as off-line and an operate command to object 12 will generate an error response.

Examples of object 10 points that maybe reported as off-line are:

- Activate setting groups - Ensure setting groups are enabled
- Reset Gen. Abnormal Timers - Ensure generator abnormal protection is enabled
- Control Inputs - Ensure control inputs are enabled

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5.4 Object 20 binary counters

Object 20, binary counters, contains cumulative counters and measurements. The binary counters can be read as their present 'running' value from object 20, or as a 'frozen' value from object 21. The running counters of object 20 accept the read, freeze and clear functions. The freeze function takes the current value of the object 20 running counter and stores it in the corresponding object 21 frozen counter. The freeze and clear function resets the object 20 running counter to zero after freezing its value.

5.5 Object 30 analog input

Object 30, analog inputs, contains information from the relay's measurements columns in the menu. All object 30 points are reported as fixed-point values although they are stored inside the relay in a floating-point format. The conversion to fixed-point format requires the use of a scaling factor, which differs for the various types of data within the relay e.g. current, voltage, phase angle etc. The data types supported are listed at the end of the device profile document with each type allocated a 'D number', i.e. D1, D2, etc. In the object 30 point list each data point has a D number data type assigned to it which defines the scaling factor, default deadband setting and the range and resolution of the deadband setting. The deadband is the setting used to determine whether a change event should be generated for each point. The change events can be read via object 32 or object 60 and will be generated for any point whose value has changed by more than the deadband setting since the last time the data value was reported.

Any analog measurement that is unavailable at the time it is read will be reported as offline, e.g. the frequency when voltage frequency is outside the tracking range of the relay. Note that all object 30 points are reported as secondary values in DNP3.0 (with respect to VT ratios).

5.6 DNP3.0 configuration using MiCOM S1

A PC support package for DNP3.0 is available as part of the settings and records module of MiCOM S1 and allows configuration of the relay's DNP3.0 response. The PC is connected to the relay via a serial cable to the 9-pin front part of the relay - see Introduction (P94x/EN IT). The configuration data is uploaded from the relay to the PC in a block of compressed format data and downloaded to the relay in a similar manner after modification. The new DNP3.0 configuration takes effect in the relay after the download is complete. The default configuration can be restored at any time by choosing 'All Settings' from the 'Restore Defaults' cell in the menu 'Configuration' column. In MiCOM S1, the DNP3.0 data is displayed on a three-tabbed screen, one screen each for object 1, 20 and 30. Object 10 is not configurable.

5.6.1 Object 1

For every point included in the device profile document there is a check box for membership of class 0 and radio buttons for class 1, 2 or 3 membership. Any point that is in class 0 must be a member of one of the change event classes 1, 2 or 3.

Points that are configured out of class 0 are by default not capable of generating change events. Furthermore, points that are not part of class 0 are effectively removed from the DNP3.0 response by renumbering the points that are in class 0 into a contiguous list starting at point number 0. The renumbered point numbers are shown at the left-hand side of the screen in S1 and can be printed out to form a revised device profile for the relay. This mechanism allows best use of available bandwidth by only reporting the data points required by the user when a poll for all points is made.

5.6.2 Object 20

The running counter value of object 20 points can be configured to be in or out of class 0. Any running counter that is in class 0 can have its frozen value selected to be in or out of the DNP3.0 response, but a frozen counter cannot be included without the corresponding running counter. As with object 1, the class 0 response will be renumbered into a contiguous list of points based on the selection of running counters. The frozen counters will also be renumbered based on the selection; note that if some of the counters that are selected as running are not also selected as frozen then the renumbering will result in the frozen counters having different point numbers to their running counterparts. For example, object 20 point 3 (running counter) might have its frozen value reported as object 21 point 1.

5.6.3 Object 30

For the analog inputs, object 30, the same selection options for classes 0, 1, 2 and 3 are available as for object 1. In addition to these options, which behave in exactly the same way as for object 1, it is possible to change the deadband setting for each point. The minimum and maximum values and the resolution of the deadband settings are defined in the device profile document; MiCOM S1 will allow the deadband to be set to any value within these constraints.

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SYMBOLS AND GLOSSARY

Date:	**2008**
Hardware Suffix:	**A or C**
Software Version:	**12**
Connection Diagrams:	**10P94yxx (y = 1 or 3) (x = 01 to 06)**

Logic Symbols

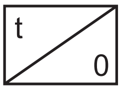
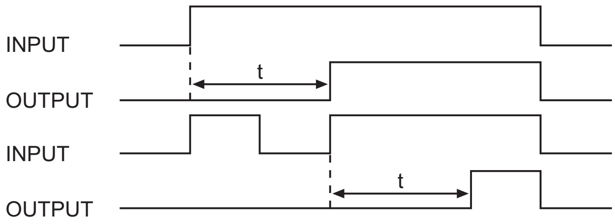
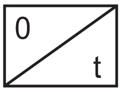
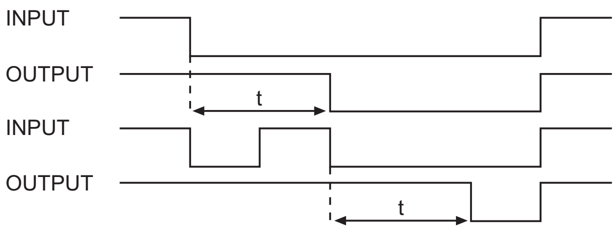
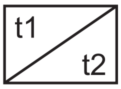
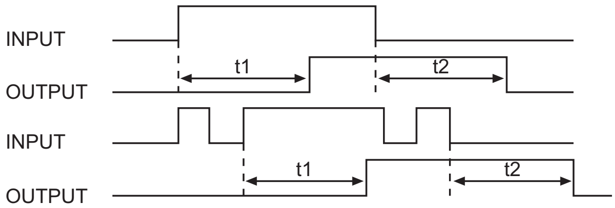
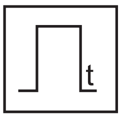
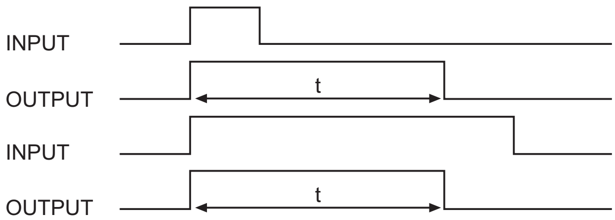
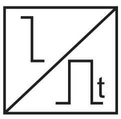
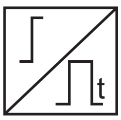
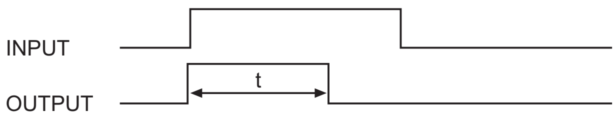
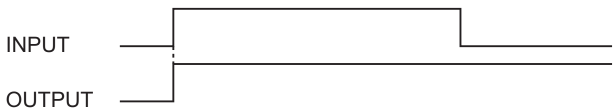
Symbols	Explanation
<	**Less than:** Used to indicate an "under" threshold, such as undercurrent (current dropout).
>	**Greater than:** Used to indicate an "over" threshold, such as overcurrent (current overload).
&	**Logical "AND":** Used in logic diagrams to show an AND-gate function.
1	**Logical "OR":** Used in logic diagrams to show an OR-gate function.
o	**A small circle on the input or output of a logic gate:** Indicates a NOT (invert) function.
	**"Read" key:** Used to move to the next page of a fault record without the need to enter the menu.
	**"Cancel" key:** Used to clear faults records without the need to enter the menu. Whilst in the menu, this key has similar usage to the "Esc" key of normal PC applications.
52a	**A circuit breaker closed auxiliary contact:** The contact is in the same state as the breaker primary contacts.
52b	**A circuit breaker open auxiliary contact:** The contact is in the opposite state to the breaker primary contacts.
Abn.	Abbreviation of abnormal
C/O	**A changeover contact having normally closed and normally open connections:** Sometimes called a "form C" contact.
CB	Circuit breaker.
CB Aux.	**Circuit breaker auxiliary contacts:** Indication of the breaker open/closed status.
CT	Current transformer.
CTRL.	**Abbreviation of "Control":** As used for the Control Inputs function.
DDB	**Digital data bus within the programmable scheme logic:** A logic point that has a zero or 1 status. DDB signals are mapped in logic to customize the relay's operation.
Df	Frequency difference used in setting the f+Df/Dt [81RAV] protection element. Sometimes labeled as Δf.
df/dt	Rate of change of frequency (ROCOF).
df/dt+t	**A rate of change of frequency protection element:** Could be labeled 81R in ANSI terminology.
Dly	Time delay.
DT	**Abbreviation of "Definite Time":** An element which always responds with the same constant time delay on operation.
Dt	Time period used in setting the f+Df/Dt [81RAV] protection element. Sometimes labeled as Δt.
f	A frequency threshold (used in the protection elements)

Symbols	Explanation
f+t	**A frequency protection element:** Could be labeled 81O or 81U in ANSI terminology.
f+df/dt	**A frequency supervised rate of change of frequency protection element:** Could be labeled 81RF in ANSI terminology.
f+Df/Dt	**A frequency supervised, average rate of change of frequency protection element:** Could be labeled 81RAV in ANSI terminology.
FLC	**Full load current:** The nominal rated current for the circuit.
Flt.	**Abbreviation of "Fault":** Typically used to indicate faulted phase selection.
FN	Function.
fn	Nominal system frequency.
Fwd.	Indicates an element responding to a flow in the "Forward" direction.
Freq.	Abbreviation of frequency.
Genr.	Abbreviation of generator
Gnd.	**Abbreviation of "Ground":** Alternative terminology to earth, especially used in distance elements to identify settings associated with earth faults.
GRP.	**Abbreviation of "Group":** Typically an alternative setting group.
H	Inertia constant of the power system or generating unit. May be used to estimate the rate of change of frequency.
ID	**Abbreviation of "Identifier":** Often a label used to track a software version installed.
IDMT	**Inverse definite minimum time:** A characteristic whose trip time depends on the measured input (e.g. current) according to an inverse-time curve.
In	**The rated nominal current of the relay:** Software selectable as 1 amp or 5 amp to match the line CT input.
Inh	An inhibit signal.
Inst.	**An element with "instantaneous" operation:** i.e. having no deliberate time delay.
I/O	**Abbreviation of "Inputs and Outputs":** Used in connection with the number of optocoupled inputs and output contacts within the relay.
I/P	Abbreviation of "Input".
IRIG-B	A method of time synchronization used on P94x, as defined by the **I**nter **R**ange **I**nstrumentation **G**roup.
LCD	**Liquid crystal display:** The front-panel text display on the relay.
LD	**Abbreviation of "Level Detector":** An element responding to a current or voltage below its set threshold.

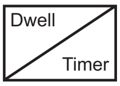
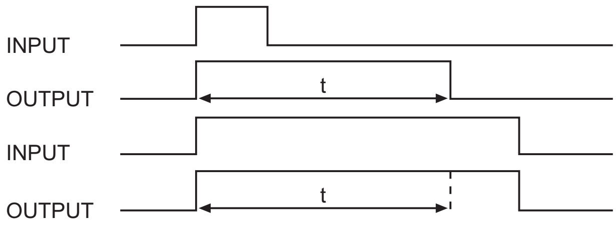
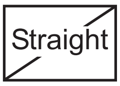
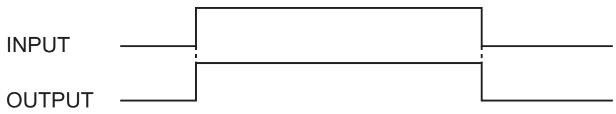
Symbols	Explanation
LED	**Light emitting diode:** Red indicator on the relay front-panel.
MCB	**A "miniature circuit breaker":** Used instead of a fuse to protect VT secondary circuits.
MR	**Abbreviation of Manual-Reset:** A signal that requires manual intervention in order to reset even though the initiating condition has disappeared or reset.
N	**Indication of "Neutral" involvement in a fault:** i.e. an earth (ground) fault.
N/A	Not applicable.
N/C	**A normally closed or "break" contact:** Sometimes called a "form B" contact.
N/O	**A normally open or "make" contact:** Sometimes called a "form A" contact.
NPS	Negative phase sequence.
NVD	**Neutral voltage displacement:** Equivalent to residual overvoltage protection.
O/P	Abbreviation of "output".
Opto	**An optocoupled logic input:** Alternative terminology: binary input.
P1	**Used in IEC terminology to identify the primary CT terminal polarity:** Replace by a dot when using ANSI standards.
P2	**Used in IEC terminology to identify the primary CT terminal polarity:** The non-dot terminal.
PCB	Printed circuit board.
Ph	**Abbreviation of "Phase":** Used in distance settings to identify settings that relate to phase-phase faults.
PSL	**Programmable scheme logic:** The part of the relay's logic configuration that can be modified by the user, using the graphical editor within MiCOM S1 software.
RMS	**The equivalent a.c. current:** Taking into account the fundamental, plus the equivalent heating effect of any harmonics. Abbreviation of "root mean square".
RP	**Abbreviation of "Rear Port":** The communication port on the rear of the relay.
S1	**Used in IEC terminology to identify the secondary CT terminal polarity:** Replace by a dot when using ANSI standards.
S2	**Used in IEC terminology to identify the secondary CT terminal polarity:**
SR	**Abbreviation of Self-Reset:** A signal that automatically resets when the initiating condition has disappeared or reset.
Stats	**Abbreviation of "Statistics":** Used to provide information on the protection operations and setting changes that have occurred in each stage (Stage Statistics).

Symbols	Explanation
t	A time delay.
TCS	Trip circuit supervision.
TE	**A standard for measuring the width of a relay case:** 5TE units = 1 inch
TMS	The time multiplier setting applied to inverse-time curves (IEC).
UV	Abbreviation of undervoltage.
V	Voltage.
V<	An undervoltage element.
V<B	Undervoltage blocking element used to prevent operation of frequency based protection.
V<1	**First stage of undervoltage protection:** Could be labeled 27-1 in ANSI terminology.
V<2	**Second stage of undervoltage protection:** Could be labeled 27-2 in ANSI terminology.
V>	An overvoltage element.
V>1	**First stage of overvoltage protection:** Could be labeled 59-1 in ANSI terminology.
V>2	**Second stage of overvoltage protection:** Could be labeled 59-2 in ANSI terminology.
V_0	**Zero sequence voltage:** Equals one third of the measured neutral/residual voltage.
V_1	Positive sequence voltage.
V_2	Negative sequence voltage.
VA	**Phase A voltage:** Might be phase L1, red phase.. or other, in customer terminology.
VB	**Phase B voltage:** Might be phase L2, yellow phase.. or other, in customer terminology.
VC	**Phase C voltage:** Might be phase L3, blue phase.. or other, in customer terminology.
Vn	**The rated nominal voltage of the relay:** To match the line VT input.
VN	Neutral voltage displacement, or residual voltage.
VN>1	First stage of residual (neutral) overvoltage protection.
VN>2	Second stage of residual (neutral) overvoltage protection.
Vres.	Neutral voltage displacement, or residual voltage.
VT	Voltage transformer.
VTS	**Voltage transformer supervision:** To detect VT input failure.
Vx	**An auxiliary supply voltage:** Typically the substation battery voltage used to power the relay.

Logic Timers

Logic Symbols	Explanation	Time Chart
	Delay on pick-up timer, t	
	Delay on drop-off timer, t	
	Delay on pick-up/drop-off timer	
	Pulse timer	
	Pulse pick-up falling edge	
	Pulse pick-up raising edge	
Latching	Latch	

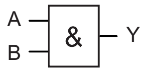
SG

Logic Symbols	Explanation	Time Chart
	Dwell timer	
	**Straight (non latching):** Hold value until input reset signal	

Logic Gates

AND GATE

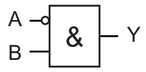
Symbol:



Truth Table:

IN		OUT
0	1	0
0	1	0
0	1	0
1	0	0
1	1	1

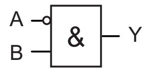
Symbol:



Truth Table:

IN		OUT
A	B	Y
0	0	0
0	1	1
1	0	0
1	1	0

Symbol:

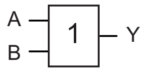


Truth Table:

IN		OUT
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

OR GATE

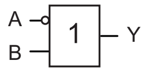
Symbol:



Truth Table:

IN		OUT
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

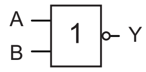
Symbol:



Truth Table:

IN		OUT
A	B	Y
0	0	1
0	1	1
1	0	0
1	1	1

Symbol:

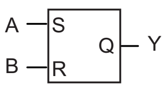


Truth Table:

IN		OUT
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

R - S FLIP-FLOP

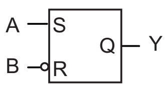
Symbol:



Truth Table:

A	B	QN	QN+	Active Mode
0	0			Hold Mode
0	1	0		Hold Mode
		1	0	Reset
1	0	0	1	Set
		1		Hold Mode
0	0	-	-	Inhibit Mode

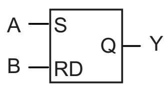
Symbol:



Truth Table:

A	B	QN	QN+	Active Mode
0	0	0		Hold Mode
		1	0	Reset
0	1			Hold Mode
1	0	-	-	Inhibit Mode
0	1	0	1	Set
		1		Hold Mode

Symbol:



* RD = Reset Dominant

Truth Table:

A	B	QN	QN+	Active Mode
0	0			Hold Mode
0	1			0
1	0	0	1	Set
		1		Hold Mode
1	1			0

EXCLUSIVE OR GATE

Symbol:

Truth Table:

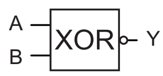
IN		OUT
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

Symbol:

Truth Table:

IN		OUT
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

Symbol:

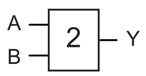


Truth Table:

IN		OUT
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

MULTI INPUT GATE

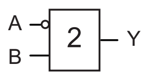
Symbol:



Truth Table:

IN		OUT
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

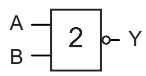
Symbol:



Truth Table:

IN		OUT
A	B	Y
0	0	0
0	1	1
1	0	0
1	1	0

Symbol:

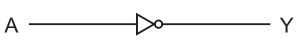


Truth Table:

IN		OUT
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

NOT GATE

Symbol:



Inverter (NOT)

Truth Table:

IN	OUT
A	Y
0	1
1	0

SG

INSTALLATION

Date:	**2008**
Hardware Suffix:	**A or C**
Software Version:	**12**
Connection Diagrams:	**10P94yxx (y = 1 or 3) (x = 01 to 06)**

CONTENTS

(IN) 15-

FIGURES

1. RECEIPT OF RELAYS

Upon receipt, relays should be examined immediately to ensure no external damage has been sustained in transit. If damage has been sustained, a claim should be made to the transport contractor and Schneider Electric should be promptly notified.

Relays that are supplied unmounted and not intended for immediate installation should be returned to their protective polythene bags and delivery carton. Section 3 of P94x/EN IN gives more information about the storage of relays.

2. HANDLING OF ELECTRONIC EQUIPMENT

Before carrying out any work on the equipment, the user should be familiar with the contents of the Safety Guide (SFTY/4L M/C11) or later issue, or the Safety and Technical Data sections of this Technical Manual and also the ratings on the equipment's rating label.

A person's normal movements can easily generate electrostatic potentials of several thousand volts. Discharge of these voltages into semiconductor devices when handling electronic circuits can cause serious damage that, although not always immediately apparent, will reduce the reliability of the circuit. The relay's electronic circuits are protected from electrostatic discharge when housed in the case. Do not expose them to risk by removing the front panel or printed circuit boards unnecessarily.

Each printed circuit board incorporates the highest practicable protection for its semiconductor devices. However, if it becomes necessary to remove a printed circuit board, the following precautions should be taken to preserve the high reliability and long life for which the relay has been designed and manufactured.

Before removing a printed circuit board, ensure that you are at the same electrostatic potential as the equipment by touching the case.

Handle analog input modules by the front panel, frame or edges of the circuit boards. Printed circuit boards should only be handled by their edges. Avoid touching the electronic components, printed circuit tracks or connectors.

Do not pass the module to another person without first ensuring you are both at the same electrostatic potential. Shaking hands achieves equipotential.

Place the module on an anti-static surface, or on a conducting surface that is at the same potential as you.

If it is necessary to store or transport printed circuit boards removed from the case, place them individually in electrically conducting anti-static bags.

In the unlikely event that you are making measurements on the internal electronic circuitry of a relay in service, it is preferable that you are earthed to the case with a conductive wrist strap. Wrist straps should have a resistance to ground between 500kΩ to 10MΩ. If a wrist strap is not available you should maintain regular contact with the case to prevent a build-up of electrostatic potential. Instrumentation which may be used for making measurements should also be earthed to the case whenever possible.

More information on safe working procedures for all electronic equipment can be found in BS EN 100015: Part 1:1992. It is strongly recommended that detailed investigations on electronic circuitry or modification work should be carried out in a special handling area such as described in the British Standard document.

3. STORAGE

If relays are not to be installed immediately upon receipt, they should be stored in a place free from dust and moisture in their original cartons. Where de-humidifier bags have been included in the packing they should be retained.

To prevent battery drain during transportation and storage a battery isolation strip is fitted during manufacture. With the lower access cover open, presence of the battery isolation strip can be checked by a red tab protruding from the positive polarity side.

Care should be taken on subsequent unpacking that any dust, which has collected on the carton, does not fall inside. In locations of high humidity the carton and packing may become impregnated with moisture and the de-humidifier crystals will lose their efficiency.

Prior to installation, relays should be stored at a temperature of between –25˚C to +70˚C (-13˚F to +158˚F).

4. UNPACKING

Care must be taken when unpacking and installing the relays so that none of the parts are damaged and additional components are not accidentally left in the packing or lost. Ensure that any User's CDROM or technical documentation is NOT discarded - this should accompany the relay to its destination substation.

Note: With the lower access cover open, the red tab of the battery isolation strip will be seen protruding from the positive (+) side of the battery compartment. Do not remove this strip because it prevents battery drain during transportation and storage and will be removed as part of the commissioning tests.

Relays must only be handled by skilled persons.

The site should be well lit to facilitate inspection, clean, dry and reasonably free from dust and excessive vibration.

5. RELAY MOUNTING

MiCOM relays are dispatched either individually or as part of a panel/rack assembly.

Individual relays are normally supplied with an outline diagram showing the dimensions for panel cutouts and hole centers. This information can also be found in the product publication.

Secondary front covers can also be supplied as an optional item to prevent unauthorized changing of settings and alarm status. They are available in size 40TE (GN0037 001) for the P941 and size 60TE (GN0038 001) for the P943.

The design of the relay is such that the fixing holes in the mounting flanges are only accessible when the access covers are open and hidden from sight when the covers are closed.

If a P991 or MMLG test block is to be included, it is recommended that, when viewed from the front, it be positioned on the right-hand side of the relay (or relays) with which it is associated. This minimizes the wiring between the relay and test block, and allows the correct test block to be easily identified during commissioning and maintenance tests.

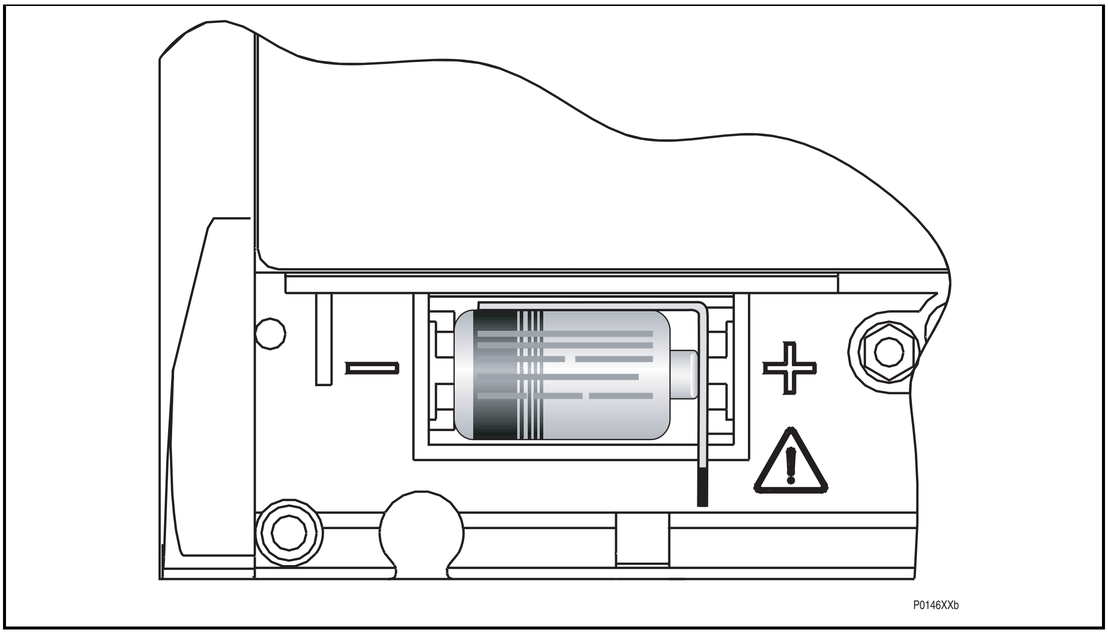


Figure 1: Location of battery isolation strip

If it is necessary to test correct relay operation during the installation, the battery isolation strip can be removed but should be replaced if commissioning of the scheme is not imminent. The red tab of the isolation strip can be seen protruding from the positive side of the battery compartment when the lower access cover is open. To remove the isolation strip, pull the red tab whilst lightly pressing the battery to prevent it falling out of the compartment. When replacing the battery isolation strip, ensure that the strip is refitted as shown in Figure 1, i.e. with the strip behind the battery with the red tab protruding.

5.1 Rack mounting

MiCOM relays may be rack mounted using single tier rack frames (our part number FX0021 001), as illustrated in Figure 2. These frames have been designed to have dimensions in accordance with IEC60297 and are supplied pre-assembled ready to use. On a standard 483mm rack system this enables combinations of widths of case up to a total equivalent of size 80TE to be mounted side by side.

The two horizontal rails of the rack frame have holes drilled at approximately 26mm intervals and the relays are attached via their mounting flanges using M4 Taptite self-tapping screws with captive 3mm thick washers (also known as a SEMS unit). These fastenings are available in packs of 5 (our part number ZA0005 105).

Note: Conventional self-tapping screws, including those supplied for mounting MiDOS relays, have marginally larger heads which can damage the front cover molding if used.

Once the tier is complete, the frames are fastened into the racks using mounting angles at each end of the tier.

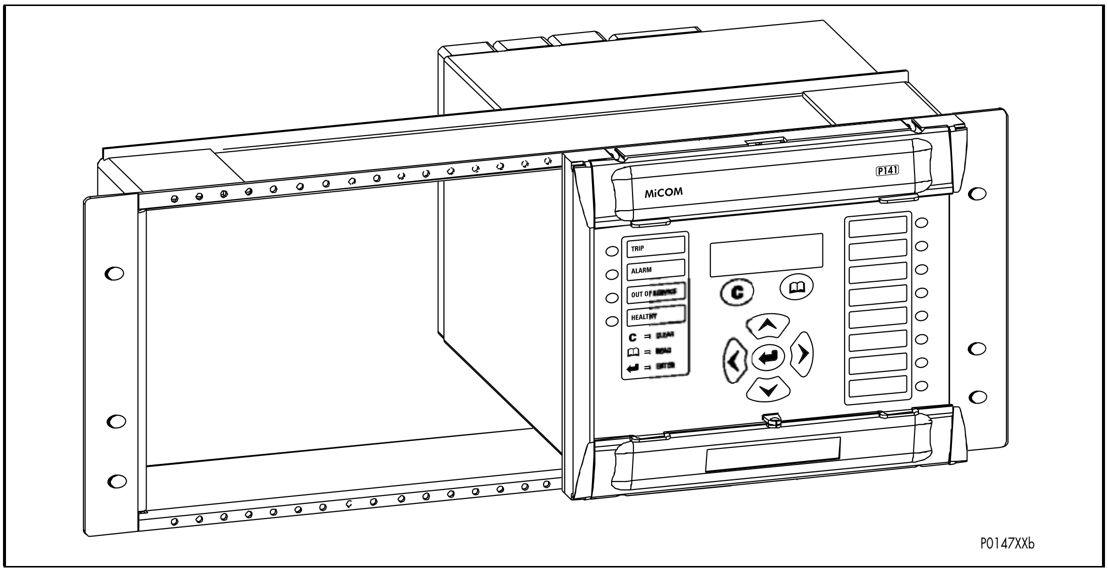


Figure 2: Rack mounting of relays

Relays can be mechanically grouped into single tier (4U) or multi-tier arrangements by means of the rack frame. This enables schemes using products from the MiCOM and MiDOS product ranges to be pre-wired together prior to mounting.

Where the case size summation is less than 80TE on any tier, or space is to be left for installation of future relays, blanking plates may be used. These plates can also be used to mount ancillary components. Table 1 shows the sizes that can be ordered.

Note: Blanking plates are only available in black.

Further details on mounting MiDOS relays can be found in publication R7012, “MiDOS Parts Catalog and Assembly Instructions”.

Case Size Summation	Blanking Plate Part Number
5TE	GJ2028 101
10TE	GJ2028 102
15TE	GJ2028 103
20TE	GJ2028 104

Table 1: Blanking plates

5.2 Panel mounting

The relays can be flush mounted into panels using M4 SEMS Taptite self-tapping screws with captive 3mm thick washers (also known as a SEMS unit). These fastenings are available in packs of 5 (our part number ZA0005 104).

Note: Conventional self-tapping screws, including those supplied for mounting MiDOS relays, have marginally larger heads which can damage the front cover molding if used.

Alternatively tapped holes can be used if the panel has a minimum thickness of 2.5mm.

For applications where relays need to be semi-projection or projection mounted, a range of collars are available.

Where several relays are to mounted in a single cutout in the panel, it is advised that they are mechanically grouped together horizontally and/or vertically to form rigid assemblies prior to mounting in the panel.

Note: It is not advised that MiCOM relays are fastened using pop rivets as this will not allow the relay to be easily removed from the panel in the future if repair is necessary.

If it is required to mount a relay assembly on a panel complying to IEC 60529 IP52 enclosure protection, it will be necessary to fit a metallic sealing strip between adjoining relays (Part No. GN2044 001) and a sealing ring around the complete assembly.

Width	**Single Tier**	**Double Tier**
40TE	GJ9018 008	GJ9018 024
60TE	GJ9018 012	GJ9018 028

Table 2: IP52 sealing rings

6. RELAY WIRING

This section serves as a guide to selecting the appropriate cable and connector type for each terminal on the MiCOM relay.

6.1 Medium and heavy duty terminal block connections

Key:

Heavy duty terminal block: CT and VT circuits, terminals with "C" prefix (black color)

Medium duty: All other terminal blocks (grey color)

Loose relays are supplied with sufficient M4 screws for making connections to the rear mounted terminal blocks using ring terminals, with a recommended maximum of two ring terminals per relay terminal.

If required, Schneider Electric can supply M4 90° crimp ring terminals in three different sizes depending on wire size (see Table 3). Each type is available in bags of 100.

Part Number	Wire Size	Insulation Color
ZB9124 901	0.25 - 1.65mm^2 (22 - 16AWG)	Red
ZB9124 900	1.04 - 2.63mm^2 (16 - 14AWG)	Blue
ZB9124 904	2.53 - 6.64mm^2 (12 - 10AWG)	Un-insulated*

Table 3: M4 90° crimp ring terminals

*To maintain the terminal block insulation requirements for safety, an insulating sleeve should be fitted over the ring terminal after crimping.

The following minimum wire sizes are recommended:

Current Transformers 2.5mm^2

Auxiliary Supply, Vx 1.5mm^2

EIA(RS)485 Port See separate section

Other Circuits 1.0mm^2

Due to the limitations of the ring terminal, the maximum wire size that can be used for any of the medium or heavy duty terminals is 6.0mm^2 using ring terminals that are not pre-insulated. Where it required to only use pre-insulated ring terminals, the maximum wire size that can be used is reduced to 2.63mm^2 per ring terminal. If a larger wire size is required, two wires should be used in parallel, each terminated in a separate ring terminal at the relay.

The wire used for all connections to the medium and heavy duty terminal blocks, except the EIA(RS)485 port, should have a minimum voltage rating of 300Vrms.

It is recommended that the auxiliary supply wiring should be protected by a 16A high rupture capacity (HRC) fuse of type NIT or TIA or smaller - refer to P94x/EN AP for further details. For safety reasons, current transformer circuits must never be fused. Other circuits should be appropriately fused to protect the wire used.

6.2 EIA(RS)485 port

Connections to the EIA(RS)485 port are made using ring terminals. It is recommended that a 2 core screened cable is used with a maximum total length of 1000m or 200nF total cable capacitance. A typical cable specification would be:

Each core: 16/0.2mm copper conductors

PVC insulated

Nominal conductor area: 0.5mm^2 per core

Screen: Overall braid, PVC sheathed

See SCADA Communications (P94x/EN CT) for detailed discussion on setting up an EIA(RS)485 bus.

6.3 IRIG-B connections (if applicable)

The IRIG-B input and BNC connector have a characteristic impedance of 50Ω. It is recommended that connections between the IRIG-B equipment and the relay are made using coaxial cable of type RG59LSF with a halogen free, fire retardant sheath.

6.4 EIA(RS)232 front port

Short term connections to the EIA(RS)232 port, located behind the bottom access cover, can be made using a screened multi-core communication cable up to 15m long, or a total capacitance of 2500pF. The cable should be terminated at the relay end with a 9-way, metal shelled, D-type male plug. The pin allocations are detailed in section 1.9 of Getting Started (P94x/EN GS).

6.5 Download/monitor port

Short term connections to the download/monitor port, located behind the bottom access cover, can be made using a screened 25-core communication cable up to 4m long. The cable should be terminated at the relay end with a 25-way, metal shelled, D-type male plug and linked as a parallel data connection.

6.6 Earth connection

Every relay must be connected to the cubicle earth bar using the M4 earth studs in the bottom left hand corner of the relay case. The minimum recommended wire size is 2.5mm2 and should have a ring terminal at the relay end.

To prevent any possibility of electrolytic action between brass or copper earth conductors and the rear of the relay, precautions should be taken. Examples include placing a nickel-plated washer between the conductor and the relay case, or using tinned ring terminals.

7. CASE DIMENSIONS

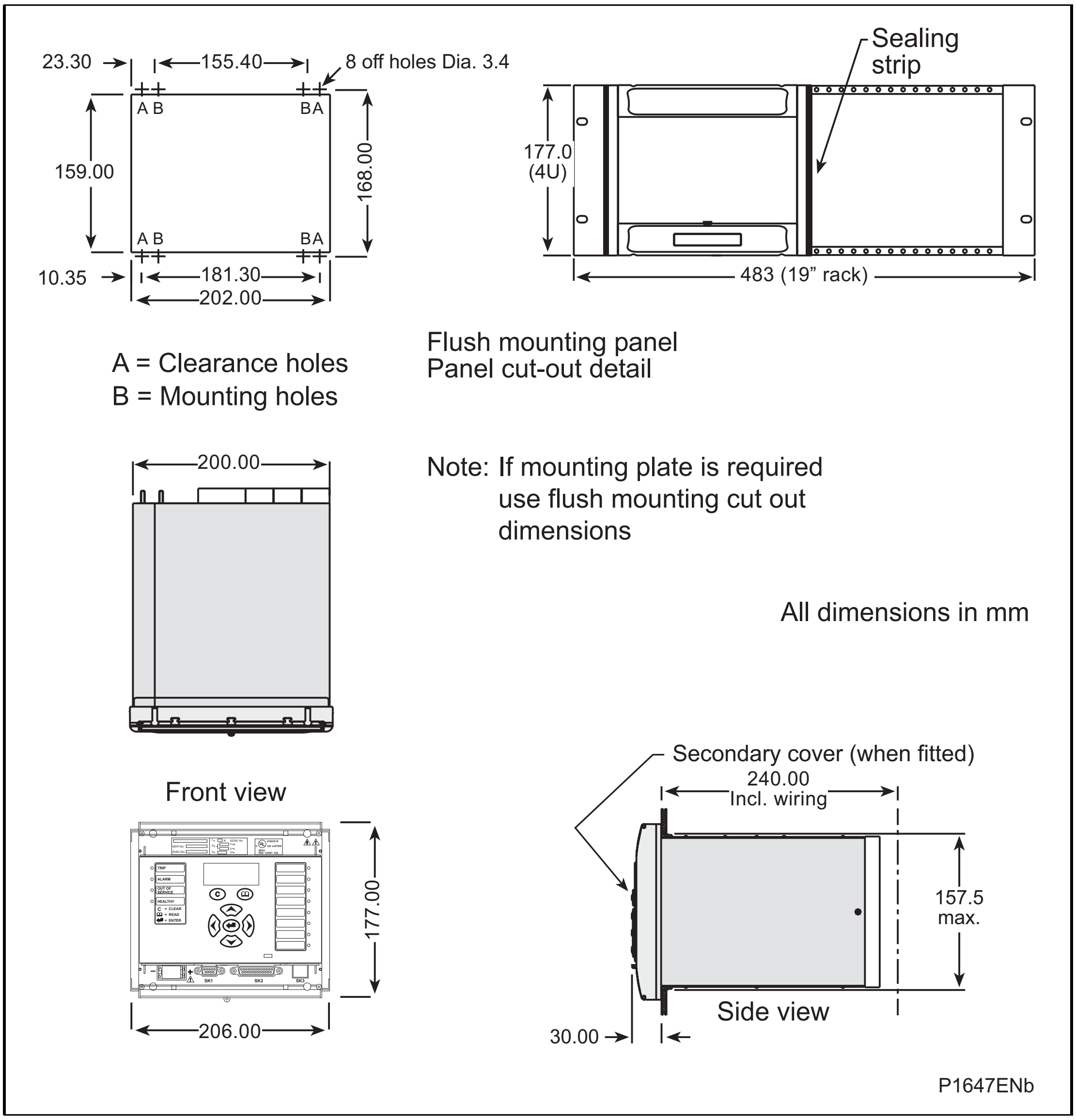


Figure 3: P941 Case Dimensions

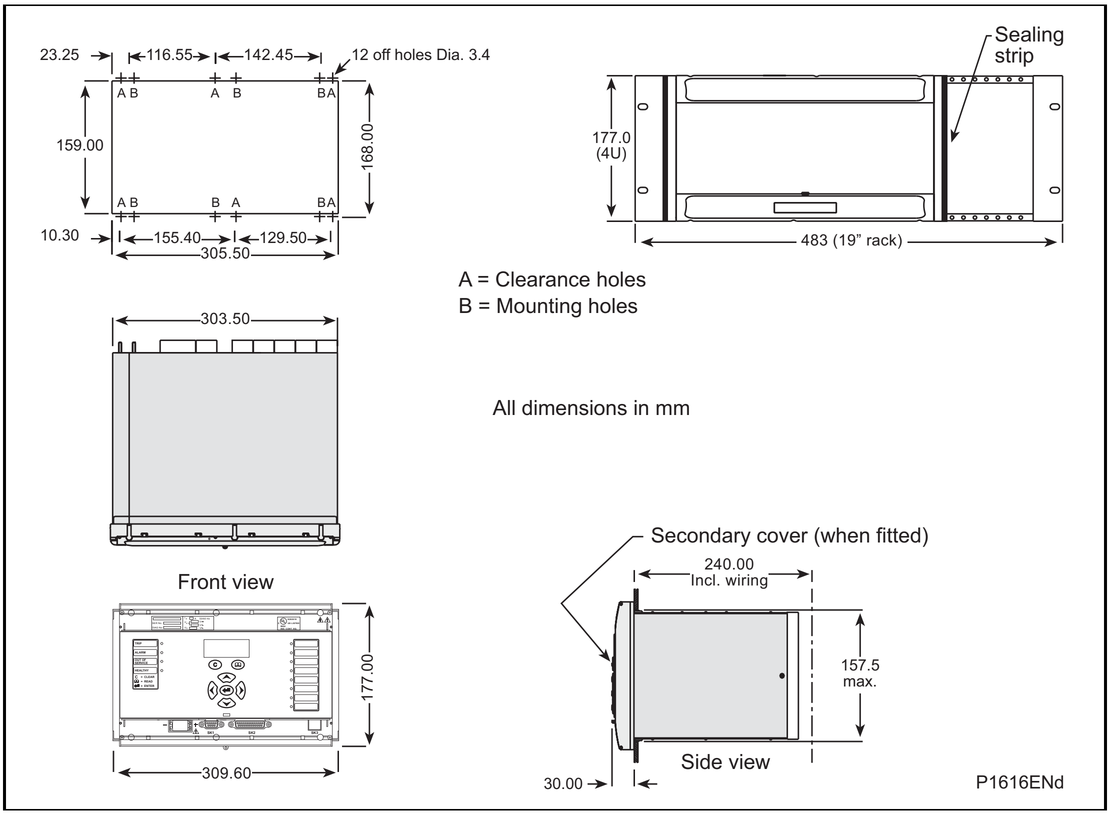


Figure 4: P943 Case Dimensions

8. EXTERNAL CONNECTION DIAGRAMS

Model Number	Digital I/O Allocation		Connection Diagram	Assembly Drawing
	Inputs	Outputs		
P941xxxAxxxxxx	8	7	Figure 5	Figure 17
P941xxxBxxxxxx	12	11	Figure 7	Figure 18
P941xxxCxxxxxx	16	7	Figure 8	Figure 18
P941xxxDxxxxxx	8	15	Figure 9	Figure 18
P942xxxAxxxxxx	8	14	Figure 10	Figure 18
P943xxxAxxxxxx	16	14	Figure 11	Figure 19
P943xxxCxxxxxx	24	14	Figure 12	Figure 20
P943xxxDxxxxxx	16	22	Figure 13	Figure 20
P943xxxExxxxxx	24	22	Figure 14	Figure 21
P943xxxFxxxxxx	32	14	Figure 15	Figure 21
P943xxxGxxxxxx	16	30	Figure 16	Figure 21

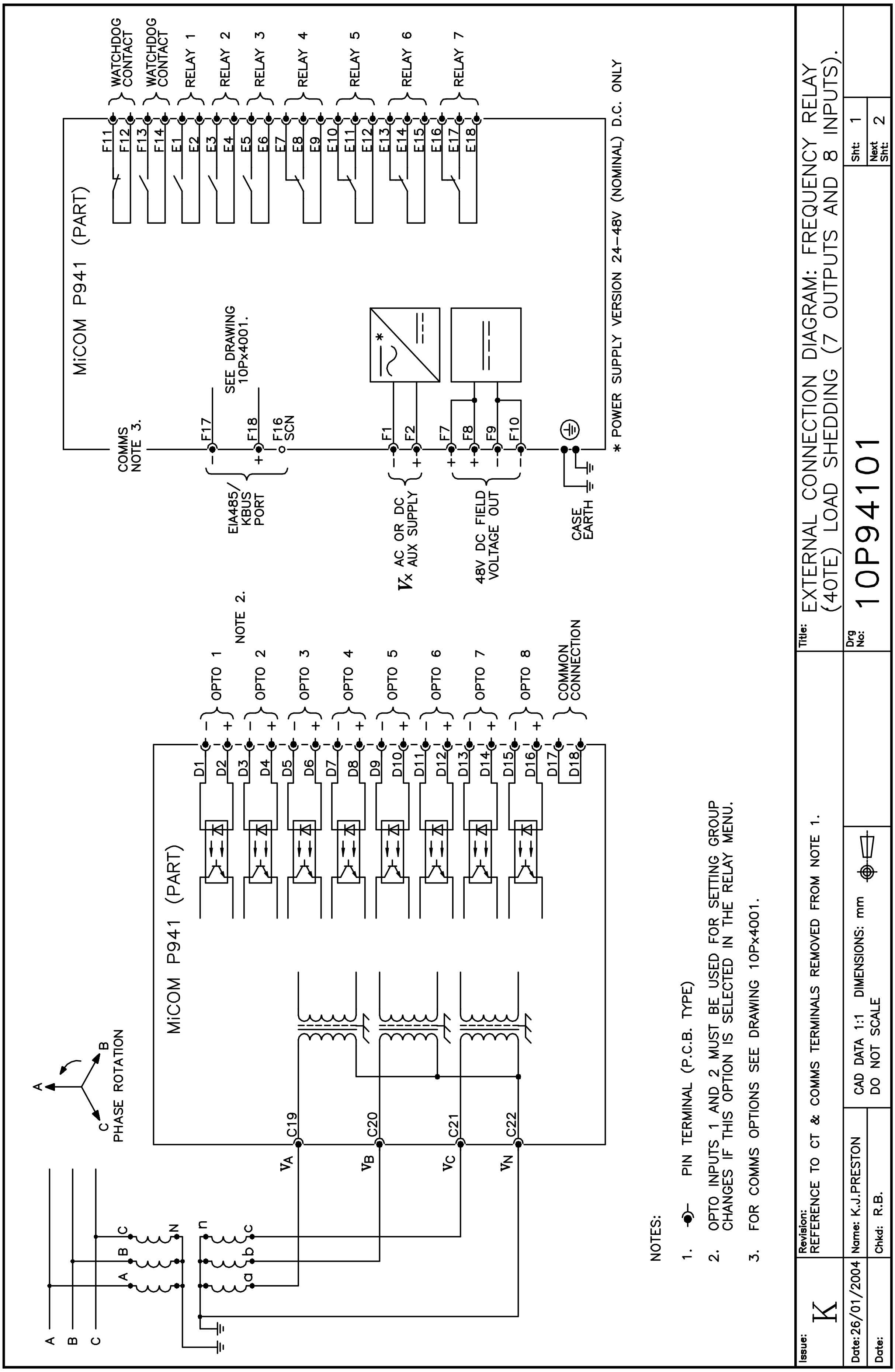


Figure 5: P941 Model A with 7 output contacts and 8 digital inputs

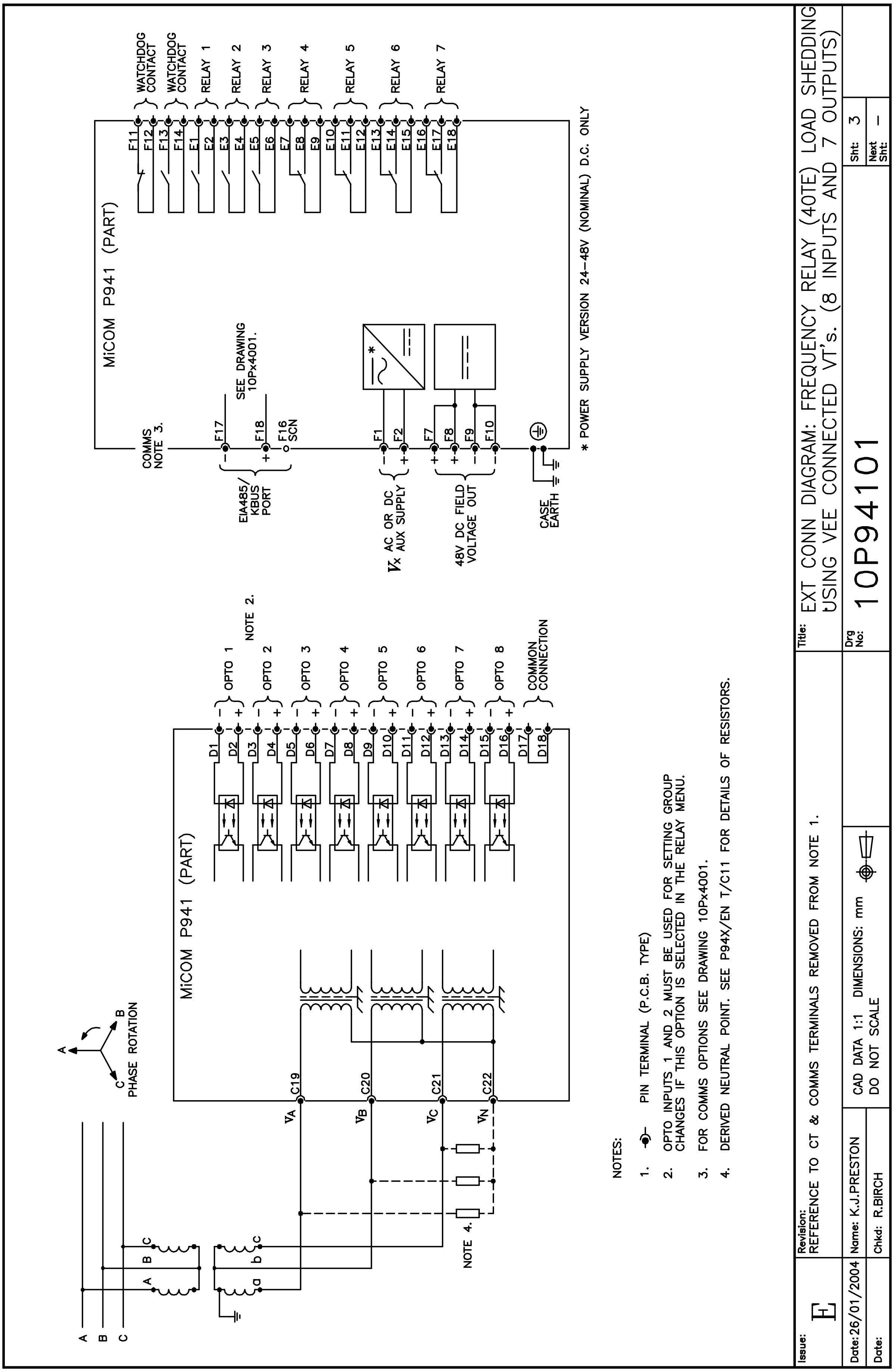


Figure 6: P941 Model A with 7 output contacts and 8 digital inputs using V-connected VT's

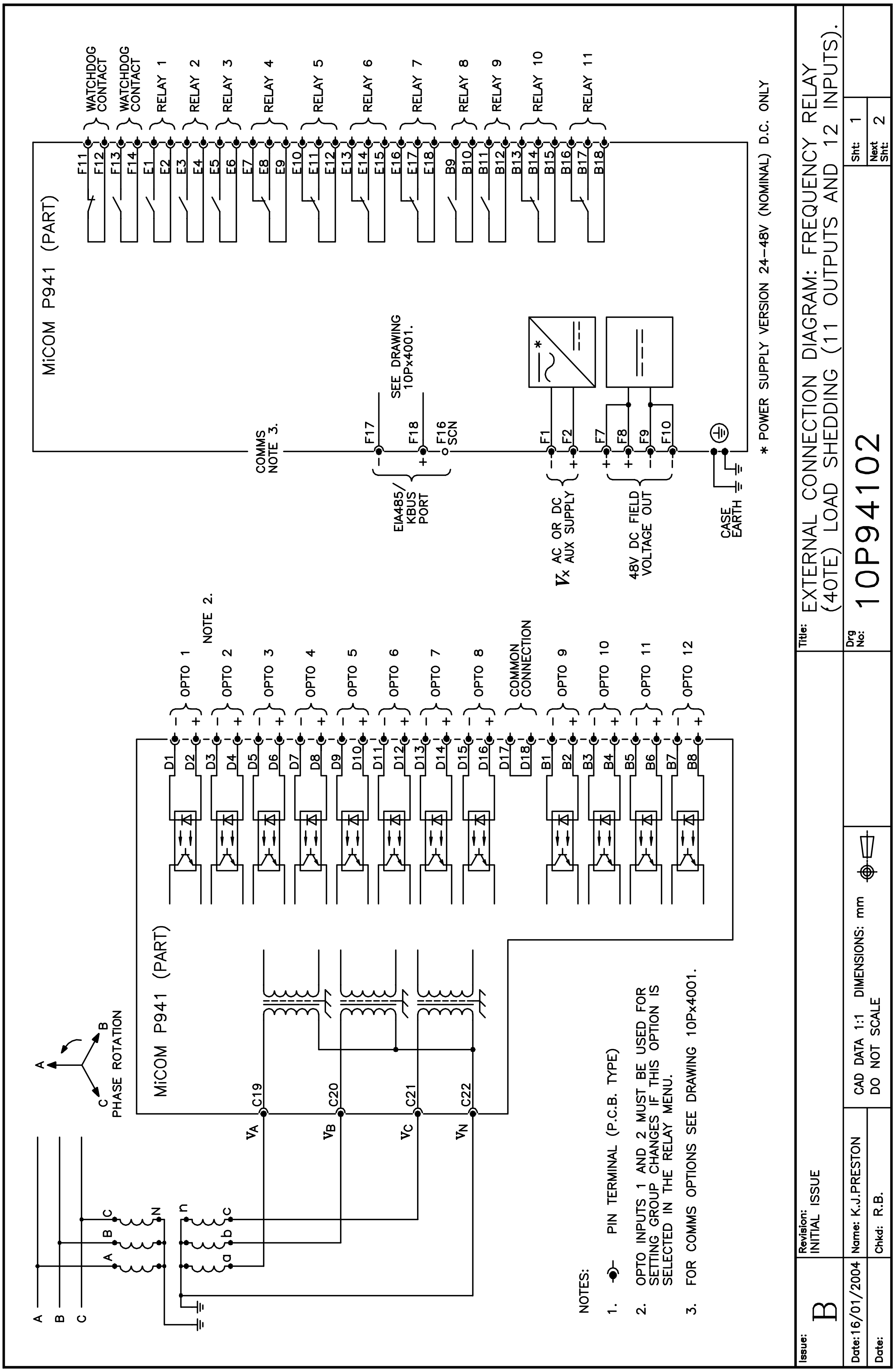


Figure 7: P941 Model B with 11 output contacts and 12 digital inputs

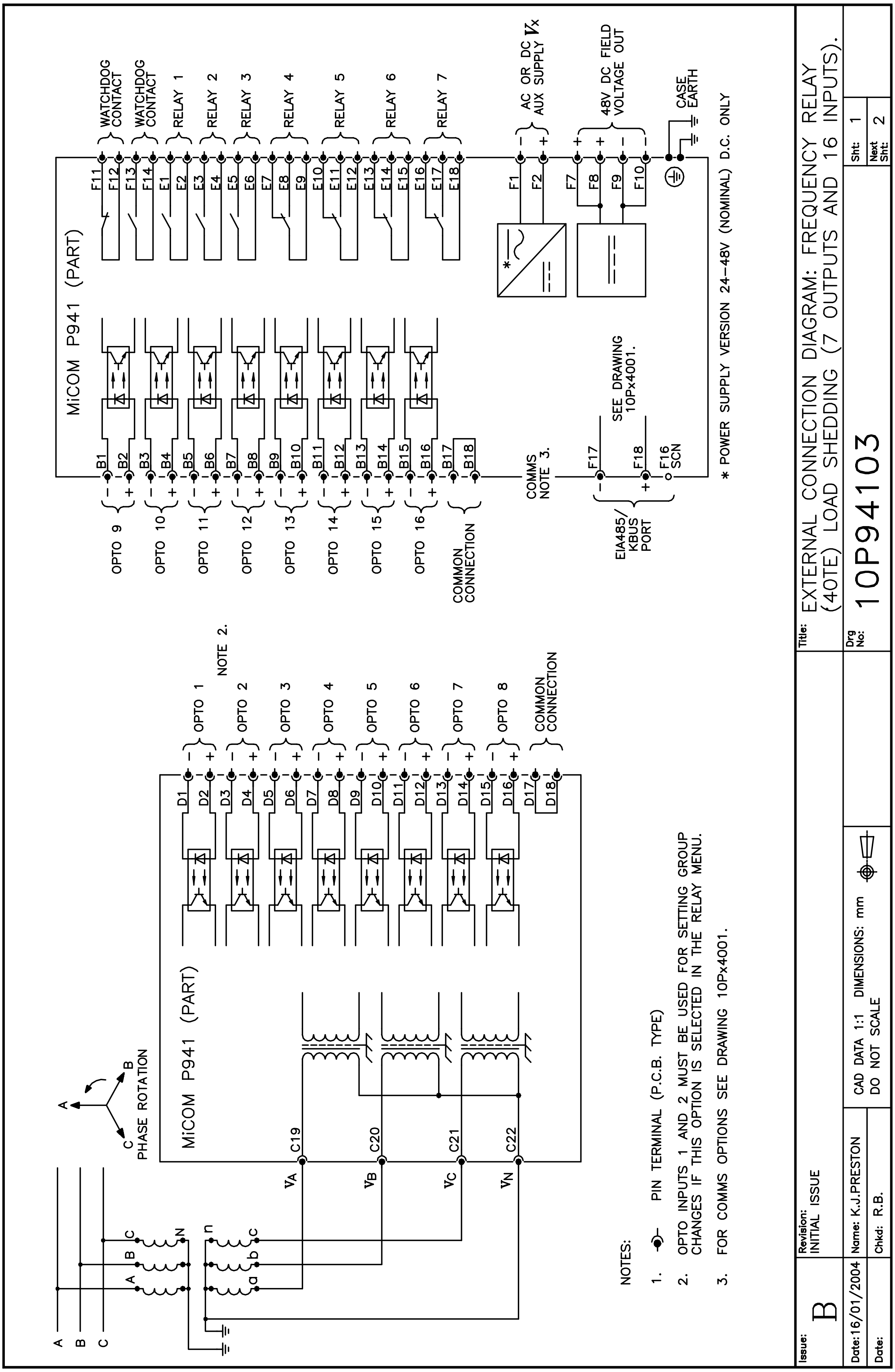


Figure 8: P941 Model C with 7 output contacts and 16 digital inputs

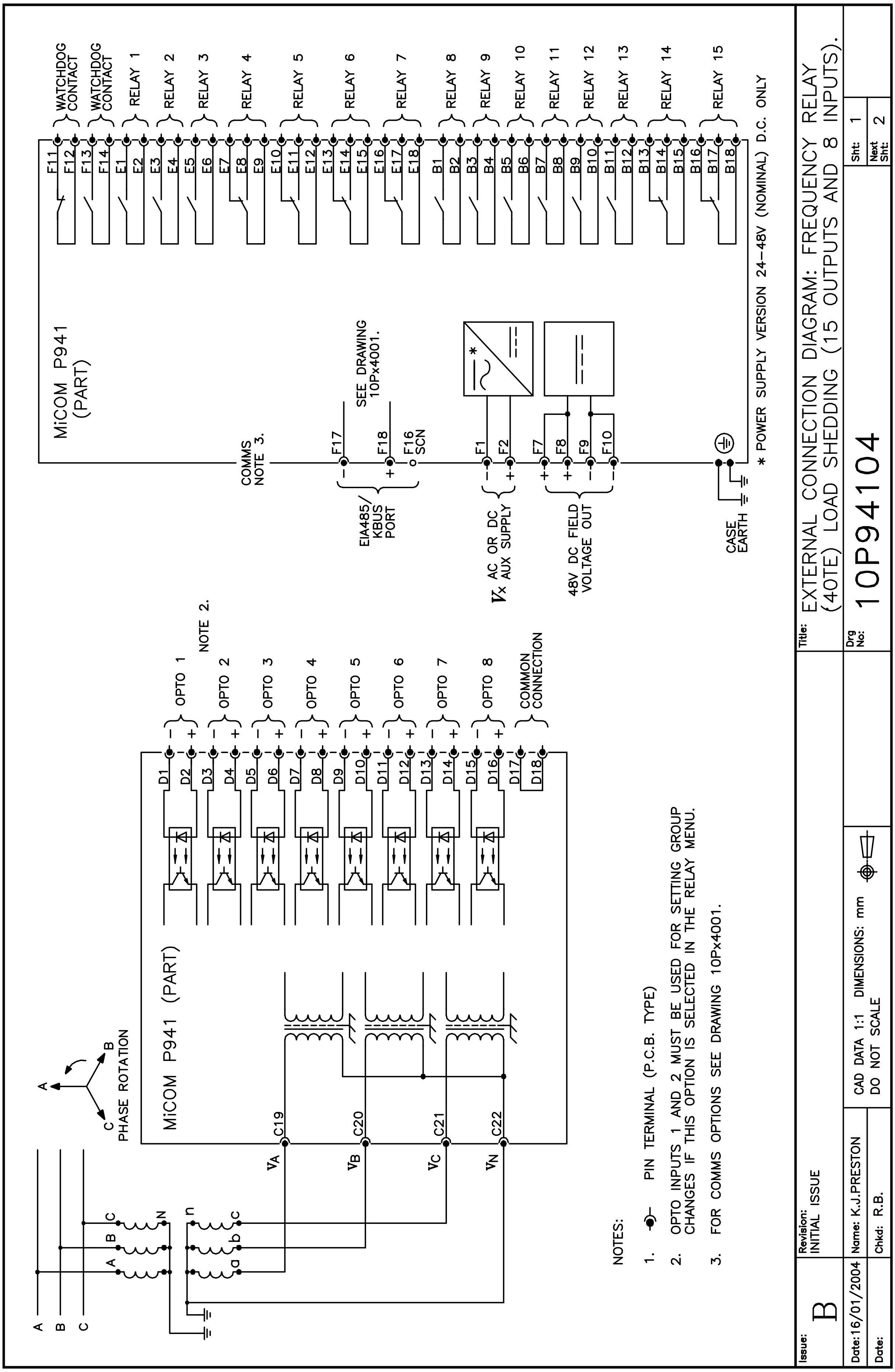


Figure 9: P941 Model D with 15 output contacts and 8 digital inputs

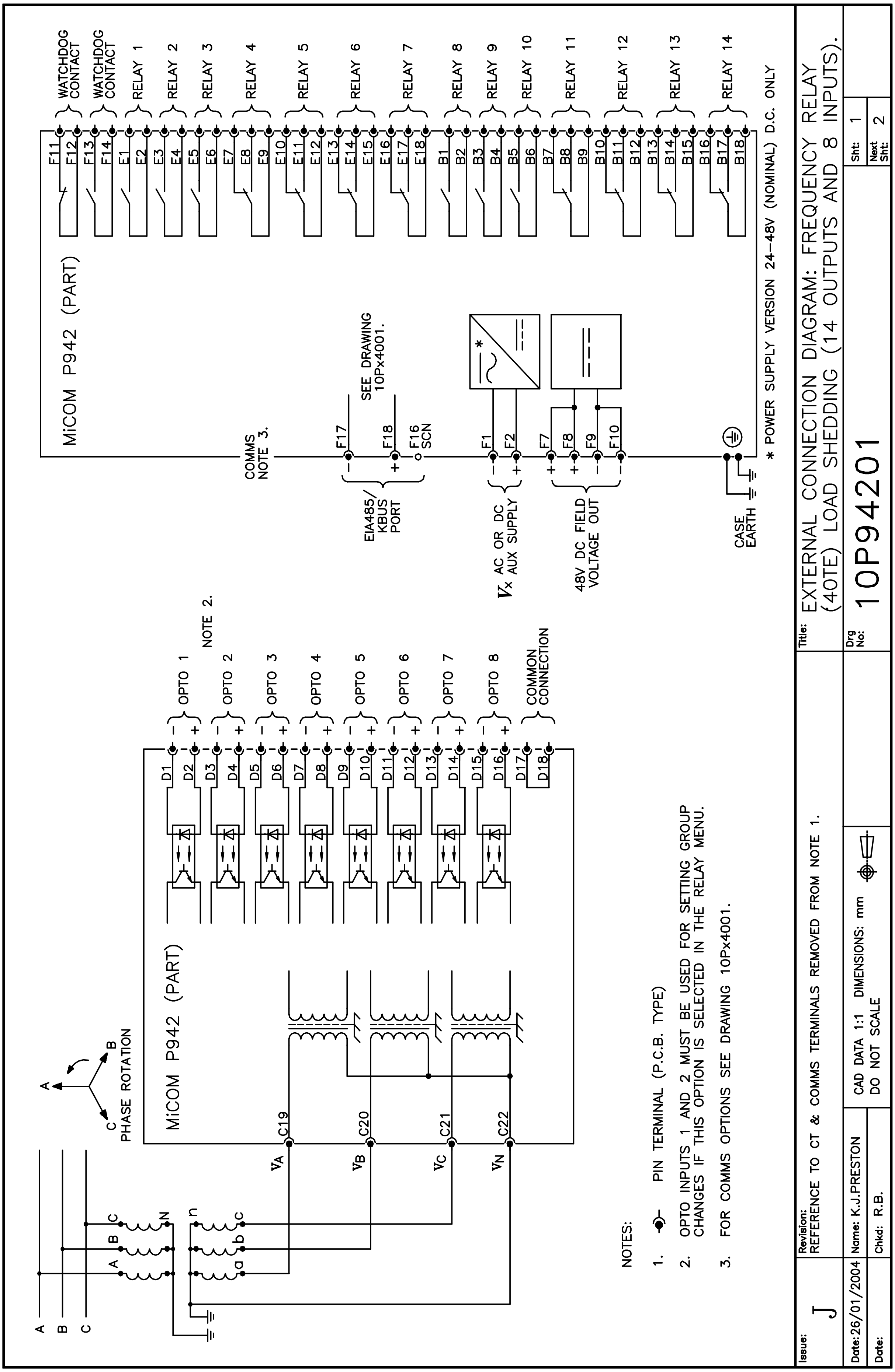


Figure 10: P942 with 14 output contacts and 8 digital inputs

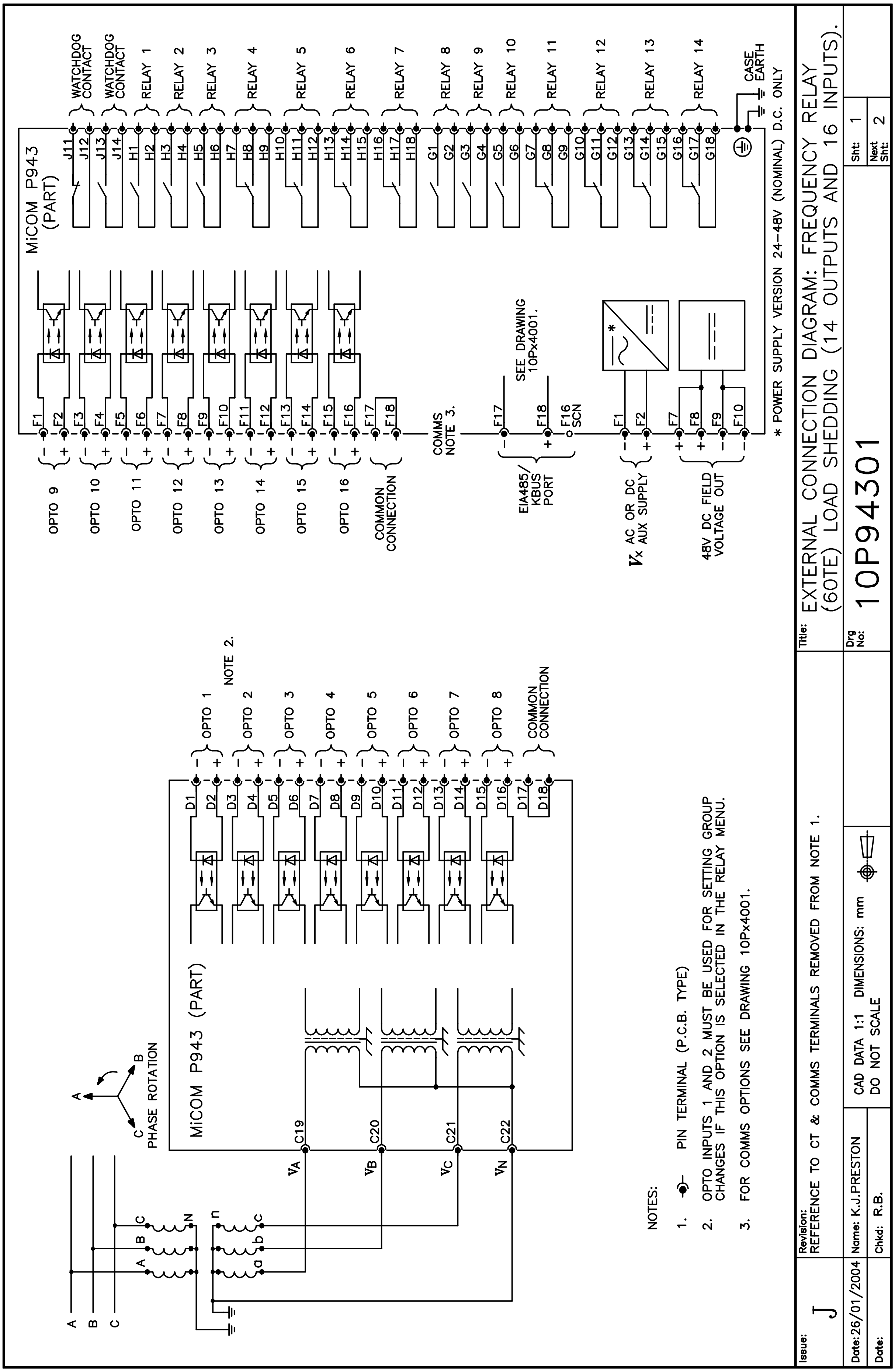


Figure 11: P943 Model A with 14 output contacts and 16 digital inputs

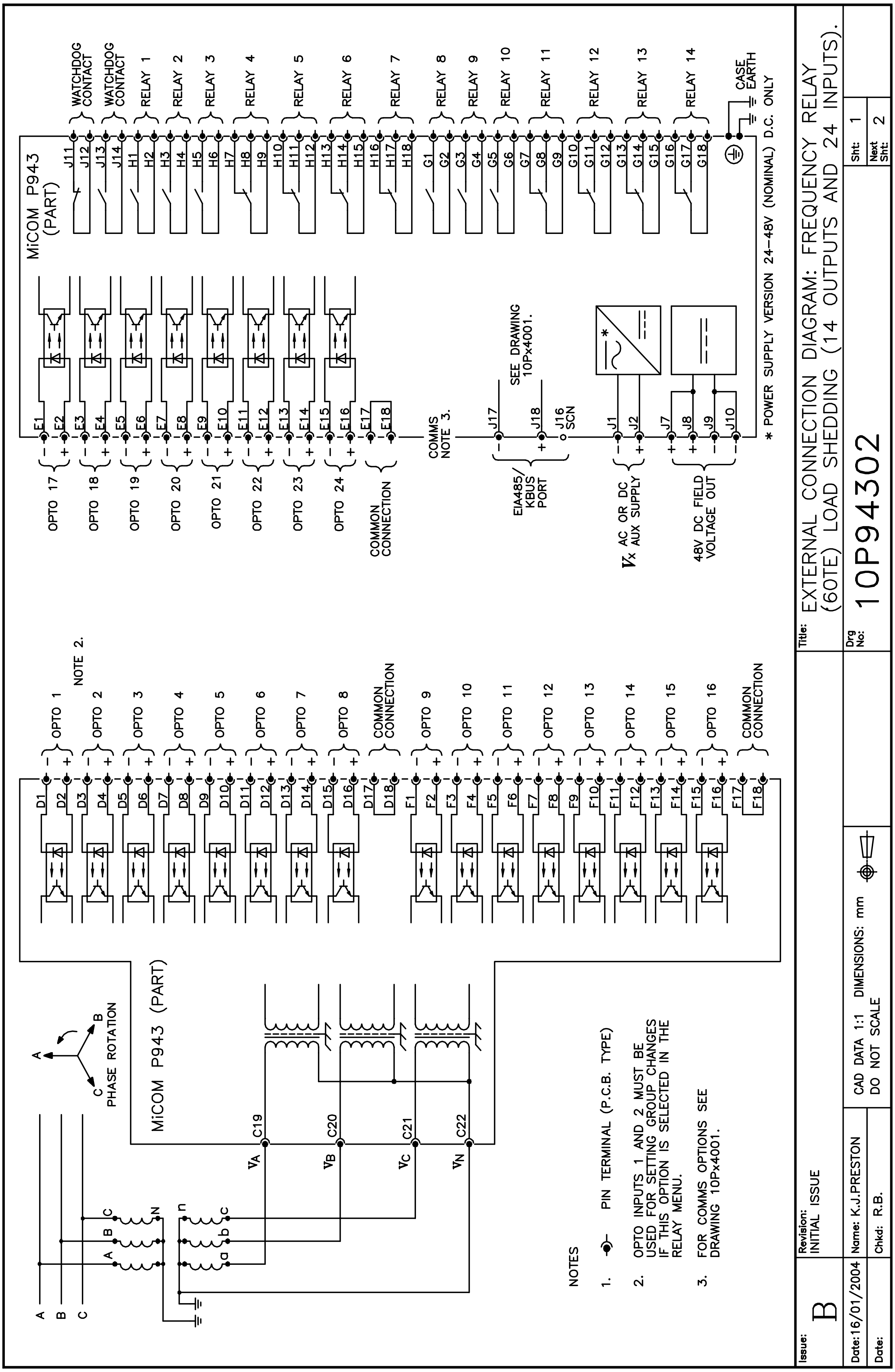


Figure 12: P943 Model C with 14 output contacts and 24 digital inputs

IN

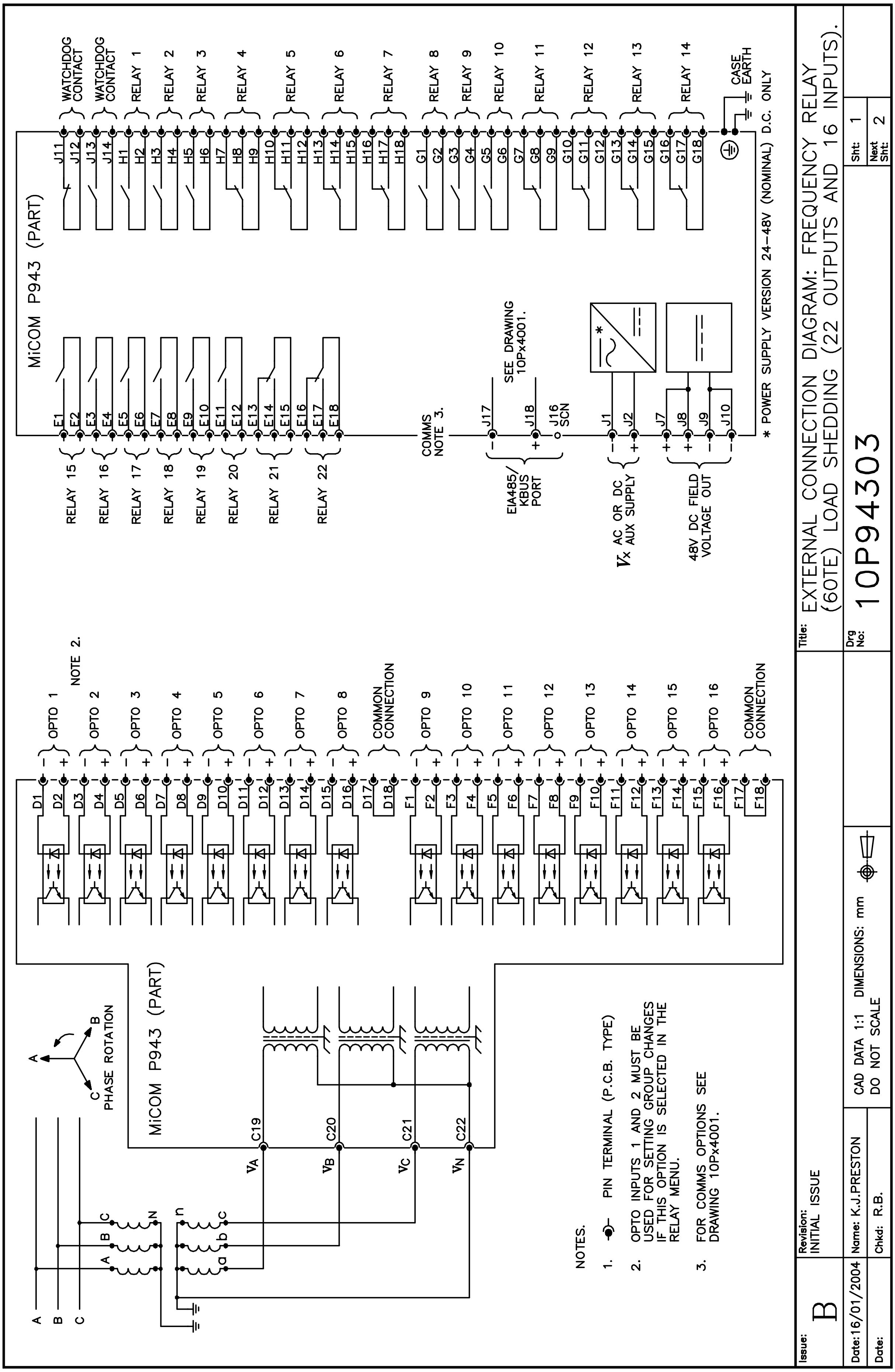


Figure 13: P943 Model D with 22 output contacts and 16 digital inputs

IN

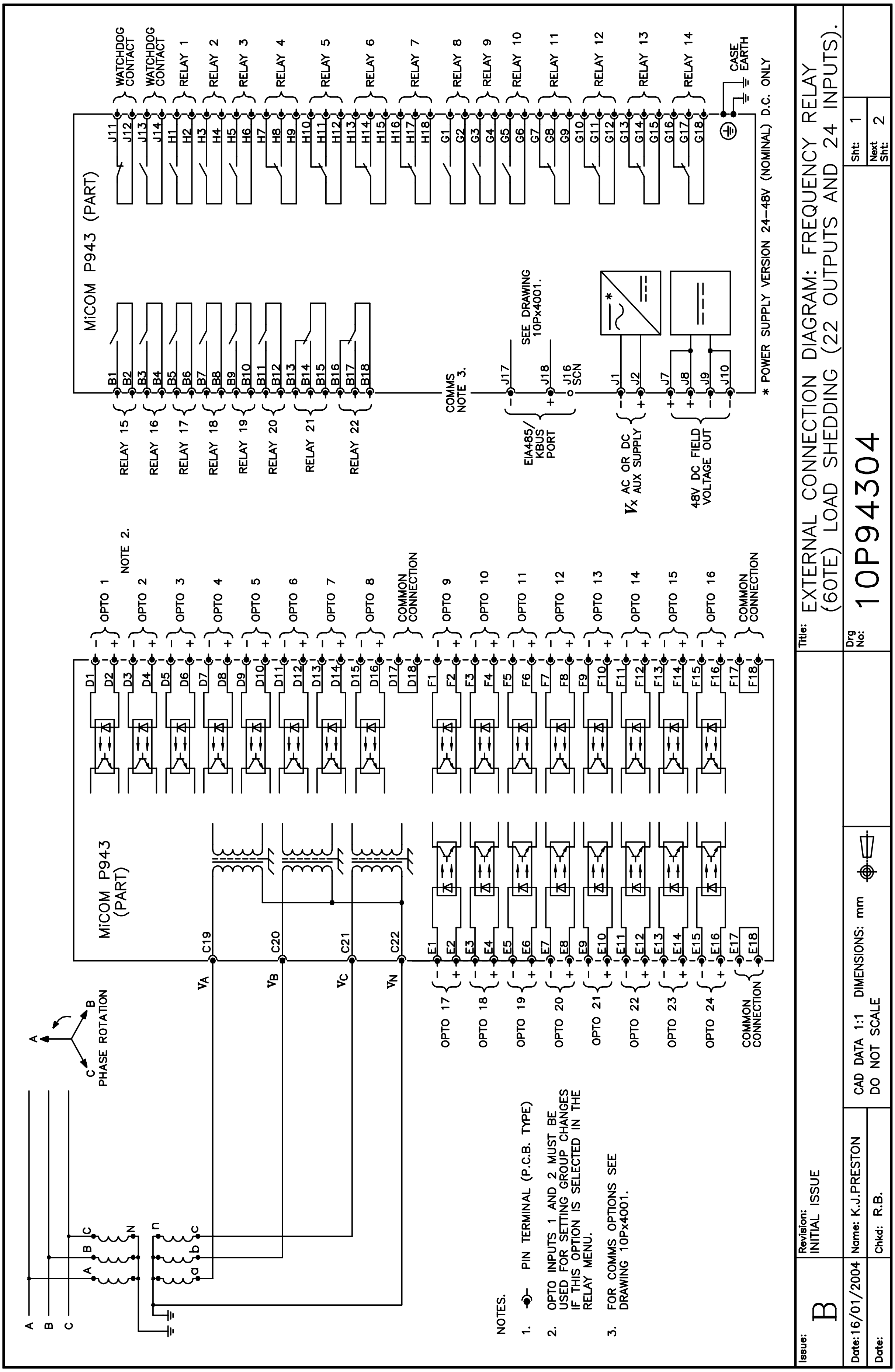


Figure 14: P943 Model E with 22 output contacts and 24 digital inputs

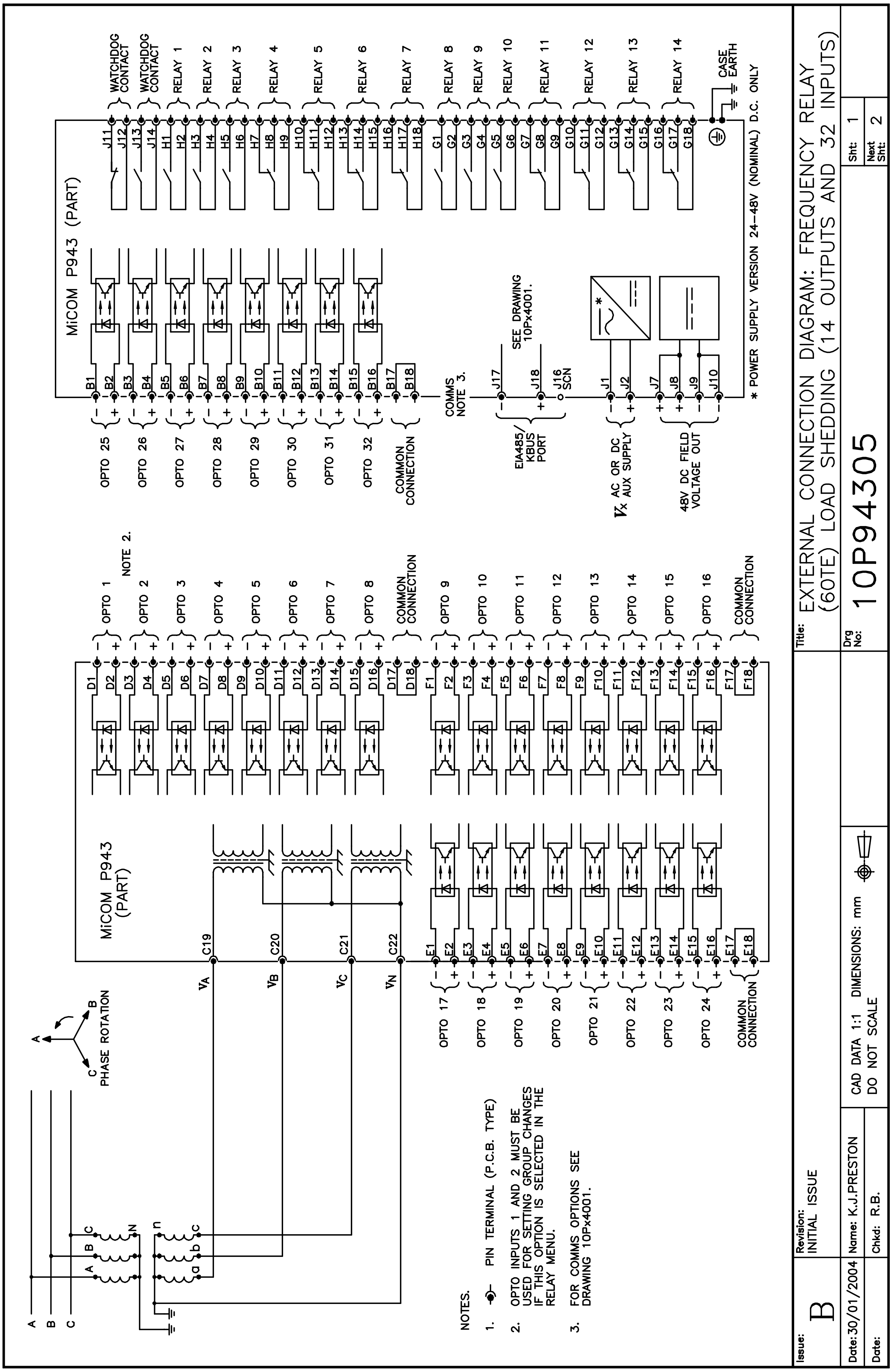


Figure 15: P943 Model F with 14 output contacts and 32 digital inputs

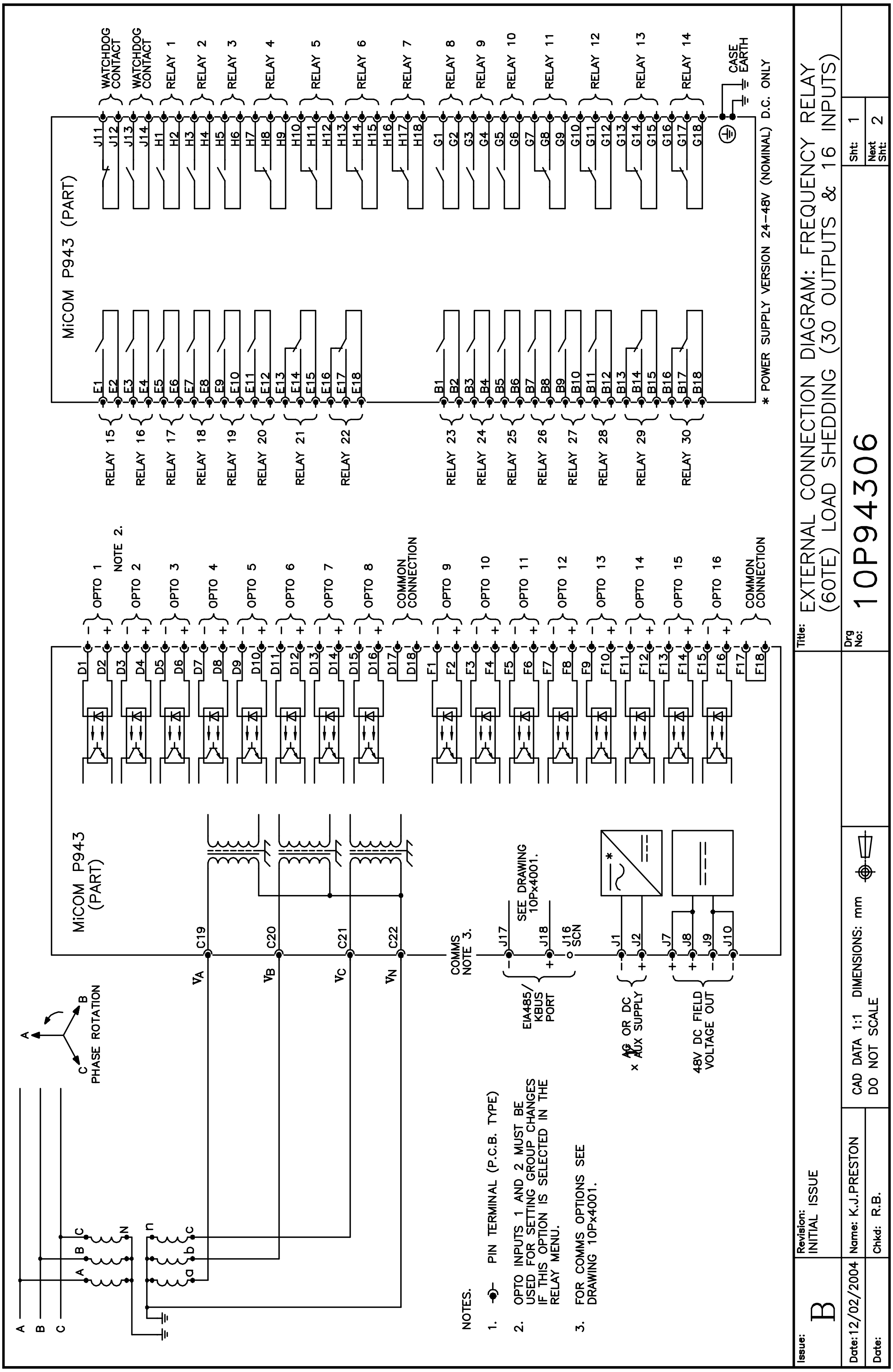


Figure 16: P943 Model G with 30 output contacts and 16 digital inputs

IN

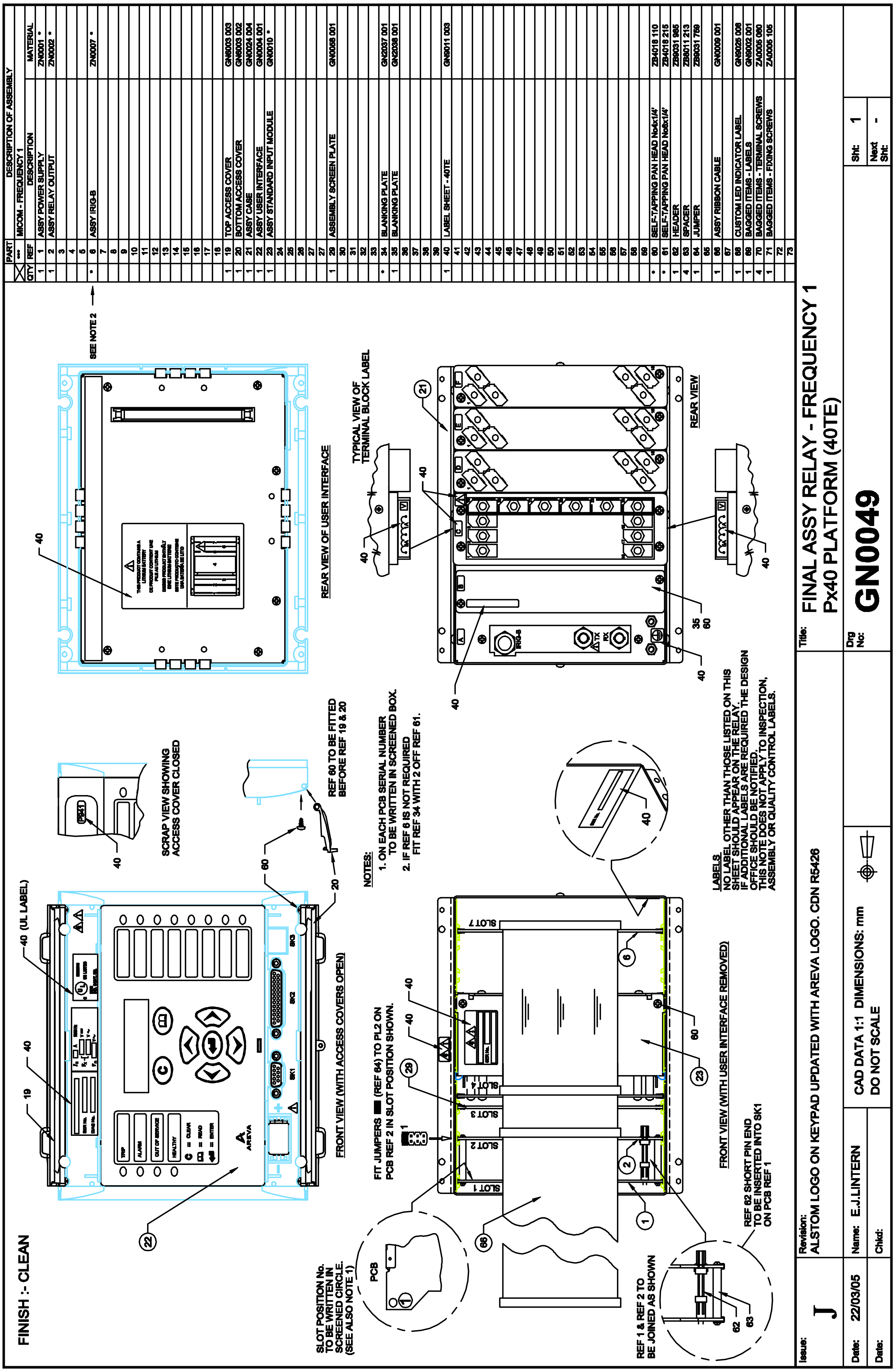


Figure 17: P941 with no digital I/O expansion

IN

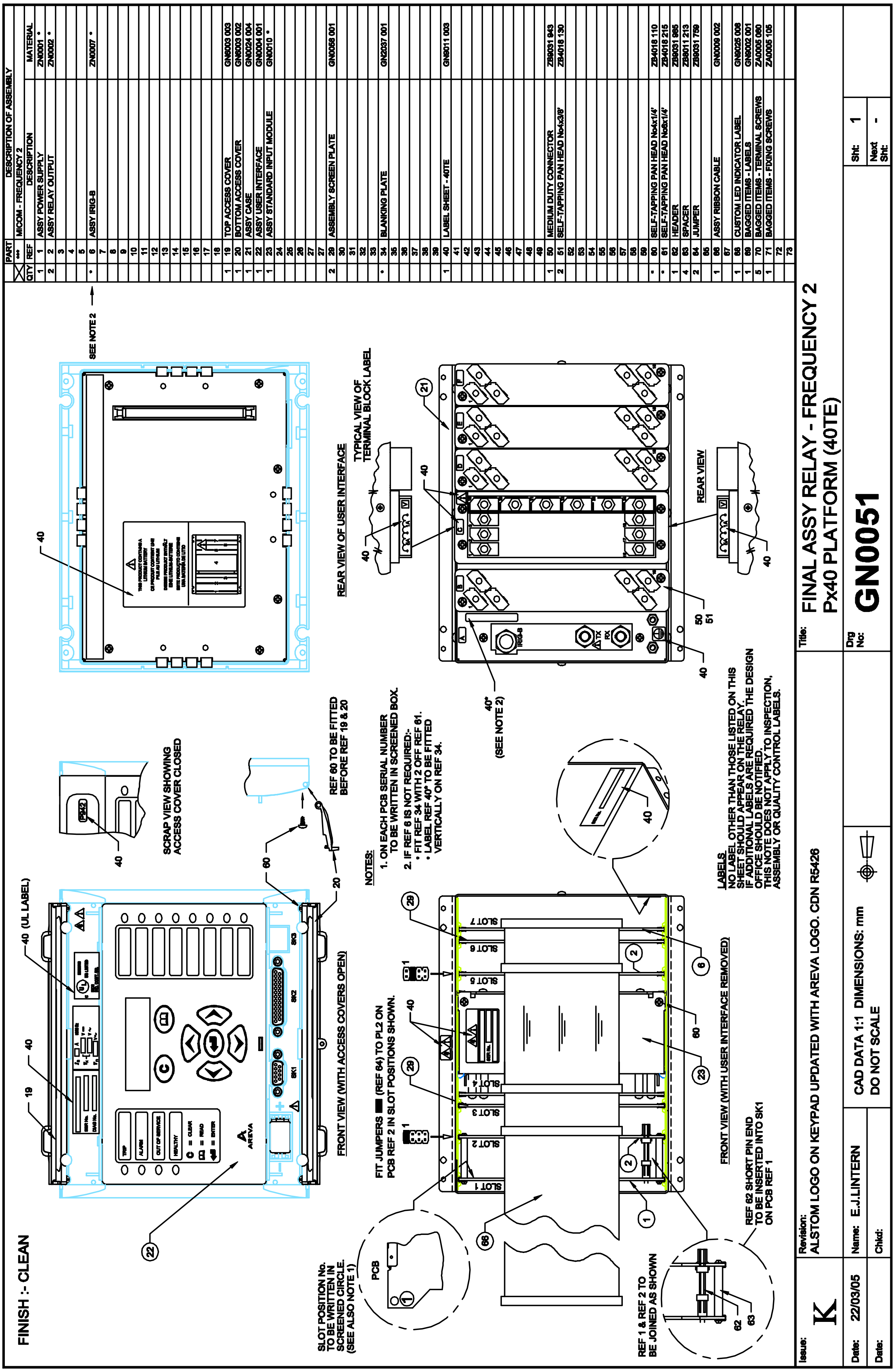


Figure 18: P941/P942 with digital I/O expansion slot used

IN

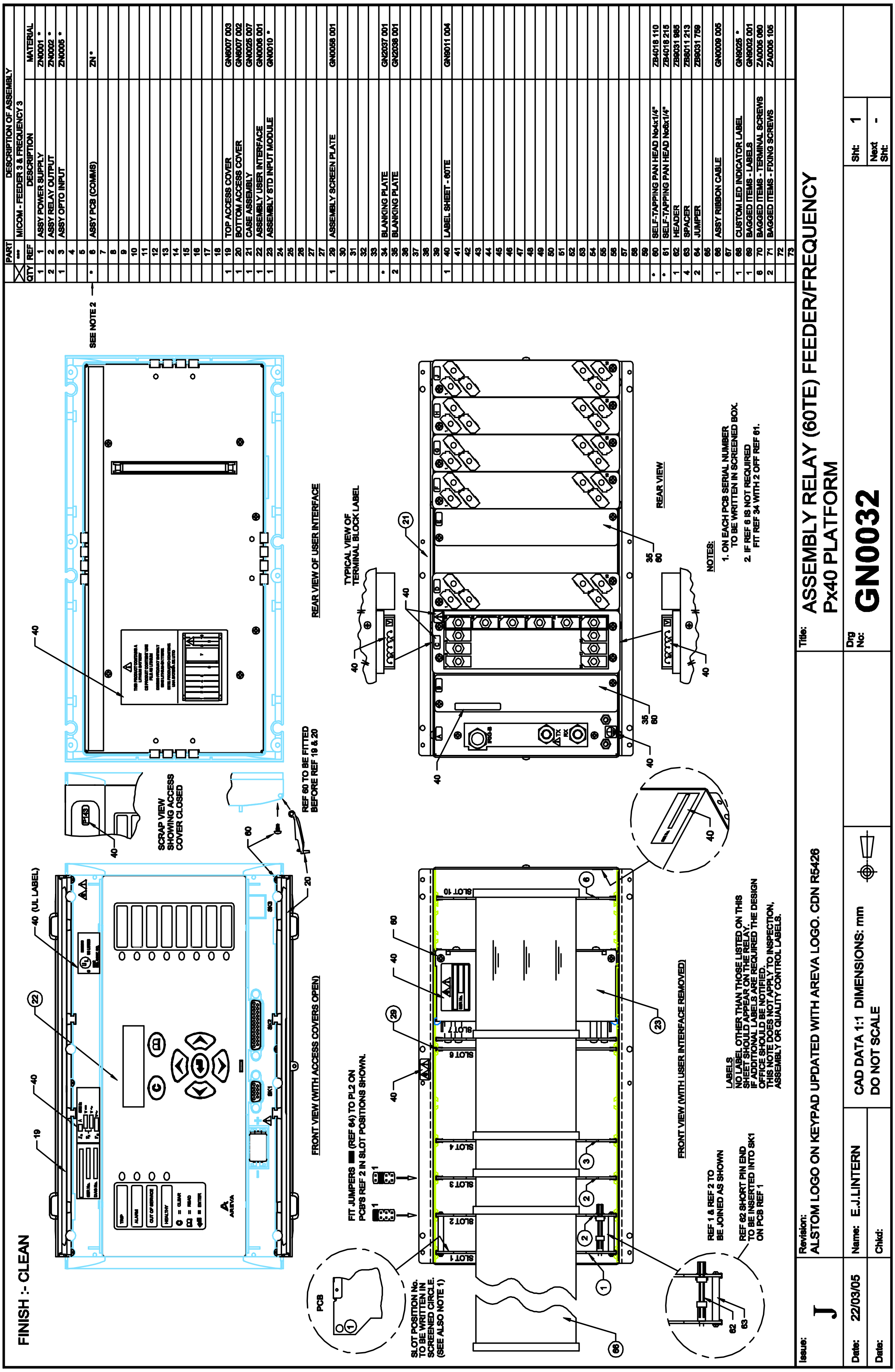
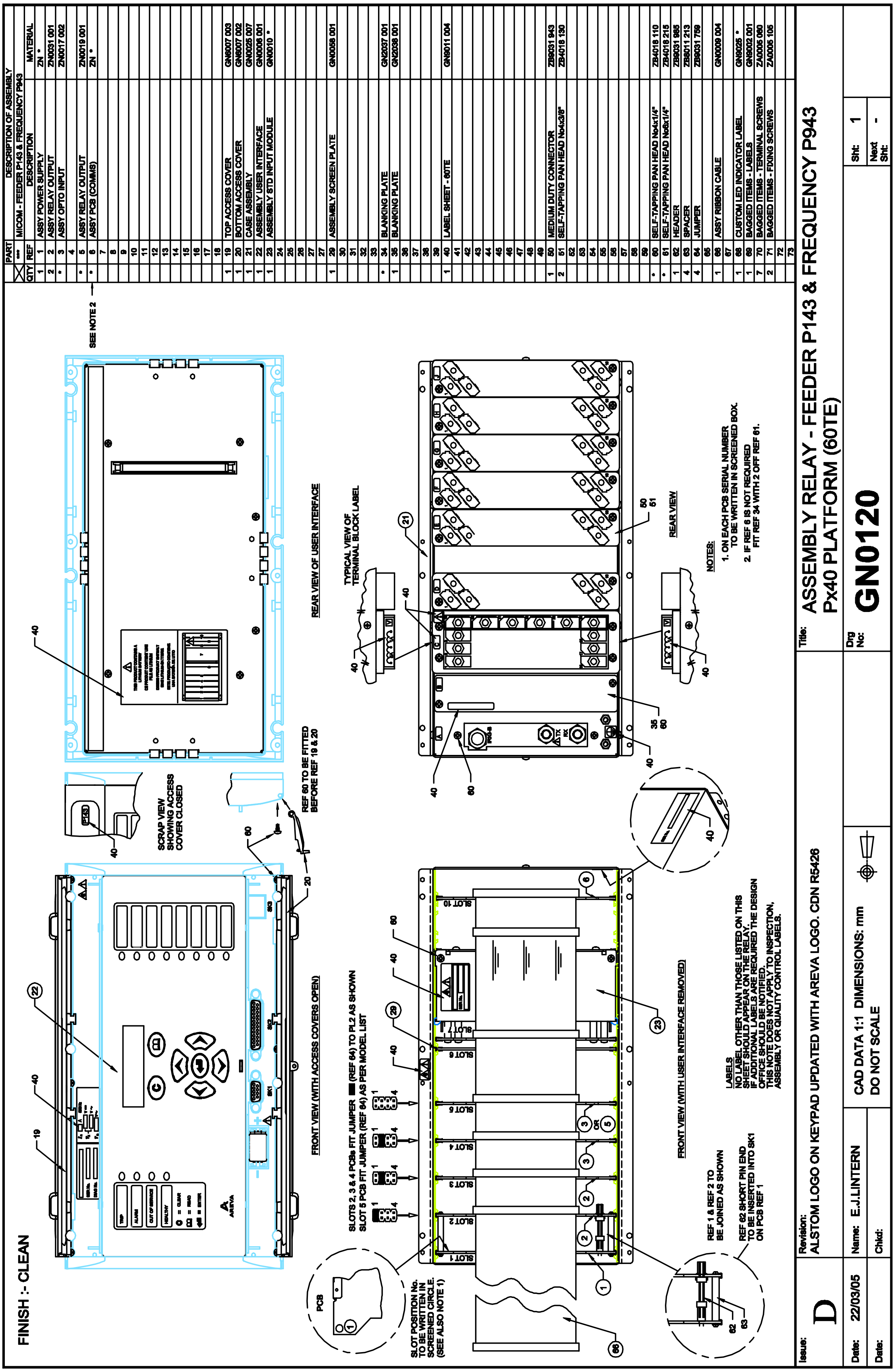


Figure 19: P943 with no digital I/O expansion



IN

Figure 20: P943 with first digital I/O expansion slot used

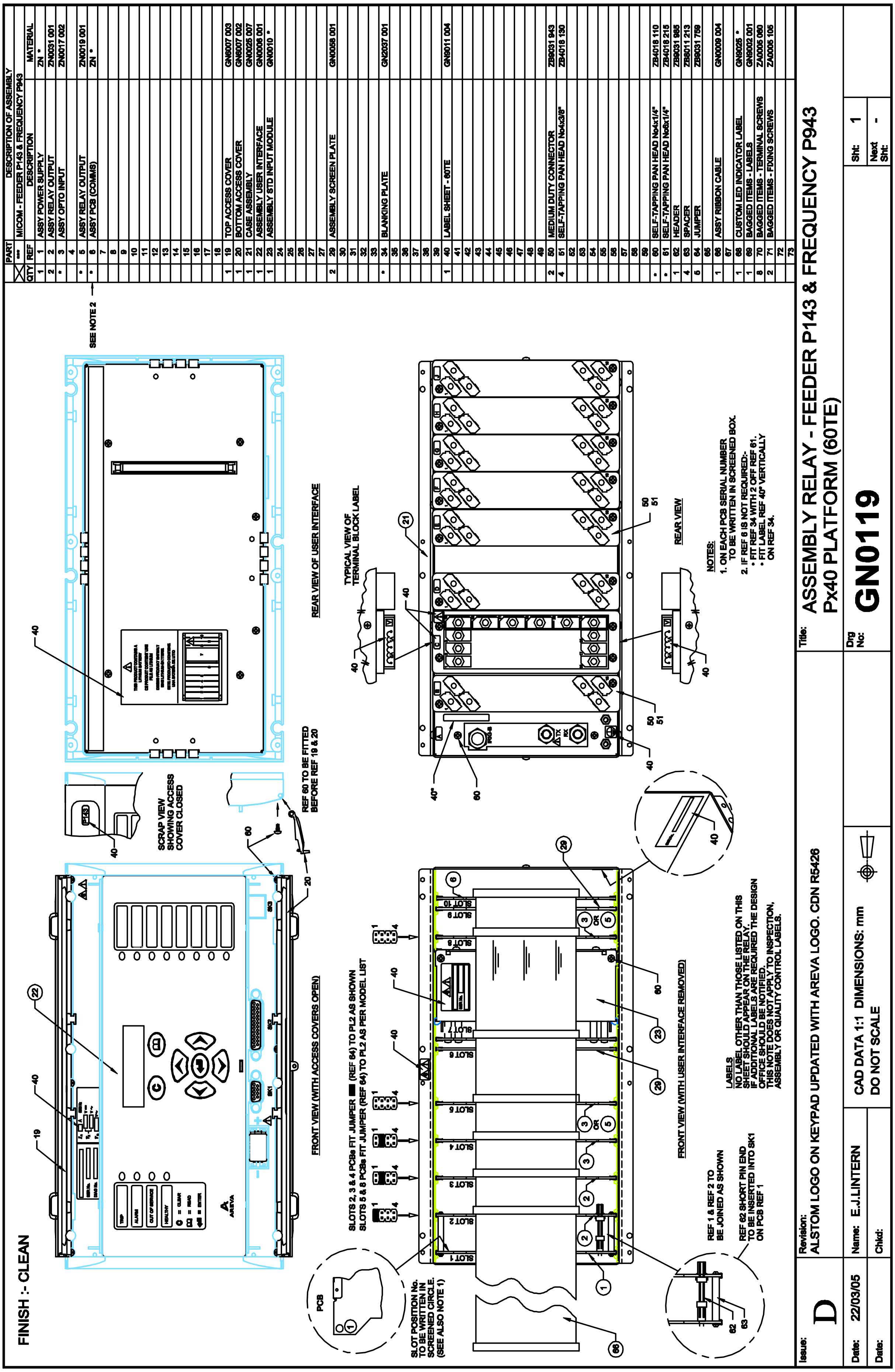


Figure 21: **P943 with both digital I/O expansion slots used**

FIRMWARE AND SERVICE MANUAL
VERSION HISTORY

Date:	**2008**
Hardware Suffix:	**A or C**
Software Version:	**12**
Connection Diagrams:	**10P94yxx (y = 1 or 3) (x = 01 to 06)**

VH

Relay type: P94x …						
Software Version		**Hardware Suffix**	**Original Date of Issue**	**Description of Changes**	**S1 Compatibility**	**Technical Documentation**
Major	Minor					
A	1	A	Feb 1999	Original Issue **Mandatory upgrade to software version 02C**	V1.00 or Later	TG8611A
B	1	A	Apr 1999	✓ f+t element modified so that it is blocked when frequency out of range ✓ Generator abnormal timers now updated every cycle ✓ Setting ranges corrected for Vn=440V models **Mandatory upgrade to software version 02C**	V1.06 or Later	TG8611A
01	A	A	Oct 1999	✓ Software reference aligned with PCS procedure ✓ Corrections to French language text ✓ Improvements to IEC60870-5-103 protocol implementation to improve operation during heavy event load **Mandatory upgrade to software version 02C**	V1.06 or Later	TG8611A
	B	A	Dec 1999	✓ Opto-input sampling modified **Mandatory upgrade to software version 02C**	V1.06 or Later	TG8611A
02	A	A	Jan 2000	✓ Trip LED status saved during power cycle ✓ Software and hardware compatibility checked on power-up (as per P14x relays) **Mandatory upgrade to software version 02C**	V1.06 or Later	TG8611A
	B	A	Feb 2002	✓ Resolved possible reboot caused by invalid MODBUS requests ✓ Prevention of software errors causing event log from being erased	V1.06 or Later	TG8611A

Relay type: P94x …						
Software Version		**Hardware Suffix**	**Original Date of Issue**	**Description of Changes**	**S1 Compatibility**	**Technical Documentation**
Major	Minor					
02 Cont.	B Cont.	A	Feb 2002	✓ IDMT curve improvements ✓ Modification to prevent possible f+t trip contact operation at start-up when the delay is set to <60ms ✓ Resolved possible reboot caused by disturbance recorder **Mandatory upgrade to software version 02C**	V1.06 or Later	TG8611A
	C	A	Oct 2003	✓ Resolved possible loss of data in disturbance recorder	V1.06 or Later	TG8611A
03	A	A	Sept 2002	✓ DNP3.0 protocol added ✓ Resolved MODBUS compatibility issues with Px2x products **Mandatory upgrade to software version 03B**	V2.00 or Later	TG8611B
	B	A	Feb 2002	✓ Resolved possible reboot caused by invalid MODBUS requests ✓ Prevention of software errors causing event log from being erased ✓ IDMT curve improvements ✓ Modification to prevent possible f+t trip contact operation at start-up when the delay is set to <60ms ✓ Resolved possible reboot caused by disturbance recorder	V2.00 or Later	TG8611B
04	A	A	Jan 2001	✓ Event filtering added ✓ Menu text modifications **Mandatory upgrade to software version 04J**	V2.00 or Later	TG8611B

Relay type: P94x …

Software Version		Hardware Suffix	Original Date of Issue	Description of Changes	S1 Compatibility	Technical Documentation
Major	Minor					
04 Cont.	B	A	Jan 2002	✓ Modification to prevent possible f+t trip contact operation at start-up when the time delay is set to <60ms **Mandatory upgrade to software version 04J**	V2.00 or Later	TG8611B
	C	A	Feb 2002	✓ Resolved possible reboot caused by disturbance recorder **Mandatory upgrade to software version 04J**	V2.00 or Later	TG8611B
	D	A	Feb 2002	✓ Resolved possible reboot caused by invalid MODBUS requests ✓ Prevention of software errors causing event log from being erased ✓ IDMT curve improvements	V2.00 or Later	TG8611B
	E	A	Oct 2003	✓ Resolved possible loss of data in disturbance recorder	V2.00 or Later	TG8611B
	F	A	Apr 2004	SPECIAL RELEASE FOR IRAN ✓ Improvements to MODBUS communications (to resolve possible conflict with front port communications)	V2.00 or Later	TG8611B
	G	A	May 2004	✓ Improvements to MODBUS communications (to resolve possible conflict with front port communications) ✓ Drop-off cycle count strategy corrected	V2.00 or Later	TG8611B
	H	A	Jul 2004	✓ Improvements to MODBUS communications (to resolve possible reboot issue and incorrect end of frame recognition) ✓ Trip LED functionality corrected for df/dt+t element	V2.00 or Later	TG8611B
	J	A	Jun 2005	✓ Improvement to MODBUS communications (to improve 60Hz system performance)	V2.00 or Later	TG8611B

Relay type: P94x …						
Software Version		**Hardware Suffix**	**Original Date of Issue**	**Description of Changes**	**S1 Compatibility**	**Technical Documentation**
Major	Minor					
05	A	A	Jan 2003	✓ User alarms added (10 self-reset, 10 manual reset) ✓ Fault Record Trigger DDB signal added ✓ Operation of Trip LED removed from fixed code and replaced by trip LED DDB signal ✓ Fault record text change for 3 phase conditions (removed ‘3’) ✓ Improved UV blocking of elements to function during settings changes ✓ Improved operation of ‘Frequency not found’ alarm to function correctly during changes in the tracking phase	V2.07 + Patch	P94x/EN T/D11
	B	A	Feb 2003	✓ Measurements refresh rate improved to once per second via communications	V2.07 + Patch	P94x/EN T/D11
	C	A	Oct 2003	✓ Resolved possible loss of data in disturbance recorder	V2.07 + Patch	P94x/EN T/D11
	D	A	Oct 2004	✓ Drop-off cycle count strategy corrected ✓ Improvements to MODBUS communications (to resolve possible reboot issue and incorrect end of frame recognition)	V2.07 + Patch	P94x/EN T/D11
	E	A	Jun 2005	✓ Improvement to MODBUS communications (to improve 60Hz system performance)	V2.07 + Patch	P94x/EN T/D11
10	A	C	Jun 2004	✓ Support for 8 input, 8 output & 4+4 digital I/O expansion cards, including “universal” opto input configuration ✓ Output contact rating increased ✓ Inrush limited power supply module ✓ 32 Control inputs included ✓ Increased DDB signals from 512 to 1023	V2.10	P94x/EN M/F32

Relay type: P94x …						
Software Version		**Hardware Suffix**	**Original Date of Issue**	**Description of Changes**	**S1 Compatibility**	**Technical Documentation**
Major	Minor					
10 Cont.	A	C	Jun 2004	✓ Increased User Alarms from 20 to 48 ✓ PSL reference ID cells included ✓ Phase angles added to sequence measurements ✓ New frequency & df/dt calculation method including removal of 20Hz/s tracking limit ✓ Pick-up & drop-off cycles replaced by selectable number of averaging cycles for frequency & df/dt calculation ✓ Generator Abnormal Protection timer range increased ✓ DDB signal availability for all password levels	V2.10	P94x/EN M/F32
	B	C	Jun 2005	✓ Improvement to MODBUS communications (to improve 60Hz system performance)	V2.10	P94x/EN M/F32
11	A	C	Sept 2006	✓ Minimum setting for df/dt calculation decreased to 0.01Hz/s ✓ Number of averaging cycles setting range increased to 48 ✓ Undervoltage blocking improvements (selectable single/three phase blocking using phase-phase or phase-neutral voltages) ✓ IDMT Under/Over Voltage stages pick-up at 100% of setting (previously setting -/+5% respectively) ✓ Text modifications (Opto labels, relay labels and manufacturers name) ✓ Improvement to MODBUS communications (to improve 60Hz system performance)	V2.12	P94x/EN M/F32

Relay type: P94x …						
Software Version		**Hardware Suffix**	**Original Date of Issue**	**Description of Changes**	**S1 Compatibility**	**Technical Documentation**
Major	Minor					
11 Cont.	B	C	April 2008	✓ Improvement of disturbance records when viewing the frequency channel (integration of the non-compressed disturbance recorder). ✓ Courier and DNP3 communications available.		P94x/EN M/F32
12	A	C	April 2008	✓ Addition of stages of time delayed frequency-protection based load shedding and restoration to cater for an emergency situation where significant load shedding is required. ✓ Enhanced time setting range for all load restoration stages to 0 -7200s in 0.25s steps. ✓ Modbus communication available.		P94x/EN M/F32
	B	C	April 2008	✓ IEC60870-5-103 interface available with the non-compressed disturbance recorder which includes support for private codes (control Inputs configurable as Pulsed/Latched).		P94x/EN M/F32

SETTING FILE COMPATIBILITY

Setting File Software Version	Relay Software Version: A1	B1	01	02	03	04	05	10	10	11	12A	12B
A1	✓	×	×	×	×	×	×	×	×	×	×	×
B1	×	✓	×	×	×	×	×	×	×	×	×	×
01	×	×	✓	✓	✓	❶	❶	×	×	×	×	×
02	×	×	✓	✓	✓	❶	❶	×	×	×	×	×
03	×	×	✓	✓	✓	❶	❶	×	×	×	×	×
04	×	×	×	×	×	✓	✓	×	×	×	×	×
05	×	×	×	×	×	✓	✓	×	×	×	×	×
10	×	×	×	×	×	×	×	✓	✓	×	×	×
11	×	×	×	×	×	×	×	×	×	✓	×	×
12A	×	×	×	×	×	×	×	×	×	×	✓	×
12B	×	×	×	×	×	×	×	×	×	×	×	✓

❶ Additional functionality was added in 04 software such that setting files from earlier software versions will need additional settings to be made.

VH

PSL FILE COMPATIBILITY

PSL File Software Version	Relay Software Version: A1	B1	01	02	03	04	05	10	11	12A	12B
A1	✓	×	×	×	×	×	×	×	×	×	×
B1	×	✓	×	×	×	×	×	×	×	×	×
01	×	×	✓	✓	❶	❶	×	×	×	×	×
02	×	×	✓	✓	❶	❶	×	×	×	×	×
03	×	×	✓	✓	✓	✓	×	×	×	×	×
04	×	×	×	×	✓	✓	×	×	×	×	×
05	×	×	×	×	×	×	✓	×	×	×	×
10	×	×	×	×	×	×	×	✓	✓	×	×
11	×	×	×	×	×	×	×	✓	✓	×	×
12A	×	×	×	×	×	×	×	×	×	✓	×
12B	×	×	×	×	×	×	×	×	×	×	✓

❶ Additional functionality was added in 03 software such that PSL files from earlier software versions may need additional logic. 05 software includes trip LED and FRT control and is not compatible with earlier versions.

MENU TEXT FILE COMPATIBILITY

Menu Text File Software Version	Relay Software Version: A1	B1	01	02	03	04	05	10	11	12A	12B
A1	✓	×	×	×	×	×	×	×	×	×	×
B1	×	✓	×	×	×	×	×	×	×	×	×
01	×	×	✓	×	×	×	×	×	×	×	×
02	×	×	×	✓	×	×	×	×	×	×	×
03	×	×	×	×	✓	×	×	×	×	×	×
04	×	×	×	×	×	✓	×	×	×	×	×
05	×	×	×	×	×	×	✓	×	×	×	×
10	×	×	×	×	×	×	×	✓	×	×	×
11	×	×	×	×	×	×	×	×	✓	×	×
12A	×	×	×	×	×	×	×	×	×	✓	×
12B	×	×	×	×	×	×	×	×	×	×	✓

❶ Menu text remains compatible within each software version but is NOT compatible across different versions.

Customer Care Centre

http://www.schneider-electric.com/sites/corporate/en/support/contact/customer-care-contact.page

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