PacT Series

Vigi**PacT** RHU and RHUs Monitoring and Protection Relay

User Guide

PacT Series offers world-class breakers and switches.

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Table of Contents

Safety Information 5
About the Book 6
Introduction 7
- Introduction to VigiPacT RHU and RHUs Relays 8
- Functional Description 10
- Technical Characteristics 11
- Integration of VigiPacT RHU Relay in Communication Architecture 13

Operation 14
- Introduction to HMI 15
  - HMI Menu Structure 16
  - HMI Description and Navigation Principles 18
  - Parameter Modification 19
- Description of Screens 20
  - Metering Menu (1/7) 21
  - Test Menu (2/7) 22
  - Settings Menu (3/7) 24
  - Communication Menu (4/7): for VigiPacT RHU Relay 27
  - Product Information (5/7) 28
  - Factory Reset (6/7) 29
  - Password Management (7/7) 31

Modbus Communication for VigiPacT RHU Relay 33
- Modbus Client-Server Principle 34
- Modbus Functions 37
- Modbus Exception Codes 38
- Modbus Registers Tables 40
- VigiPacT Registers 42
- Channel Summary Registers 44
- Channel Detailed Registers 47

Troubleshooting 48

Safety Information

Important Information

Read these instructions carefully, and look at the equipment to become familiar with the device before trying to install, operate, service, or maintain it. The following special messages may appear throughout this documentation or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.

The addition of this symbol to a “Danger” or “Warning” safety label indicates that an electrical hazard exists which will result in personal injury if the instructions are not followed.

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

⚠ DANGER

DANGER indicates a hazardous situation which, if not avoided, **will result in** death or serious injury.

⚠ WARNING

WARNING indicates a hazardous situation which, if not avoided, **could result in** death or serious injury.

⚠ CAUTION

CAUTION indicates a hazardous situation which, if not avoided, **could result** in minor or moderate injury.

NOTICE

NOTICE is used to address practices not related to physical injury.

Please Note

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

A qualified person is one who has skills and knowledge related to the construction and operation of electrical equipment and its installation, and has received safety training to recognize and avoid the hazards involved.

About the Book

Document Scope

The aim of this guide is to provide users, installers, and maintenance personnel with the technical information needed to operate the VigiPacT RHU/RHUs relays in compliance with the IEC standards.

Validity Note

This document is valid for:

- VigiPacT RHU/RHUs relays and VigiPacT toroids.
- Vigirex RHU/RHUs relays and Vigirex toroids.

NOTE: VigiPacT RHU/RHUs is the new name of Vigirex RHU/RHUs relays.

Online Information

The information contained in this guide is likely to be updated at any time. Schneider Electric strongly recommends that you have the most recent and up-to-date version available on www.se.com/ww/en/download.

The technical characteristics of the devices described in this guide also appear online. To access the information online, go to the Schneider Electric home page at www.se.com.

Related Documents

Title of Documentation	Reference Number
VigiPacT RHU/RHUs Residual-Current Relay with Separate Toroid – Instruction Sheet	NHA34634

You can download these technical publications and other technical information from our website at https://www.se.com/en/download.

Introduction

What's in This Part

Introduction to VigiPacT RHU and RHUs Relays 8
Functional Description 10
Technical Characteristics 11
Integration of VigiPacT RHU Relay in Communication Architecture 13

Introduction to VigiPacT RHU and RHUs Relays

PacT Series Master Range

Future-proof your installation with Schneider Electric's low-voltage and medium-voltage PacT Series. Built on legendary Schneider Electric innovation, the PacT Series comprises world-class circuit breakers, switches, residual current devices and fuses, for all standard and specific applications. Experience robust performance with PacT Series within the EcoStruxure-ready switchgear, from 16 to 6300 A in low-voltage and up to 40.5 kV in medium-voltage.

Overview

VigiPacT is a complete range providing earth-fault protection for all types of AC installations, including power distribution, sub-distribution, and industrial control systems. VigiPacT devices operate on TT, TNS, and IT systems for protection of persons against direct contact. For IT system, the VigiPacT devices operate only where the loop impedance is high.

The relays are type A and type AC as defined by the standard IEC/EN 60947-2 (annex M).

The VigiPacT RHU/RHUs relay installed on the front of switchboards and panels provides valuable assistance in the maintenance of electrical installations.

VigiPacT RHU/RHUs relay perform the following functions:

- Monitors the earth-leakage current.
- Helps to identify the insulation faults before they become hazardous for life and property.
- Helps to protect the motors, the earthing conductors, and the property against fire hazard.
- Helps to protect the people against indirect contact and provides complementary protection against direct contact.

Standards

The VigiPacT RHU/RHUs relays are designed to comply with the following standards:

Standards	Description
IEC/EN 60755	General rules for residual-current protection devices.
IEC/EN 60947-2 (annex M)	Low-voltage switchgear and controlgear, part 2 (circuit breakers).
IEC/EN 60947-5-1	Low-voltage switchgear and controlgear, part 5-1(electromechanical devices).
IEC/EN 61000-4-2	Electrostatic-discharge immunity test.
IEC/EN 61000-4-3	Radiated, radio-frequency, electromagnetic-field immunity test.
IEC/EN 61000-4-4	Electrical fast transient/burst immunity test.
IEC/EN 61000-4-5	Surge immunity test.
IEC/EN 61000-4-6	Immunity to conducted disturbances, induced by radiofrequency fields.
CISPR 11	Limits and methods of measurement of electromagnetic disturbance characteristics of industrial, scientific and medical (ISM) radio frequency equipment.
EN 61000-6-2	Immunity to industrial environments.
EN 50081-1	Emissions for commercial and residential environments.
IEC/EN 60664-1	Insulation coordination for equipment within low-voltage systems, part 1.

Standards	Description
EN 50102	Degrees of protection provided by electrical enclosures against external mechanical impact.
IEC 60364 and NF C 15100	Installation rules for low-voltage electrical distribution.

VigiPacT RHU/RHUs relay is compliant with the standard IEC 60947-2 (Annex M). For achieving this standard, it has passed test sequence MI to MIV. The VigiPacT range also has a CB scheme certificate.

Functional Description

Overview

The earth-fault protection consists of measuring the earth-leakage current in an electrical installation, and disconnecting the installation when the current becomes hazardous to life and property.

Functions

The VigiPacT RHU/RHUs relay is used together with a VigiPacT toroid (open or closed) or a rectangular sensor.

- Measures the earth-leakage current detected by the toroid.
- Displays the earth-leakage current.
- Trips the installation protection circuit breaker through an MN or MX release if the earth-leakage current exceeds the threshold IΔN for a time greater than the delay Δt.
- Implements two earth-leakage current thresholds, one corresponding to a pre-alarm and an other to an alarm.
- Communicates via the Modbus communication serial line (only for VigiPacT RHU relay).

Alarm Detection

The alarm threshold I alarm corresponds to an earth-leakage current that is hazardous for the installation.

An alarm is active when the measured earth-leakage current is greater than the set alarm threshold (I alarm) on toroid for a period of time greater than the set alarm delay (t alarm in milliseconds or seconds).

- When an alarm is active, the **ALARM** and **PRE-AL** LEDs are switched on.
- When alarm is detected, the **Metering** screen is displayed, and the earth-leakage current value blinks.

Pre-alarm Detection

The pre-alarm threshold I pre-alarm correspond to an earth-leakage level that must be eliminated before it becomes hazardous for the installation.

A pre-alarm is active when the measured earth-leakage current is greater than the set pre-alarm threshold for a period of time greater than the set pre-alarm trip delay (t pre-alarm in milliseconds or seconds).

- When a pre-alarm is active, the **PRE-AL** LED is switched on.
- When pre-alarm is detected, the **Metering** screen is displayed and the earth-leakage current value blinks.

Technical Characteristics

Monitored Systems

Characteristic	Value
Low-voltage AC – System voltage	50/60/400 Hz ≤ 1000 V
System earthing arrangements	TT, TNS, IT(1)
(1) Case where the loop impedance is high.	

Electrical Characteristics

Characteristic		Value
Supply voltage		110-130 Vac, 220-240 Vac, -15% / +10%
Maximum consumption		8 VA
Operating temperature		-25 °C / +55 °C
Storage temperature		-40 °C / +85 °C
Current measurement	Measurement range	from 20% to 200% of IΔn(1)
	Measurement accuracy for IΔn	± 7%
	Display refresh time	0.4 s
Alarm	Threshold I alarm (IΔn)	Adjustable threshold from 0.03 A to 1 A in 0.001 A step, from 1 A to 30 A in 0.1 A step.
	Accuracy	+0 / +10%
	Time delay t alarm (Δt)	Instantaneous for IΔn = 0.03 A. For other ranges adjustable time delay from 60 ms to 4.5 s in 10 ms steps.
	Settings	Keypad or Modbus communication
	Output contact	Changeover type with latching
Pre-alarm	Threshold I pre-alarm	Adjustable threshold from 0.015 A to 1 A in 0.001 A step, from 1 A to 30 A in 0.1 A step.
	Accuracy	+0 / +10%
	Time delay t pre-alarm	Adjustable time delay from instantaneous to 4.5 s in steps of 10 ms.
	Settings	Keypad or Modbus communication.
	Output contact	NO type without latching
Test: with or without alarm activation	VigiPacT RHU/RHUs relay	Local, remote or Modbus communication (only for VigiPacT RHU relay).
	Toroid-relay connection	Continuous
(1) If earth-leakage current < 20% of IΔn, display = 0. If earth-leakage current > 200% of IΔn, display = SAT		

Output Contact Characteristics as Defined by IEC 60947-5-1

Characteristic		Value					
Rated thermal current (A)		8					
Minimum load		10 mA at 12 V					
Utilization category		AC				DC	
		AC12	AC13	AC14	AC15	DC12	DC13
Rated operational current (A)	24 V	6	6	5	5	6	2
	48 V	6	6	5	5	2	-
	110-130 V	6	6	4	4	0.6	-
	220-240 V	6	6	4	4	-	-
	250 V	-	-	-	-	0.4	-
	380-415 V	5	-	-	-	-	-
	440 V	-	-	-	-	-	-
	660-690 V	-	-	-	-	-	-

Mechanical Characteristics

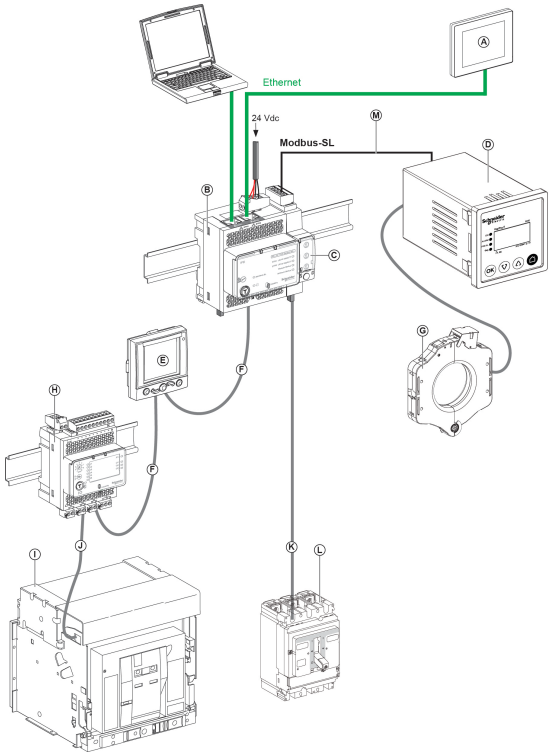
Characteristic		Value
Front-panel mount dimensions		72 x 72 mm
Weight		0.3 kg
Degree of protection IEC 60529	Front face	IP40
	Other faces	IP30
	Connections	IP20
Front face impact resistance (EN50102)		IK07 (2 joules)
Vibrations (Sinus Lloyd's and Veritas)		2 to 13.2 Hz ± 1 mm and 13.2 to 100 Hz - 0.7 g

Environmental Characteristics

Characteristic		Value
Damp heat, equipment not in service (IEC 60068-2-30)		28 cycles +25 °C / +55 °C / HR 95%
Damp heat, equipment in service (IEC 60068-2-56)		48 hours, environment category C2
Salt mist (IEC 60068-2-52)		KB test, severity 2
Degree of pollution (IEC 60664-1)		3
Electromagnetic compatibility for both relay and toroid:	electrostatic discharges (IEC 61000-4-2)	Level 4
	radiated susceptibility (IEC 61000-4-3)	Level 3
	low-energy conducted susceptibility (IEC 61000-4-4)	Level 4
	high-energy conducted susceptibility (IEC 61000-4-5)	Level 4
	radio-frequency interference (IEC 61000-4-6)	Level 3
	conducted and radiated emissions (CISPR11)	Class B

Integration of VigiPacT RHU Relay in Communication Architecture

Communication Architecture



A	FDM128 Ethernet display for eight devices
B	IFE Ethernet switchboard server
C	IFM Modbus-SL interface for one circuit breaker
D	VigiPacT RHU monitoring and protection relay
E	FDM121 ULP display for one circuit breaker
F	RJ45 male/male ULP cord
G	VigiPacT toroid
H	IO input/output application module for one circuit breaker
I	MasterPact NW circuit breaker
J	Circuit breaker BCP ULP cord
K	NSX cord
L	ComPacT NSX circuit breaker
M	Cable for Modbus SL-1x RJ45 and 1x Free wires

Operation

What's in This Part

Introduction to HMI 15
Description of Screens 20

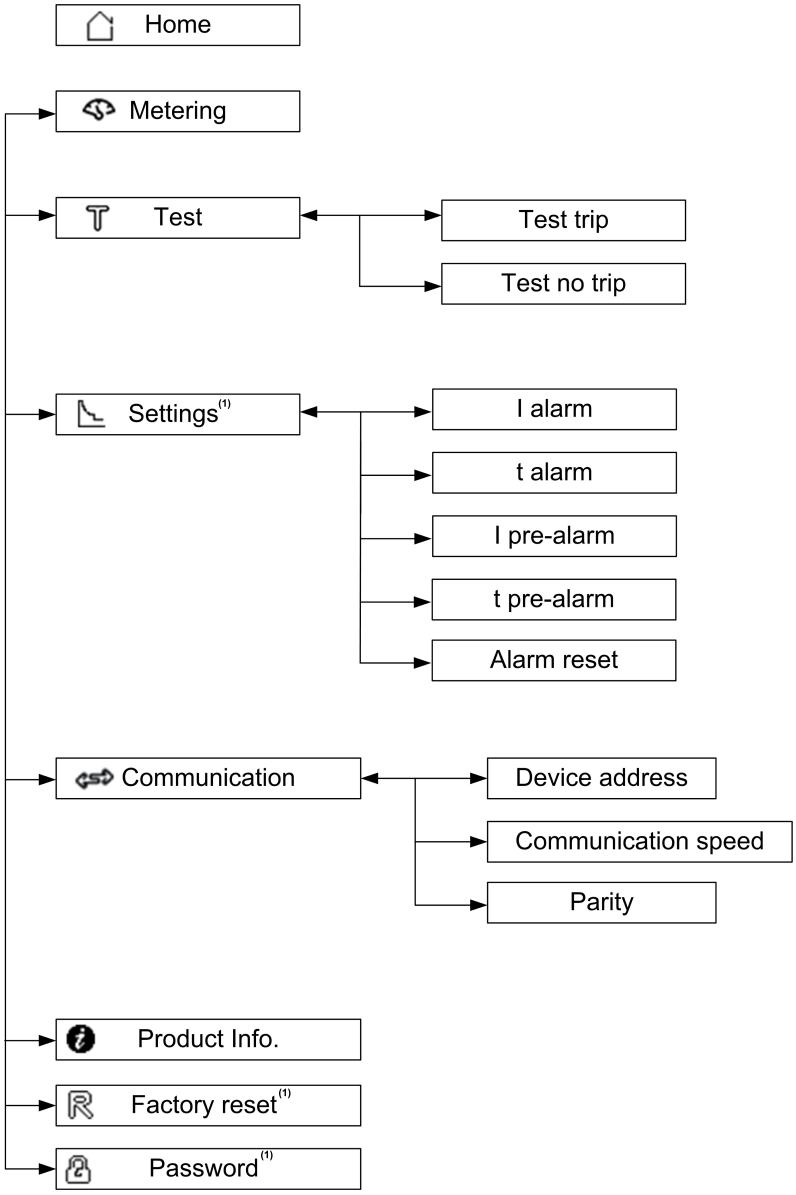
Introduction to HMI

What's in This Chapter

HMI Menu Structure 16
HMI Description and Navigation Principles 18
Parameter Modification 19

HMI Menu Structure

Overview



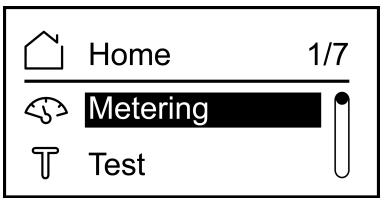
(1) Modification in the menu item is protected by a password.

Home Menu

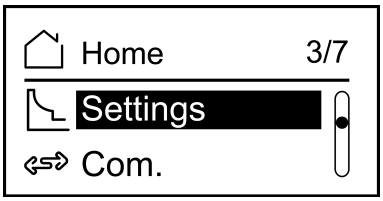
The **Home** screen displays the list of menu items.

- Metering
- Test
- Settings
- Communication
- Product information
- Factory reset
- Password

Example of Metering Menu

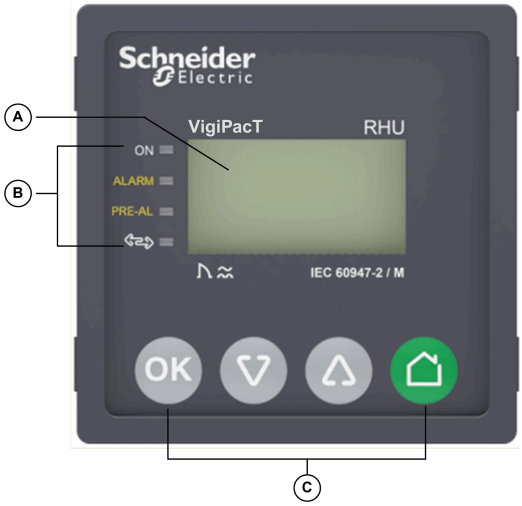


Example of Settings Menu



HMI Description and Navigation Principles

Overview



Legend	Description	Function
A	LCD screen	Displays the parameter settings and the measurement values.
B	Status LEDs	Indicates power on, status of alarm, pre-alarm, and communication (only for VigiPacT RHU relay).
C	Navigation buttons	Allows to navigate.

Status LED

Status LED	Color	Description
ON	Green	Is switched on when the VigiPacT relay is powered.
ALARM	Red	Is switched on when an alarm is active.
PRE-AL	Orange	Is switched on when a pre-alarm is active.
	Green	Blinks when the VigiPacT relay detects or sends a Modbus frame (only for VigiPacT RHU relay).

Navigation Buttons

Button	Icon	Function
Validation		Allows to: • modify parameter. • select an item. • validate current setting. • start test mode. • exit test mode at the end of the test.
Down		• Allows to move to: ◦ next screen. ◦ next menu item. • Allows to decrease the numerical value while setting the parameters.
Up		• Allows to move to: ◦ previous screen. ◦ previous menu item. • Allows to increase the numerical value while setting the parameters.
Home		Allows to access the Home menu.

Parameter Modification

Overview

To modify the value of a parameter, follow either of the methods described below:

- Select a value in a list.
- Modify a numerical value, digit by digit.

Selecting a Value in a List

To select a value, use the menu buttons as described below:

Icons	Description
	Allows to scroll up to select the desired value.
	Allows to scroll down to select the desired value.
	Allows to save the selected parameter value.
	Allows to exit the current value selection.

Modifying a Numerical Value

The numerical value of a parameter is made up of digits from 0 to 9.

To modify the numerical value, use the menu buttons as described below:

Icons	Description
	Allows to increase the numerical value.
	Allows to decrease the numerical value.
	Allows to: • confirm the new parameter value and to move to the next digit. • save the parameter once the last digit is set.
	Allows to exit the current parameter entry.

NOTE: After entering the value if no button is pressed for 10 seconds then the parameter modification is cancelled. The current screen remains unchanged.

Pressing Multiple Buttons

If multiple buttons are pressed simultaneously, no action is performed and the pressed buttons are ignored except for the password reset function (refer to Password Management (7/7), page 31). Release the pressed buttons to press another button.

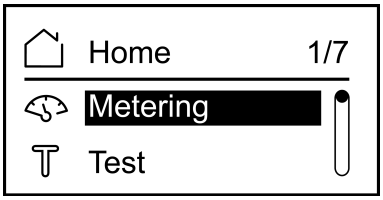
Description of Screens

What's in This Chapter

Metering Menu (1/7) 21
Test Menu (2/7) 22
Settings Menu (3/7) 24
Communication Menu (4/7): for VigiPacT RHU Relay 27
Product Information (5/7) 28
Factory Reset (6/7) 29
Password Management (7/7) 31

Metering Menu (1/7)

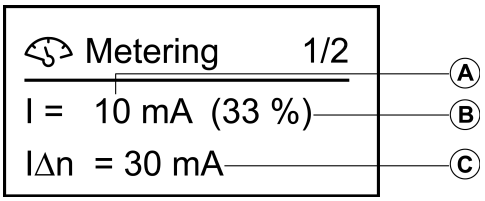
Overview



The **Metering** menu displays **Metering** and **Maximum** screens.

Metering Screen

The **Metering** screen displays the measured earth-leakage current (**I**) and the threshold current (**IΔn**). It also displays the earth-leakage current (**I**) metering in percentage with respect to the alarm threshold.



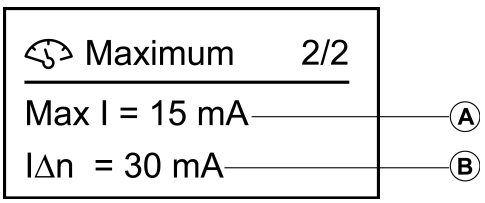
A Measured earth-leakage current in mA from 10 mA to 999 mA (1 A to 60 A).

B Measured earth-leakage current as percentage of alarm threshold value.

C Display alarm threshold value in mA from 30 mA to 999 mA (1 A to 30 A).

Maximum Screen

The **Maximum** screen displays the maximum earth-leakage current detected by the device after the device is on.



A Maximum measured earth-leakage current from 10 mA to 999 mA (1 A to 60 A).

B Display alarm threshold value from 30 mA to 999 mA (1 A to 30 A).

Resetting the Maximum Measured Earth-Leakage Current

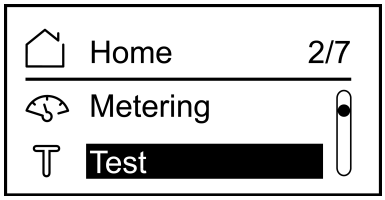
To reset the maximum measured earth-leakage current in the **Maximum** screen, press OK for 10 seconds and then release the button.

NOTE:

- After OK is pressed for 5 seconds, the display starts blinking. If it is released after 5 seconds, the reset is cancelled.
- The maximum measured earth-leakage current can be reset only in the **Maximum** screen.

Test Menu (2/7)

Overview



The **Test** menu allows to test multiple functions of the VigiPacT RHU/RHUs relay:

- The display lights up for a few seconds.
- The indicators light up for a few seconds.
- Channel measurement.

The two types of tests that can be performed are:

- **Test trip**: It is a complete test with action on the pre-alarm and alarm outputs.
- **Test no trip**: It is a test with no action on the pre-alarm and alarm outputs.

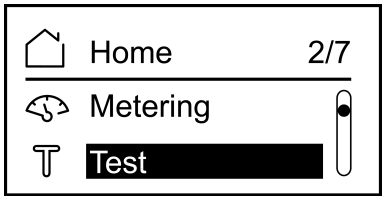
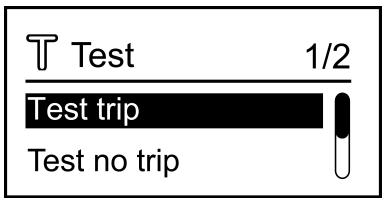
A self-test can be performed:

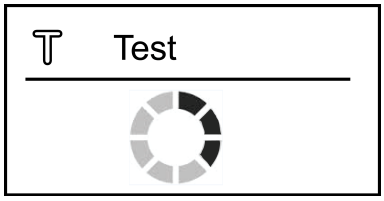
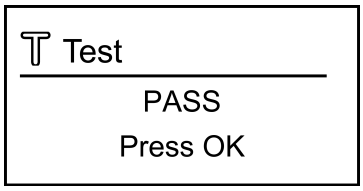
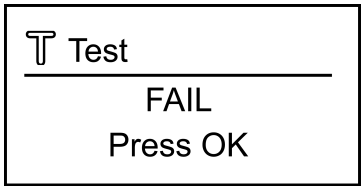
- Through **Test** menu on HMI.
- Remotely through the Modbus network (only with VigiPacT RHU relay).
- Remotely through output connectors (pins 25, 26).

NOTE: A self-test cannot be performed when:

- resetting the maximum current value.
- an alarm relay is active.

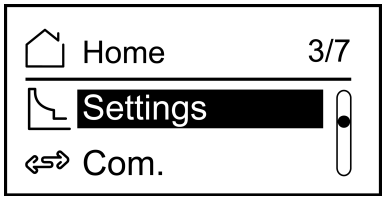
Testing Procedure

Step	Action
1	Navigate to the **Test** menu and press OK. 
2	Select the required test sequence. 

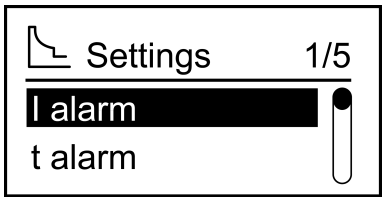
Step	Action
3	Press OK to launch the selected test sequence. 
4	At the end of test: • If the test is passed, the following screen is displayed.  • If the test is failed, the following screen is displayed until the button is pressed.  **NOTE:** Refer to Troubleshooting, page 48 if the test is failed. • Press either: ◦ OK to display the **Metering** screen. ◦ to display the **Home** menu.

Settings Menu (3/7)

Overview



The **Settings** menu displays the setting parameters.



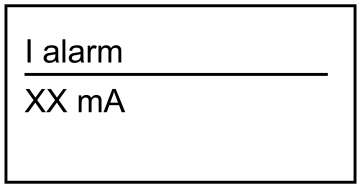
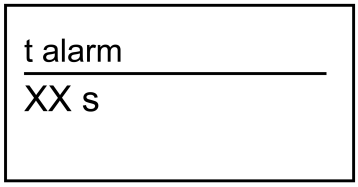
The **Settings** screen allows to set the following parameters:

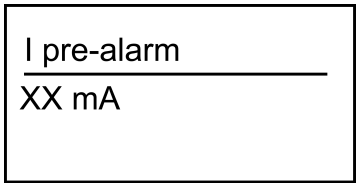
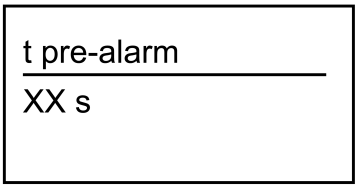
- **I alarm**: Alarm threshold
- **t alarm**: Alarm time delay
- **I pre-alarm**: Pre-alarm threshold
- **t pre-alarm**: Pre-alarm delay
- **Alarm reset**: Manual or Automatic

A password must be entered in the settings menu to modify the parameters.

Select the parameter to set and press OK to display the parameter screen.

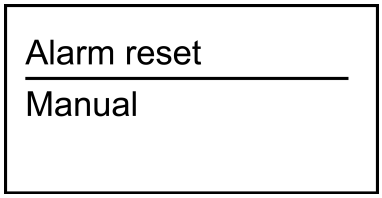
Functional Parameter Settings

Parameter	Description
Alarm threshold	 Where, • **XX** displays the alarm threshold setting value in mA/A. ◦ Factory setting: 30 mA ◦ Minimum value: 30 mA ◦ Maximum value: 30 A ◦ Setting step: 1 mA from 30 mA to 999 mA and 0.1 A from 1 A to 30 A. **NOTE:** After the validation of the new alarm threshold value: • The pre-alarm threshold value is set by 50% of the new alarm threshold value.
Alarm time delay	 Where, • **XX** displays the alarm time delay setting value in seconds.

Parameter	Description
	◦ Factory setting: 0 s ◦ Minimum value: 0 s ◦ Maximum value: 4.5 s ◦ Setting step: 0.01 s **NOTE:** • The values between 0 s and 60 ms are prohibited (the setting values are: 0, 60, 70..., 4500 ms). • When **I alarm** is 30 mA, **t alarm** is locked at 0 seconds. Under this circumstance, if you try to modify the **t alarm**, **/!\ I alarm = 30mA** is displayed in the third line.
Pre-alarm threshold	 Where, • **XX** displays the pre-alarm threshold setting value in mA/A. ◦ Factory setting: 15 mA ◦ Minimum value: 15 mA ◦ Maximum value: 30 A ◦ Setting step: 1 mA from 15 mA to 999 mA and 0.1 A from 1 A to 30 A. **NOTE:** • The pre-alarm threshold value is locked and cannot be increased further if it is increased up to the alarm threshold value. • The pre-alarm threshold value is locked and cannot be decreased further if it is decreased up to 20% of the alarm threshold value. • When there is a new alarm threshold, the pre-alarm threshold value is set to 50% of the new alarm threshold value.
Pre-alarm time delay	 Where, • **XX** displays the alarm time delay setting value in seconds. ◦ Factory setting: 0.2 s ◦ Minimum value: 0 s ◦ Maximum value: 4.5 s ◦ Setting step: 0.01 s **NOTE:** The values between 0 and 60 ms are prohibited (the setting values are: 0, 60, 70 to 4500 ms).The pre-alarm time delay will be set to alarm time delay value automatically if the pre-alarm time delay is above the alarm time delay when the alarm threshold and pre-alarm threshold are equal.

Alarm Reset Mode

The **Alarm reset** screen allows to select the alarm reset mode as Manual or Automatic.



The alarm reset can be configured through the HMI and Modbus (only for VigiPacT RHU relay).

If the alarm reset mode is Automatic, then the alarm is reset automatically.

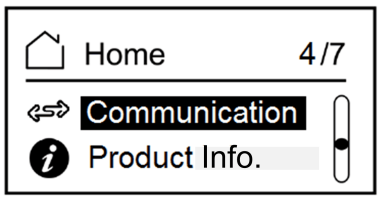
If the alarm reset mode is Manual, you can reset the alarm manually through one of the following options:

- by pressing OK on the relay
- by using a Reset button wired to the Reset input of the relay
- by sending a reset command through Modbus communication (only for VigiPacT RHU relay)

NOTE: Depending on the selection of Manual or Automatic mode, the VigiPacT RHU/RHUs relay is considered as protection relay (Manual mode) or a monitoring relay (Automatic mode).

Communication Menu (4/7): for VigiPacT RHU Relay

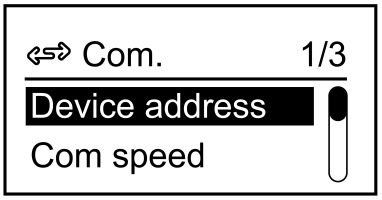
Overview



The **Communication** settings menu allows to set the following parameters:

- **Device address**
- **Communication speed**
- **Parity**

The figure displays the **Communication** settings menu.



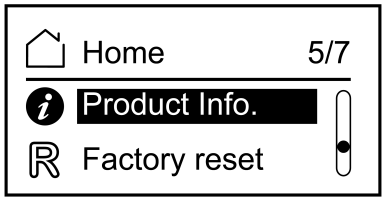
Communication Parameters

Parameters	Authorized Value	Factory Value
Device address	**1 to 247**	**247**
Com speed	• **4800** • **9600** • **19200** • **38400** • **Auto**	**19200**
Parity	• **None** • **Odd** • **Even**	**Even**

NOTE: When the communication speed is set to **Auto**, the parity is not available because the parity is adapted automatically with the speed.

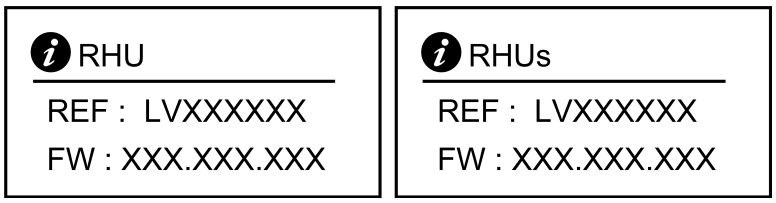
Product Information (5/7)

Overview



The **Product information** screen displays the commercial reference and the embedded firmware version.

The figure displays the **Product information** screen.



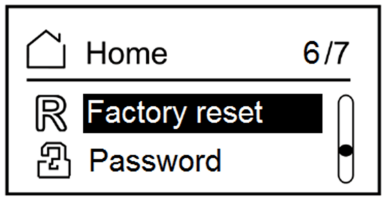
Where,

- **LVXXXXXX** displays the commercial reference of the VigiPacT RHU/RHUs relay.
- **XXX.XXX.XXX** displays the embedded firmware version.

NOTE: Press or OK to exit the **Product information** screen.

Factory Reset (6/7)

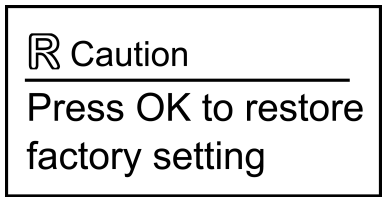
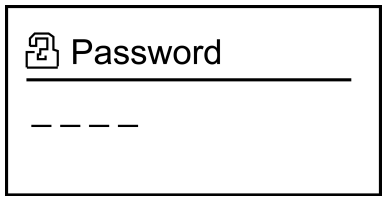
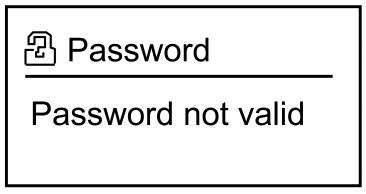
Overview

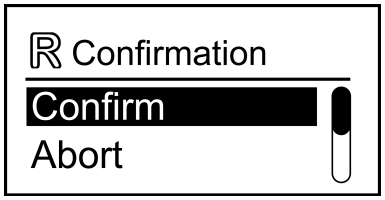
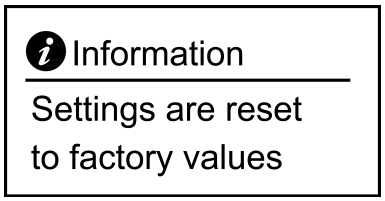


The **Factory reset** menu allows you to reset the following settings to factory values:

- Alarm threshold
- Alarm time delay
- Pre-alarm threshold
- Pre-alarm time delay
- Alarm reset mode
- Communication speed
- Device address
- Parity

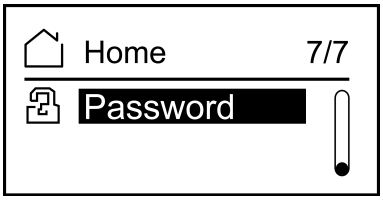
Resetting to Factory Setting

Step	Action
1	Select **Factory reset** from the **Home** menu, and then press OK. **Result:** Displays the **Caution** screen. 
2	Press OK and enter the password to log in.  **NOTE:** If the password is incorrect, the password invalid screen is displayed and then, **Caution** screen is displayed. 

Step	Action
3	After the login is successful, **Confirmation** screen is displayed.  Press OK within 10 seconds to confirm or abort. **NOTE:** Press ⌂ to cancel the factory reset. If you do not press any button within 10 seconds, the factory reset is cancelled automatically.
4	The settings are reset to factory value and the **Information** screen is displayed. 
5	Press ⌂ within 40 seconds to display the **Home** menu. **NOTE:** The **Metering** screen displays if you: • press OK when settings are reset to factory value. • do not press any button within 40 seconds.

Password Management (7/7)

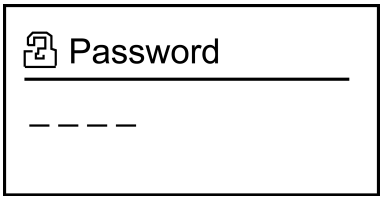
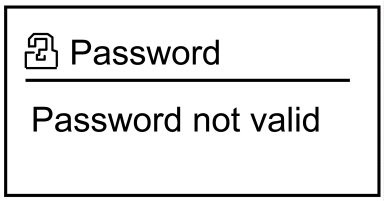
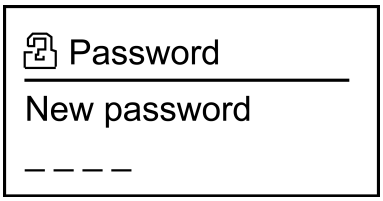
Overview

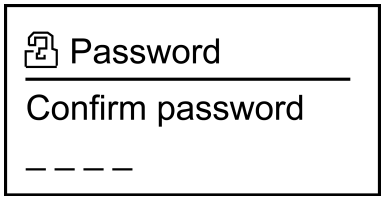


A password must be entered to access or modify the following parameters:

- Functional settings
- Factory reset
- Changing password

Changing the Password

Step	Action
1	Select **Password** from **Home** menu, and then press OK. **Result:** Displays the password entry screen.  • Press OK to select the digit. Pressing this button moves the selection from left to right. • Press △ to increase the value of the selected digit from 0 to 9. • Press ▽ to decrease the value of the selected digit from 9 to 0. If the password is correct, then you can access the next screen. If the password is incorrect, then the following screen is displayed for 10 seconds:  The previous screen is displayed if you press OK within 10 seconds or if you do not press any button.
2	The screen prompts to enter the new password if the entered old password is correct.  Enter the new password, and then press OK.

Step	Action
3	After entering the new password, the screen prompts to confirm the password.  Enter the password again. **Result:** The message **OK** is displayed on the screen for 40 seconds if the new password and the confirmed password are same. **NOTE:** If both the new password and the confirmed password are different, **Not valid** message is displayed for 40 seconds. Press OK within 40 seconds to change the password again. The screen prompts you to enter the new password again.
4	Press within 40 seconds to navigate to **Home** menu. **NOTE:** The **Metering** screen is displayed if you do not press any button within 40 seconds.

Resetting the Password

If you forget the password, the password can be reset to the default password **0000**. For more information on resetting the password, contact Schneider Electric technical support.

Modbus Communication for VigiPacT RHU Relay

What's in This Part

Modbus Client-Server Principle 34
Modbus Functions 37
Modbus Exception Codes 38
Modbus Registers Tables 40
VigiPacT Registers 42
Channel Summary Registers 44
Channel Detailed Registers 47

Modbus Client-Server Principle

Overview

The Modbus RTU protocol exchanges information using a request-reply mechanism between a client and a server. The client-server principle is a model for a communication protocol in which one device (the client) controls one or more other devices (the servers). In a standard Modbus network, there is one client and up to 31 servers.

A detailed description of the Modbus protocol is available at www.modbus.org.

Characteristics of the Client-Server Principle

The client-server principle is characterized as follows:

- Only one client is connected to the network at a time.
- Only the client can initiate communication and send requests to the servers.
- The client can address each server individually using its specific address or all servers simultaneously using address 0.
- The servers can only send replies to the client.
- The servers cannot initiate communication, either to the client or to other servers.

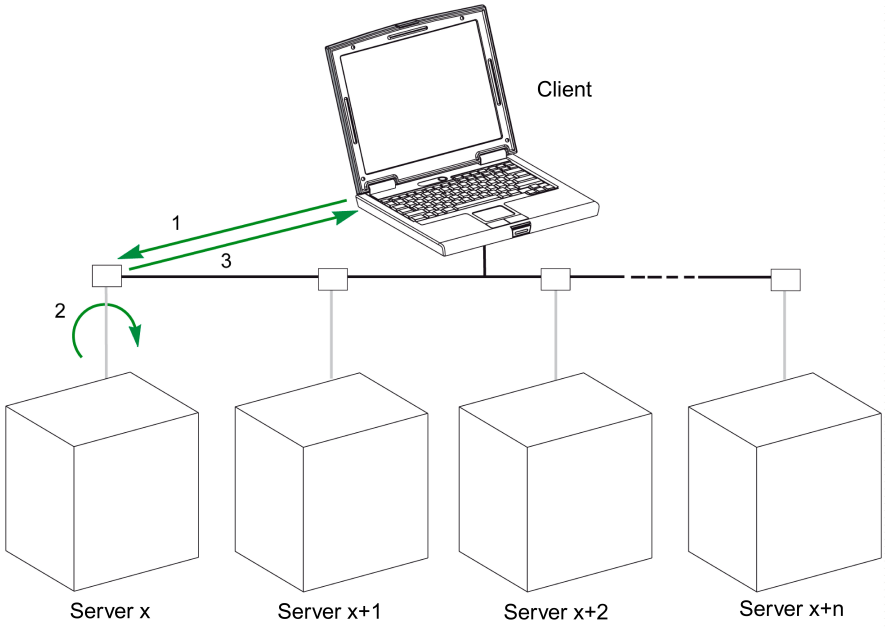
Client-Server Communication Modes

The Modbus RTU protocol can exchange information using the two communication modes:

- request-reply mode
- broadcast mode

Request-Reply Mode

In the request-reply mode, the client addresses a server using the specific address of the server. The server processes the request then replies to the client.



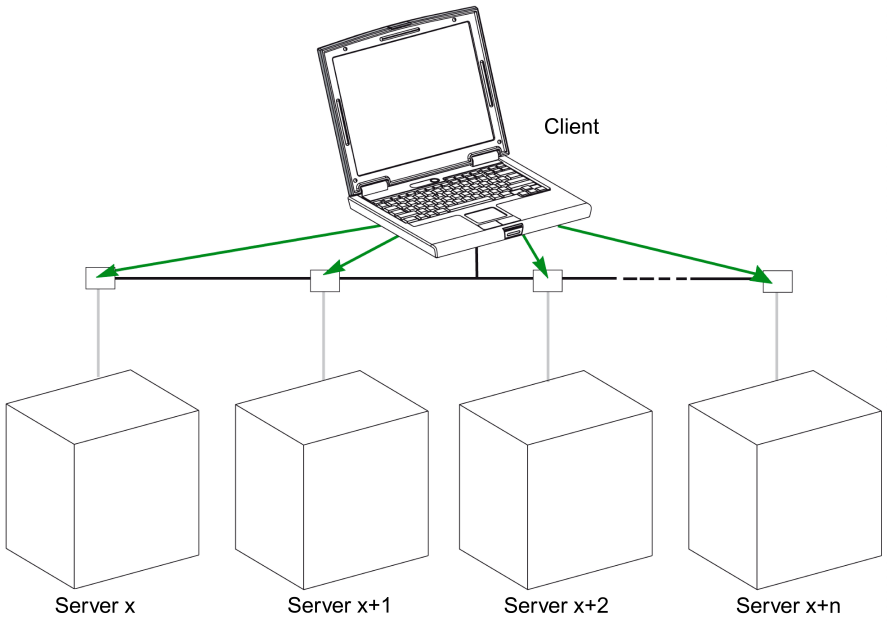
1 Request

2 Process

3 Reply

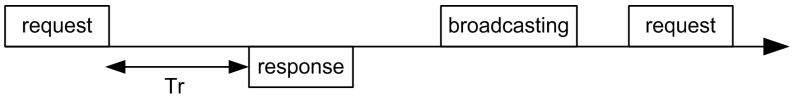
Broadcast Mode

The client can also address all servers using address 0. This type of exchange is called broadcasting. The servers do not reply to broadcasting messages.



Response Time

The response time Tr is the time needed by a server to respond to a request sent by the client:



Values with the Modbus protocol are:

- Typical value < 10 ms for 90% of the exchanges
- Maximum value is around 700 ms. Hence it is recommended to implement a 1 second time-out after sending a Modbus request.

Data Exchange

The Modbus protocol uses 2 types of data:

- bits
- 16-bit words called registers

VigiPacT relays support both types of data.

Each register has a register number. Each type of data (bit or register) has a 16-bit address.

The messages exchanged with the Modbus protocol contain the address of the data to be processed.

Registers and Addresses

The address of register number n is n-1. The tables detailed in the following parts of this document provide both register numbers (in decimal format) and corresponding addresses (in hexadecimal format). For example, the address of register number 100 is 0x0063 (99).

Frames

All the frames exchanged with the Modbus protocol have a maximum size of 256 bytes and are composed of 4 fields:

Field	Definition	Size	Description
1	Server number	1 byte	Destination of the request: • 0: broadcasting (all servers concerned) • 1–247: unique destination
2	Function codes	1 byte or 2 bytes	Refer to Modbus Functions, page 37
3	Data	n registers	Request or reply data
4	Check	2 bytes	CRC16 (to check transmission errors)

Modbus Functions

General Description

The Modbus protocol offers a number of functions that are used to read or write data over the Modbus network. The Modbus protocol also offers diagnostic and network-management functions.

Only the Modbus functions handled by the VigiPacT relays are described here.

Functions

The following functions are available:

Function Code	Subfunction Code	Name	Description
1 (0x01)	–	Read coils	Read output bits
2 (0x02)	–	Read discrete inputs	Read input bits
3 (0x03)	–	Read holding registers	Read n registers
5 (0x05)	–	Write single coil	Write 1 bit
6 (0x06)	–	Write single register	Write 1 register
16 (0x10)	–	Write multiple registers	Write n registers
43 (0x2B)	14 (0x0E)	Read device identification	Read the identification data of the server

Read Register Example

The following table shows how to read the measured current in register 1005. The address of register 1005 is 1005-1 = 1004= 0x03EC. The Modbus address of the Modbus server is 247 = 0xF7.

Client Request		Server Reply	
Field Name	**Example**	**Field Name**	**Example**
Modbus server address	0xF7	Modbus server address	0xF7
Function code	0x03	Function code	0x03
Address of the register to read (MSB)	0x03	Data length in bytes	0x02
Address of the register to read (LSB)	0xEC	Register value (MSB)	0x12
Number of registers (MSB)	0x00	Register value (LSB)	0x34
Number of registers (LSB)	0x01	CRC (MSB)	0xXX
CRC (MSB)	0xXX	CRC (LSB)	0xXX
CRC (LSB)	0xXX	–	

The content of register 60023 1005 (address 0x03EC) is 0x1234 = 4660. Therefore the measured current is 4660 mA.

Modbus Exception Codes

Exception Responses

Exception responses from either the client or a server can result from data processing errors. One of the following events can occur after a request from the client:

- If the server receives the request from the client without a communication error and can handle the request correctly, it returns a normal response.
- If the server does not receive the request from the client due to a communication error, it does not return a response. The client program eventually processes a timeout condition for the request.
- If the server receives the request from the client but detects a communication error, it does not return a response. The client program eventually processes a timeout condition for the request.
- If the server receives the request from the client without a communication error, but cannot handle it (for example, the request is to read a register that does not exist), the server returns an exception response to inform the client of the nature of the error.

Exception Frame

The server sends an exception frame to the client to report an exception response. An exception frame is composed of 4 fields:

Field	Definition	Size	Description
1	Server number	1 byte	Destination of the request • 0: broadcasting (all servers concerned) • 1–247: unique destination
2	Exception function code	1 byte	Request function code + 128 (0x80)
3	Exception code	n bytes	Refer to Exception Codes, page 38
4	Check	2 bytes	CRC16 (to check transmission errors)

Exception Codes

The exception response frame has 2 fields that differentiate it from a normal response frame:

- The exception function code of the exception response is equal to the function code of the original request plus 128 (0x80).
- The exception code depends on the communication error that the server encounters.

The following table describes the exception codes handled by the circuit breaker:

Exception Code	Name	Description
01 (0x01)	Illegal function	The function code received in the request is not an authorized action for the server. The server may be in the wrong state to process a specific request.
02 (0x02)	Illegal data address	The data address received by the server is not an authorized address for the server.
03 (0x03)	Illegal data value	The value in the request data field is not an authorized value for the server.
04 (0x04)	Server device failure	The server fails to perform a requested action because of an unrecoverable error.
05 (0x05)	Acknowledge	The server accepts the request but needs a long time to process it.

Exception Code	Name	Description
06 (0x06)	Server device busy	The server is busy processing another command. The client must send the request once the server is available.
07 (0x07)	Negative acknowledgment	The server cannot perform the programming request sent by the client.
08 (0x08)	Memory parity error	The server detects a parity error in the memory when attending to read extended memory.
10 (0x0A)	Gateway path unavailable	The gateway is overloaded or not correctly configured.
11 (0x0B)	Gateway target device failed to respond	The server is not present on the network.

Modbus Registers Tables

Description

The Modbus registers of the VigiPacT relay provide information that can be read, like electrical measures, monitoring information.

Table Format

Address	Register	RW	Unit	Type	Range	Factory	Saved	Bit	Description

- **Address:** a 16-bit register address in hexadecimal. The address is the data used in the Modbus frame.
- **Register:** a 16-bit register number in decimal (register = address + 1).
- **RW:** register read-write status
  - R: read-only access
  - RW: read access and write access using Modbus functions
- **Unit:** the unit the information is expressed in.
- **Type:** the encoding data type (refer to Data Types, page 40).
- **Range:** the permitted values for this register, usually a subset of what the format allows.
- **Factory:** value of the variable in a new device, and after a reset to factory setting command.
- **Saved:**
  - YES: the value is saved in case of power loss.
  - NO: the value is not saved in case of power loss.
- **Bit:** bit number for BITMAP description.
- **Description:** provides information about the register and restrictions that apply.

Data Types

Data Types	Description	Range
INT16U	16-bit unsigned integer	0 to 65535
INT16	16-bit signed integer	-32768 to +32767
INT32U	32-bit unsigned integer	0 to 4 294 967 295
INT32	32-bit signed integer	-2 147 483 648 to +2 147 483 647
STRING	Text string	1 byte per character
BITMAP	16-bit register	–

Data Type: BITMAP

A BITMAP register is a 16-bit register that can be read:

- as a 16-bit unsigned integer, using the Read multiple register function (function code 0x03)
- as a collection of bits, using the Read bits functions (function code 0x01 or 0x02)

Notes

- The type column tells how many registers to read to get the variable. For instance INT16U requires reading one register, whereas INT32 requires reading 2 registers.
- Some variables must be read as a block of multiple registers. Reading the block partially may result in an error or incorrect data.
- Reading from an undocumented register results in a Modbus exception. Refer to Modbus Exception Codes, page 38.
- Numerical values are given in decimal. When it is useful to have the corresponding value in hexadecimal, it is shown as a C language type constant: 0xdddd. For example, the decimal value 123 is represented in hexadecimal as: 0x007B.
- INT32U or INT32 variables are stored in big-endian format: the most significant register is transmitted first, the least significant second.
- Out of order and not applicable values depend on the data type.

Data Type	Out of Order and Not Applicable Values
INT16U	65535 (0xFFFF)
INT16	-32768 (0x8000)
INT32U	4294967295 (0xFFFFFFFF)
INT32	0x80000000

VigiPacT Registers

Identification and Status

Address	Register	RW	Units	Type	Range	Factory	Saved	Bit	Description
0x0064–0x0069	101–106	R	NA	STRING	NA	NA	Yes	–	Serial number on 12 ASCII characters PPYYWWDnnnn with • PP: plant code • YY: year of manufacture [05–99] • WW: week of manufacture [1–53] • D: day of manufacture [1–7, 1 for Monday) • nnnn: sequence number [0001–9999]
0x006A–0x006E	107–111	R	NA	STRING	NA	NA	No	–	Boot software version on 9 ASCII characters Example : "000.000.001"
0x006F	112	R	NA	BITMAP	NA	NA	No		Reserved
0x0070–0x0074	113–117	R	NA	STRING	NA	NA	No	–	Exploit software version on 9 ASCII characters Example : "000.000.001"
0x0075	118	R	NA	BITMAP	NA	NA	No		Reserved
0x0076–0x007A	119–123	R	NA	STRING	NA	NA	Yes	–	Hardware version on 9 ASCII characters Example : "000.000.001"
0x007B	124	R	NA	BITMAP	NA	NA	No		Reserved
0x007C	125	R	NA	BITMAP	NA	0x00FF	No	–	Validity of each bit of VigiPacT status: 0 = invalid 1 = valid
0x007D	126	R	NA	BITMAP	NA	0x0000	No	–	VigiPacT status
								0	Alarm relay is active
								1	Pre-alarm relay is active
								2	Test is on going
								3	Test is passed and not reset
								4	Test is failed and not reset
								5	Toroid loss is active
								6	RM12T communication malfunction is active
								7	VigiPacT internal malfunction is active
								8–15	Reserved
0x007E–0x007F	127–128	R	–	–	–	–	No	–	Reserved
0x0080–0x0081	129–130	R	NA	INT32U	0 to 0xFFFF-FFFF	0	No	–	Number of frames not understood (Bad function code, Modbus exception, …)

Global Parameters

Address	Register	RW	Units	Type	Range	Factory	Saved	Bit	Description
0x0096	151	R	NA	BITMAP	NA	0x0001	No	–	Validity of each bit of Global parameters: 0 = invalid 1 = valid
0x0097	152	R	NA	BITMAP	NA	0x0000	No		Global parameters
								0	0 = manual alarm reset mode 1 = automatic alarm reset mode
								1–15	Reserved

Channel Summary Registers

Channel Status

Address	Register	RW	Units	Type	Range	Factory	Saved	Bit	Description
0x00C8	201	R	NA	BITMAP	NA	0x0001	No	–	Validity of each bit of alarm status: 0 = invalid 1 = valid
0x00C9	202	R	NA	BITMAP	NA	0x0000	No		Alarm status
								0	0 = no alarm 1 = alarm
								1–15	Reserved
0x00CA	203	R	NA	BITMAP	NA	0x0001	No	–	Validity of each bit of pre-alarm status: 0 = invalid 1 = valid
0x00CB	204	R	NA	BITMAP	NA	0x0000	No	–	Pre-alarm status
								0	0 = no pre-alarm 1 = pre-alarm
								1–15	Reserved
0x00CC	205	R	NA	BITMAP	NA	0x0001	No	–	Validity of each bit of alarm memorized: 0 = invalid 1 = valid
0x00CD	206	R	NA	BITMAP	NA	0x0000	Yes		Alarm memorized
								0	0 = no alarm memorized 1 = alarm memorized
								1–15	Reserved
0x00CE	207	R	NA	BITMAP	NA	0x0001	No	–	Validity of each bit of toroid status: 0 = invalid 1 = valid
0x00CF	208	R	NA	BITMAP	NA	0x0000	No	–	Toroid status
								0	0 = no toroid connected 1 = toroid connected
								1–15	Reserved
0x00CE	209	RW	NA	INT16U	NA	0x0000	Yes		Alarm reset mode 0 = manual 1 = automatic

Measurements

Address	Register	RW	Units	Type	Range	Factory	Saved	Description
0x0190	401	R	mA	INT16U	0–60000	0x0000	No	Measured earth-leakage current.
0x01A4	421	R	mA	INT16U	0–60000	0x0000	No	Maximum of earth-leakage current measured.
0x01B8	441	R	NA	INT16U	0–200	0x0000	No	Threshold percentage of measured earth-leakage current.

Parameters

Address	Register	RW	Units	Type	Range	Factory	Saved	Description
0x01F4	501	RW	mA	INT16U	30–30000	30	Yes	Alarm threshold
0x0200	513	RW	ms	INT16U	0–4500	0	Yes	Alarm trip delay
0x020C	525	RW	mA	INT16U	15–30000	15	Yes	Pre-alarm threshold
0x0218	537	RW	ms	INT16U	0–4500	0	Yes	Pre-alarm trip delay

Command Registers

Address	Register	RW	Units	Type	Range	Factory	Saved	Description
0xEA76	60023	RW	NA	INT16U	0–2	0x0000	Yes	Allow to test the device. • 0: no test • 1: test trip • 2 : test no trip
0xEA77	60024	RW	NA	INT16U	0–1	0x0000	Yes	Alarm reset Bit 0 = 1: To reset the alarm
0xEA78	60025(1)	RW	NA	INT16U	1–247	0x00F7	Yes	Device Modbus address
0xEA79	60026(1)	RW	NA	INT16U	0–3	0x0002	Yes(2)	Communication speed setting • 0 : 4800 • 1 : 9600 • 2 : 19200 • 3 : 38400
0xEA7A	60027(1)	RW	NA	INT16U	0–2	0x0002	Yes(2)	Communication parity setting • 0 : None • 1 : Odd • 2 : Even
0xEA7B	60028(1)	RW	NA	INT16U	0–1	0x0000	Yes	• 0 : Autogo is not active • 1 : Autogo is active

(1) Communication may be broken if the parameter is modified. Communication has to be re-established with the new value written in the register.

(2) Modifiable only if Autogo is not active.

Diagnostics Registers

Address	Register	RW	Units	Type	Range	Factory	Saved	Description
0xEA7C	60029	R	NA	INT16U	0-0x0FFF	0x0000	Yes	Number of software resets.
0xEA7D	60030	R	NA	INT16U	0-0x0FFF	0x0000	Yes	Number of times the device is powered on.

Channel Detailed Registers

Mapping of the Detailed Channel Register

Address	Register
0x03E8–0x03FB	1001-1020

Status and Control Registers

Address	Register	RW	Units	Type	Range	Factory	Saved	Bit	Description
0x03E8	1001	R	NA	BITMAP	NA	0x003F	No	–	Validity of each bit of Status: • 0 = invalid • 1 = valid
0x03E9	1002	R	NA	BITMAP	NA	0x0000	No		Channel 1 status
								0	Alarm
								1	Pre-alarm
								2	Alarm is memorized
								3	Toroid is connected
								4	Alarm relay is active
								5	Pre-alarm relay is active
								6–15	Reserved
0x03EA–0x03EB	1003–1004	R	NA	–	NA	0x8000	No	–	Reserved

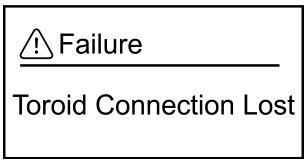
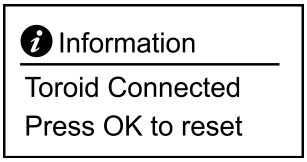
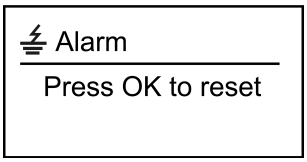
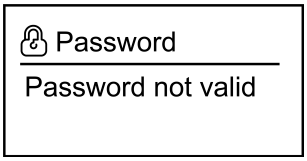
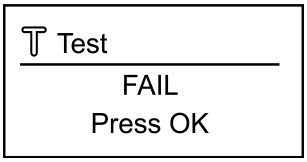
Measurement Registers

Address	Register	RW	Units	Type	Range	Factory	Saved	Description
0x03EC	1005	R	mA	INT16U	0–60000	0x0000	No	Measured earth-leakage current.
0x03ED	1006	R	mA	INT16U	0–60000	0x0000	No	Maximum of earth-leakage current measured
0x03EE	1007	R	%	INT16U	0–200	0x0000	No	Threshold percentage of measured earth-leakage current.

Parameter Registers

Address	Register	RW	Units	Type	Range	Factory	Saved	Description
0x03EF	1008	RW	mA	INT16U	30–30000	30	Yes	Alarm threshold
0x03F0	1009	RW	ms	INT16U	0–4500	0	Yes	Alarm trip delay
0x03F1	1010	RW	mA	INT16U	15–30000	15	Yes	Pre-alarm threshold
0x03F2	1011	RW	ms	INT16U	0–4500	0	Yes	Pre-alarm trip delay
0x03F3–0x03FB	1012–1020	R	–	BITMAP	–	0x0000	No	Reserved

Troubleshooting

Event	Diagnostics	Action
LED **ON** switch is off	No indication of power supply.	• Check the power supply of the relay. • After verification, if the problem persists, replace the relay by a new one.
Toroid connection lost	 Alarm LED: blinking Alarm relay: active	• Check the connection of the toroid to the relay. • After verification, if the problem persists, replace the toroid by a new one.
Toroid connection detected		If the alarm reset mode is Manual, press OK to acknowledge the information.
Alarm detected	 Alarm LED: blinking Alarm relay: active	If the alarm reset mode is Manual, press OK to reset the alarm and deactivate the relay.
Password not valid		• Enter the right password. • Reset the password, if the password is lost.
Test failed		• Do the factory reset of the relay. • After the factory reset, if the test fails, replace the relay by new one.

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As standards, specifications, and design change from time to time, please ask for confirmation of the information given in this publication.

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