Application Note - Using Modbus With Conext™ RL Inverters

976-2110-01-01
Revision A

Contents

Section	Page
Introduction	3
Overview	3
Key Points	3
Related Documents	4
Modbus Physical Layer	5
RJ-45 Connection	5
Termination Resistor	6
Communication parameters	7
Inverter Configuration	9
Setting the Modbus Slave Address (Inverter ID)	9
Modbus Logical Layer	11
Modbus Logical Layer	11
Modbus Packet Structure	11
Slave address field	11
Function field	11
Data field	11
Error check field (checksum)	12
Packet communications	12
Modbus functions supported by the inverter	12
Function 03: Read Holding Registers	12
Function 16: Preset Multiple Registers	13
Function 43: Device Discovery	14
Broadcasts	17
Modbus Data Types	18
16-bit integer format	18

Schneider Electric

Section	Page
32-bit integer format	19
8-bit Unsigned Character Format	19
Modbus Error Responses	20
Function Code Field	20
Data Field	20
Modbus Error Response Example	21
Conext RL Modbus Map	22
Modbus Address	22
Modbus Register Description	22
Modbus Register Access type	22
Modbus Register Units	22
Modbus Register Size	23
Invalid Registers	23
Modbus Map	23
Appendix A: CRC-16 calculation	45
Pseudocode For CRC-16 Generation	46
Appendix B: Leading and Lagging Power Factors	47

⚠ DANGER

HAZARD OF FIRE, ARC FLASH, OR ELECTRIC SHOCK FROM MULTIPLE SOURCES

- This Application Note is in addition to, and incorporates by reference, the installation and operation manual for the Conext™ RL 3000 E, 4000 E, and 5000 E photovoltaic grid tie inverters. Before reviewing this Application Note you must read the Conext RL installation and operation manual (part number:975-0687-01-01). Unless specified, information on safety, specifications, installation, and operation is as shown in the primary documentation received with the product. Ensure you are familiar with that information before proceeding.
- To be installed and serviced only by qualified personnel.
- This document is intended for use by qualified installers only.
- Before servicing, disconnect all the sources and wait at least one minute.

Failure to follow these instructions will result in death or serious injury.

Introduction

Overview

Modbus is a simple and robust open communication protocol used to provide interoperability between products from many different vendors. The purpose of this application note is to provide a brief overview of the Modbus hardware and software implementation of the:

Conext RL 3000 E-S (part number PVSNVC3000S and PVSNVC3000ST)

Conext RL 3000 E (part number PVSNVC3000 and PVSNVC3000T)

Conext RL 4000 E-S (part number PVSNVC4000S and PVSNVC4000ST)

Conext RL 4000 E (part number PVSNVC4000 and PVSNVC4000T)

Conext RL 5000 E-S (part number PVSNVC5000S and PVSNVC5000ST)

Conext RL 5000 E (part number PVSNVC5000 and PVSNVC5000T)

photovoltaic grid tie inverters, so that you can quickly and easily interface the inverter with any third-party Modbus devices.

The Inverter part numbers with suffix “T” (eg: PVSNVC3000ST) are intended to be installed

in Thailand.

The inverter performs Modbus communications according to the Modbus register definition in Table 23. It is assumed that you are familiar with the Modbus protocol and with serial communications in general.

Key Points

The inverter is capable of communicating via the RS-485 serial communication standard. The RS-485 medium allows for multiple devices on the same serial bus network.

All communications on the network conform to a Master/Slave scheme. In this scheme, information and data are transferred between a Modbus Master device and up to 31 Slave devices.

The Master device initiates and controls all the information transfer on the Modbus serial bus network. There may be **only one master** for any Modbus network.

A Slave device never initiates a communication sequence, and must remain silent unless addressed specifically by the Master.

All the communication activity on the Modbus serial bus network occurs in the form of packets. A packet is a serial string of up to 255 8-bit bytes.

All packets transmitted by the Master are requests. All the packets transmitted by a Slave are responses.

At most, one Slave can respond to a single request from a Master.

The Conext RL 3000 E, 4000 E, and 5000 E photovoltaic grid tie inverters support only the Modbus/RTU protocol.

Related Documents

Table 1 Related documents

Document reference	Document title	Document number	Version
1	Modbus Application Protocol Specification	From www.modbus.org	1.1b
2	Conext RL 3000 E, 4000 E, and 5000 E Installation and Operation Manual	975-0687-01-01	C

Modbus Physical Layer

The Conext RL inverter supports the Modbus communication protocol via an RS485 interface. An RJ-45 wiring interface is supported. The module is shown in Figure 1.

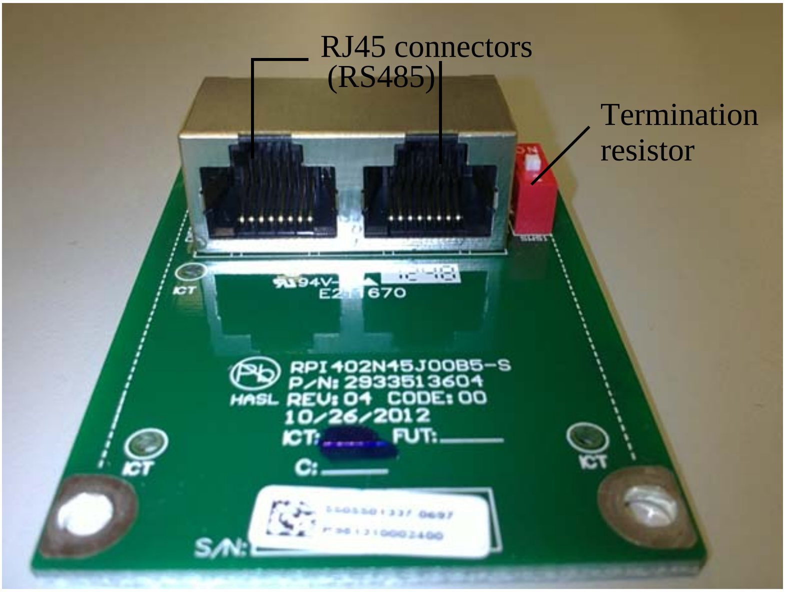


Figure 1 Communication module

RJ-45 Connection

The RS-485 bus is a multi-drop bus implemented as a daisy chain. The RJ-45 connector is provided with two ports to allow ease of daisy chaining. Either port can be connected to the upstream or downstream devices.

A standard Ethernet (straight-through) patch cable may be used to connect to the upstream and downstream devices. Ethernet cross-over cables **must not** be used.

The RJ45 connector provides D+, D-, and signal Ground connections.

The pin definitions of the RJ-45 connection are shown in Table 2. For the location of pin 8, see Figure 2.

Table 2 RJ-45 pin definitions

Pin	Function
4	DATA+
5	DATA-
7	NC (Not connected)
8	Modbus ground

For pin numbering, see

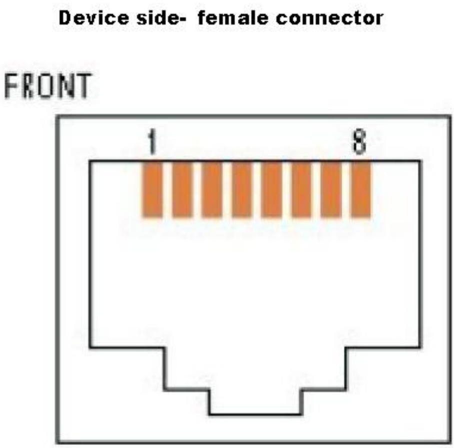


Figure 2 pin numbering

Termination Resistor

You must enable the termination resistors if the inverter is on the end of the Modbus device chain. To do this, use a DIP switch on the communication interface board. If the inverter is the first or the last device of the RS485-chain, set the termination resistor to on; otherwise, set it to off.

The location of the termination resistor is shown in Figure 3. The settings are shown in Table 3.

Figure 3 Termination resistor—switch

Table 3 Termination resistor settings

Switch	Result
Off	The termination resistor is off.
On	The termination resistor is on.

Communication parameters

Table 4 shows the communication parameters used by the RS-485 Modbus interface on the inverter.

These parameters must be set identically on the Modbus Master device or PC program used to communicate with the inverter. To determine how to set the communication parameters of the Modbus Master device, see the documentation that accompanies the device.

Table 4 RS485 communication parameters

Parameter	Value
Baud rate	9600
Data bits	8
Stop bits	1
Parity	None

Inverter Configuration

Setting the Modbus Slave Address (Inverter ID)

The Modbus Slave address (or Inverter ID) must be unique for each device on the Modbus network. The Modbus Slave address may be read and/or modified via the front panel display of the inverter. The Inverter ID is selected using the Select button as shown in Figure 4 below. Once the desired inverter ID is selected, press Enter to confirm the ID. The Inverter ID can be any number between 1 and 254.

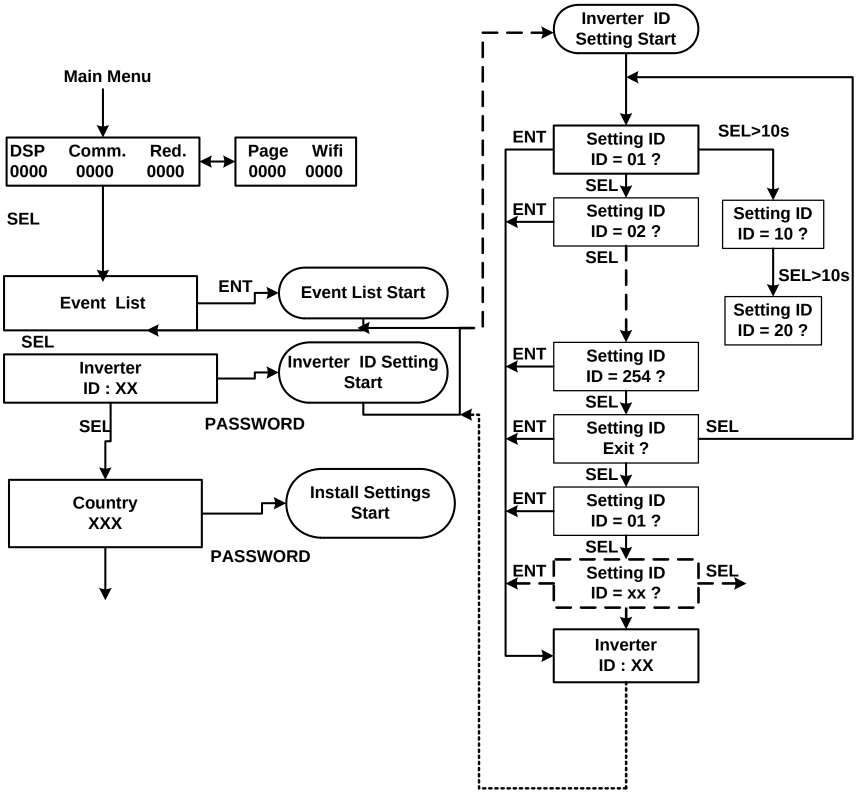


Figure 4 Setting the Inverter ID

Reviewing the Modbus Slave Address (Inverter ID)

To review the current Modbus Slave Address (Inverter ID) setting:

From the main menu, select **Inverter Information**.

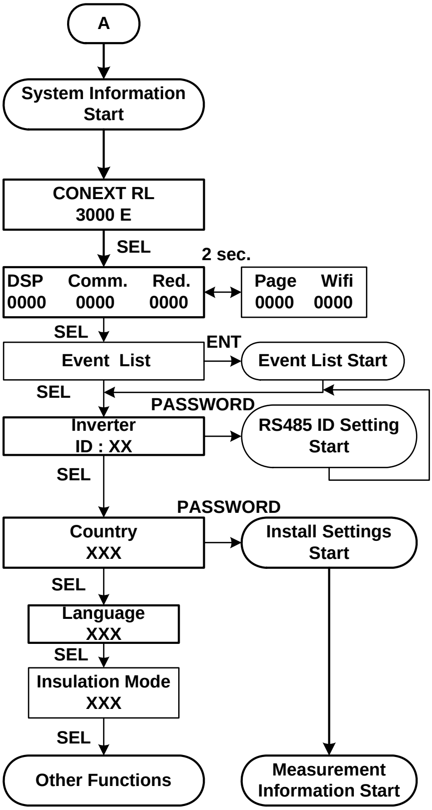


Figure 5 Review Inverter ID

Modbus Logical Layer

Modbus Packet Structure

Every Modbus packet consists of four fields:

- Slave address field
- Function field
- Data field
- Error check field (checksum)

NOTICE
• The values shown in the packets are in hexadecimal format. • In the tables that show the packet structure, white background denotes the DATA field of the packet.

Table 5 Modbus packet structure

Address	Function Code	Data	Checksum

Slave address field

The slave address field of a Modbus packet is one byte in length and uniquely identifies the slave device involved in the transaction. Valid addresses range between 1 and 255.

A slave device performs the command specified in the packet when it receives a request packet with the slave address field matching its own address.

A response packet generated by the slave has the same value in the slave address field.

Function field

The function field of a Modbus request packet is one byte in length and tells the addressed slave which function to perform. Similarly, the function field of a response packet tells the master what function the addressed slave has just performed.

Data field

The data field of a Modbus request is of variable length, and depends on the function. This field contains information required by the slave device to perform the command specified in a request packet or data being passed back by the slave device in a response packet.

Data in this field is contained in 16-bit registers. Registers are transmitted in the order of high-order byte first, low-order byte second.

Example:

A 16-bit register contains the value 0x12AB. This register is transmitted:

- High order byte = 0x12
- Low order byte = 0xAB

This register is transmitted in the order 12 AB.

Error check field (checksum)

The checksum field lets the receiving device determine if a packet is corrupted with transmission errors. In Modbus RTU mode, a 16-bit Cyclic Redundancy Check (CRC-16) is used.

The sending device calculates a 16-bit value, based on every byte in the packet, using the CRC-16 algorithm. The calculated value is inserted in the error check field.

The receiving device performs the calculation, without the error check field, on the entire packet it receives. The resulting value is compared to the error check field. Transmission errors are indicated when the calculated checksum does not equal the checksum stored in the incoming packet. The receiving device ignores a bad packet.

For more information on CRC-16 calculations, see “Appendix A: CRC-16 calculation” on page 45.

Packet communications

This section describes the Modbus functions supported by the inverter.

Modbus functions supported by the inverter

Table 6 Modbus functions supported by the inverter

Function (Decimal/ Hex)	Meaning	Action	See this section:
03/03h	Read Holding Registers	Reads a value from one or more consecutive holding registers in the inverter.	“Function 03: Read Holding Registers” on page 12
16/10h	Write Multiple Registers	Writes a value into one or more consecutive holding registers in the inverter.	“Function 16: Preset Multiple Registers” on page 13
43/2Bh	Read Device Identifier	Reads the Manufacturer, Model, and Version information for the device.	“Function 43: Device Discovery” on page 14
08/08h	Diagnostics	Sub function code 00: Return query data	“Function 08: Diagnostics” on page 18

Function 03: Read Holding Registers

To read the inverter parameter values, a master must send the slave device (inverter) a Read Holding Registers request packet.

The Read Holding Registers request packet specifies a start register and a number of registers to read. (You can read 1 or more registers.) The start register may be from 0 to 65535 (0xFFFF).

Note: Addresses are 0 based ("on the wire" addressing) and not 1 based ("traditional" addressing).

The inverter responds with a packet containing the values of the registers in the range defined in the request.

Table 7 Read Holding Registers packet structure

Request packet (master to slave)	Response packet (slave to master)
Unit ID/slave address (1 byte)	Unit ID/slave address (1 byte)
03 (function code) (1 byte)	03 (function code) (1 byte)
Start register (sr) (2 bytes)	Byte count (2 x nr) (1 byte)
# of registers to read (nr) (2 bytes)	First register in range (2 bytes)
CRC checksum	Second register in range (2 bytes)
	…
	CRC checksum (2 bytes)

Example:

The inverter is configured as a Modbus slave device with slave address 1. The master requests to read the grid voltage. This parameter is made available in the Modbus map at address 0x17F8 with a scaling factor of 10.

Table 8 Request packet

Slave	Function	Start register		# of registers (3)		CRC checksum	
01	03	17	F8	00	03	00	4F

Table 9 Response packet

Slave	Function	Byte count	Register 1		CRC checksum	
01	03	02	08	FC	BF	C5

The master retrieves the data from the response:

- Register 0x17F8: 0x04B1 = 1201 (scaled: 120.1)

Function 16: Preset Multiple Registers

The Preset Multiple Registers command packet allows a Modbus master to configure or control the slave inverter.

A Preset Multiple Registers data-field request packet contains a definition of a range of registers to write to, and the values that are written to those registers.

The slave inverter responds with a packet indicating that a write was performed to the range of registers specified in the request.

The Preset Multiple Registers request and response packet formats are shown in the following example transaction.

Table 10 Preset Multiple Registers packet structure

Request packet (master to slave)	Response packet (slave to master)
Unit ID/slave address (1 byte)	Unit ID/slave address (1 byte)
16 (function code) (1byte)	16 (function code) (1 byte)
Start register (sr) (2 bytes)	Start register (sr) (2 bytes)
# of registers to write (nr) (2 bytes)	# of registers written (nr) (2 bytes)
Byte count (2 x nr) (1 byte)	CRC checksum (2 bytes)
First register in range (2 bytes)	
Second register in range (2 bytes)	
...	
CRC checksum (2 bytes)	

NOTE: Except for the register data fields, the Preset Registers Response packet has the same fields as the Read Registers Request packet.

Example:

Write to the “Reactive power mode select” register of the inverter at Modbus address 01 (0x01) to set "cos phi as a function of P”. The reactive power mode select register is at address 0xFA60, and it must be set to “2” (0x0002) to set the "cos phi as a function of P”.

Table 11 Request packet

Slave	Function (Hex)	Start register		# of registers	Byte count	Register 1		CRC checksum	
01	10	FA	60	01	02	00	02	25	A9

Table 12 Response packet

Slave	Function	Start register		# of registers		CRC checksum	
01	10	FA	60	00	01	31	0F

Function 43: Device Discovery

Function code 43 checks for the presence of a device at a specific address on the Modbus device chain. A Modbus master may request Function Code 43 data from each Modbus address. A device with the requested address must report at least three pieces of data, as shown in Table 13.

Table 13 Mandatory components of a reply to Function Code 43

Object ID	Object name / description	Type
0x00	Manufacturer Name	ASCII String
0x01	Product Identification	ASCII String
0x02	Product Version Number	ASCII String

In the case of the 03KW inverter (Conext RL 3000 E), it will report the following:

- Manufacturer Name: Schneider Electric
- Product Identification: PVSNVC3000
- Product Version Number: 000.000

NOTICE

The Product Version Number is not used on the Conext RL inverter. It will always report 000.000.

Example:

The Modbus master asks the device at Modbus address 01 to identify itself.

The Modbus function code 43 (0x2B) uses a sub-function code to distinguish different behaviors for the function. The Conext RL inverter supports sub-function 14 (0x0E).

Table 14 Request packet

Slave	Function	Sub-function	ID Code	Object ID	CRC checksum	
01	2B	0E	01	00	70	77

The ID Code field supports four values:

- 01: request to get the basic device identification (stream access)
- 02: request to get the regular device identification (stream access)
- 03: request to get the extended device identification (stream access)
- 04: request to get one specific identification object (individual access)

NOTICE

The Conext RL inverter only supports ID code 01.

The value of Object ID determines the items in the response, as shown in Table 15.

Table 15 Contents of response, depending on Object ID

Object ID	Manufacturer name	Product identification	Product version number
0x00	✓	✓	✓
0x01		✓	✓
0x02			✓

Response Packet:

Slave ID	01	Indicates the address of the responding slave device
Function Code	2B	Indicates a function code 43 (0x2B) response
Sub Code	0E	Sub code 14 (0x0E) is the only sub code supported
Read Device ID Code	01	Same as the Read Device ID code in the request packet
Conformity Level	01	Identifies the conformity level of the device to Function Code 43. 01 = basic identification, and is the only value supported by the Conext RL inverter.
More Follows	00	If there is not enough room in the packet, this field will indicate that more data follows with FF.
Next Object ID	00	Specifies the starting ID of the object in the next response if "More Follows" is FF.
Number of Objects	03	Specifies the number of objects contained in this response.
Object ID	00	The identifier for the following object: 00 = Manufacturer
Object Length	12	Specifies the length of the following object (in bytes). 0x12 = 18 bytes.

Object Data									
53	63	68	6E	65	69	64	65	72	20
S	c	h	n	e	i	d	e	r	

Object Data							
45	6C	65	63	74	72	69	63
E	l	e	c	t	r	i	c

Object ID	01	The identifier for the following object: 01 = Product Code

Object Length	0A	Specifies the length of the following object (in bytes). 0x0A = 10 bytes.

Object Data									
50	56	53	4E	56	43	33	30	30	30
P	V	S	N	V	C	3	0	0	0

Object ID	02	The identifier for the following object: 01 = Product Code

Object Length	07	Specifies the length of the following object (in bytes). 0x07 = 7 bytes.

Object Data						
30	30	30	2E	30	30	30
0	0	0	.	0	0	0

CRC Checksum	A7	2E

Broadcasts

Broadcast request packets from the master are supported. Broadcasts are valid only with Function 16 and are triggered by setting the slave address to zero (0). All slaves will receive and execute the request, but will not respond.

Function 08: Diagnostics

Only sub-function code 00 “Return Query Data is supported”

The data passed in the request data field is to be returned (looped back) in the response. The entire response message will be identical to the request.

Example:

Request packet:			
Slave/ Function	Sub-function	Data field	CRC Checksum
01/ 08	00/ 00	66/ B3	9A/ 56

If Slave 01 is active on the bus you will receive a response.

Response packet:			
Slave/ Function	Sub-function	Data field	CRC Checksum
01/ 08	00/ 00	66/ B3	9A/ 56

Modbus Data Types

This section describes the data types supported by the inverter. The available formats may vary, depending on your inverter type and firmware.

Table 16 Modbus data types

Format	Data type	Range
UINT16	16-bit unsigned integer	0 to 65,535
INT16	16-bit signed integer	-32,768 to +32,767
UINT32	32-bit unsigned integer	0 to 4,294,967,295
INT32	32-bit signed integer	-2,147,483,648 to +2,147,483,647
UINT8	8-bit unsigned character	0 to 255

16-bit integer format

The unsigned and signed 16-bit integer formats are the smallest addressable units when using the Modbus protocol. Each input register to the module corresponds to one 16-bit Modbus holding register output.

32-bit integer format

To accommodate values that can reach beyond the 16-bit range, the Modbus Slave module provides 32-bit integer format as an output option.

A 32-bit register is passed via communications as two 16-bit registers—one high-order register and one low-order register.

High-order register

- $register_{high}$=value/65536

Low-order register

- $register_{low}$= value modulus 65536
- value = $register_{high}$ x 65536 + $register_{low}$ or
- value = $register_{high}$ | $register_{low}$

Example (unsigned 32-bit):

Value 12345678 is passed in unsigned 32-bit integer format:

- 12345678 = 0x00BC614E
- $Register_{high}$ = 0x00BC (unsigned) = 188
- $Register_{low}$ = 0x614E (unsigned) = 24910
- Value = 188 x 65536 + 24910 = 12345678

In unsigned 32-bit integer format, both the high-order and low-order registers are unsigned 16-bit integers.

Example (signed 32-bit):

Value -12345678 is passed in signed 32-bit integer format:

- -12345678 = 0xFF439EB2
- $Register_{high}$ = 0xFF43 (signed) = -189
- $Register_{low}$ = 0x9EB2 (unsigned) = 40626
- value = -189 x 65536 + 40626 = -12345678

In signed 32-bit integer format, the high-order register is a signed 16-bit number, but the low-order register is unsigned.

8-bit Unsigned Character Format

The 8-bit Unsigned Character format is used to encode ASCII strings within the Modbus registers.

The Characters are stored in the order they occur within the string, and populate the Most Significant Byte (MSB) of the Modbus 16-bit register followed by the Least Significant Byte (LSB) of the Modbus 16-bit register. For example, the ASCII string “HELLO!” would be encoded as 3 consecutive 16-bit registers with the values 0x4845, 0x4C4C, and 0x4F21.

Table 17 Modbus ASCII string encoding example

Register 1		Register 2		Register 3	
4845		4C4C		4F21	
48	45	4C	4C	4F	21
H	E	L	L	O	!

Modbus Error Responses

If the inverter receives an unsupported Modbus request, it returns an exception response informing the Modbus master of the nature of the error.

The Modbus Error Response message has two fields that differentiate it from a normal response: Function Code Field, and Data Field.

Function Code Field

In a normal response, the inverter echoes the function code of the original request in the function code field of the response. All the function codes have a most-significant bit (MSB) of 0 (their values are all below 0x80).

In an exception response, the inverter sets the MSB of the function code to 1. This makes the function code value in an exception response exactly 0x80 higher than the value for a normal response. For example, a normal response of 0x03 (Read Holding Registers), becomes 0x83 (Unable to Read Holding Registers).

Data Field

In an error response, the inverter uses the data field of the response packet to return an error code to the Modbus Master. Four error codes are supported, as shown in Table 18.

Table 18 Modbus error codes

Error code	Error name	Error description
01	Illegal Function	The inverter does not support the function code specified in the Modbus Request Packet.
02	Illegal Address	The address range specified in the Modbus Request Packet contains an illegal register address.
03	Illegal Data Value	The Modbus Request Packet contains an illegal number of bytes in the data field.
04	Slave Device Failure	An unrecoverable error occurred while the inverter (slave) was attempting to perform the requested action

Modbus Error Response Example

A Modbus master requests 22 registers at address 0x0014 using the following query:

Table 19 Request packet

Slave	Function	Start registers		# of registers (1)		CRC checksum	
01	03	00	14	00	16	84	00

In this case, 0x0014 is a valid address, but the range from 0x0014 to 0x001F has two missing registers at addresses 0x001E, and 0x001F, so the inverter responds with an “Illegal Address” error response.

The response packet is shown in Table 20.

Table 20 Response packet

Slave	Function	Error code	CRC checksum	
01	03	02	A1	31

Conext RL Modbus Map

The Modbus map defines the location of the Conext RL registers, which can be used to retrieve the status information or to control the inverter.

The Modbus map is defined as a data table, the columns of which define the register attributes. (The following sections describe each of the columns in the table.) The Modbus registers are defined one per row.

The Modbus map is shown in Table 23.

Modbus Address

The addresses in the Modbus map are zero-based and are specified in hexadecimal notation, so that they correspond directly with the address field specified in the Modbus Request Packet. This makes it easier to troubleshoot when capturing the data “over-the-wire”.

If you need to enter these values into the data definition file of a Modbus Master device, which is expecting a “Register Number”, you need to convert the address to decimal (base 10), and add one to the address.

For example, the “Operational Mode State” register is at address 0x1700.

0x0x1700 = 5888 decimal.

Adding one to this gives a Register Number of 5889.

Modbus Register Description

The Description column provides brief details about the purpose of the Modbus register, for example, “Energy Since Commissioning”, or “Operational Mode State”.

Modbus Register Access type

The Access types may be either “Read Only” or “R/W” (Read/Write). The values of “Read Only” registers cannot be changed via Modbus, so they cannot be used to configure or alter the behavior of the inverter in any way. The “Read/Write” registers may be altered at run-time and may directly affect the operation of the inverter.

Modbus Register Units

The Units column specifies two pieces of information separated by a / symbol. The first is the units of the value contained in the register, for example, kWh, V, A, Vrms. The second is the scaling factor to convert the raw binary value contained within the register to the units specified before the / symbol.

Table 21 Scale factor in the Units column

Scale factor	Action
X1	No divide necessary: result equals raw value
X10	Divide raw value by 10 to yield the result
X100	Divide raw value by 100 to yield the result

For example, if the Units column is kWh/X10, and the raw value retrieved from the Modbus register is 24, divide this value by 10 to yield 2.4 kWh.

Modbus Register Size

The Size column specifies the total size of the data at the register address specified by the Address column.

Examples:

Table 22 Modbus Register size and total size of data

Size	Number of bytes	Number of 16-bit Modbus registers
8-bit unsigned integer x 20	20 bytes	10
32-bit unsigned integer	4 bytes	2
32-bit signed integer	4 bytes	2
16-bit signed integer	2 bytes	1
16-bit unsigned integer	2 bytes	1

Invalid Registers

In the inverter Modbus register map, there are gaps between some registers. For example, the next register after 0x17F4 is 0x17F8. The unmapped registers (0x17F5 through to 0x17F7) are **invalid**. The requests to read data from invalid registers generate an “Invalid Address” exception. When an invalid register is written, the inverter responds with an “Invalid Address” exception. For an example of this, see “Modbus Error Response Example” on page 21.

Invalid Data

If the value or the data written to an address is out of range, the inverter returns ExceptionCode = 02.

For example, the valid ranges for address 0xFA61 are +80 to +100 and -80 to -100. If the value 35 or -150 is written to the address, the inverter returns ExceptionCode = 02.

Modbus Map

For a complete description of the Conext RL registers available via Modbus, see Table 23.

Table 23 Modbus map

Address (hexadecimal)	Description	Access	Units	Size
0x0001 - 0x0009	Product Model Designation	Read Only	“C” style null terminated ASCII string	Uint8 x 18

Table 23 Modbus map (Continued)

Address (hexadecimal)	Description	Access	Units	Size
0x0014 - 0x001D	Serial Number	Read Only	"C" style null terminated ASCII string	Uint8 x 20
0x0082 - 0x008B	Software Part Number for Processor A	Read Only	"C" style null terminated ASCII string	Uint8 X 20
0x0096 - 0x009F	Software Part Number for Processor B	Read Only	"C" style null terminated ASCII string	Uint8 X 20
0x00AA-0x00B3	Software Part Number for Processor C	Read Only	"C" style null terminated ASCII string	Uint8 X 20
0x0802 (H word) - 0x0803 (L word)	Energy since Commissioning	Read Only	KWhr/X10	32 bit unsigned integer
0x0804(H word), 0x805 (L word)	Energy Today	Read Only	KWhr/X10	32 bit unsigned integer
0x0806, 0x807	Energy Today (1 day earlier)	Read Only	KWhr/X10	32 bit unsigned integer
0x0808, 0x809	Energy Today (2 days earlier)	Read Only	KWhr/X10	32 bit unsigned integer
0x080A, 0x80B	Energy Today (3 days earlier)	Read Only	KWhr/X10	32 bit unsigned integer
0x080C, 0x80D	Energy Today (4 days earlier)	Read Only	KWhr/X10	32 bit unsigned integer
0x080E, 0x80F	Energy Today (5 days earlier)	Read Only	KWhr/X10	32 bit unsigned integer

Table 23 Modbus map (Continued)

Address (hexadecimal)	Description	Access	Units	Size
0x0810, 0x811	Energy Today (6 days earlier)	Read Only	KWhr/X10	32 bit unsigned integer
0x081E, 0x081F	Operating Hours	Read Only	Hr/x1	32 bit unsigned integer
0x1700	Operational Mode State	Read Only	Enum 0x0002 Reconnecting 0x0003 Online 0x0014 Standby 0x0015 No DC 0x0016 Alarm	16 bit unsigned integer
0x1701	Temperature 1, NTC on control board	Read Only	C/x10	16-bit signed integer
0x1702	Temperature 2, Boost module 1	Read Only	C/x10	16-bit signed integer
0x1703	Temperature 3, Boost module 2	Read Only	C/x10	16-bit signed integer
0x1704	Temperature 4, Inverter module	Read Only	C/x10	16-bit signed integer
0x17F1	Apparent Power	Read Only	kVA/x10	16-bit signed integer
0x17F4	Reactive Power	Read Only	kVAr/ X10	16-bit signed integer
0x17F8	Grid voltage	Read Only	Vrms/x10	16-bit signed integer
0x17FB	Phase A current	Read Only	Arms/x10	16-bit signed integer
0x17FF	PV1 voltage	Read Only	V/x10	16-bit signed integer

Table 23 Modbus map (Continued)

Address (hexadecimal)	Description	Access	Units	Size
0x1800	PV1 Current	Read Only	A/x10	16 bit signed integer
0x1801	PV1 Power	Read Only	kW/x10	16 bit signed integer
0x1828	Fault Code	Read Only	See Alarm (section 4) and Installation and Operation Manual	16 bit unsigned integer
0x180D	DC Voltage	Read Only	V/x10	16 bit unsigned integer
0x1802	Grid Frequency	Read Only	Hz/x10	16 bit unsigned integer
0x1829	PV2 Voltage	Read Only	V/X10	16 bit signed integer
0x181B	Real Power	Read only	kW/x10	16 bit signed integer
0x182A	PV2 Current	Read Only	A/X10	16 bit signed integer
0x182F	PV2 Power	Read Only	kW/x10	16 bit signed integer
0xF9ED	Power Ramp Up Recover Time	R/W	Increment = 0.01sec Range: 0 to 600 seconds Enter: 0 to 60000 Default: 30000	16 bit unsigned integer

Table 23 Modbus map (Continued)

Address (hexadecimal)	Description	Access	Units	Size
0xF9EE	Cos(φ) Lock-in Voltage	R/W	Increment: 0.1V Range: 230.0 to 253.0 V Enter: 2300 to 2530 Default: 2415	16 bit unsigned integer
0xF9EF	Cos(φ) Lock-out Voltage	R/W	Increment: 0.1V Range: 225.4 to 230.0 V Enter: 2254 to 2300 Default: 2300	16-bit unsigned integer

Table 23 Modbus map (Continued)

Address (hexadecimal)	Description	Access	Units	Size
0xF9F0	KVAr(U) Lock-in Power%	R/W	Increment: 1% Range: 10 to 100% Enter: 10 to 100 Default: 20	16-bit unsigned integer
0xF9F1	KVAr(U) Lock-out Power%	R/W	Increment: 1% Range: 5 to 95% Enter: 5 to 95 Default: 15	16-bit unsigned integer
0xF9FB	User Phase Angle *	R/W	Increment = 1 deg Range: +37 capacitive (leading) to -37 inductive (lagging) Enter:+/- 37 Default = 0 degrees	16bit signed integer

Table 23 Modbus map (Continued)

Address (hexadecimal)	Description	Access	Units	Size
0xFA19	User Active Power Reference	R/W	kW /x10 Increment = 0.1 kW Range: 0 to 30 for 0kW- 3kW 0 to 40 for 0kW - 4kW 0 to 50 for 0kW - 5kW Enter: 0 to 50 depending on model Default: 30,40,50 depending on model	16 bit unsigned integer

Table 23 Modbus map (Continued)

Address (hexadecimal)	Description	Access	Units	Size
0xFA1B	User Reactive Power Reference	R/W	kVAr /x10 Increment = 0.1 kVAr Range: 0 to 17 for 0 to1.7 kVar for 3kW 0 to 23 for 0 to 2.3kVAr for 4kW 0 to 28 for 0 to 2.8kVAr for 5kW Range: 0 to-17 for 0 to -1.7 kVAr for 3kW 0 to -23 for 0 to - 2.3kVAr for 4kW 0 to -28 for 0 to - 2.8kVAr for 5kW Enter: 0 to +/-28 based on model Default: 0	16 bit signed integer
0xFA60	Reactive Power Mode Select	R/W	0: Disable (Default) 1: Fixed cos(φ) 2: cos(φ) as function of P 3: Fixed kVAr 4: kVAr as function of U	16 bit unsigned integer

Table 23 Modbus map (Continued)

Address (hexadecimal)	Description	Access	Units	Size
0xFA61	Fixed_Cos(φ)	R/W	Increment = 1 unit Range: capacitive 0.80 to 1.00 Enter: +80 to +100 inductive: 0.80 to 1.00 Enter: -80 to -100 Default: 100	16 bit signed integer
0xFA62	Cos(φ)with Power Upper limit	R/W	Increment = 1 unit Range: capacitive 0.80 to 1.00 Enter: +80 to +100 inductive: 0.80 to 1.00 Enter: -80 to -100 Default: +90	16 bit signed integer
0xFA63	Cos(φ)with Power Lower limit	R/W	Increment = 1 unit Range: capacitive 0.80 to 1.00 Enter: +80 to +100 inductive: 0.80 to 1.00 Enter: -80 to -100 Default: 90	16 bit signed integer

Table 23 Modbus map (Continued)

Address (hexadecimal)	Description	Access	Units	Size
0xFA64	Cos(φ)with % power Lower limit	R/W	Increment = 1% Range: 0~100% Enter:0-100 Default: 0%	16 bit unsigned integer
0xFA65	Cos(φ)with % power Upper limit	R/W	Increment = 1% Range: 0~100% Default: 100%	16 bit unsigned integer
0xFA66	Fixed kVAr %	R/W	Increment = 1% Range: +53% capacitive (leading) to -53 inductive (lagging) Enter:+/-53 Default: 0%	16 bit signed integer Refer Appendix B for more details
0xFA67	kVAr(U) as % of VA Upper limit	R/W	Increment = 1% Range: -53 to +53% Default: +44%	16 bit signed integer Refer Appendix B for more details
0xFA68	kVAr(U) as % of VA Lower limit	R/W	Increment = 1% Range: -53 to +53% Enter: +/- 53 Default: -44%	16 bit signed integer Refer Appendix B for more details

Table 23 Modbus map (Continued)

Address (hexadecimal)	Description	Access	Units	Size
0xFA69	kVAr(U) Vmin	R/W	Unit: 0.1 V Range: 100~264 V Default: 184V Enter: 1000 to 2640	16 bit unsigned integer
0xFA6A	kVAr(U) Vmax	R/W	Unit: 0.1 V Range: 100~264 V Default: 253V Enter: 1000 to 2640	16 bit unsigned integer
0xFA6B	kVar(U) Uac_Lower limit	R/W	Unit: 0.1 V Range: 100~264 V Default: 230 V Enter: 1000 to 2640	16 bit unsigned integer
0xFA6C	kVar(U) Uac_Upper limit	R/W	Unit: 0.1 V Range: 100~264 V Default: 230 V Enter: 1000 to 2640	16 bit unsigned integer
0xFA6D	kVar(U) Hysteresis	R/W	Unit: 0.1 V Range: 0~30 V Default: 0 V Scale: x10 Enter: 0 to 300	16 bit unsigned integer

Table 23 Modbus map (Continued)

Address (hexadecimal)	Description	Access	Units	Size
0xFA6E	Response Time	R/W	Unit: 0.01 sec Range: 10~60 sec Default: 10 sec Scale: x100 Enter: 1 to 6000	16 bit unsigned integer
0xFA6F	Mode registers	R/W	0: OFF 1: Graph-A 2: Graph-B	16 bit unsigned integer
0xFA70	Actual /rated power	R/W	0: Actual power 1: Rated power	16 bit unsigned integer
0xFA71	Start frequency	R/W	Increment: 0.01HZ Range: 47-63Hz Enter: 47-63 Default: Country specific	16 bit unsigned integer
0xFA72	Stop frequency	R/W	The Value of the stop frequency is calculated as per gradient Refer the Inverter manual and graph	16 bit unsigned integer
0xFA73	Recover frequency	R/W	Increment: 0.01HZ Range: 47-63Hz Enter: 47-63 Refer the Inverter manual since it is dependent on the country selection	16 bit unsigned integer

Table 23 Modbus map (Continued)

Address (hexadecimal)	Description	Access	Units	Size
0xFA74	Gradient	R/W	Increment: 0.1% Range:40-100% Enter: 400-1000 Refer the Inverter manual since it is dependent on country selection	16 bit unsigned integer
0xFA7D	Statism	R/W	Increment: 0.1% Range:2-5% Enter: 20-50 Refer the Inverter manual since it is dependent on country selection	16 bit unsigned integer
0xFA75	Recovery Time	R/W	Increment: 1sec Range: 0-300Sec (ex :Italy) Enter: 0-300 Refer the Inverter manual since it is dependent on country selection	16 bit unsigned integer
0xFA76	Active Power vs frequency Mode	R/W	0: OFF 1: Enabled Default: Enabled	16 bit unsigned integer
0xFA25	LVRT low voltage threshold (H) (Voltage1)	R/W	Range: 20-90% Enter: 0-xx % Refer the Inverter manual since it is dependent on the country selection.	16 bit unsigned integer

Table 23 Modbus map (Continued)

Address (hexadecimal)	Description	Access	Units	Size
0xFA26	LVRT fast low voltage threshold (L) (V-Drop)	R/W	Increment: 1% Range: 0-90% Enter: 0-90% Refer the Inverter manual since it is dependent on country selection.	16 bit unsigned integer
0xFA77	K factor	R/W	Increment: 1% Range: 0-10 Enter: 0-10 Default: 2.0(example:Italy) Refer the Inverter manual since it is dependent on country selection.	16 bit unsigned integer
0xFA78	Dead Band -Vh	R/W	Increment: 1% Range: 0 to +10% Enter: 0 -10% Refer the Inverter manual since it is dependent on country selection	16 bit unsigned integer
0xFA79	Dead band -VL	R/W	Increment: 1% Range: -10 to 0% Enter: -10 to 0 Refer the Inverter manual since it is dependent on country selection	

Table 23 Modbus map (Continued)

Address (hexadecimal)	Description	Access	Units	Size
0xFA7A	Time1	R/W	Increment: 0.01 sec Range: 0-5000 msec Enter: 0-500 Refer the Inverter manual since it is dependent on country selection	16 bit unsigned integer
0xFA7B	Time2	R/W	Increment: 0.01sec Range: 0-5000msec Enter: 0- 500 Refer the Inverter manual since it is dependent on country selection.	16 bit unsigned integer
0xFA7C	Time3	R/W	Increment: 0.01sec Range: 0-5000 msec Enter: 0- 500 Refer the Inverter manual since it is dependent on country selection.	16 bit unsigned integer
0xFAF0	User Active Power management Mode	R/W	0: Inverter rated power (Rated) 1: Inverter Present Power (Actual) Default: 0	16 bit unsigned integer

Table 23 Modbus map (Continued)

Address (hexadecimal)	Description	Access	Units	Size
0xFAF1	User Active Power Management Percentage	R/W	Increment = 1% Range: 0 to 100% Default: 100%	16 bit unsigned integer
0XFAF5	Multifunction relay	R/W	0: Disable 1: Fault/Error/ warning (only 3) 2: Power production 3: External load control 4: Control external Fans Default: 0	16 bit unsigned integer
0XFAF6	Fault1/Error1 code	R/W	Default: 0000(no fault/error) Range: FFFF (All fault/error) Configure the required fault or error	16 bit unsigned integer
0XFAF7	Fault2/Error2 code	R/W	Default: 0000(no fault/error) Range: FFFF (All fault/error) Configure the required fault or error	16 bit unsigned integer

Table 23 Modbus map (Continued)

Address (hexadecimal)	Description	Access	Units	Size
0XFAF8	Fault3/Erro3 code	R/W	Default: 0000 (no fault/error) Range: FFFF (All fault/error) Configure the required fault or error	16 bit unsigned integer
0XFAF9	Power production	R/W	0: Disable 1: Enable Default: 0 (disable) Enable the relay when inverter is exporting the power to the grid	16 bit unsigned integer
0xFAFA	Output power	R/W	kW /x10 Range: 0 to 5.25KW Default: 0 Enter: 0 to 525	16 bit unsigned integer
0xFAFB	Duration	R/W	Range: 0 to XXX minutes Enter: 0 to XXX Default: XXX	16 bit unsigned integer
0xFAFC	Minimum Duration	R/W	Range: 0 to XXX minutes Enter: 0 to XXX Default: XXX	16 bit unsigned integer

Table 23 Modbus map (Continued)

Address (hexadecimal)	Description	Access	Units	Size
0xFAFD	Temperature 1	R/W	C/X10 Range: 0 to XX Degree Enter: 0 to XX Default: xx	16-bit signed integer
0xFAFE	Temperature 2	R/W	C/X10 Range: 0 to XX Degree Enter: 0 to XX Default: xx	16-bit signed integer

Note: If the value is 'XX' or 'XXX' refer the Conext RL User Manual for details.

ALARM (ALERT) CODES

Three types of alarms are defined:

- Warning: The unit reports the warning condition but continues to operate.
- Error: The unit stops operation when the Error condition is detected and the unit automatically recovers if the condition that caused the error goes away.
- Fault: The unit stops operation when the Fault condition is detected. The unit requires manual intervention for clearing the fault to resume operation.

The alarm codes shall be prioritized for reporting purposes since only one active alarm can be reported at a time. The highest priority alarms are faults, followed by errors, and then warnings. If more than one alarm of the same type is active, the one with the higher priority shall be reported. For example, if there are two simultaneous active faults, the one with the higher priority shall be reported.

The Priority numbers are such that the lower number is higher priority, e.g. priority 1 is the highest.

Table 24 Alarm Codes

Alarm Type	Schneider Alarm Code (Decimal)	Priority	Message to Display	Description
Error	0000	18	No Alarm	No Active Alarms
	2402	07	AC Freq High	AC connected Fail
	2401	08	AC Freq Low	Under Frequency Range
	2440	17	Grid Quality	Grid Quality
	2110	16	HW Connect Fail	AC connected Fail
	2450	15	No Grid	No Grid
	2406	09	AC Volt Low	Under Voltage Range_R
	2407	03	AC Volt High	Over Voltage Range_R
	2407	04	AC Volt High	Slow Over Voltage Range_R
	2606	12	PV Voltage High	String1 PV input voltage too high
	2606	13	PV Voltage High	String2 PV input voltage too high
	2403	10	Slow Over Frequency Range	Slow Over Frequency Range R
	2404	11	Slow Under Frequency Range	Slow Over Frequency Range R
	2408	12	Slow Under Voltage Range	Slow Under Voltage Range R

Table 24 Alarm Codes (Continued)

Alarm Type	Schneider Alarm Code (Decimal)	Priority	Message to Display	Description
	2616	14	Isolation Impedance Error	Insulation
Warning	6627	2	PV OC Voltage Low	SOLAR_1_UVR
	6627	3	PV OC Voltage Low	SOLAR_2_UVR
Fault	0701	32	DC Injection	DC Injection_R
	0084	18	Thermal Condition (OTP)	Over Temperature Protection
	0032	19	Thermal Sensor 1	Heat Sink Ntc1 Circuit Fail
	0080	20	Thermal Condition (LTP)	Lower Temperature Protection
	0103	21	Thermal sensor 2	Heat Sink Ntc2 Circuit Fail
	0104	22	Thermal Sensor 3	Heat Sink Ntc3 Circuit Fail
	0105	23	Thermal Sensor 4	Heat Sink Ntc4 Circuit Fail
	0010	29	AC Switch Response	Relay Open
	0120	35	Analog Input Bias 1	DSP ADC Vgrid/Iout Bias Fail
	0121	36	Analog Input Bias 2	DSP ADC Vin/ Vbus Bias Fail
	0122	37	Analog Input Bias 3	DSP ADC Iin/ Iboost Bias Fail

Table 24 Alarm Codes (Continued)

Alarm Type	Schneider Alarm Code (Decimal)	Priority	Message to Display	Description
	0123	38	Analog Input Bias 4	Red. ADC Vgrid/Vinv Bias Fail
	0124	39	Analog Input Bias 5	Red. ADC Iout_dc Bias Fail
	0130	28	HW Efficiency	Efficiency Abnormal
	0095	41	HW COMM2	Internal Communication Fault (between Redundant)
	0195	42	HW COMM1	Internal Communication Fault (between Display)
	0702	26	Ground Current High	Residual Current Over Rating
	0140	25	RCMU Fault	RCMU Circuit Fail
	0150	30	Relay Test S/C	Relay Test Short
	0151	31	Relay Test O/C	Relay Test Open
	0601	15	Overvoltage DC	Bus voltage over rating
	0460	14	AC current high	Output Current Transient Over Rating_R
	0460	13	AC current high	Output Current Over Rating_R
	0031	04	Current Sensor	CT current sensor Fail_A

Table 24 Alarm Codes (Continued)

Alarm Type	Schneider Alarm Code (Decimal)	Priority	Message to Display	Description
Fault	0461	01	AC Over Current	HW OOCP circuit
	0160	40	HW ZC Fail	Zero Cross Circuit Fail
	0620	20	DC Overcurrent	PV1 Current Over Rating
	0621	06	DC Overcurrent	PV2 Current Over Rating
	0620	07	DC Overcurrent	PV1 Current Transient Over Rating
	0621	08	DC Overcurrent	PV2 Current Transient Over Rating

Appendix A: CRC-16 calculation

This appendix describes how to obtain the CRC-16 error check field for a Modbus RTU frame.

A frame can be considered as a continuous, serial stream of binary data (ones and zeros). The 16-bit checksum is obtained by multiplying the serial data stream by 2^{16} (10000000000000000) and then dividing it by the generator polynomial $x^{16}+x^{15}+x^{2}+1$, which can be expressed as the 16-bit binary number 11000000000000101.

The quotient is ignored and the 16-bit remainder is the checksum, which is appended to the end of the frame.

In calculating the CRC, all the arithmetic operations (additions and subtractions) are performed using MODULO TWO, or EXCLUSIVE OR operation. A step-by-step example shows how to obtain the checksum for a simple Modbus RTU frame.

To generate the CRC-16 checksum:

1. Drop the MSB (Most Significant Bit) of the generator polynomial and reverse the bit sequence to form a new polynomial. This yields the binary number 1010 0000 0000 0001, or 0xA001.
2. Load a 16-bit register with initial value 0xFFFF.
3. Exclusive OR the first data byte with the low-order byte of the 16-bit register. Store the result in the 16-bit register.
4. Shift the 16-bit register one bit to the right.
5. If the bit shifted out to the right is one (1), Exclusive OR the 16-bit register with the new generator polynomial, store the result in the 16-bit registers. Return to step 4.
6. If the bit shifted out to the right is zero (0), return to step 4.
7. Repeat steps 4 and 5 until 8 shifts have been performed.
8. Exclusive OR the next data byte with the 16-bit register.
9. Repeat steps 4 through 7 until all bytes of the frame are Exclusive OR with the 16-bit register and shifted 8 times.

The content of the 16-bit register is the checksum and is appended to the end of the frame.

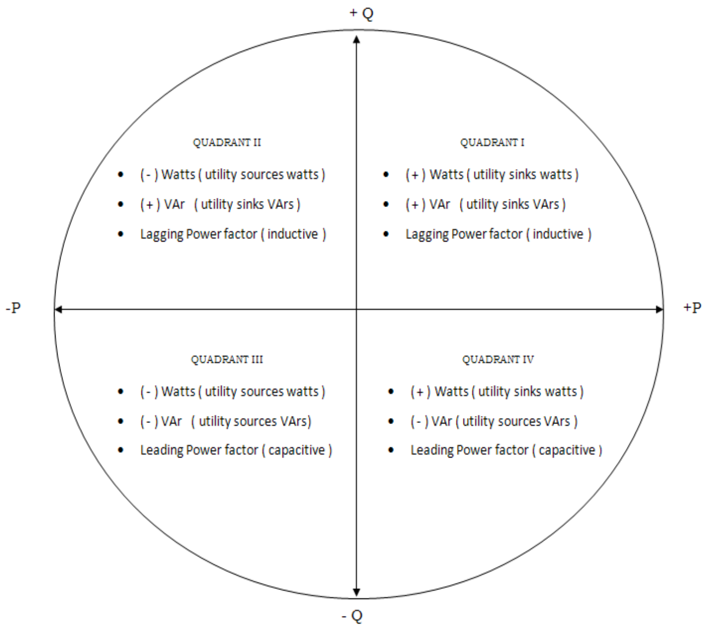
Pseudocode For CRC-16 Generation

For users familiar with computer programming, the following is the pseudocode for calculating the 16-bit Cyclic Redundancy Check.

```
Initialize a 16-bit register to 0xFFFF

Initialize the generator polynomial to 0xA001

FOR n=1 to # of bytes in packet

    BEGIN

    XOR nth data byte with the 16-bit register

    FOR bits_shifted = 1 to 8

        BEGIN

            SHIFT 1 bit to the right

            IF (bit shifted out EQUAL 1)

                XOR generator polynomial with the 16-bit register and
                store result in the 16-bit register

        END

    END
```

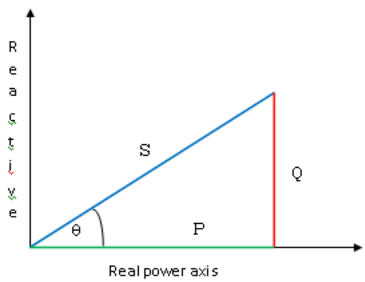
The resultant 16-bit register contains the CRC-16 checksum.

Appendix B: Leading and Lagging Power Factors



Notes on the above figure:

- All the above is as seen from the utility's perspective (looking toward the inverter).
- The direction of **reactive** power flow determines **leading** or **lagging** power factor.
- The terms **leading** and **lagging** always refer to the current with respect to the voltage.



In the above figure:

- S = Apparent power; has dimensions of volt-amps (VA)
- P = Active or real power; has dimensions of watts (W)
- Q = Reactive power; has dimensions of volt-amp-reactive (VAr)
- PF = power factor; has no units. It is defined as the cosine of angle θ (the ratio of P over S)

Exclusion for Documentation

UNLESS SPECIFICALLY AGREED TO IN WRITING, SELLER
(A) MAKES NO WARRANTY AS TO THE ACCURACY, SUFFICIENCY OR SUITABILITY OF ANY TECHNICAL OR OTHER INFORMATION PROVIDED IN ITS MANUALS OR OTHER DOCUMENTATION;
(B) ASSUMES NO RESPONSIBILITY OR LIABILITY FOR LOSSES, DAMAGES, COSTS OR EXPENSES, WHETHER SPECIAL, DIRECT, INDIRECT, CONSEQUENTIAL OR INCIDENTAL, WHICH MIGHT ARISE OUT OF THE USE OF SUCH INFORMATION. THE USE OF ANY SUCH INFORMATION WILL BE ENTIRELY AT THE USER'S RISK; AND
(C) REMINDS YOU THAT IF THIS MANUAL IS IN ANY LANGUAGE OTHER THAN ENGLISH, ALTHOUGH STEPS HAVE BEEN TAKEN TO MAINTAIN THE ACCURACY OF THE TRANSLATION, THE ACCURACY CANNOT BE GUARANTEED. APPROVED CONTENT IS CONTAINED WITH THE ENGLISH LANGUAGE VERSION WHICH IS POSTED AT WWW.SCHNEIDER-ELECTRIC.COM.

Date: January 2014 **Revision:** Revision A **Document Number:** 976-2110-01-01

Contact Information

www.schneider-electric.com

	?		?
N. America	1 408 987 6255	1 925 245 1022	re.techsupport@schneider-electric.com
France	+33 (0) 825 012 999		
Deutschland	+49 (0) 180 575 3 575	+49 (0) 2102 404 7101	pv-service@de.schneider-electric.com
España	+34 902 101813	+34 93 305 5026	es-sat@es.schneider-electric.com
L'Italia	+39 035 4151111	+39 035 4153200	IT-pronto-contatto@it.schneider-electric.com
Nederland	0031 235 124124	0031 235 124111	salesassistance@nl.schneider-electric.com

For other country details, contact your local Schneider Electric Sales Representative or visit our website at:
http://www.schneider-electric.com/sites/corporate/en/support/operations/local-operations/local-operations.page