

# PACiS MPP MODBUS

Gateway and C264

MPP/EN MODBUS/D10

PACiS V5

Master Protocol Profile  
MODBUS

Issue A1



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## 1. INTRODUCTION

### 1.1 Scope of the document

This document is a chapter of PACiS MiCOM C264 and the PACiS gateway documentation binders. It describes the MODBUS master protocols, i.e. communication with IED (Intelligent Electronic Device) on legacy bus, implemented on PACiS MiCOM C264 and PACiS GATEWAY.

TCP/IP communication is implemented only on PACiS GATEWAY.

Protocols table:

	<b>C264 Serial</b>	<b>GTW Serial</b>	<b>GTW TCP/IP</b>
GENERIC MODBUS (MODICON)	√	√	√
MiCOM MODBUS Px2X (MiCOM S20)	√	√	
MiCOM MODBUS M300	√		
MiCOM MODBUS Px4X (MiCOM S40)	√		
SEPAM S20		√	
SEPAM S40	√	√	√
SEPAM S80	√	√	√
M230	√		
ABB-Flexgate	√		
RISHABH (RISH ducer M01)	√		

### Glossary

<b>GI</b>	General Interrogation
<b>IED</b>	Intelligent Electronic Device

## 2. COMMON CONSIDERATIONS

### 2.1 Finality

MODBUS is a legacy bus master/slave protocol that is used by many devices such as relays, computers or monitoring devices.

The aim of this chapter is not to describe the protocol itself and its mechanisms (refer to other documents and standards) but to give the specificity of the functions that will be implemented in the PACiS C264 computer and the PACiS GATEWAY.

These are the MODBUS function numbers that will be used, the way how each type of data – i.e. CO, MEAS, DI, disturbance files – will be internally or externally updated, the general mechanisms used for the time synchronization and the configuration needs.

As the PACiS C264 computer or the PACiS GATEWAY is the master on the legacy bus - regards to protections and IEDs - this protocol is referenced as “Master MODBUS” in the PACiS C264 computer or the PACiS GATEWAY.

Prerequisites: The reader shall know the MODBUS protocol.

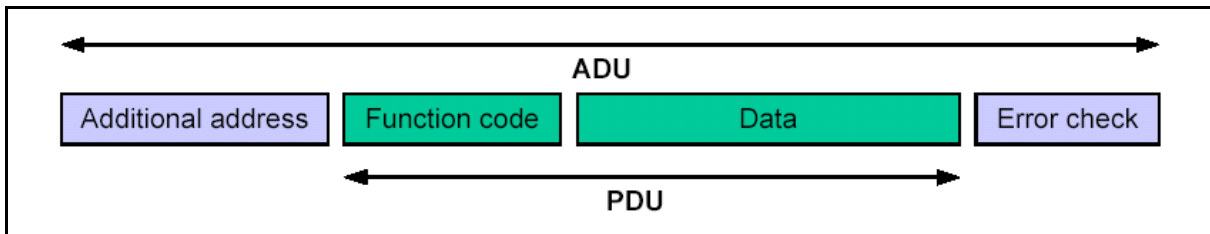
### 2.2 MODBUS frame

C264 and PACiS GATEWAY can communicate with IED using MODICON MODBUS protocol on serial link (RS232 or RS485).

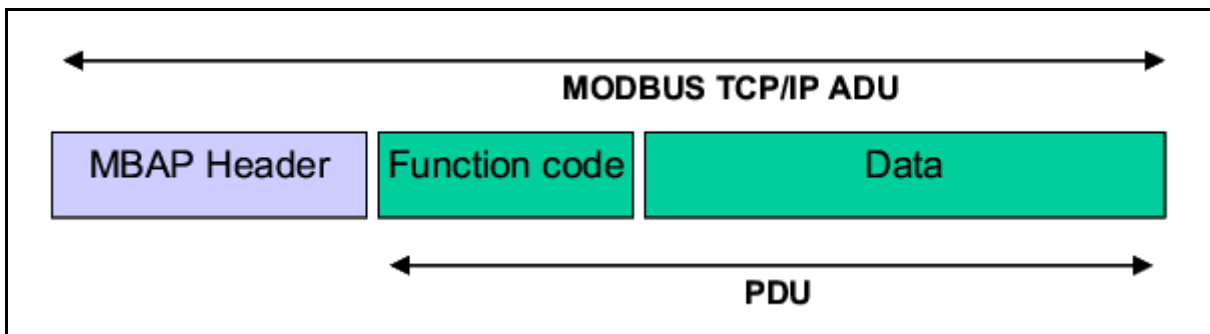
PACiS GATEWAY can communicate with IED using TCP MODBUS protocol on Ethernet link.

TCP/IP MODBUS client has the same interoperability than the master serial MODBUS.

#### 2.2.1 Serial MODBUS RS232/RS485



#### 2.2.2 TCP MODBUS



PDU is identical for both serial and TCP. For TCP the first field "Additional address" is the "MBAP Header" the «Error check" disappear (CRC control already done by TCP).



MBAP (MODBUS Application Protocol header) is seven bytes filed as follow:

Fields	Length (bytes)	Description	GTW	IED
Transaction Identifier	2	Identification of a MODBUS Request/ Response transaction	Initialized by the PACiS GATEWAY. IED reply is refused if "Transaction Identifier" is different from the one sent by PACiS GATEWAY.	Should be recopied by the IED from the received request.
Protocol Identifier	2	0 = MODBUS protocol	Initialized by the PACiS GATEWAY. IED reply is refused if "Protocol Identifier" is different from 0.	Should be recopied by the IED from the received request.
Length	2	Number of following bytes	Initialized by the PACiS GATEWAY (request)	Initialized by the IED (response)
Unit Identifier	1	Identification of a remote slave connected on a serial line or on other buses.	Initialized by the PACiS GATEWAY . Always 0. IED reply is refused if "Unit Identifier" is different from 0.	Should be recopied by the IED from the received request.

### 2.2.3 Time synchronization

All IEDs connected to a given network must have the same synchronization procedure (address, time and date format) because the synchronization will be performed through a broadcast frame.

There are 4 types of synchronization depending on a configuration parameter:

- None synchronization
- MiCOM synchronization
- SEPAM synchronization
- ABB Flexgate

Each format, address and synchronization procedure is described in the synchronization associated chapter.

Default type is 'None synchronization'.

No calculation of the transmission delay is performed.

The synchronization state in the timestamp of an event is always given by the dating equipement:

- Dated Events sent by IED have their State of Synchronization given by the IED (independently of the master's synchronization state).
- When events (state's changes and analogue's changes) are elaborated by the master, the synchronization state is the one of the master.

## 2.2.4 Implemented functions

Function number	Sub-code	Used for	Commentary
01 – 02	/	Read DIs	Read N bits
03 – 04	/	Read DIs / MEAS / Disturbance files	Read N words
05	/	Write CO	Write 1 bit
15	/	Write CO	Write N bits
07	/	Polling	Read status byte.
08	0	Polling	Echo: This function can be used in order to detect if an IED is present or not.
06	/	Write AO	Write 1 word (Can be used for tunnelling on C264)
16	/	Write AO	Write N words (Can only be used for tunnelling on C264)

- NOTES:
- Tunnelling is not available on PACiS GATEWAY.
  - Function code 06 is used to write AO.

## 2.3 Configuration

## 2.3.1 PACiS GATEWAY restrictions

- For a DPC the address of CLOSE contact shall be the address of the OPEN contact plus one. Both addresses shall be in the same register.
- For modbus DPS addresses of Open and Close DI are consecutive. Address of Close contact is equal to Address of Open contact plus one. Both addresses shall be in the same register.

## 2.3.2 MODBUS data configuration

## 2.3.2.1 For each MODBUS network

Following parameters are to be set:

Communication Interface:

- C264: Serial port (port number, transmission rate, parity).
- GATEWAY: Serial port (port number, transmission rate, parity) or MODBUS TCP/IP (port number, IP address).

Link layer parameters:

- Number of retries.
- Acknowledgement time-out (x 100ms).
- Synchronization: NONE, MiCOM, SEPAM, FlexGate.
- Synchronization cycle (x 10s).
- Downgraded cycle (x 100ms).
- Inter frame duration.

Specific to GATEWAY in redundant configuration:

- Acquisition mode: Simplex or Duplex.
- Timestamp Tolerancy Window (ms).
- SATRED Local and Remote IP Address and port number.
- SATRED communication time-out.

## 2.3.2.2 For each IED on the network

Following parameters are to be set:

- 'IED type' (in MODBUS acq type field) possible values are:
  - C264: MODICON, M300, MiCOM Px2x, M230, WAGO, MiCOM S40, Rish Pro M01, ABB Flexgate, SEPAM.
  - GATEWAY: MODICON, MiCOM Px2x, SEPAM.
- IED address on the MODBUS network.
- For MODBUS TCP/IP: IED IP address, Port number (502 to be used).
- For SEPAM:
  - Event table number: 40, 70
  - IED type: S20, S40, S80
- Polling frame:
  - Function: 1-2-3-4-7-8 (status byte, mirror frame...).
  - Mapping address: (bit address if function 1 or 2) or word address (if function 3 or 4) or sub code (if function 8) depending on the polling function used.
  - Zise to read: number of bits (if function 1 or 2) between 0 and 2047 or number of words (if function 3 or 4) between 0 and 127.

## 2.3.2.3 Binary Input

Following parameters are to be set:

- Digital input type: Simple, double.
- MODBUS function to be used (1-2-3-4)
- Digital input address:
  - Function 1 & 2: mapping address
  - Function 3 & 4: mapping address & bit number.
- Contact identifier: unused, close, open.
- For single point BI: contact identifier "unused" shall be selected.
- For Double point BI: contact identifier "close" or "open" shall be selected.

- The “unused” option is forbidden for double point DI (see §2.3.1 “*PACiS GATEWAY restrictions*”):
  - Contact identifier is “open”: The filled address is the one of the “Open” contact of the DPS.
  - Contact identifier is “closed”: The filled address is the one of the “Close” contact of the DPS.
  - The adresse of the close contact must be the adresse of the open contact plus one.
  - Open and close contacts addresses shall be in the same register in order to avoid bad transitory states (JAMMED [0,0] or UNDEFINED [1,1]).

**WARNING: ON PACiS GATEWAY, WHEN EVENT MESSAGES ARE USED TO SEND DOUBLE POINTS CHANGE OF STATE (MODBUS SEPAM OR MODBUS MICOM), TRANSITORY STATES WILL BE SEEN IN THE APPLICATION.**

## 2.3.2.4 Analogue Input

Following parameters are to be set:

- MODBUS function to be used (function 3-4) for Analogue Inputs.
- Analogue Inputs address in the IED mapping (word address)
- Format of the Analogue Input:

18 formats of Analogue Inputs are supported by the PACiS C264 computer and PACiS GATEWAY and can be set through configuration:

Format	Comments	
INT8_LB INT8_HB	Signed integer on 8 bits	Modbus does not provide a 'Read byte' function. So, a 'Read word' function is used. The 'LB' or 'HB' letters indicate which Byte of the Word is used (respectively, 'Low' or 'High').
UINT8_LB UINT8_HB	Unsigned integer on 8 bits	
INT16	Signed integer on 16 bits	
UINT16	Unsigned integer on 16 bits	
INT32_LW_LB INT32_LW_HB INT32_HW_LB INT32_HW_HB	Signed integer on 32 bits	The first couple of letters indicates if the low word (LW) or the high word (HW) is sent first.  The second couple of letters indicates if the low byte (LB) or the high byte (HB) is sent first in a word.
UINT32_LW_LB UINT32_LW_HB UINT32_HW_LB UINT32_HW_HB	Unsigned integer on 32 bits	
REAL32_LW_LB REAL32_LW_HB REAL32_HW_LB REAL32_HW_HB	Float IEEE754 on 32 bits	

Using format INT32\_LW\_LB to UINT32\_HW\_HB will cause a loss precision on big values.

#### 2.3.2.5 Counter

See §2.3.2.4 “Analogue Input”

#### 2.3.2.6 Multi Point Status (MPS)

Not implemented for Master Modbus protocol.

#### 2.3.2.7 Binary outputs (SPC / DPC)

Following parameters are to be set:

- Order type: “Select Before Operate” or “Direct Execute”.
- MODBUS function to be used (function Number 5 or 15 )
- Digital output address:
  - Function 5: mapping address
  - Function 15: mapping address & bit number.
- Contact type:
  - Contact identifier is “Open”: The filled address is the one of the “Open” contact of the DPS.
  - Contact identifier is “Closed”: The filled address is the one of the “Close” contact of the DPS.
  - The adresse of the “Close” contact must be the adresse of the “Open” contact plus one.
  - Both Open and Close contacts addresses shall be in the same register.

#### 2.3.2.8 SetPoint

Following parameters are to be set:

- Order type: The only choice is “Direct Execute”
- MODBUS function to be used : Fixed to function “6”
- Mapping address
- Minimum Value
- Maximum Value.

### 3. GENERIC MODBUS COMMUNICATION

#### 3.1 Interface

##### 3.1.1 Implemented function numbers

See §2.2.4 "Implemented function"

##### 3.1.2 Connection polling management

The IED shall be considered connected when the connection check frame reply is correct (good CRC and IED address) and received before the "*response time-out*".

When an IED is seen connected, it will be re-integrated in the standard polling cycle. Data will only be updated when polled with the associated polling time.

The IED shall stay disconnected when the connection check frame reply is not correct (CRC error or wrong IED address) or not received before the response time-out.

The connection check frame is never repeated (there is no retry on incorrect reply or no reply before the response time-out).

The "*connection check frame*" shall be selected during configuration within frames supported by the IEDs. Possible choices are:

- Status byte frame request,
- Digital input frame request,
- Analogue input frame request,
- Echo frame request (0x08 function code),
- User defined frame request.

The "Connection Check time-out" delay shall be filled in configured.

##### 3.1.3 Regular polling and disconnection management

Slave IEDs are polled one after the other. Master shall wait for the answer to a request sent to a device before sending a new request.

There are 2 types of polling:

- The polling performed by the application for Analogue Inputs and Digital Inputs acquisition.
- The connection check polling used to detect the presence of an IED on the network (see connection check requirements).

For an IED, application polling and connection check polling are never active simultaneously.

Application polling is active on connected IEDs while connection check polling is active on disconnected IEDs.

When an IED doesn't correctly answer to a polling request (response with bad CRC or bad IED address) or don't answer to the polling request within the configured "response timeout" delay, the request is to be retried (the same request is sent again by the master to the IED).

The maximum "number of retries" is limited and must be configured. When the "number of retries" is reached, the IED shall be considered as disconnected.

When an IED is disconnected, all associated data shall be qualified as UNKNOWN.

The value of a disconnected data shall be the last valid received value.

At boot time default value are: "0" for SPS, "00" for DPS, "0" for AI, "0" for counters. IED data are considered disconnected.

Time tag of UNKNOWN values is the time of disconnection (master local time-tag).

The "response timeout" and the the "number of retries" delays shall be filled in configuration.

### 3.2 Data received from IEDs

#### 3.2.1 Analogue Inputs

The application reads the Analogue Inputs by polling IEDs:

- On serial link MODBUS IEDs are polled one after the other.
- On TCP MODBUS link IEDs are polled simultaneously.

Within an IED AI blocks are read in sequence.

There is a fix interval delay between two blocks polling request

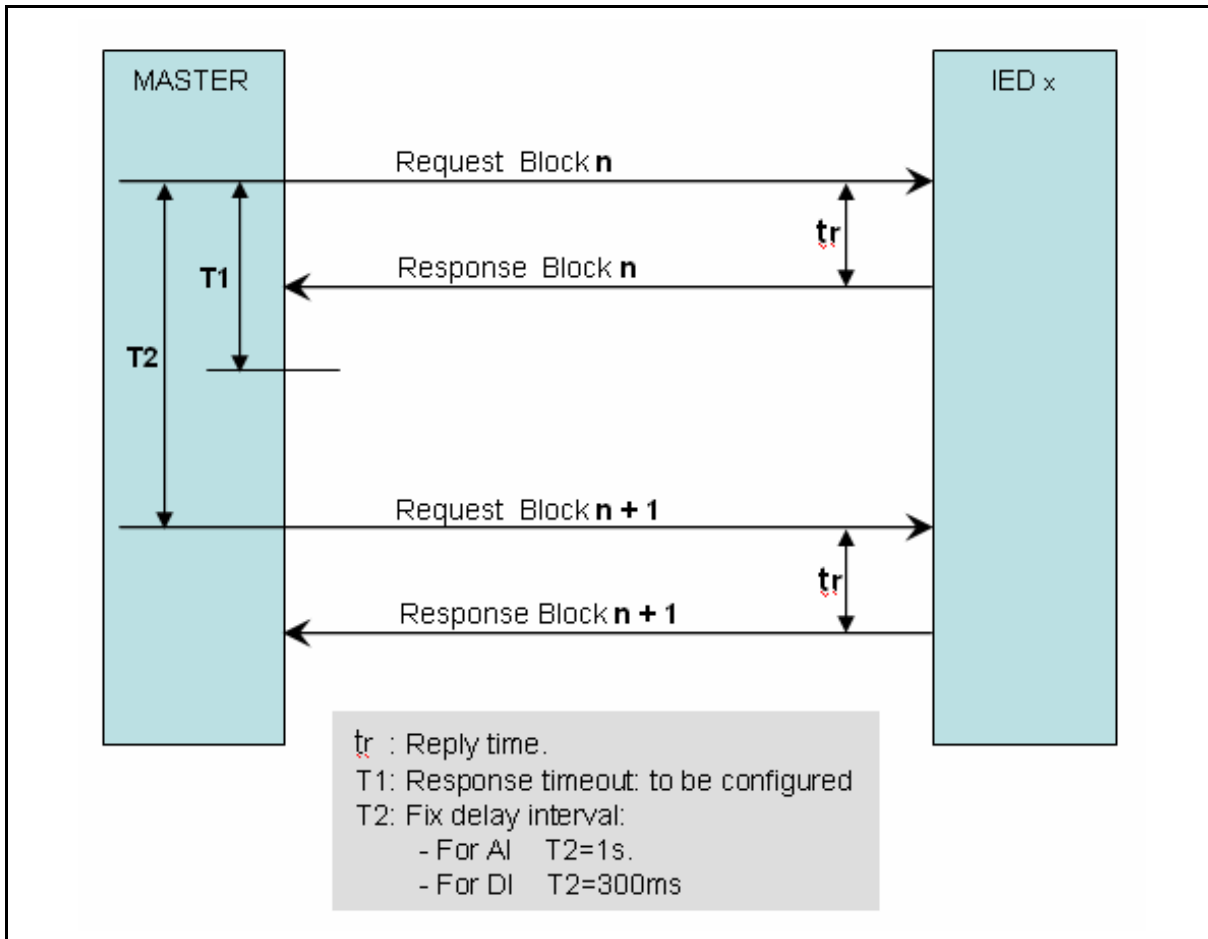


FIGURE 1: DATA POLLING AND ASSOCIATED "INTERVAL REQUEST DELAY"

(E.g. polling all AI of 10 IEDs with 10 blocks of AI each will take 100 seconds).

A block of Analogue Inputs is defined as a set of Analogue Inputs that have been configured at consecutive addresses. As a result, to improve the polling performance, all the Analogue Inputs of a block will be read thanks to just one exchange having regard to the number of Analogue Inputs to be read.

Quality bites are not available on GENERIC MODBUS transmitted data. Data received from MODBUS network are then always VALID.

Available analogue input format are described in §2.3.2.4 "Analogue Input"



### 3.2.2 Digital Inputs

The application reads the Digital Inputs by polling IEDs.

- On serial link MODBUS IEDs are polled one after the other.
- On TCP MODBUS link IEDs are polled simultaneously.

Within an IED DI blocks are read in sequence.

There is a fix interval delay between two blocks polling request (see *Figure 1: Data polling and associated "interval request delay"*).

A block of Digital Inputs is defined as a set of Digital Inputs that have been configured at consecutive addresses. As a result, to improve the polling performance, all the Digital Inputs of a block will be read thanks to just one exchange having regard to the number of Digital Inputs to be read.

The application compares the state of each Digital Input with the previous state of this Digital Input. So the master itself performs the time stamping of a change of state of a Digital Input.

Quality bites are not available on GENERIC MODBUS transmitted data. Data received from MODBUS network are then always VALID.

Configuration of digital Inputs is described in §2.3.2.3 "*Binary Input*"

### 3.2.3 Disturbance files

Disturbance files are not managed by GENERIC MODBUS (MODICON).

## 3.3 Data sent to IEDs

### 3.3.1 Time synchronization

GENERIC modbus don't manage events and associated time-stamp.

Time-stamping of state changes is done by the master.

Parameter: 'None synchronization' is to be used.

### 3.3.2 Commands

Commands are sent to the IED with a higher priority than polling.

An acknowledgement (answer from the IED or server (on TCP) to the master in MODBUS exchange) is awaited by the application within the acknowledgement timeout.

If the acknowledgement is not received after the acknowledgement timeout, master considers that the command has not been taken into account. A negative acknowledgement is sent to the application.

#### Generic behavior

A command is not sent to the IED if one of the following checks is negative:

- Existence in database of DOs or AOs related to commands.
- IED status check (the IED shall be connected).
- Legal command ((For DO: OPEN, CLOSE; For AO: min<val<max ).
- Feedback state for command with feedback (feedback and command state requested shall be different)

NOTE: Quality is not available on MODBUS and consequently not in the check process.

When a feedback is configured, the feedback update shall be checked.

- For a DO: status of feedback is required to be the one requested by the command. Otherwise, a failure message is to be sent to the kernel with the corresponding failure code.

- For an AO: The feedback value shall change no matter the new value is. Otherwise a failure message is to be sent to the kernel with the corresponding failure code.

When, for any reason, a command fails, a negative acknowledgement is sent to the application.

### 3.4 Error management

The MODBUS protocol handles a mechanism of exception answer. This means that an IED can answer with an exception (refer to MODICON standard).

Management of exception codes:

Exception code	Meaning	C264 behavior	PACiS GATEWAY behavior
01	Illegal function	Send a "Configuration error" message to the application and continue	The request associated datapoints quality shall be set to « UNKNOWN ». The value shall be kept unchanged. The new state (value and quality) shall be sent as a change of state to the kernel. And then continue.
02	Illegal data address	Send a "Configuration error" message to the application and continue	Same as ExceptionCode 01
03	Illegal data value	Send a "Configuration error" message to the application and continue	Same as ExceptionCode 01
04	Slave device failure	Send a "IED error" message to the application	Same as ExceptionCode 01
05	IED busy because of a long treatment duration	Retry after a defined temporization	Same as ExceptionCode 01
06	IED busy	Retry after a defined temporization	Same as ExceptionCode 01
07	Treatment not possible	Send a "IED error" message to the application	Same as ExceptionCode 01
08	IED memory parity error	Send a "IED error" message to the application	Same as ExceptionCode 01

### 3.5 Limits and Performances

Performances depend on the number of devices connected on the MODBUS link, the number of data's groups per IED and the frame length.

It is recommended to connect devices that have the same performance on a given network, i.e. the same reply time.

Only one protocol type is managed per master link.

Each device on a MODBUS network must have the same synchronization mode.

#### Master legacy protocols limitations

PACiS C264 computer:

- Up to 4 links can be configured.
- Up to 16 IEDs can be connected on a link.

Pacis Gateway:

- Up to 16 links can be configured.
- Up to 64 IEDs can be connected on a link.
- Up to 200 IEDs can be connected on Legacy master protocols

## 4. MiCOM MODBUS COMMUNICATION

### 4.1 Finality

To complete the generic MODBUS MODICON and offer a response to customers needs thanks to his products, MICOM has developed rules that should be common to every MiCOM device. This is described in document "Communication's Rules for MiCOM devices on a MODBUS network".

Different IED types that conforms to the MiCOM rules:

- M300: Energy analyzer and measure central.
- Px2x: Products MICOM S20.
- Px4x: Products MICOM S40.

C264 and PACiS GATEWAY are able to manage IED using MiCOM MODBUS.

For PACiS GATEWAY it is only possible to configure Px2x: Products MICOM S20

### 4.2 Interface

#### 4.2.1 Implemented function numbers

Function number	Sub-code	Used for	Commentary
7	/	Read event status of an IED.	Each IED is polled regularly. Read status byte: This function is used for detecting a DI change of state, the presence of disturbance files. Format is described in document "Communication's Rules for MiCOM devices on a MODBUS network".

Function 07 is available in order to detect a DI change of state or the presence of disturbance file (MICOM IEDs). Disturbance files are not managed by PACiS GATEWAY.

Other available function codes are described in §2.2.4 "Implemented function".

#### 4.2.2 Connection polling management

Refer to generic MODBUS §3.1.2 "Connection polling management"

The "Read status byte" frame should be used to check the connection of IEDs (MODBUS function number 7).

The IED shall respect the following status format:

N° bit	Description	Comment	Event
b0	General State of the device	1 = In Service, 0 = Out of Service	Yes
b1	Presence of a minor failure (*)	1 = Present / 0 = Absent	Yes
b2	Presence of a dated event not Discharged	1 = Present / 0 = Absent	No
b3	State of synchronisation (* *)	1= synchronised, 0 = not synchronised Compatible OPN7000 / MODN	Yes
b4	Presence of an Disturbance record not extracted	1= present, 0 = absent Compatible OPN7000 / MODN	Yes on Set
b5	Presence of Fault record not extracted	1 = Present / 0 = Absent	Yes on Set
b6	Trip Alarm Set	1= A trip has occurred, not acknowledge	No
b7	Alarm Set	1=At least one alarm bit in alarm cell not acknowledged	No

NOTE: IEDs not significant status bit shall remains to "0"

Any change of state generates an event. Except for b2 set/reset, b4 and b5 reset, b6 and b7 set/reset.

The bit b1 "Presence of a minor failure" indicates a device failure («SRAM Failure»... see Maintenance records), this generate an event.

The bit b3 "State of synchronisation" to 0 indicates that synchronisation was not received or not understood since 1 min, according to protection criteria (by MODBUS or IRIG-B synchronism). This rule covers potential drift of 10 ms of non synchronised device.

Management of event "loss of synchronisation" has a major impact on all events treatment. All events coming from a device that has lost its synchronisation need special treatment in sub-station chronological list of event. This event helps to determine also network disconnection in device history.

Events, Fault Records, Disturbance files are stored in a circular buffer of product defined size. When event, FREC or Disturbance file is acknowledged by master, protective device should free this place in its memory for future events, FREC ...

When all events, FREC, DR have been cleared from buffer, corresponding bit is reset in status byte without generating event.

If a device is disconnected, the protective device buffering functions save all history. If one of those buffers fill-up then:

- Event is generated to inform that this buffer was filled (evently erasing oldest event if the queue is full), and saturation reset event is send when the buffer is no more filled up.
- Oldest data in filled buffer are replaced by new one (event, FREC, Disturbance file).

PACiS GATEWAY specific:

- PACiS GATEWAY doesn't implement FREC or Disturbance file; it only implements events of DI.
- On PACiS GATEWAY, events occurring between disconnection and connection are rejected (history is lost).

## 4.2.2.1 Px2x series

Px2x is managed by PACiS C264 and PACiS GATEWAY.

## 4.2.2.2 M300

PACiS GATEWAY doesn't manage M300

For M300 communication, c264 uses also function 7 but bits have different meanings:

- Bit 0 : Availability of Disturbance record [0 ⇔ not available; 1 ⇔ available]
- Bit 4 : 0 ⇔ In Service; 1 ⇔ Out Of Service
- Bit 5 : 1 ⇔ Presence of Event
- Bit 6 : 1 ⇔ Presence of Alarm.

## 4.2.2.3 Px4x series

PACiS GATEWAY doesn't manage Px4x series.

With MiCOM S40 (Px4x series), the status can be read with MODBUS function 3 or 4 in register 3x00001 (@ 0).

The format of this 16 bits status is described below:

Bit No	Value / bit mask	Meaning	Conform
0	0x0001	In Service Status (1 = In Service / 0= Out Of Service)	OK
1	0x0002	Minor Self Test Failure (1 = Failure / 0 = No failure)	OK
2	0x0004	New event available (1 = Available / 0 = Not Available)	OK
3	0x0008	Time Synchronization (=1 after Modbus time synch. Resets to 0 after 5 minutes unless it is time synched again. Other time sources do not affect this bit).	OK
4	0x0010	New auto extraction disturbance record available (1 = Available / 0 = Not available)	OK
5	0x0020	Fault (Not used - always 0).	NOK
6	0x0040	Trip LED status (1 = LED on, 0 = LED off).	-
7	0x0080	Alarm status summary (logical OR of all alarm status bits).	-
8	0x0100	Unused	-
9	0x0200	Unused	-
10	0x0400	Unused	-
11	0x0800	Unused	-
12	0x1000	Unused	-
13	0x2000	Unused	-
14	0x4000	Unused	-
15	0x8000	Unused	-

Even if the access function (3 or 4 instead of 7) is not conforming to the MICOM MODBUS Rules, as the bits 2 & 3 are conform, Events management is possible from the C264.

#### 4.2.3 Polling

Refer to generic MODBUS §3.1.3 “Regular polling and disconnection management”

C264 and PACiS GATEWAY use frame ‘Read status byte’ to check if IED is synchronised or not.

### 4.3 Data received from IEDs

#### 4.3.1 Analogue Inputs

Refer to generic MODBUS §3.2.1 “Analogue Inputs”

- NOTES:
- Analogue Inputs should have the same format (if possible): [Format = length + type of data] For example: signed integer on 4 bytes.
  - Recommended format is Real **IEEE 754**.

The known formats on PACiS GATEWAY and C264 are currently:

- IEEE STD 754
- signed integer or not on 1 Byte
- signed integer or not on 2 Bytes
- signed integer or not on 4 Bytes (for energy metering precision)

Analogue Inputs shall be gathered at consecutive MODBUS addresses to increase the acquisition performances.

Analogue input of a same group must have the same format. If all Analogue Inputs have not the same format, they shall be grouped using several groups with the same format.

Analogue Inputs must provide a value directly usable. Single scaling (e.g. \*1000) is accepted. Complex computation using boundary scaling is forbidden for measurements. .

The transmission of the measurements in double must start by most significant byte.

INTEL	1	2	3	4
Motorola	4	3	2	1
Most Common (2 consecutive addresses)	2	1	4	3
Recommended transmission MODBUS	4	3	2	1

The units of the measurement must be identical for a range of products. If possible they should respect the list of the recommended units. The format for encoding IEEE makes unit coding easy, as it is possible to treat at system level the large or small values without using non standardised units (example: 1/10 of Amperes, 10 of Volts, MW).

Units	Units
Volts	V
Amperes	A
Kilowatt	KW
Kilo Volt Ampere	kVA
Kilo VAR	kVAR
Kilo Watt . Hour	kW/h
Kilo Volt Ampere . Hour	kVA/h
Kilo VAR . Hour	k VA/h
Hertz	Hz
Celsius centigrade Degree	°C
Ohms-1	$\Omega^{-1}$
Ohms	$\Omega$
Seconds of closing time	s
Degree of angle	degree of angle
Without unit	-

For all quality descriptor used for measurement or counter, it is asked since version D to split quality descriptor indication (like CP8(i+1) Info + Quality from IEC 870-5-4) from value in separate group of address.

Analogue Input States meaning Valid/Invalid is given by binary indication on some IED. For the one that have this feature, AI State indications should be grouped in consecutive words.

#### 4.3.1.1 Px2x series

Px2x is managed by PACiS C264 and PACiS GATEWAY.

Measurements shall be read through the MODBUS functions Number 3 or Number 4 (read word functions). Be careful of indicating the convenient format for the measurement: 16 or 32 bit values. Notice that the low word of 32 bit values is generally transmitted first and in each word, the high byte is transmitted first (use formats such as YYYY32\_LW\_HB for 32 bit values).

Basic Address (Mapping address)	0xyyyyy
Extra Address:	Modbus function (3 or 4)
Format:	See above.



## 4.3.1.2 M300

PACiS GATEWAY doesn't manage M300.

The measurements are regularly polled. Configuration available:

Measurement format (M300)	Format to be configured	Comments
T1	UINT16 (5)	16 bit unsigned value: "12345" (0x3039) represents 12345
T3	UINT16 (5)	16 bit unsigned value with 2 decimals: "12345" (0x3039) represents 123,45
T8	INT16 (4)	16 bit signed value with 3 decimals: "-12345" (0xCFC6) represents -12,345
T9	UINT32_HW_HB (13)	32 bit signed value: "big indian": the high word is transmitted first, the high byte in the word is transmitted first
T10	UINT32_HW_HB (13)	32 bit signed value with 2 decimals: "big indian": the high word is transmitted first, the high byte in the word is transmitted first
T11	UINT32_HW_HB (13)	32 bit signed value with 3 decimals: "big indian": the high word is transmitted first, the high byte in the word is transmitted first
T13	UINT32_HW_HB (13)	32 bit signed value with 5 decimals: "big indian": the high word is transmitted first, the high byte in the word is transmitted first
T20	See comment	Energy: T09 for the primary values (base unit kWh) and T11 for the secondary values (base unit Wh)
T21	See comment	Power: T10 for the primary values (base unit kW) and T12 for the secondary values (base unit W)
T39	See comment	Voltage: T10 for the primary values (base unit V) and T11 for the secondary values (base unit V)
T40	See comment	Current: T10 for the primary values (base unit A) et T13 for the secondary values (base unit A)
T53	See comment	Same as T1

The formats described above do not take into account the multiplying factor. Moreover, the next table gives a non exhaustive list of measurements (in secondary mode):

Measurement	Multiplying factor	Address	Comments
Va	0.001	0x01C6	T39 (=T11 for the secondary mode)
Vb	0.001	0x01C8	T39 (=T11 for the secondary mode)
Vc	0.001	0x01CA	T39 (=T11 for the secondary mode)
Vab	0.001	0x01CC	T39 (=T11 for the secondary mode)
Vbc	0.001	0x01CE	T39 (=T11 for the secondary mode)
Vca	0.001	0x01D0	T39 (=T11 for the secondary mode)
Ia	0.0001	0x01D2	T40 (=T12 for the secondary mode) Warning : it is written T11 in the documentation
Ib	0.0001	0x01D4	T40 (=T12 for the secondary mode, cf. (*))
Ic	0.0001	0x01D6	T40 (=T12 for the secondary mode, cf. (*))
In	0.0001	0x01D8	T40 (=T12 for the secondary mode, cf. (*))
Frequency	0.001	0x01DA	T11
Power	0.0001		T21 (=T12 for the secondary mode, cf. (*))
Energies	0.001		T20 (=T11 en mode secondaire)

(\* ) Warning: it is written T11 in the documentation

The addresses 0x01DB, 0x01DC, 0x01DE and 0x01DF generate an exception frame with code Number 2.

#### 4.3.1.3 Px4x series

PACiS GATEWAY doesn't manage Px4x series.

Measurements should be read through the MODBUS functions Number 3 or Number 4 (read word functions). Be careful of indicating the convenient format for the measurement: 16 or 32 bit values. Notice that the low word of 32 bit values is generally transmitted first and in each word, the high byte is transmitted first (use formats such as YYYY32\_LW\_HB for 32 bit values).

Basic Address (Mapping address): 0xyyyyyy  
 Extra Address: Modbus function (3 or 4)  
 Format: See above.

#### 4.3.2 Digital Inputs

##### 4.3.2.1 IED not synchronized

When the IED is not synchronized the state change is elaborated by the PACiS C264 master as for generic Modbus. Refer to §3.2.2 "Digital Inputs".

Even if the IED is not synchronized, PACiS GATEWAY get DI's value by uploading events with timestamps from the IED.

##### 4.3.2.2 IED synchronized

The status byte taking place in an MICOM IED contains the information indicating that events (Digital Input changes) are present.

As a result, the status byte is regularly polled by the link layer through a low level polling and compared with the previous one.

If a change is detected in the status byte, the master reads the event queue of the IED, checks which data have changed, checks if they have been configured and then reads the information itself.

Notice that in this case, Digital Input changes are timestamped by the IED and the master downloads events including time-stamps tagged by the IED.

Some Digital Inputs are gathered at consecutive addresses (there are in the same group). These Digital Inputs can be read in only one MODBUS request (except if the number of Digital Input is higher than the capacity of a MODBUS message, and except may be for fast status word).

At connection or at given period, master can ask the global states of one device in a single message.

Transient Digital Input is in fact an event not associated to a reel state but to a transition (e.g. Trip order). It is only SET never RESET. This concept is common on other protocol. Actual IED shows that state approach is more commonly used and help in knowing global status at connection. In practice transient Digital Inputs like the trip order, is maintained for configurable time (300ms), and it is accepted to get then 2 events one for for SET the other for RESET. IED should translate an inner transient Digital Input to a pulsed indication on network (of configurable time e.g. 100 to 300ms).

PACiS GATEWAY ignores transient Digital inputs. With PACiS GATEWAY each time the value of DI changes an event is transmitted to the application.

#### 4.3.2.3 Px2x series

Digital Inputs shall be configured and accessed through function number Nr 3 or 4 (read word functions):

	Basic address	Extra address 1	Extra address 2	Extra address 3
<i>MODBUS</i>	<i>(Mapping Address)</i>	<i>(bit Number)</i>	<i>(Modbus function)</i>	<i>(Not Used)</i>
	0x0010	0	4	x

PACiS GATEWAY master gets all DI's value by reading @3600 with Function Code 0x03 to read an event.

#### 4.3.2.4 M300

PACiS GATEWAY doesn't manage M300.

Dated events of M300 aren't treated (there isn't any indication on the state of synchronisation of the M300). Consequently, Digital Inputs of the M300 are acquired by polling and dated in the C264.

Digital Inputs shall be read through Modbus function Number 4 (read words) by indicating the mapping address in the basic address field, by setting 4 in the extra address 2 field and the bit number in the extra address 1 filed.

Configuration sample for reading the 2 Digital inputs of a M300 device:

DI	Basic address	Extra address 1	Extra address 2	Extra address 3
BI0	28d	0	4	/
BI1	28d	1	4	/

Configuration sample for reading alarm status of a M300 device (@30030):

DI	Basic address	Extra address 1	Extra address 2	Extra address 3
BI16	30d	0 "Erreur EEPROM: Replages groupe d'alarme 4"	4	/
BI17	30d	1	4	/
BI23	30d	7 "Défaut port série sortie analogique"	4	/
BI0	31d	0 "Echec test temporisation chien de garde"	4	/
BI1	31d	1	4	/
BI15	31d	15 "Erreur EEPROM: Replages groupe d'alarme 3"	4	/

If you want to read bit fields in 32 bit values, don't forget to configure at least one BI in each part of the long value (low word and high word) as described in the previous example.

#### 4.3.2.5 Px4x series

PACiS GATEWAY doesn't manage Px4x series.

Digital Inputs shall be configured and accessed through function number Nr 3 or 4 (read word functions):

DI	Basic address	Extra address 1	Extra address 2	Extra address 3
MODBUS	(Mapping Address)	(bit Number)	(Modbus function)	(Not Used)
	0x0010	0	4	x

#### 4.3.3 Disturbance files

PACiS GATEWAY Modbus Master doesn't implemented Disturbance file upload.

By disturbance record, one should understand any file transfer (of measurements at high sampling period), not only classical disturbance, but also monitoring data (pressures for GIS, harmonics from Quality, brush distance in CB closure ...).

Such file is cut in limited size blocks (defined by MODBUS wording) in standard uploading.

Any file data format can be used if a converting source code exists to standard file format COMTRAD or at least CSV format (Excel, Matlab...). No other assumption is made in transmitted data (compressed...).

Whatever the kind of transmission, it is expected that a header define kind of data transfer (file or column values), tool version to use at end. Master gives the name of exploitation files (usually COMTRAD) by association of configured device, master reference, IED MODBUS reference, and cyclic disturbance number.

Master is informed that a disturbance is stored by bit b4 from Status word (STAT1). Each block is transmitted after master inquires. It is only at the global end of transfer, after master check-up on the file, that master send the "Ack.DO" and that device can erase its disturbance file. If another "disturbance file" is still present bit b4 remains set (e.g. EPAC multi disturbance upload).

Note that date in disturbance file should be the same than in events (for trip indication...).

Two types of compliances are managed:

Device is compliant to file upload mechanism (Stream of data).

Device is compliant to disturbance upload mechanism (Column of values):

- The column principle is used for Px2x. It looks similar to VDEW/T101 or old KBM extraction. This way can be used also for file transfer but is not optimised.

COMMENT	IED	NET	MASTER	
**	**	**	**	**
**	TRIP-storage-disturb**	**	**	**
**	↓	**	**	**
Disturbance-ready**	Bit-Disturbance-ready**	**	Poll-status**	**
**	**	**	=>Disturbance-available**	**
**	**	**	**	**
Option**	**	**	Poll-disturbance-address**	**
Option**	=> Patrimoine-ask**	**	**	**
Option**	**	**	**	**
Option**	@Disturb-Word¶ @First-Pack-Page¶ @Last-Pack-Page¶ Number-Channel/Pack**	**	**	**
Option**	**	**	=> Disturb. Addresses**	**
**	**	**	**	**
**	**	**	**	**
Select-Channel**	**	**	Select-Channel/Pack¶ First-non-ack-disturbance**	**
**	=> channel-selected**	**	**	**
**	**	**	**	**
**	Prepare-Block**	**	**	**
**	**	**	**	**
**	Answer-channel-info**	**	**	**
**	**	**	=>Get-Channel-data**	**
**	**	**	**	**
Data-upload**	**	**	Poll-PACK**	**
(PACK= Value-column-or**	**	**	**	**
**	**	**	Poll-Block**	**
(Block-250-words)**	=> read-block**	**	**	**
**	Answer-Data-Block**	**	=>-get-block**	**
**	**	**	**	**
**	**	**	=>until-last-Block**	**
**	**	**	**	**
**	**	**	Repeat-Next-PACK¶ Until-last-PACK**	**
**	**	**	**	**
**	**	**	Poll-Index**	**
First-disturbance-acknowledge**	=> read-index**	**	**	**
**	Disturb-READED**	**	=>-get-index,time,no-error**	**
**	**	**	**	**
**	**	**	CHECK-VALIDITY**	**
**	**	**	**	**
Acknowledge-Disturbance**	**	**	Send-DO-ACK**	**
**	⇔ DO-ACK¶ ⇔ Disturb-read**	**	**	**
**	Erase-disturb-file¶ Change-index-disturb¶ Refresh-bit-disturb**	**	**	**

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## 4.3.3.1 M300

There is 2 kind of Disturbance record:

- Waveform Analysis Record (max = 1 file)
- Disturbance Record (max = 4 files)

The detection of the availability of a disturbance record in the M300 is done by regularly polling the status of the M300 and analysing the state of the bit “Availability of Disturbance record”.

Disturbance Polling for M300:

The PACiS C264 computer regularly looks for disturbance availability on IED:

FOR (each IED) WHILE (maximum number of simultaneous disturbance upload is not reached)

IF (a disturbance record is available for the IED)

Upload the disturbance record

END IF

END FOR

The disturbance record of an IED is uploaded only if the maximum number of simultaneous disturbance uploading is not reached for the Modbus line and the opening of a disturbance file on the PACiS C264 computer is possible.

Upload of a Disturbance file M300:

It opens a file on the PACiS C264 computer to store disturbance data. If open isn't possible, it's the end of treatment. Selection of the type of disturbance to upload by writing to register @40567 (0x0237) to: '0' for a Waveform Analysis; '1' for a Disturbance Record).

Selection of a record number is done by writing to register @40568 (0x0238). '0' is written in order to select the last one.

Then, c264 read general information and write of this information to the file.

- Serial number of the IED [8 words at @30001 (0x0001)]
- Frequency [@40572 (0x023C)]
- Trigger date [@30055 (0x0037) → @30060 (0x003C)]
- Available channels [@30061 (0x003D)]
- Type of channels [@30062 (0x003E)]
- Number of sample by channel [@30063 (0x003F)]
- Number of page [of sample] by channel [@30064 (0x0040)]
- Number of sample by cycle [@40560 (0x0230)]
- Trigger position [@30066 (0x0042)]
- Time base [@30067 (0x0043)]
- Scaling factors of analogue channels [@30068 (0x0044) → @30081 (0x0044)]
- Names of analogue channels
- Names of TOR channels

Disturbance data is uploaded channel by channel beginning by channel '0' which is the time channel, and for each channel, page by page:

- FOR each channel
  - ▲ Selection of the channel [Write the channel Number in register @40569 (0x0239)]
  - FOR each page
    - Selection of the page [Write the page Number in register @40570 (0x023A)]
    - Read the number of sample in the page [@30065 (0x0041)]
    - Read the sample of the page [N words @30390 (0x0186)]
    - Write the sample in the disturbance file
  - END FOR each page
- END FOR each channel

To finish the process, c264 close the disturbance file.

The bit 7 of register @40047 allows erasing ALL the disturbance record.

The following table indicates the configuration information needed by the PACiS C264 computer to allow the disturbance management of an IED:

Chart	Field	Comments
External device	disturb_auto	Must be set to 1 to allow the disturbance management of the IED by the PACiS C264 computer
	file_status_bi_norgint	Must be configured to allow the signalisation (to the UCA or legacy centre) of the presence of the disturbance file in the PACiS C264 computer.
	dist_file_type	Gives the type of extension of the disturbance file on the PACiS C264 computer.
Modbus IED type	Type_ied	Gives the type of IED. As each kind of IED may have different way to upload disturbance record, this information is very important.
External device label Class	Label_ext_device	The IED label enables to build the disturbance file name.

Mapping for Disturbance Management for M300

Below, the mapping M300 used for disturbance management:

@ Mapping	@ Hexadecimal	MODBUS Function	Words Number	Format	Description
Disturbance State					
30053		4	1	T46	Disturbance State
30054	0x0036	4	1	T45	Total Number of disturbance records. Stocked.
Description of record data of disturbance selected.					
30055 30060	0x0037	4	6	T52 [CEI 870]	Disturbance Start Date
30061	0x003D	4	1	T49	Available Ways [1 bit by way – Bit0 for way 1 – Bit to 1 ⇔ presence of way]
30062	0x003E	4	1	T49	Ways types [1 bit by way – Bit0 for way 1 – Bit to 1 ⇔ analogical way]
30063	0x003F	4	1	T49	Samples number by ways
30064	0x0040	4	1	T1	Page Samples number by ways
30065	0x0041	4	1	T48	Samples number in selected page
30066	0x0042	4	1	T49	Triggering position
30067	0x0043	4	1	T56	Time base (Scale Factor for the temporisation way = 50ns)
Scale factor of analogical ways					
30068 30069	0x0044	4	2	T50 Signed Int 16 bits to split by 108	Scale Factor – way 1
30070 30071	0x0046	4	2		Scale Factor – way 2
30072 30073	0x0048	4	2		Scale Factor – way 3
30074 30075	0x004A	4	2		Scale Factor – way 4
30076 30077	0x004C	4	2		Scale Factor – way 5
30078 30079	0x004E	4	2		Scale Factor – way 6
30080 30081	0x0050	4	2		Scale Factor – way 7
Analogical ways names					
30082 30088	0x0052	4	7	T51	Analogical way name 1
...	...	...	...	...	...
30124 30130	0x007C	4	7	T51	Analogical way name 7
Logical ways names					
30152 30158	0x0098	4	7	T51	Logical way name 1
...	...	...	...	...	...
30383 30389	0x017F	4	7	T51	Logical way name 34



@ Mapping	@ Hexadecimal	Modbus Function	Words Number	Format	Description
Samples page [Samples of page & selected way]					
30390	0x0186	4	1	T41	Sample N°1
...	...	...	...	...	...
30453	0x01C5	4	1	T41	Sample N°64
Disturbance parameters					
40560	0x0230	3,6,16	1	T1	Samples number by cycles [0 ⇔ 24 samples ; 1 ⇔ 48 samples]
40561	0x0231	3,6,16	1	T1	Records Configuration (0 ⇔ 1 record, ... 3 ⇔ 4 records)
40562	0x0232	3,6,16	1	T1	Cycle after Triggering
40563 40564	- 0x0233	3,6,16	2	T58	Consign Triggering
40565	0x0235	3,6,16	1	T57	Logical Inputs Triggering
Triggering command of Disturbance					
40566	0x0236	3,6,16	1	T34	Capture/recorded command of disturbance
Disturbance reading					
40567	0x0237	3,6,16	1	T37	Selection of record type [0 ⇔ Disturbance Analyse; 1 ⇔ Record]
40568	0x0238	3,6,16	1	T42	Selection of record number [0 ⇔ the most recent]
40569	0x0239	3,6,16	1	T55	Selection of way number [0 ⇔ temporization way ; 1 ⇔ 1st way ; ...]
40570	0x023A	3,6,16	1	T1	Selection of the sample page
40571	0x023B	3,6,16	1	T36	Selection of record number
System Datas					
30001 30008	- 0x0001	4	8	T54 [Ascii]	Model number
40572	0x023C	3,6,16	1	T1	Frequency

#### 4.3.3.2 Px2x series

The Px2x can store up to five (5) Disturbance records. The number of channels depends on the kind of Px2x (From 6 to 9)

The detection of the availability of a disturbance record in the Px2x is done by regularly polling the status of the Px2x and analysing the state of the bit "Presence of Disturbance record".

##### Upload of a Disturbance file Px2x Models

The PACiS C264 computer shall open a file to store disturbance data. If file open isn't possible the treatment is aborted.

PACiS C264 computer reads the Number of Disturbance records and the associated information (Read of 36 Words at @0x3D00). This information enables to know the number (between 0 and 4) of the latest unacknowledged disturbance record. If there isn't any unacknowledged disturbance record, it's the end of treatment.

PACiS C264 computer reads the IED identification model of the form "Px2x" in order to determine the number of channels and the selection size (Read of 5 Words at @0x0000) and after, it write this information to the disturbance file.

The disturbance data are uploaded channel by channel, and for each channel, page by page:

- FOR each channel (from 0 to  $N_c - 1$ )
  - ▲ @channel = HighByte( 0x38 + Nd ) + LowByte( Channel Number )
  - ▲ Selection of the channel [Read of Ss Words at @channel]
  - ▲ Write this information to the disturbance file
  - ▲ Determine the number of pages to read and the number of sample in the last page [all other page contain 250 words of samples]
- FOR each page
  - @page = HighByte( 0x09 + page Number ) + LowByte( 00 )
  - Read the sample of the page [N words @page]
  - Write the sample in the disturbance file
- END FOR each page
- END FOR each channel

C264 reads the index frame of the disturbance (Read 7 words at @ 0x2200) and write this information to the disturbance file.

After, PACiS C264 computer close the disturbances file and acknowledge the Disturbance is in the Px2x. To acknowledge the disturbance record, set bit @0x4032 to 1. Once the disturbances file is acknowledged, another Disturbance record can be uploaded from the IED.

The following table indicates the configuration information needed by the PACiS C264 computer to allow the disturbance management of an IED:

Table	Field	Comments
External device	disturb_auto	Must be set to 1 to allow the disturbance management of the IED by the PACiS C264 computer
	file_status_bi_norgint	Must be configured to allow the signalisation [to the UCA or legacy centre] of the presence of the disturbance file in the PACiS C264 computer .
	dist_file_type	Gives the type of extension of the disturbance file on the PACiS C264 computer .
Modbus IED type	Type_ied	Gives the type of IED. As each kind of IED may have different way to upload disturbance record, this information is very important.
External device label Class	Label_ext_device	The IED label enables to build the disturbance file name.

Below, the disturbance management difference between Px2x Models:

Products	Number of analogue channels	Number of TOR channels	Total number of channels	selection information size (Pages 0x38 thru 0x3C)
P120	No disturbance management			
P121	No disturbance management			
P122	5 (IA,IB, IC, I0, Frequency)	1 ( 3 Inputs, 7 Outputs)	6	11 Words
P123	5 ( IA, IB, IC, I0, Frequency)	1 (5 Inputs, 9 Outputs)	6	11 Words
P124D	5 ( IA, IB, IC, I0, Frequency)	1 (5 Inputs, 9 Outputs)	6	11 Words
P124S	No disturbance management			
P125	No disturbance management			
P126	6 (IA, IB, IC, I0, V, Frequency)	1 (7 Inputs, 9 Outputs)	7	19 Words
P127	8 (IA, IB, IC, I0, VA, VB, VC, frequency)	1 (7 Inputs, 9 Outputs)	9	19 Words
P220	5 ( IA, IB, IC, I0, Frequency)	1 (5 Inputs, 6 Outputs)	6	11 Words
P225	6 ( IA, IB, IC, I0, UAC, Frequency)	1 (6 Inputs, 6 Outputs)	7	19 Words
P226C	6 ( IA, IB, IC, I0, UAC, Frequency)	1 (6 Inputs, 6 Outputs)	7	19 Words
P521	7 ( IA, IB, IC, I0, timing)	2 (5 Inputs, 9 Outputs, 9 internal data)	9	11 Words
P920	No disturbance management			
P921	No disturbance management			
P922	5 ( Voltage, Frequency)	1 (5 Inputs, 9 Outputs)	6	19 Words
P923	5 (Voltage, Frequency)	1 (5 Inputs, 9 Outputs)	6	19 Words
P925	No disturbance management			

## 4.3.3.3 Mapping for Disturbance Management for Px2x Models

Below, the mapping Px2x used for disturbance management.

@ Mapping	Modbus Function	Number of Words	Format	Description
Pages 0x09 thru 0x21 : Disturbance Data. Each page contains the samples [250 data word] of the selected channel.				
0x0900 → 0x09FA	3	250	SINT16	Up to 250 samples
0x0A00 → 0x0AFA	3	250		Up to 250 samples
.....				
0x2100 → 0x21FA	3	250		Up to 250 samples
Page 0x22 : Index of the Disturbance				
0x2200	3	1	UINT16	Disturbance record Number
0x2201 → 0x2204	3	4	Time Stamp	Disturbance record finish date
0x2205	3	1	UINT16	Disturbance record starting condition
0x2206	3	1	UINT16	Frequency at the post-time beginning

@ Mapping	Modbus Function	Number of Words	Format	Description
Page 0x3D : Number of disturbance records available				
0x3D00	3	1	UINT16	Number of disturbance records available [1 .. 5]
0x3D01	3	1		Oldest disturbance record Number (n)
0x3D02 → 0x3D05	3	4	Time Stamp	disturbance record Date
0x3D06	3	1		disturbance record starting origin
0x3D07	3	1		0 ⇔ Not Acknowledged; 1 ⇔ 1 Acknowledged
0x3D08	3	1		disturbance record previous Number (n+1)
0x3D09 → 0x3D0C	3	4	Time Stamp	disturbance record Date
0x3D0D	3	1		disturbance record starting origin
0x3D0E	3	1		0 ⇔ Not Acknowledged; 1 ⇔ 1 Acknowledged
....				
0x3D1D	3	1		disturbance record previous Number (n+4)
0x3D1E → 0x3D21	3	4	Time Stamp	disturbance record Date
0x3D22	3	1		disturbance record starting origin
0x3D23	3	1		0 ⇔ Not Acknowledged; 1 ⇔ 1 Acknowledged

@ Mapping	Modbus Function	Number of Words	P122 / P123 / P124D / P220 [11 words are uploaded for each access reading]	P126 [19 words are uploaded for each access reading]	P127 [19 words are uploaded for each access reading]	P225 / P226C [19 words are uploaded for each access reading]	P521 [11 words are uploaded for each access reading]	P922 / P923 [19 words are uploaded for each access reading]
Pages 0x38 thru 0x3C : Selection of the Disturbance and channel [Each page correspond to 1 of the 5 Disturbance record].								
0x..00	3	1	la	la	la	la	la	Ua
0x..01	3	1	lb	lb	lb	lb	lb	Ub
0x..02	3	1	lc	lc	lc	lc	lc	Uc
0x..03	3	1	lo	lo	lo	lo	lo	Vo
0x..04	3	1	Frequency	reserved	Ua	Frequency	Timing	Frequency
0x..05	3	1	TOR	reserved	Ub	TOR	TOR1	TOR
0x..06	3	1	unavailable	Uo	Uc/Uo	Ua-c	TOR2	unavailable
0x..07	3	1		Frequency	Frequency	unavailable	unavailable	
0x..08	3	1		TOR	TOR			

For each register read request, the following information are uploaded. This information describes the selected channel:

Word	P122 / P123 / P124D / P220	P126	P127	P225 / P226C		P922 / P923
0	Total Number of samples	Total Number of samples	Total Number of samples	Total Number of samples	Total Number of samples	Total Number of samples
1	Sample number in pre-time	Sample number in pre-time	Sample number in pre-time	Sample number in pre-time	Sample number in pre-time	Sample number in pre-time
2	Sample number in post-time	Sample number in post-time	Sample number in post-time	Sample number in post-time	Sample number in post-time	Sample number in post-time
3	Primary phase CT ratio	Phase primary CT ratio	Primary phase CT ratio	Primary phase CT ratio	Primary phase CT ratio	Primary phase CT ratio
4	Secondary phase CT ratio	Phase secondary CT ratio	Secondary phase CT ratio	Secondary phase CT ratio	Secondary phase CT ratio	Secondary phase CT ratio
5	Eath primary CT ratio	Earth primary CT ratio	Eath primary CT ratio	Eath primary CT ratio	Primary earthCT ratio	Eath primary CT ratio
6	Earth secondary CT Ratio	Earth secondary CT ratio	Earth secondary CT Ratio	Earth secondary CT Ratio	Secondary earthCT Ratio	Earth secondary CT Ratio
7	Phase internal CT ratio	Phase internal CT ratio	Phase internal CT ratio	Phase internal CT ratio	Internal phase CT ratio	Phase internal CT ratio
8	Earth internal CT Ratio	Earth internal CT ratio	Earth internal CT Ratio	Earth internal CT Ratio	Internal Earth CT Ratio	Earth internal CT Ratio
9	Last page Number	Reserved	Primary phase VT Ration [LB]	Primary phase VT Ration [LB]	Last page Number	Primary phase VT Ration [LB]
10	Last page word number	Reserved	Primary phase VT Ration [HB]	Primary phase VT Ration [HB]	Last page word number	Primary phase VT Ration [HB]
11	unavailable	Reserved	Secondary phase VT ratio	Secondary phase VT ratio	unavailable	Secondary phase VT ratio
12		Earth primary VT ratio [LB]	Earth Primary VT Ration [LB]	Reserved		Earth Primary VT Ration [LB]
13		Earth primary VT ratio [HB]	Earth Primary VT Ration [HB]	Reserved		Earth Primary VT Ration [HB]
14		Earth secondary VT ratio	Earth secondary VT Ratio	Reserved		Earth secondary VT Ratio
15		Internal VT ratio – numerator 100	Internal VT Ratio – numerator 100	Internal VT Ratio – numerator 100		Internal VT Ratio – numerator 100
16		Internal VT Ratio – denominator	Internal VT Ratio – denominator	Internal VT Ratio – denominator		Internal VT Ratio – denominator
17		Last page Number	Last page Number	Last page Number		Last page Number
18		Last page words number	Last page word number	Last page word number		Last page word number

Specific treatments:

For P126, the channels are not consecutive: the 5<sup>th</sup> & 6<sup>th</sup> channels must be skipped.

For P127, the address 0x0127 must be read to have the voltage wiring of the IED. This value must be written in the file (but it doesn't change the uploading process).

For P922 & P923, the mapping address 0x0126 must be read. It gives the voltage wiring of the IED. This value must be written in the file.

For P922 & P923, this value changes the uploading process: in some case, channels have to be skipped.

Wiring value	Voltage wiring of the IED	Used channels	
0	3Vpn (3 simple tension)	0	Ua
		1	Ub
		2	Uc
		3	Not used
		4	Frequency
		5	TOR
1	3Vpn + Vr (3 simple tension + homopolar)	0	Ua
		1	Ub
		2	Uc
		3	Vo
		4	Frequency
		5	TOR
2	2Vpp + Vr (2 composed tension + homopolar)	0	Uab
		1	Ubc
		2	Not used
		3	Vo
		4	Frequency
		5	TOR
3	3Vpp + Vr (3 composed tension + homopolar)	0	Uab
		1	Ubc
		2	Uca
		3	Vo
		4	Frequency
		5	TOR

## 4.3.3.4 Px4x series

Upload of Px4x disturbance is not implemented in C264.

#### 4.3.4 Events

An event is a change of state of a logical data that is time tagged. As expressed before this state can be scanned using Digital Inputs rules. Then, the Master can read the current status of logical information when the protection gets connected.

The dated Events are gathered in only one file. The bit ' b2 ' of the status indicates the presence of at least one event not extracted. Events are stored by protective device, and are read one by one by the master, starting from the oldest event.

Master reading of one event should not withdraw it off the file. Event is withdrawn by the device, from its event list:

- only on acknowledgement by Master MODBUS
- or on saturation of the file of the events (cyclic queue with loss of the oldest events)
- or directly after master reading if automatic event retrieval is set on IED. The event can always be re read at address @event +1 (3601h if last event address is 3600h). Event reply is 0 is event list is empty.

First case, Master reads one event, then master sends "DO ok" if it correctly receive the event. When receiving this acknowledgement, the protection can erase its last event, and refresh its events list (adding to event bit possible reset in status word). This should give an assurance that no events are lost. DO acknowledgement is b13 0400h.

Second case, IED and master configured for automatic event retrieval. (Master checks at start-up B12 at 0400h.) Master reads last event. IED shift this event to next address (in event list). Master detecting transmission error can read again the event on address +1. Now, Modbus Master only read one event one time. Process is likely as Any change of status of a logical information in the protection must generate a dated event (Physical inputs, physical outputs i.e. output relay and logical Information as alarms, logical inputs or threshold).

Events are generated on transition from 0 to 1 and 1 to 0 or on transition of any input assigned or not to a protective feature.

Event must have the followings information:

- Date and Time, using inverse order IEC 870-5-4 CP56T2a format (no short format).
- MODBUS mapping address of logical information that has changed.
- New state value of the transmitted data (new value of the word, stored at the MODBUS mapping address).

All events are transmitted to the master. Master is in charge to filter between all events the ones needed by upper system functions and to send it to corresponding service: automation, alarms, textual message converter, event & logging printing....). The master event data filtering (as the polling period, as low level communication parameters) are defined in master configuration. Now, filter of events in PACiS GATEWAY Modbus Master can not be configured. PACiS GATEWAY Modbus Master only manage DI event.

The time tag of the event must be with the same format as time synchronisation.

The master should be able to manage several changes of state in a same event (for changes in same time accuracy period, to increase communication transfer ...), even if each event have only one change of state. Then, one change of state is linked to one event and one event is linked to several possible changes of state (if they are in same MODBUS map address). PACiS GATEWAY Modbus Master only manage DI event.



4.3.4.1 Px4x series

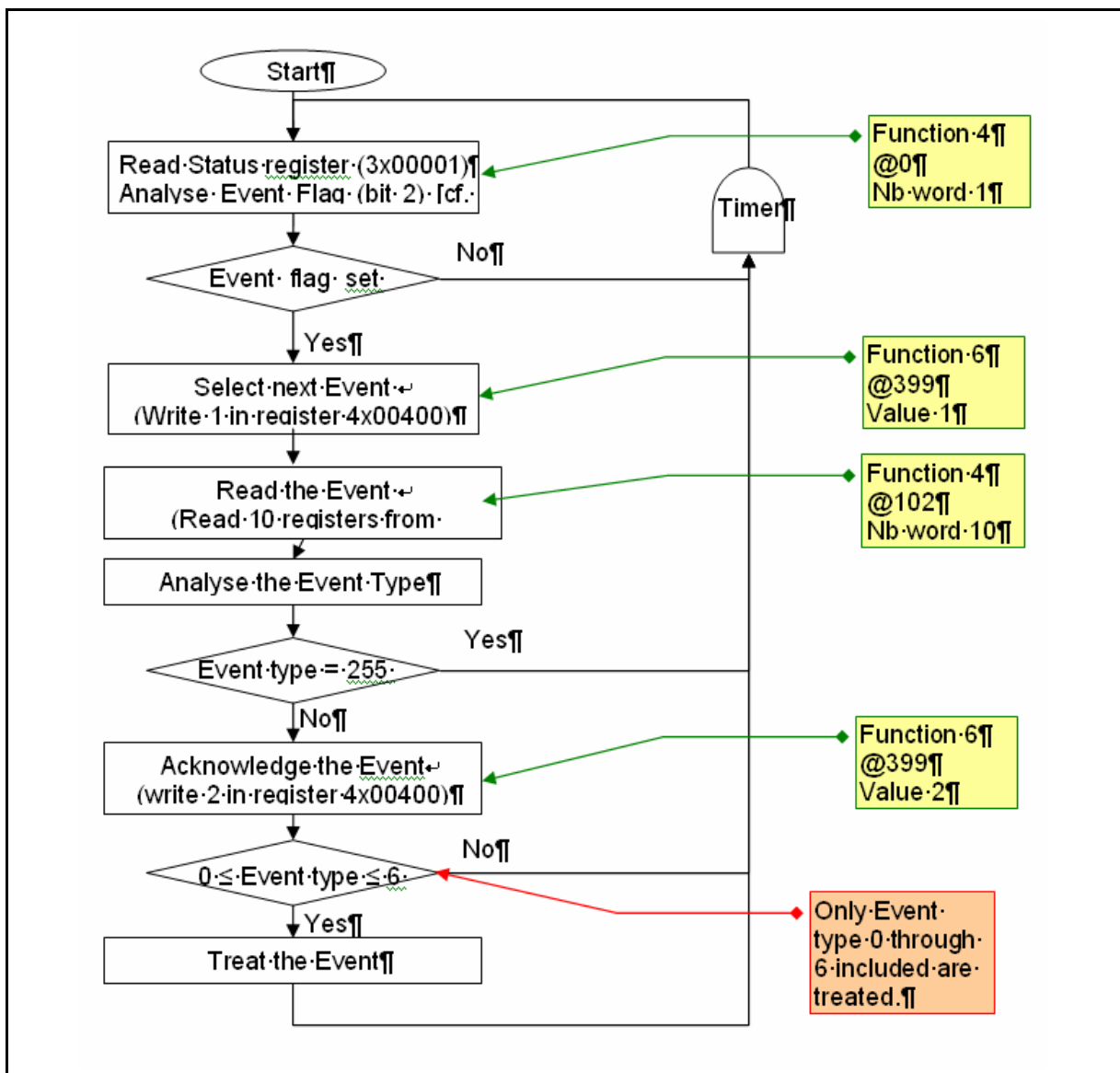
PACIS GATEWAY doesn't manage Px4x series.

The command register can be written with Modbus function 6 in register 4x00400 [@ 399]. The format of this 16 bits register is as shown below:

Bit No	Value / bit mask	Meaning
0	0x0001	Select next event
1	0x0002	Accept Event
2	0x0004	Select next Disturbance Record
3	0x0008	Accept disturbance record
4	0x0010	Select Next Disturbance record page
x	x	Other bits are Unused

Each action is activated when a '1' is written in the corresponding bit.

Automatic event-record extraction allows records to be extracted as they occur. Event records are extracted in sequential order.



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The Modbus master can determine whether the Px4x has any events stored that have not yet been extracted. This is performed by reading the Px4x's status register 3x00001 (G26 data type). If the event bit, of this register, is set then the Px4x contains event records that have not yet been extracted.

To select the next event for sequential extraction, the master station writes a value of one to the command register 4x00400 (G18 data type). The event data together with any fault/maintenance data can be read from the registers as specified in the flow chart and table shown in Once the data has been read, the event record can be marked as having been read by writing a value of two to register 4x00400.

Alternatively, since the G18 data type consists of bit fields, it is possible to both marks the current record as having been read and to automatically select the next unread record by writing a value of three to the register.

When the last (most recent) record has been accepted the event flag in the status register (3x00001) will reset.

If the last record was accepted by writing a value of three to the command register (4x00400), then a *dummy* record will appear in the event record registers, with an "Event Type" value of 255.

Attempting to select another record, when none are available will result in a Modbus exception code 3 – "Invalid value".

Events have the followings format:

Modbus Register Address	Contents	Description	Nb Register
3x00103 ... 3x00106 102 ... 105	(G12) Time stamp of the Event	IEC870 Time & Date (Format: see §3.3.1 "Time synchronization")	4
3x00107 106	(G13) Event type	Code 0,1,2,3=Alarm event Code 4=output contact event Code 5=opto input event Code 6=Protection events Code 7=General events Code 8=Fault record events Code 9 =Maintenance events 255 = dummy event	1
3x00108 ... 3x00109 107 ... 108	(G27) Event value	New values of the 32 bits register containing the BI(s) which have changed.	2
3x00110 109	(G1) 32 bits Register reference	Modbus address of the 32 bits register containing the BI(s) which have changed. Caution, real Modbus address must be re-computed by subtracting 30001 !!!  if Event type=0,1,2,3 → 11 If Event type = 4 → 723 If Event type = 5 → 725 If Event type = 6 → associated DDB status register: 727 to 785	1
3x00111 110	Event Index	if Event type=0,1,2,3 → Alarm ID If Event type = 4 → Not used – set to 0 If Event type = 5 → Not used – set to 0 If Event type = 6 → bit 16 = state, bits 1-15 DDB ID if Event type = 7, 8, 9 → Not used	1
3x00112	Not used by C264	-	1

According to the *Event Type*, the *Event Index* can be used – or not – to analyses the Event. Two cases have to be considered.

First case: Event type 0,1,2,3 and 6. In this case, the *Event Index* can be used.

- Bit16 of the *Event Index* indicates the new Digital Input state (0 or 1)
- Bit1-15 of the *Event Index* [modulo 32] indicate the Bit Number of the Digital Input in the 32bits register
- The *32bits register reference* and the Digital Input *Bit Number* allows finding the Digital Input in the C264 DB (if configured).

Second case: Event type 4 and 5. In this case, the *Event Index* is not significant and can't be used. The C264 DB has to be parsed against the *Event Value*, looking for a change of state of all Digital Input of the *32bits register reference*.

#### 4.3.5 File Upload

PACiS GATEWAY doesn't implement File Upload function.

File is defined by a header a parameter set and a stream of data. Each time a block of data is ridden by master, the IED shifts data to the next page (Repeat page) and replaced by new block of data. In case of transmission error, the master inquires the block wrongly received on the repeat page.

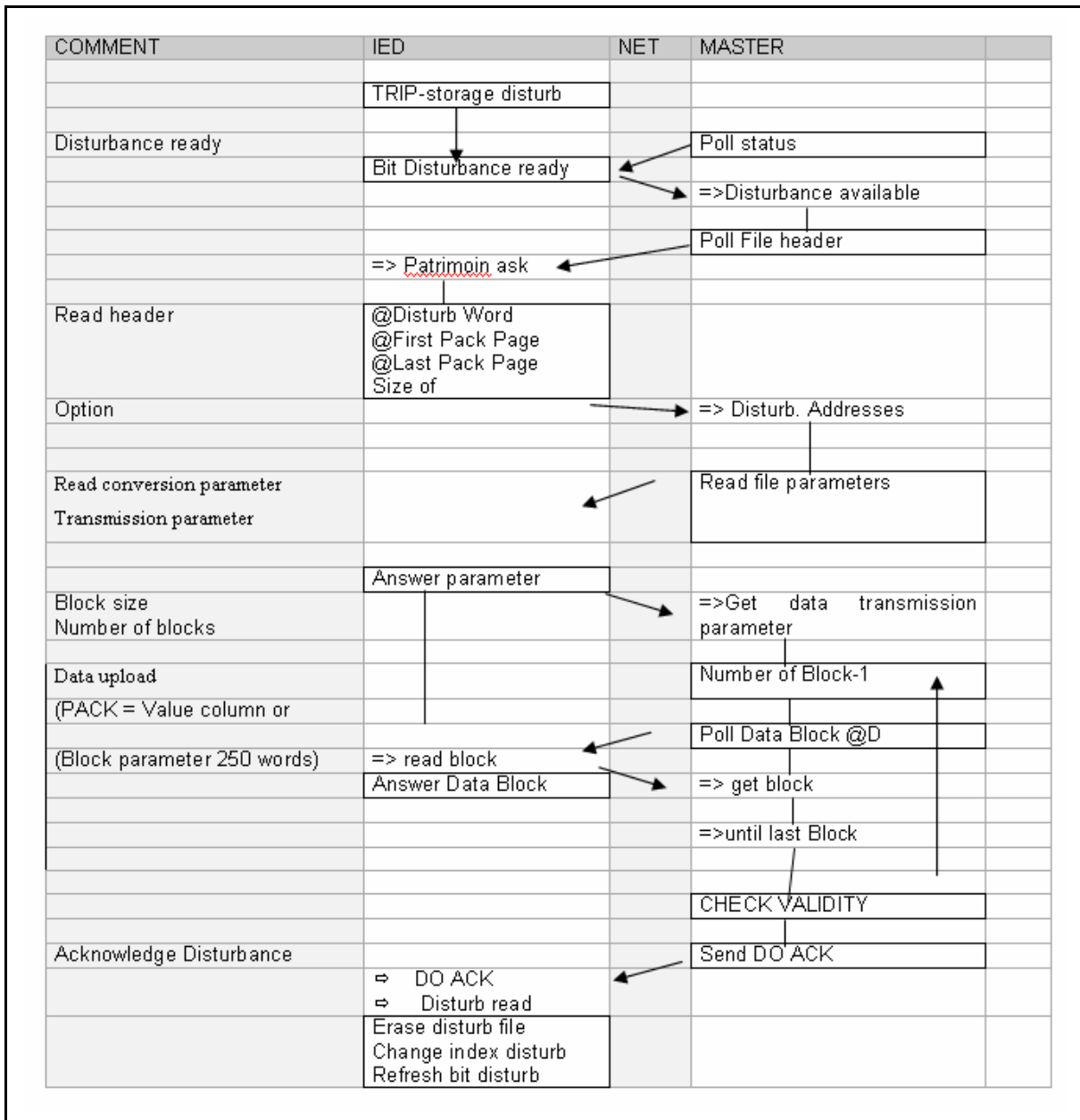
Addresses	Function	Contents
FA00 to FAFA	Read 24 words	Read header
FB00 to FBFA	Read N words	Read N words of file parameters and shift parameter stream
FC00 to FCFA	Read N words	Read N words again of file (repeat)
FD00 to FDFA	Read N words	Read N words of file data and shift data stream
FE00 to FEFA	Read N words	Read N words again of file (repeat)

This header defines data to transmit as byte stream and file treatment to trigger by master on received data.

All data sampling are transmitted one after the other without compression.

Word	Meaning for decoding software	Comment
0-1	First value of first sampling	
2-3	Second value of first sampling	
Nb_Byte_Data	Last word	

Algorithm:



For setting download, the operation is made through function 15 or 16 writing at specific address. Return code inform master application of acceptance. From system point of view, it is expected that a write operation is accepted over several consecutive addresses to speed-up the global downloading.

**4.4 Data sent to IEDs**

**4.4.1 Time synchronisation**

The format of the synchronisation frame is private and defined for MiCOM.

All the devices connected to a given network must have the same synchronization procedure (address and time and date format) because the synchronization will be performed through a broadcast frame.

Date and time conform to the inverted IEC 870-5-4 CP56Time2a format:

Words	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0		
1	0								Year								00..99	
	0	0	0	0	0	0	0	0										
2	0				Month				Day of Week		Day of Month					1..12 1..7 1..31		
	0	0	0	0														
3		0		Hour				Minutes								0..23 0..59		
	S	0	0						I	0								
	u								v									
4	Millisecond Hi								Millisecond Low								0..59 999(second+milliseconds)	
	$2^{15}$								$2^8$								$2^7$	$2^0$

*Su (=0 Standard, =1 Summer Time) IV (=0 valid =1, non valid or non synchronised in system case) First day of the week is Monday*

Date and time is set at address 0800h with Modbus function 16.

No calculation of the transmission delay is performed.

If an equipment does not have (this) synchronisation, it must be unaware of these synchronisation messages (no error indication, no failure).

With IED that does not respect rule, MODBUS master can be able to supply non synchronised devices with its own time tagging of IED DI polling. The time accuracy is deeply degraded leading to system non conformity.

Device should not generate any event when receiving the synchronisation, or when missing one broadcast message. Synchronisation is classical function in a system. It is coming from specialised clock device like GPS with average polling of 1 minute. The first bit is the reference. Master transmits time with correction of its treatment delay (highest priority). It sends Synchronic-message with configurable period (e.g. 3 times per minutes). "Loss of synchronisation" event could be defined on device lack of reception after 1 minute.

"Loss of synchronisation" event should be correctly set/reset. Synchronisation information is also present in event via "IV bit" in the time tag of event meaning that when event occurs device was or not synchronised.

Any IED with 2 clocks system, synchronization MODBUS mechanism AND an IRIG B (or other), should have an inner setting to deactivate each clock. Synchronisation on net is always sending in broadcast, and this acquisition should be deactivated if needed.

A master that has lost its own synchronisation still send time tagging (but with IV bit set) to still synchronise IED with a same reference (relative time tagging of desynchronised events). For PACiS GATEWAY , local time is impossible lost, as a result, even though the time of PACiS GATEWAY is not accurate, IV bit in synchronize broadcast frame will not be set.

No calculation of the transmission delay is performed.

## 4.4.1.1 M300

PACiS GATEWAY doesn't manage M300.

The M300 manages 2 formats of synchronisation:

- The Modbus MICOM synchronization format, which is used only to set the Date & Time.
- The M300 format which is used to set the Date & Time in the M300 or for time stamping in the M300 (e.g : Disturbance time stamping).

The synchronisation according to the Modbus MICOM rules is accepted by the M300 only if the bit "summer" isn't set.

## 4.4.1.2 Px2x series

The Px2x manages 2 formats of date:

- MICOM synchronization format, which is used only to set the Date & Time in the Px2x.
- Px2x format which is used for time stamping in the Px2x (e.g.: Event & Disturbance time stamping).

The time stamping format is as follow:

Word Number	Word	
	High Byte	Low Byte
0	Low Word of Seconds	
1	High Word of Seconds	
2	Low Word of MilliSecondes	
3	High Word of MilliSecondes	

The number of seconds given in the previous array (32 bit value set in word 0 and 1) is the number of seconds elapsed since 1994 January 1<sup>st</sup>.

Since the V4C version of the PX2X relays, the date can be chosen between a private format and the IEC format. It must choose the IEC format to obtain a correct event decoding. Moreover, a PX2X relay becomes unsynchronized after a 1min delay. As a result, choose a synchronization period less than 60 seconds.

## 4.4.1.3 Px4x series

PACiS GATEWAY doesn't manage Px4x series.

The Px4x manages the MICOM synchronization format. To maintain the Px4x synchronized, the C264 must sends synchronization frame at least once every 5 minutes. So, in SCE, the field "synchronization cycle (x10s)" must be less than 30.

It is now possible to use both Px2x and Px4x relays in MODBUS protocol on the same communication channel and to activate the synchronizing feature.

The register 4x00306 is used to configure the time format managed by the relay:

- Writing value '0' in this register selects the 'standard IEC' time format (default value).
- Writing value '1' in this register selects the 'reverse IEC' time format (Modbus MICOM time format used by the C264).

So, at connection of the Px4x, value "1" must be written in register @305 [4x00306] to tell the Px4x to manage Modbus MICOM time format.

If the 'Modbus MICOM format' is selected (see above), the time tag format in events is as described below:

Word No	Byte No	Data (Msb first)	Mask
0	0	Dummy byte (set to 0)	0x00
	1	Years	0x7F
1	2	Month	0x0F
	3	Day of week / Day of Month	0xE0, 0x1F
2	4	Summertime / Hours	0x80, 0x1F
	5	Validity / Minutes	0x80, 0x3F
3	6	Milli-seconds MSB	0xFF
	7	Milli-seconds LSB	0xFF

#### 4.4.2 Commands

Refer to generic Modbus §3.3.2 “Commands”.

Any control send from master to device is called Digital Outputs:

- Logical control: Digital Output of acknowledge Disturbance record; Digital Output of acknowledge dated event, Digital Output of specific protective function activation (or inhibition).
- Physical control: Digital Output of opening and closure of a feeder circuit breaker or specific Output.

To simplify Master MODBUS configuration and run time, it is desirable to gather controls (seen as Digital Outputs from upper stage) at consecutive addresses. PACiS GATEWAY doesn't gather controls.

Communication Digital Outputs or control are transmitted by Modbus writing functions: via Modbus function 5 (Writing of 1 bit), Modbus function 6 (Writing Word) or Modbus function 15 (writing N bits). If function 6 or 15 can be used on a device, the word of control must be organised in field of bits.

The Digital Output used to acknowledge reception of dated event, must always be accepted by the protection, even if it is in local parameter setting mode (no protection mode filtering on this particular Digital Output).

For single control on bits field, the feedback DI changes consecutive of control action is enough to control execution.

Not implemented for PACiS GATEWAY Modbus Master. Several devices on IED lead to define more elaborate control message sequence between a master and IED. The choice for control message is to keep Modbus acknowledgement rules.

An IED receiving a control query replies code 0 (OK) as far as function/address/data was correct.

If it's inner algorithm forbid it to initiate ordered sequence with physical Digital Output (because of interlock, locking, running control, invalid position...), IED transmits an “application” error code via event Digital Input (polled by master).

Master has to get into its configuration such Digital Input in order to determine if sequence is accepted, and if it runs correctly (for higher control algorithm or protocol conversion).

Not implemented for PACiS GATEWAY Modbus Master. The recommended choice to define a standard in control sequence messages is based on AFS solution on existing PD/PS/CF but “extended” to standard computer “application return code”.

When operating control is implemented on IED (OBS, Cx2x, P4xx) a lot of failure case are defined, and over several plant.

Minimal principle is to use for each controlled plant only one word (4 control bits set by master and reset by IED, and 12 main informative bits). Associate words can be defined for further automation indication.

Not implemented for PACiS GATEWAY Modbus Master. Switching device case need to be splitted between synchronised CB and disconnections:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
																0	0	0	Plant position MOTION
																0	0	1	Plant position OPEN
																0	1	0	Plant position CLOSE
																0	1	1	Error!
																1	0	0	Plant position INVALID (DBI00)
																1	1	1	Plant position INVALID (DBI11)
																1	0	1	Other INVALID (polarity...)
																1	1	0	Reserve other INVALID
																0/1			(opt)Plant in LOCAL/REMOTE
																0/1			(opt)Plant LOCKED (WITHDRAW)
			(opt) DI select in SBO																
			(Opt) Synchro-check OK																
			Control Fail Abnormal termination																
			Control Fail mismatch plant position																
			Control Fail Lock (pressure,...)																
			Control Fail Interlock																
			Control accepted Latch (any control)																
			OPEN control																
			CLOSE control																
			(opt) CLOSE2 control (Forced)																
			(opt) SELECT control																
Monitoring: Control Plant secondary DI Plant State																			
Control All Digital Outputs Latched by master, cell is reset at end of sequence by IED																			

Not implemented for PACiS GATEWAY Modbus Master. Transformer case with TPI position on other word:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0				
																0/1			Plant position MOTION / FIXE
																0/1			Mini CB OPEN/CLOSE
																1			Plant position INVALID
																0/1			(opt)AVRegulation ON/OFF
																			(opt)Plant LOCKED
																			Reserve
																			Low Tap Reach
																			High Tap Reach
																			Control Fail Abnormal termination
																			Control Fail Lock (oil,...)
			Control Fail Interlock (unusual)																
			Control accepted Latch (any control)																
			Tap RAISE control																
			Tap CLOSE control																
			(opt)Regulation ON Control																
			(opt) Regulation OFF Control																
Monitoring: Control Plant secondary DI Plant State																			
Control All Digital Outputs Latched by master, cell is reset at end of sequence by IED																			

Not implemented for PACiS GATEWAY Modbus Master. To broadcast Digital Outputs is asked for Load shedding or metering freezing/restart.



Not implemented for PACiS GATEWAY Modbus Master. Management of any measurement that can be frozen (Maintenance counter, metering, or classical measurement) leads to define several kind of control. The following “control structure” byte can used for each measurement:

7	6	5	4	3	2	1	0	
							0/1	AI Valid/Invalid
						0/1		AI not Frozen/Frozen
				X	X			Reserve Topical, saturated...
			1					Reserve
		1						Unitary reset
	1							Unitary reset & start
1								Unitary restart
								Unitary Freeze
Control				Monitoring				

Not implemented for PACiS GATEWAY Modbus Master. Any IED has kind of alarm management that deeply differs than the one used at system or SCADA level. Alarm is any indication given to an operator to advise of non standard condition, usually LED indications on IED (2 states ON/OFF), alarm list at upper level (with 4 states defined by STANDING/RESET, NOT\_ACK/ACKNOWLEDGE).

It is asked that IED alarms indication can be access in one address. A Digital Output can acknowledge/reset globally alarms (but one alarm is maintained if its condition is still present). It is expected in future product that each alarm could be individually reset. Cell words have a first byte of alarm indication, and a byte+8 for each alarm reset.

PACiS GATEWAY manage 2 kinds of CO and 1 kind of SP. SPC and DPC. In case of SPC, the address of point can address SPC. In case of DPC, the “Open” contact address of point can only address the “Open” contact of DPC and “Close” contact address of point can address the “Close” contact of DPC.

4.4.2.1 M300

PACiS GATEWAY doesn't manage M300.

There is one register of command in the M300 [@40047 (0x002F)]. This register can by set through Modbus function 6. Each bit of the register corresponds to a different command.

- Basic Address (Mapping Address): 0x002F
- Extra Address 1 (bit Number): Bit number to write
- Extra Address 2 (Modbus function): 6
- Extra Address 3 (Not Used): x

## 4.4.2.2 Px2x series

There are 3 registers of command in the Px2x [@0x0400, @0x0402, 0x0403]. This register can be set through Modbus function 5, 6 or 15. Each bit of the register corresponds to a different command.

@ Mot	@Bit	Usable Function	
0x0400	0x4000 → 0x400F	5, 6, 15	Remote control Word N° 1
0x0402	0x4020 → 0x402F	5, 6, 15	Remote control Word N° 2
0x0403	0x4030 → 0x403F	5, 6, 15	Remote control Word N° 3

Configuration using function 5 of the bit4 [Remote closing] of register 0x0400:

Basic Address (Mapping Address): 0x4003

Extra Address 1 (bit Number): X

Extra Address 2 (Modbus function): 5

Extra Address 3 (Not Used): X

Configuration using function 6 of the bit4 of register 0x0402:

Basic Address (Mapping Address): 0x0402

Extra Address 1 (bit Number): 4

Extra Address 2 (Modbus function): 6

Extra Address 3 (Not Used): X

Special commands used by the PACiS C264 computer:

@Bit	Comment
0x400C	Set to « 1 » in order to switch in manual acknowledgement mode for Event and Disturbance uploading
0x400D	Set to « 1 » in order to acknowledge the last Event
0x4032	Set to « 1 » in order to acknowledge the last uploaded Disturbance

## 4.4.2.3 Px4x series

PACiS GATEWAY doesn't manage Px4x series

There is no specific treatment done for commands towards Px4x.

## 4.4.3 Analogues Outputs

The analogue control or Analogue Output or Set point, or control reference is a value transmitted from master to device using Modbus function 6. They can be used to define reference (for physical output in regulation scheme, generator...) or to define a protection parameter (threshold...).

Note: Function 16 is only used for time synchronization.

The values to write must respect formats and units described for Analogues Inputs (IEEE signed 754, Integer / not signed on 1/2 Bytes) .PACiS GATEWAY doesn't manage units of AI.

When on an IED several values at consecutive addresses can be written, IED should support global write over this set of addresses.

#### 4.4.4 Setting of the Current relays

PACiS GATEWAY doesn't implement this function.

In order to parameterise the remote relays, one set of setting software is necessary.

Connection of the setting software by Modbus is made by rear connection (the commonly used by system in run time).

If possible, a front face connection is wished with the same software and same framing protocol for customer validation or after sale phase.

Use of setting software should match the following criteria:

- Interface with at least a DLL for Emission / Acceptance of messages developed by the supervisor system, in order to use the software with other link than serial port. Modbus message has to be encapsulated by system sub-station protocol to be used in system architecture.
- Possibility of inhibiting certain options of the menu (pooling, disturbance upload ...).
- Complete management of the function by the application (Timer on failure to reply, causes of failure...).
- Off line setting before download
- In run-time the Modbus master is the only master. The setting software should not disturb the standard polling of events and data.

IED is compliant to an MICOM global file downloading for specific setting group (or global).

### 4.5 Error management

Refer to generic Modbus §3.4 "Error management".

#### 4.5.1 Faults Records

Currently, PACiS GATEWAY doesn't implement this function.

The processing of Fault recommended record is the next:

- Creation of a map zone dedicated to description of Fault, at another address from Fault itself.
- Grouping information of Fault record by type of data.

Fault Record has always same Modbus address for a whole range of products. (Means same address for the last fault-n not Discharged). The best should be to have the same address for all MICOM product (e.g. 0x003E for none acknowledge FREC).

The access to Fault Record will be made by the functions of reading word (3/4).

FREC/MREC is no more translated by master in a set of Digital Inputs for events/alarms, maintenance historical graph since all FREC/MREC data are present in device mapping.

#### 4.5.2 Alarms

PACiS GATEWAY doesn't implement this function.

Most IED have LED indications that can be configured for alarms. In most case they are managed in two states way that differ greatly between IED or with system alarm management (5states).

An alarm is a standard event (time tagged change of state managed by event rules), that is memorised into the IED until acknowledgement, and which aim is to prevent operator (basically via LED).

There is 2 set of alarm:

- TRIP (open control send to breaker when a particular protective function is set).
- And ALARM (other information that operator should notice).

Each alarm/trip indication is managed by a bit in a set of consecutive cells (like Digital Inputs). Bit memorises that alarm condition has been set (even if condition is no more standing). A global Digital Output acknowledges 'Alarm/trip' is used to reset all alarm indications. If one alarm reason is still standing, the corresponding bit is not changed by IED, else it is reset (with event generation).

When at least one Alarm is set in alarm cells (single alarm appearance) , bit 7 of fast status byte is set. When at least one Trip function is set in trip cells, bit 6 of fast status byte is set. Each bit is reset when all alarm/trip appearance condition has disappeared and a global ACK alarm Digital Output is received.

A global ALARM/TRIP\_ACK\_DO is defined in mapping to reset bit. Later evolution of rules may include separate Digital Output for ALARM\_ACK and TRIP\_ACK. IED mapping should explicitly give the list of cells/bits showing alarm/trip information with effect on bit b6, b7.

Answer to global ALARM ACK DO or global TRIP ACK DO (if exist) to the master can never be BUSY (no applicative mechanism, only transport error code).

B6 and b7 are directly linked to LED on front face. The rule manages only 2 states for LED ON or OFF, and no third state is managed. State ON can be fix or blinking. Current mechanism is a global acknowledges AND erase of alarm list if alarm appearance condition has been reset.

#### 4.6 Limits and Performances

Refer to generic Modbus § 3.5 "Limits and Performances".

It is imperative that within the same link, equipment has an identical operation:

- Management of the events file (Format of the event / Address of the file / Address of acknowledge Digital Output).
- Management of Fault records (Format of Fault, Addresses basic of Fault, Address descriptive zone, Address of acknowledges Digital Output...).
- Digital Input, Digital Output, Analogue Input are grouped at identical basic addresses.
- Format of AI.
- Format of Status.
- Address range of the fundamental data.

In order to use information coming from MODBUS device in fast automation, or to answer SCADA inquires, or in alarm tagging, the following performances are desirable:

Operating time, answering time to the various requests < 20 ms.

Filtering at low level by address of the non-concerned inquires.

Respect of MODBUS protocol control (correct CRC, parity check, separate message silence of 3.5 char time, continuous flow in same message means silence limited to 1.5 char transmission time).

Speed of communication at least at 19200 bauds (38400 is usual).

When overbooked, device should answer BUSY (exception code 06) or at least not answer (it is said disconnected then reconnected).

Device should not answer with a delay greater than 20ms (response is no more correlated to good inquiry, other devices may answer another inquires...).

IED can ask to implement a FAR BUSY (code 05) to solve SRAM access problem. Master repeats inquire at N times its polling period. After 10 BUSY answers the device is disconnected. Not implemented in PACiS GATEWAY.

#### 4.7 Configuration

Refer to generic Modbus § 2.3 "Configuration".

---

## 5. SEPAM

### 5.1 Finality

SEPAM family of protections and metering units may be connected to a supervisor or any other device with a master modbus communication channel.

Changes of logic inputs are time-tagged and stored inside a queue. These data can be accessed by reading and acknowledging an event table.

PACiS C264 computer manages SEPAM S40 and S80.

PACiS GATEWAY manages SEPAM S20, S40 and S80.

MODBUS TCP/IP is only managed by the PACiS GATEWAY.

### 5.2 Interface

#### 5.2.1 Implemented function numbers

Refer to common considerations §2.2.4 “Implemented function”.

#### 5.2.2 Connection polling management

Refer to generic MODBUS §3.1.2 “Connection polling management”

The “connection check frame” shall be the “Echo” frame request (function 08).

#### 5.2.3 Polling

Refer to generic MODBUS §3.1.3 “Regular polling and disconnection management”

The Digital Input management for IED SEPAM S20/S40/S80 is a Digital Input pooling and an event management.

Three polling modes have to be managed: ‘GI’, ‘IED synchronized’ and ‘IED not synchronized’:

- The synchronization status of the IED, along with the presence of events is obtained by mean of reading the IED “check word”.
- The ‘General Interrogation’ is done at the end of initialization (event queue used shall be emptied), for the disappearance of data loss signal. Then, it executes a polling of the whole Digital Inputs.
- PACiS GATEWAY systematically discards queued events on IED connection. At connection the PACiS GATEWAY master protocol will reset the SEPAM IED event queue before doing the GI polling request.
- When IED is not synchronous, event management is not used. The Digital Inputs are updated by a polling of IED database. Digital Inputs are read and decoded group by group.
- When IED is synchronous, event management is used. Presence of events is checked by reading the “check word”. The Digital Input are updated when event is decoded.

SEPAM and Event table management availability for PACiS C264 and GATEWAY:

	Available tables	Check Word @	Check Word bits	Check Word read function	Exchange word @	PACiS C264 computer	PACiS GATEWAY
S80	Evts Table 1	000Ch	8-15	7	0040h	Yes	Yes
	Evts Table 2	000Ch	0-7	3	0070h	No	Yes
S40	Evts Table 1	0100h	8-15	7	0040h	Yes	Yes
	Evts Table 2	0100h	8-15	7	0070h	No	Yes
S20	Evts Table 1	0100h	8-15	7	0040h	No	Yes

NOTES: The exchange word includes two fields:

- The exchange number.
- The exchange number contains a numbering byte which identifies each exchange.

The exchange number is initialized to zero when SEPAM IED is energized. When it reaches its maximum value (FFh), it automatically returns to 0. SEPAM IED numbers each exchange and the master shall acknowledge the exchange on the base of the exchange number for the event to be suppressed from the event list.

5.2.4 Disturbance files

Disturbance files upload is not managed by PACiS MODBUS master SEPAM.

5.3 Data sent to IEDs

5.3.1 Time synchronization

Refer to Common Considerations §2.2.3 “Time synchronization”

The type of synchronisation is ‘**SEPAM synchronization**’.

Date and time conform to the SEPAM (Merlin Gerin) documentation (SEPAM1000+S20, SEPAM1000+S40, PM500, PM650, SEPAM2000 ...) [Day/month/Year Hour.Min:Ms] [14/5/38 6.43:16785] for the 38th year since 1970 (ie. 2008), the 14<sup>th</sup> May at 6 hours 43 minutes and 16785 milliseconds:

IEC: time coding format using four words as per IEC 60870-5-4:

Words	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	reserved								Year (0 to 99)							
2	0	0	0	0	month (1 to 12)				0	0	0	day (1 to 31)				
3	0	0	0	hour (0 to 23)				minutes (0 to 59)								
4	millisecond (0 to 59999)															

Address for synchronization is 0x0002.

5.3.2 Commands

Refer to generic Modbus §3.3.2 “Commands”.

5.4 Error management

Refer to generic Modbus §3.4 “Error management”.

5.5 Limits and Performances

Refer to generic Modbus § 3.5 “Limits and Performances”.

The Rish M01 IED do not manage TUNNELING and DISTURBANCE.

## 5.6 Configuration

Refer to generic Modbus § 2.3 “Configuration”.

- ‘IED type’ is SEPAM.
- ‘Synchronization type’ is SEPAM.

## 6. M230

### 6.1 Finality

The aim is to manage the M230 equipments which are central measurement and analysis of energy.

The M230 MODBUS is not supported by the PACiS GATEWAY.

### 6.2 Interface

#### 6.2.1 Implemented function numbers

Refer to common considerations §2.2.4 “Implemented function”.

#### 6.2.2 Connection polling management

Refer to generic MODBUS §3.1.2 “Connection polling management”

To test IED communication, **code 4, address 1, length 3** can be used.

#### 6.2.3 Polling

Refer to generic MODBUS §3.1.3 “Regular polling and disconnection management”

### 6.3 Data received from IEDs

#### 6.3.1 Analogue Inputs

Refer to generic MODBUS §3.2.1 “Analogue Inputs”

Analogue Inputs are regularly polled.

6 new formats of Analogue Inputs are supported by the C26x and can be set through configuration: The standard formats are always available.

M230_T5_TYPE	Formats for M230 equipment. See M230 documentation for more information (ref “Centrale de Mesure Communicante de Type M230”)
M230_T6_TYPE	
M230_T7_TYPE	
ION_MODULUS_10000_UNSIGNED	Formats for ION Modulus equipment. See ION documentation for more information (ref “ION 7300 Series Meter”).
ION_MODULUS_10000_SIGNED	
KITZ202_K8	Formats for equipments under KITZ202. See KITZ202 documentation for more information.

#### 6.3.2 Digital Inputs

Refer to Generic Modbus §3.2.2 “Digital Inputs”.

The M230 does not manage Digital Inputs.

#### 6.3.3 Disturbance files

The M230 does not manage the disturbance files.

### 6.4 Data sent to IEDs

#### 6.4.1 Time synchronization

The M230 is not synchronized using Modbus.

Parameter: ‘None synchronization’ is to be used.

Setting software: IDSP application can’t be use to set Date and Time, only front panel is useable



#### 6.4.2 Commands

Refer to generic Modbus §3.3.2 “Commands”.

The M230 does not manage commands.

#### 6.5 Error management

Refer to generic Modbus §3.4 “Error management”.

#### 6.6 Limits and Performances

Refer to generic Modbus § 3.5 “Limits and Performances”.

The M230 can be setted using PACiS C264 computer Tunnelling mode. IDSP application M230 setting software can be used through tunnelling mode to set or reads data.

#### 6.7 Configuration

Refer to generic Modbus § 2.3 “Configuration”.

‘IED type’ (in MODBUS acq type field) is M230.

MV ‘Data format’ shall be selected for each MV where M230 specific formats are made available see §6.3.1 “Analogue Inputs”.

## 7. RISHABH

### 7.1 Finality

This chapter gives some information about Modbus communication between a PACiS C264 computer and a RISH ducer M01 (Rish Pro M01 ). The IED Mxx series of multi-transducers simultaneously measure several variables of an electric power system. They are built by Rishabh.

Rishabh Rish M01 is not supported by the PACiS GATEWAY.

### 7.2 Interface

#### 7.2.1 Implemented function numbers

Refer to common considerations §2.2.4 “Implemented function”.

#### 7.2.2 Connection polling management

Refer to generic MODBUS §3.1.2 “Connection polling management”

##### Initialization sequence

To establish the communication with the transducer, the following initialization sequence must be done (only once):

- Read registers 202,221,222
- Read registers 300 to 392

This initialization sequence is done:

- At start-up of the C264 (first connection of the IED)
- After each disconnection (i.e. loss of communication or communication error with the IED)

##### Time delay before polling BI and MV

After initialization sequence, a time delay [~ 1.2 seconds] must be waited before sending any frame to the IED. This lets time to the IED for its initialization. After this time delay expiration, BI and MV polling is done. This time delay is managed after each initialization sequence.

##### Management of Modbus exception

In case of trouble, the IED sends Modbus exception 'Busy'. In this case, the C264 has to consider the IED disconnected (that will force the initialization sequence to be redone) **but without setting IED information to unknown.**

These functioning are hard-coded in the C264, nothing is configurable regarding them. They are activated only for IED of type "Rish Pro M01", which is said by configuration.

#### 7.2.3 Polling

Refer to generic MODBUS §3.1.3 “Regular polling and disconnection management”

The action table manages a temporization to delay the beginning of Digital Inputs and Analogue Inputs polling after the end of Rish Pro M01 initialization.

The MODBUS layer 2 can send a synchronous frame during the initialization phase. Depending on the function and the read use in this frame, the RISH PRO M01 answer with a correct frame or an exception frame but without invalidating the initialization.

### 7.3 Data received from IEDs

#### 7.3.1 Analogue Inputs

Refer to generic MODBUS §3.2.1 “Analogue Inputs”

#### 7.3.2 Digital Inputs

Refer to Generic Modbus §3.2.2 “Digital Inputs”.

#### 7.3.3 Disturbance files

The Rish Pro M01 does not manage the disturbance files.

### 7.4 Data sent to IEDs

#### 7.4.1 Time synchronization

The Rish Pro M01 is not synchronized using Modbus.

Parameter: ‘None synchronization’ is to be used.

#### 7.4.2 Commands

Refer to generic Modbus §3.3.2 “Commands”.

The Rish Pro M01 does not manage commands.

### 7.5 Error management

Refer to generic Modbus §3.4 “Error management”.

The RISH PRO M01 has no register to read status value and the modbus function code 07h is not supported. So exception codes sent by the Rish Pro M01 are the only means to detect problems.

Rish Pro M01 generates following error codes:

Error code	Meaning
01h	Use of an unsupported function code.
02h	Uses of an invalid memory register address: Use of invalid register number or attempt to write to a memory protected register.
03h	Use of invalid data, i.e. an invalid number of registers.
06h	Device is busy. This code signals that the transducer is occupied with functions performed via the local RS232 interface. These may be: changing configuration, simulation or calibration of analog outputs.
0Ah	Possible change of rated values. The device configuration has been modified since the last request for measurands or this is the first request for measurands since transducer was switched-on. You have to read the table of measurands to be evaluated and the scaling factors table.

Error code 06h and 0Ah are treated as a disconnection of the IED and a new initialization phase must be completed before data read of the RISH PRO M01.

Other code can be treated as Modicon working.

Only error from initialization sequence or polling of Digital Inputs and Analogue Inputs return an error code.

In case of trouble, the RISH PRO M01 sends Modbus exception 'Busy'. The C264 has to consider the IED disconnected (that will force the initialization sequence to be redone) **but without setting IED information to unknown.**

**7.6 Limits and Performances**

Refer to generic Modbus § 3.5 “Limits and Performances”.

The Rish M01 IED do not manage TUNNELING and DISTURBANCE.

**7.7 Configuration**

Refer to generic Modbus § 2.3 “Configuration”.

‘IED type’ (in MODBUS acq type field) is "Rish Pro M01".

## 8. ABB FLEXGATE MODBUS COMMUNICATION

### 8.1 Finality

The Flexgate is a universal protocol converter of ABB's Protection and Control IED's with SPA protocol, into an ABB system.

Flexgate MODBUS is not supported by the PACiS GATEWAY.

### 8.2 Interface

#### 8.2.1 Implemented function numbers

Refer to common considerations §2.2.4 "Implemented function".

#### 8.2.2 Connection polling management

Refer to generic MODBUS §3.1.2 "Connection polling management"

At C264 starting, a polling request is sent to determinate the IED status (function 7). If there is a response from the IED, the Flexgate IED is considered connected.

#### 8.2.3 Polling

Refer to generic MODBUS §3.1.3 "Regular polling and disconnection management"

Analogue Inputs polling is the same than generic Modbus.

Digital Inputs polling don't exist: a Digital Input change is signalled by an event.

The c264 realize a polling on fields bits which named 'Internal status bits'. It polls the modbus address 18993 to 19000 with function 2.

Include in the polling (18993 to 19000), the field 'Events pending bit' is at modbus address 18993 and indicates if a new event is present or not.

Include in the polling (18993 to 19000), the field 'time is not send from Modbus master within last 16 minutes' is at modbus address 18994 and indicates if the Flexgate IED is synchronized with c264

Include in the polling (18993 to 19000), the field 'time is not synchronized by minute pulse within last 1.5 minutes' is at modbus address 18995 and **not used**.

### 8.3 Data received from IEDs

#### 8.3.1 Analogue Inputs

Refer to generic MODBUS §3.2.1 "Analogue Inputs"

#### 8.3.2 Digital Inputs

Refer to Generic Modbus §3.2.2 "Digital Inputs".

The c264 realize a polling on fields bits which named 'Internal status bits'. It polls the modbus address 18993 to 19000 with function 2.

Except at start (or restart or error management), there isn't Digital Input polling.

If an event is received (flag at modbus address 18993), c264 reads the events queue.

To read the events, c264 realize an alternative reading between addresses 39001 and 39011, which allows reading next event.

If c264 reads the same address – without any other request in between – it gives the same event.

The Flexgate send a response written on six words. For detail of these fields, see "FLEXGATE Protocol Converter (1KEL614903-06).pdf".

C264 continues to read the event file until there is no new event. Then, it polls the flags bits named 'Internal status bits'.

In the event response, the sequence number is between 1 and 65535.

In the event response, the sequence number 0 is reserved to indicates that's no more events.

In the event response, the sequence number 1 is reserved when the converter (Flexgate) has been reinitialized

In the event response, the event number 50 is reserved to indicates the reinitialization of the converter (Flexgate).

In the event response, the event number 51 is reserved to indicates an overflow events buffer. The event buffer size is 200. The Flexgate system not allowed new events added until the event 51 is reading. At this moment, the c264 considers that one or more event were lost. In this case, the C264 does again a General Interrogation, and the cycle continues from internal status bits polling.

If an error occurred for sequence number (not consecutive number), it consider that an event was lost. In this case, the C264 does again a General Interrogation. And the cycle continues from internal status bits polling.

### 8.3.3 Disturbance files

Disturbance files are not treated in ABB Flexgate.

## 8.4 Data sent to IEDs

### 8.4.1 Time synchronization

The type of synchronisation is '**Flexgate**':

Date and Time are sent in one request with function 16 at modbus addresses 49001...49007 (2328h to 232Eh).

The following format is used to write the date: [year/month/day/hour/minutes/milliseconds since midnight] with two words by information except for milliseconds which use four words.

C264 sends periodically the date to synchronize the Flexgate IED. The time must be send with a period smaller than 16 minutes.

C264 synchronization request isn't send in broadcast but with the specific address of equipment.

### 8.4.2 Commands

Refer to generic Modbus §3.3.2 "Commands".

## 8.5 Error management

Refer to generic Modbus §3.4 "Error management".

Specific exception code meaning:

Exception code	Meaning	Processing performed by the master
03	Illegal data value	Send a "Configuration error" message to the application and continue

Code exception 03 is also used by ABB IED equipment to indicate a hardware malfunction as an interlock condition not ok on a protective relay.

## 8.6 Limits and Performances

Refer to generic Modbus § 3.5 “Limits and Performances”.

Only one “ABB Flexgate” IED can be configured on a master MiCOM C264 computer (this limitation because synchronization message isn't sends in broadcast but with the specific address of IED).

## 8.7 Configuration

Refer to generic Modbus § 2.3 “Configuration”.

'IED type' (in MODBUS acq type field) is ABB Flexgate.

'Synchronization' in Modbus/Acquisition field is 'Flexgate'.

For 'Digital Input' simple and double, the field 'event – slave number' corresponds to equipment number on the sub-network behind the Flexgate.

For 'Digital Input' simple and double, the field 'event – channel number' corresponds to the channel communication number of the equipment number on the sub-network behind the Flexgate.

For 'Digital Input' simple, the field 'event – event number 'Change 0 to 1' corresponds to the event number to indicate a DI state change from 0 to 1

For 'Digital Input' simple, the field 'event – event number 'Change 1 to 0' corresponds to the event number to indicate a DI state change from 1 to 0

For 'Digital Input' double, the field 'event – event number 'Open (10)' corresponds to the event number to an Open State.

For 'Digital Input' double, the field 'event – event number 'Close (01)' corresponds to the event number to a Close State.

For 'Digital Input' double, the field 'event – event number 'Start Moving (00)' corresponds to the event number to indicate a transient State

For 'Digital Input' double, the field 'event – event number 'Get error status (11)' corresponds to the event number to indicate an error state.

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