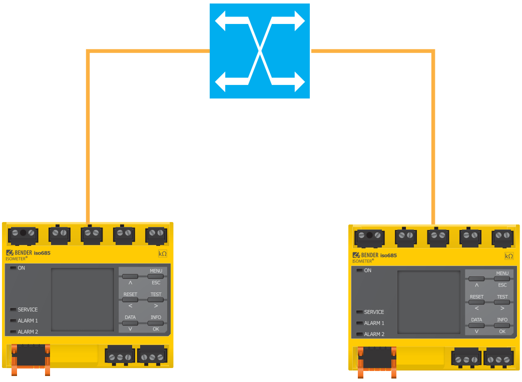
EN Manual

The Power in Electrical Safety™

Modbus/TCP Integration



Reference guide for integrating Bender equipment into Modbus/TCP networks

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1. Introduction

1. 1 What This Manual Provides

This manual is intended as a reference guide for system integrators and IT professionals to integrate Bender equipment into Modbus/TCP networks. It provides:

- Overview of Bender communication topology
- Instructions for integrating Bender equipment into Modbus/TCP masters
- Reference for common data points

This manual assumes the following:

- The Modbus/TCP network is installed by qualified personnel
- The Bender equipment has already been installed into the electrical system by qualified maintenance personnel

1. 2 What This Manual Does NOT Provide

This manual is designed ONLY for technicians who are otherwise qualified to integrate Bender equipment into Modbus/TCP networks. It does NOT provide the following:

- Installing, setting, or troubleshooting Modbus/TCP or Ethernet networks
- Installing, setting, or troubleshooting Modbus/TCP masters
- Installing, setting, or troubleshooting third party devices
- Installing, setting, or troubleshooting Bender devices not related to communication (i.e. electrical system installation, setup, etc.)

If you are not otherwise qualified to install this equipment, do not proceed with installation and consult a system integrator or manufacturer of the Modbus/TCP hardware and software. Installation of Bender equipment into an electrical system shall only be performed by qualified maintenance personnel.

1. 3 Modbus/TCP Master Used As Example

For the purposes of instruction in this manual, Modbus/TCP master simulation software was used. Masters vary by manufacturer and application and will vary from what is shown in this manual. Typical Modbus/TCP masters include programmable logic controllers (PLC) and custom software.

2. Safety Instructions

2. 1 General Safety Warning

DANGER

Hazard of Electric Shock, Burn, or Explosion

Only qualified maintenance personnel should operate or service this equipment. These instructions should not be viewed as sufficient for those who are not otherwise qualified to operate or service this equipment. No responsibility is assumed by BENDER for any consequences arising from use of this document.

Turn OFF all sources of electric power before performing any inspections, tests, or service on this equipment. Assume all circuits are live until they have been properly de-energized, tested, grounded, and tagged. Failure to observe these precautions will result in equipment damage, severe personal injury, or death.

Proper operation of this equipment depends on proper installation. Refer to all federal, state, and local standards and codes for installation standards. Neglecting fundamental installation techniques will result in equipment damage, severe personal injury, or death.

Do not make any modifications to the equipment. Failure to observe this precaution will result in equipment damage or personal injury.

Use only manufacturer's and manufacturer recommended accessories with this equipment. Failure to do so may damage the equipment beyond repair.

2. 2 Using This Manual

Read these instructions carefully and become familiar with the equipment before attempting to install, operate, or service it. Throughout this manual, special messages may appear to warn of potential safety hazards or to call attention to information which clarifies instructions or procedures. Observe all safety messages that appear throughout this manual to avoid possible injury or death. An explanation of these symbols is given below.

DANGER

DANGER: *Indicates a hazardous situation which, if not avoided,* ***will*** *result in death or severe injury.*

WARNING

WARNING: *Indicates a potentially hazardous situation which, if not avoided, may result in death or injury.*

CAUTION

CAUTION: *Indicates a potentially hazardous situation which, if not avoided, may result in injury or equipment damage.*

NOTE: *Provides additional information to clarify instructions for a product or procedure.*

3. Compatible Devices

3. 1 BCOM-Compatible Equipment

Devices designated as "BCOM-Compatible" are devices which have built-in Modbus/TCP support and RJ45 connectors. These devices connect directly to a Modbus/TCP network. Bender devices with this capability include, but are not limited to:

- iso685 ground fault detector (including connected EDS440 ground fault location modules)
- PEM735 power quality meter

3. 2 Bender RS-485 Equipment

Devices with communication capability over RS-485 require a communication gateway for Modbus/TCP communication. Devices with this capability include, but are not limited to:

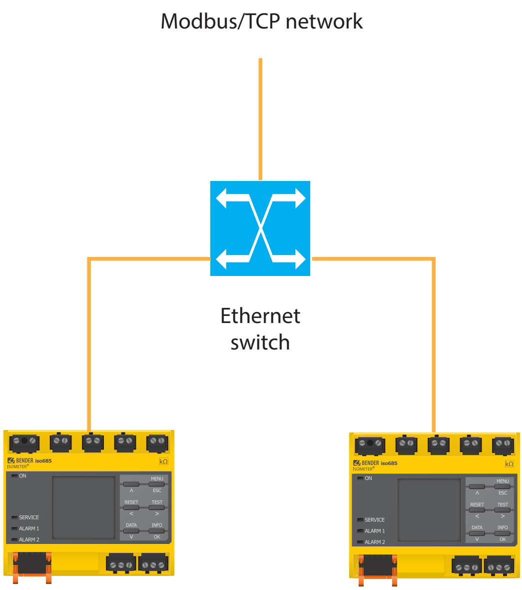
- IRDH275B / IRDH375B / IRDH575 ground fault detectors
- isoPV series solar ground fault detector
- LIM2010 line isolation monitor
- EDS460 / EDS490 / EDS440-L ground fault location modules
- RCMS460 / RCMS490 multi-channel ground fault monitors
- RCMA421-DCB / RCMA426-DCB GFCI modules

4. Bender Network Topology and Installation

4. 1 Connecting Bender BCOM-Compatible Equipment

Bender devices designated as "BCOM-compatible" have built-in Modbus/TCP support. The devices do not require a Bender communication gateway. BCOM-compatible devices connect directly to an Ethernet network using an RJ45 cable, typically via an Ethernet switch. Refer to figure below.

All queries from the Modbus master are sent to the individual devices, identified by their unique IP addresses. Responses are sent from the individual Bender device. BCOM address assignment is not necessary for Modbus/TCP networks.



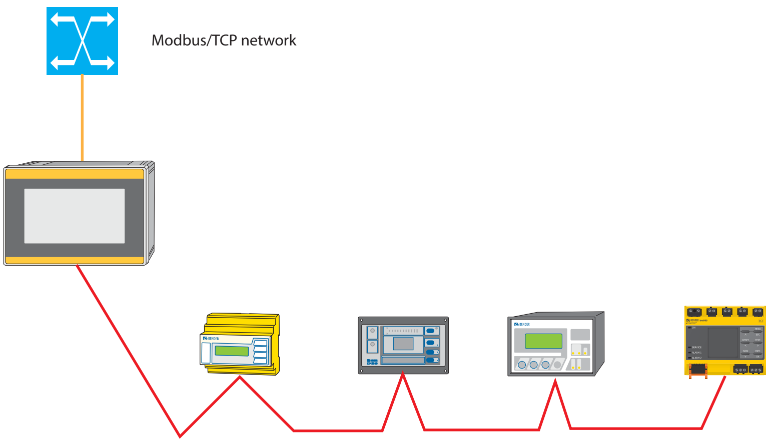
4. 2 Connecting Bender RS-485 Equipment

Bender devices which use RS-485 for communication require the use of a Bender COM465IP or CP700 to act as a gateway between the Bender RS-485 network and the Modbus/TCP network. Refer to figure below.

RS-485 devices are connected in a daisy-chain configuration. Order of devices is unimportant. Termination resistors must be placed / activated at the beginning and ending of the chain. Most devices have a switch to enable this resistor. The communication gateway is then connected to the Modbus/TCP network with an RJ45 cable.

Each Bender RS-485 device MUST have a unique address. This address is configured on the device itself. Refer to the applicable user manual for instructions on assigning an address.

For this topology, all queries from the Modbus master are sent to the IP address of the COM465IP or CP700. Based on the query, the communication gateway will parse the requested data from the respective Bender device. Responses will be always be sent from the communication device to the Modbus master. Refer to the COM465IP / CP700 user manual for instructions regarding installation and IP settings.



5. Reading Data - BCOM-Compatible Devices

5. 1 General Setup

5.1.1 Enable Modbus Control Where Applicable

Some Bender devices may require enabling Modbus Control before data can be accessed. Typically, this feature is enabled either through the device's menu settings, or through the built-in web server. Refer to the applicable device-specific user manual for more information.

5.1.2 IP Information

IP address: Use the unique IP address assigned to the device.

Port: 502

5. 2 Reading Data

NOTE: *Locate the data table for the correct device in Section 7. 1. The table contains information for common data points acquired through BCOM-compatible devices.*

5.2.1 Create Query

Locate the data table for the applicable device in Section 7. 1. In order to build the request string, locate the values listed below using the data in Section 7.1.

Type	**No. of bytes**	**Description**
Transaction ID	2	Dictated by Modbus master (i.e. 0x0000)
Protocol identifier	2	0x0000
Length	2	0x0006 (number of bytes following this in the request string)
Unit identifier	1	BCOM address set for the device
Function code	1	0x03 (Read Holding Registers)
Starting address	2	Found in Section 7. 1 under column "Starting Address," given in Hexadecimal value
Number of registers	2	Found in Section 7. 1 under column "Number of Registers"

Concatenate the values together in hexadecimal to create the request string, which is a total of 11 bytes. Refer to Section 5. 3 for an example compiled string.

Additionally, the following information is not used to build the request string, but is required for proper interpretation of the response:

Type	**Description**
Response format and measurement units	Found in Section 7. 1 under columns "Format" and "Scale / Units"

5.2.2 Interpreting Response

Data is returned as a hexadecimal value. Refer to the value in Section 7. 1. The columns "Format" and "Scale / Units" show the formatting of the response, as well as the magnitude and the units of measurement. For general use, The Modbus master must be able to combine the values returned in each register, convert the value from Hexadecimal to the appropriate format, and scale the unit accordingly.

5. 3 Example

The following is used for the purposes of this example:

- A PEM735 power quality meter
- IP address configured as 192.168.0.253
- BCOM address configured as 1
- Obtaining the voltage of L1 to the neutral (L1-N voltage), which is currently measured as 276.31 V

Refer to Section 7.1.2. Locate the value "Voltage, L1-N." The following information is given for the value:

- Starting register: 0000 (decimal value)
- Number of registers: 2
- Format: Float (floating point number)
- Scale / units: V (units in volts, scale of x1)

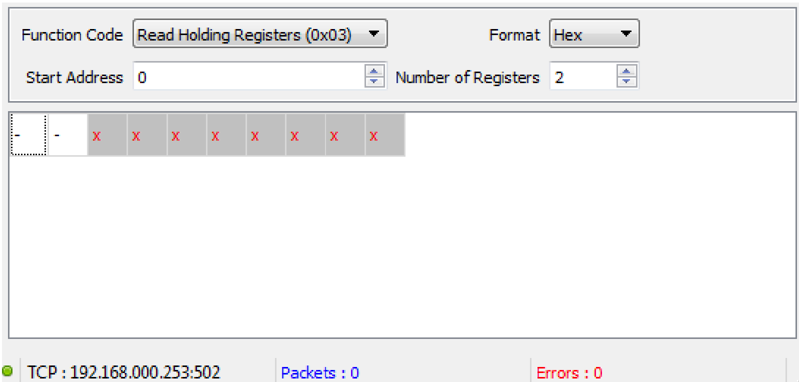
Use the table in Section 5.2.1 to compile the information required for the request string:

- Transaction ID: 0x0000
- Protocol identifier: 0x0000
- Length: 0x0006
- Unit identifier: 0x01
- Function code: 0x03
- Starting address: 0x0000
- Number of registers: 0x0002

Concatenate the values together to create the request string:

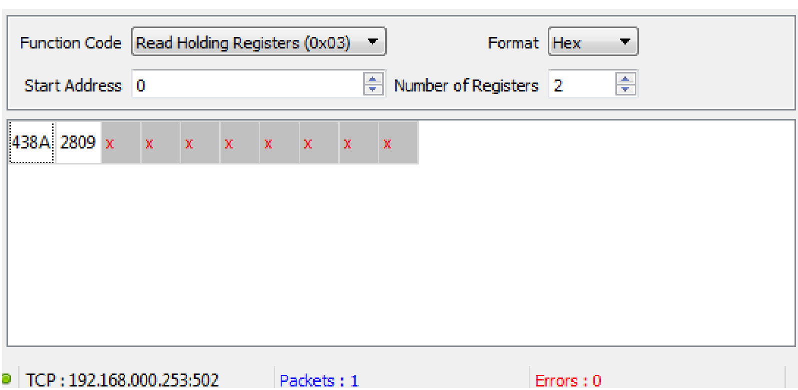
00 00 00 00 00 06 01 03 00 00 00 02

General query information using master simulation software is shown below:



After the query is sent, the response will be returned in a hexadecimal value. In this example, the values returned in each register are:

- Register 0: 438A
- Register 1: 2809



Concatenate the two values to form a hexadecimal number. In this example, the final value is 438A2809.

According to Section 7.1.2, the L1-N value is a floating point number. For general use, follow the steps below. Typically, Modbus masters, their associated software, and/or the end user's control system may be able to perform these functions.

- Convert the value from hexadecimal to a floating point number
- Convert the floating point number into a decimal value

Converting to a floating point number gives the requested value of 276.31. According to Section 7.1.2, the units of the number are in volts, and the scale is multiplied by 1. The final value is determined to be 276.31 V.

5. 4 Reading Data and Additional Information

Some devices, such as the iso685, provide an additional two registers to each value providing additional information such as alarm status and units of measurement. To retrieve this information, a four-register query is required. Additional information requests vary by device. Refer to the respective device's user manual for more information.

6. Reading Data - RS-485 Devices

6. 1 General Setup

6.1.1 Enable Modbus Control on COM465IP / CP700

Modbus control must be enabled on the communication gateway before Modbus actions may take place. Follow the steps below:

- Using a web browser on a PC connected to the network, log into the built-in web server. Enter the IP address of the gateway into a web browser.
- Go to "Bus Overview."
- Select the gateway device (COM465IP or CP700).
- Select "Menu."
- Select "Settings."
- Under the Settings Menu, Select "Interface," then "Modbus."
- Under Modbus, set option Control to ON.
- Under Modbus/TCP, set option Modbus/TCP to ON.
- Close the web browser.

6.1.2 IP Information

IP address: For all requests, use the IP address assigned to the communication gateway.

Port: 502

6. 2 Reading Data

NOTE: *This section requires referencing the following tables located at the end of this manual:*

- *Channel designation table for the appropriate device, located in Section 7.2.5 through Section 7.2.8*
- *Channel memory table in Section 7.2.1*
- *Alarm state codes table in Section 7.2.2*
- *Unit codes table in Section 7.2.3*
- *Measurement details table in Section 7.2.4*

6.2.1 Determine Starting Register Manually

The Modbus process image is stored in the communication gateway. In order to retrieve the desired value, the starting address must be determined. The address is composed of two parts:

- The RS-485 (BMS) address of the device
- *The "channel" where the value is stored.*

Values stored in each channel vary by device:

- Single monitoring point devices: Devices such as the IRDH275 and LIM2010 monitor a single system or branch. Each channel stores a different measurement reading. For example, the LIM2010 stores the Total Hazard Current value in one channel, and the transformer load in a different channel.
- Multi-branch devices: Devices with multiple monitoring points, such as the RCMS490, have 12 separate monitoring points. The first 12 channels are used to store each respective ground fault measurement. Channels after this are used for other values not related to a specific branch.

To determine the starting address, follow the steps below:

1 Locate the RS-485 address for the targeted device.

2 Determine the desired channel. Locate the correct channel designation table in Section 7.2.5 through Section 7.2.8. The table will show channel designations for alarms for common devices. If the device is not listed, refer to the device specific manual for more information.

3 Refer to the figure below. This figure is also found in Section 7.2.1. Locate the desired channel in the table. Add the hexadecimal number in the left-most “LoByte” column together with the STARTING hexadecimal number in the group above it.

Memory image of a BMS device																
LoByte	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0x00	------------------------- Device type --------------------------										------ Time stamp ------				C D	R.
0x10	Channel 1				Channel 2				Channel 3				Channel 4			
0x20	Channel 5				Channel 6				Channel 7				Channel 8			
0x30	Channel 9				Channel 10				Channel 11				Channel 12			
0x40	Channel 13				Channel 14				Channel 15				Channel 16			
0x50	Channel 17				Channel 18				Channel 19				Channel 20			
0x60	Channel 21				Channel 22				Channel 23				Channel 24			
0x70	Channel 25				Channel 26				Channel 27				Channel 28			
0x80	Channel 29				Channel 30				Channel 31				Channel 32			

For example, Channel 2 is targeted. Using the table above, Combine the value in the left column (10) with the starting value designed for channel 2 (4) to obtain 14.

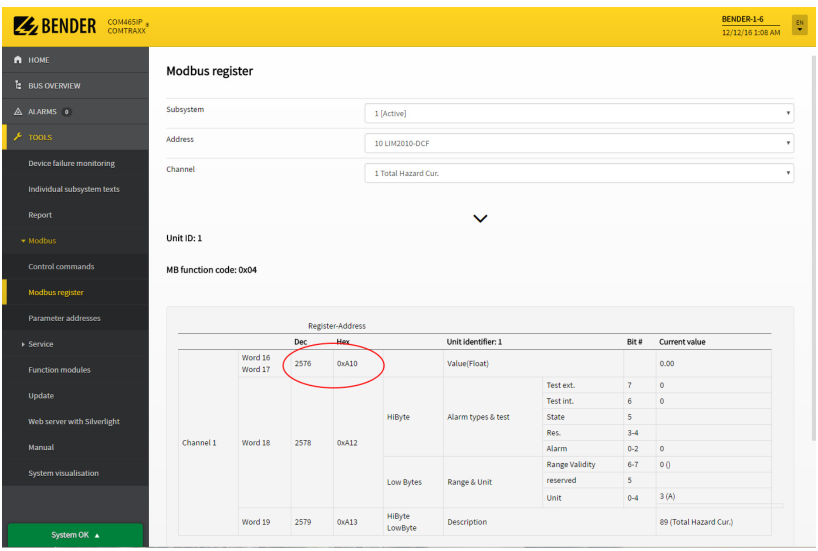
4 Concatenate the BMS address with the number obtained in Step 3 to obtain the final starting register. For example, an RS-485 device with address 2 would be combined with the above value of 14 to obtain a value of 214. This is the final starting register for the value at Address 2, Channel 2.

6.2.2 Determine Starting Register Using The Web Interface

NOTE: *This method is only for requests using Function Code 4.*

The web interface for the COM465IP and CP700 provides a method for automatically determining the starting register for a desired value.

1. Navigate to the web interface of the connected COM465IP / CP700 by entering the IP address into the web browser.
2. Under the main menu, open the menu option "Tools."
3. Under the menu option "Modbus," select the menu option "Modbus register."



Select the following for each menu option:

- Subsystem: Select the subsystem containing the device (typically 1). The number listed is the Unit ID in the request.
- Address: Select the specific device requested.
- Channel: Select the requested value.

The number circled in the image above is the starting register for the value. The column "Dec" is the starting register as a decimal number, and "Hex" is the starting register as a hexadecimal number.

6.2.3 Create Query

The query from the master is set up as follows:

Type	No. of bytes	Description
Transaction ID	2	Dictated by Modbus master (i.e. 0x0000)
Protocol identifier	2	0x0000
Length	2	0x0006 (number of bytes following this in the request string)
Unit identifier	1	Subsystem address for device as defined in connected COM465IP / CP700 (typical / default value of 0x01)
Function code	1	0x04 (Read Input Registers)
Starting address	2	Value determined using instructions in Section 6.2.1
Number of registers	2	0x0004

Concatenate the values together in hexadecimal to create the request string, which is a total of 11 bytes. Refer to Section 6. 3 and Section 6. 4 for example compiled strings.

Additionally, the following information is not used to build the request string, but is required for proper interpretation of the response:

Type	Description
Response format and measurement units	Refer to Section 6.2.4, “Interpreting Response”

6.2.4 Interpreting Response

The response is broken down into four parts across the four response registers. An example is given below:

3BE0 9FE8	05	03	0059
1	2	3	4

1 The requested value. The value is a floating point number stored in hexadecimal format. This number must be converted from hexadecimal to a floating point number, then to a decimal number if desired.

2 A code to determine the alarm state of the device. Refer to Section 7.2.2 for a list of codes and their descriptions.

3 A code designating the units of measurement that apply to the value. Refer to Section 7.2.3 for a list of codes and their applicable units.

4 A code giving a more detailed description of the measured value. Refer to the applicable device in Section 7. 2 for a list of codes applicable to the device, or refer to Section 7.2.4 for a complete list of codes sorted numerically.

6. 3 Example - Single-Point Device - LIM2010

The following is used for the purposes of this example:

- A LIM2010 line isolation monitor
- RS-485 (BMS) address 4
- Obtaining the measured Total Hazard Current of 6.8 mA, which puts the LIM2010 into the alarm state

Follow the procedure below to obtain the measured value:

- Refer to Section 7.2.5. The table shows that the Total Hazard Current is stored in Channel 1.
- The LIM2010 is set to address 4 on the RS-485 bus. This is the first portion of the starting address.
- Refer to Section 7.2.1. Locate Channel 1 in the table. The left column is 10, and the first bit for channel 1 is 0. Add together 10 and 0 to get 10 in hexadecimal.
- Concatenate 4 and 10 together to get 410 as the starting address in hexadecimal. If the Modbus master requires a decimal starting address (as the software simulation example shows), convert the number to decimal to obtain 1040.

Use the table in Section 6.2.3 to compile the information required for the request string:

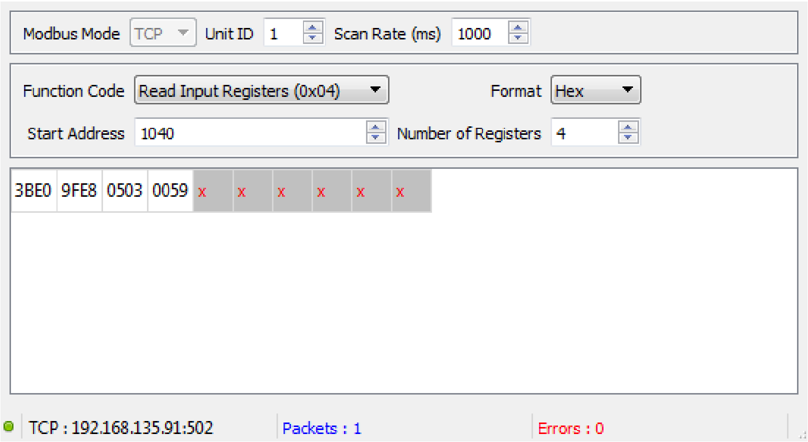
- Transaction ID: 0x0000
- Protocol identifier: 0x0000
- Length: 0x0006
- Unit identifier: 0x01
- Function code: 0x04
- Starting address: 0x0410

Number of registers: 0x0004

Concatenate the values together to create the request string:

00 00 00 00 00 06 01 04 04 10 00 04

Query configuration using Modbus master simulation software is shown below, with response:



The response is broken down in the following sections.

6.3.1 Example - LIM2010 - Response, Part 1 (Value)

The first portion of the response is 3BE0 9FE8. According to Section 7.2.5, this number is the Total Hazard Current value, given as a floating point number in hexadecimal format. Use a conversion from hexadecimal to floating point (then decimal if required) to obtain the value.

In this example, converting 3BE09FE8 from hexadecimal, to a floating point number, and finally to decimal gives a value of 0.0068.

6.3.2 Example - LIM2010 - Response, Part 2 (Alarm State)

The second portion of the response is 05. Refer to Section 7.2.2. This value is a coded response which designates the type of alarm that is active, if the device is in alarm at all. In this example, 05 designates that the LIM2010's main alarm is active.

6.3.3 Example - LIM2010 - Response, Part 3 (Units)

The third portion of the response is 03. This value is a coded response designating the units of measurement for the value. Refer to Section 7.2.3. In this example, 03 designates that the units of measurement are amperes (A).

6.3.4 Example - LIM2010 - Response, Part 4 (Meas. Type)

The final portion of the responser is 0059. This value is a coded response giving more details for the measured value. Refer to Section 7.2.4. In this example, 0059 designates that the type of measurement is Total Hazard Current.

6. 4 Example - Multi-Branch Device - RCMS490

The following is used for the purposes of this example:

- An RCMS490 multi-branch ground fault monitor
- RS-485 (BMS) address 2
- Obtaining the ground fault current measured on branch 3 of 10 mA

Follow the procedure below to obtain the measured value:

- Refer to Section 7.2.8. The table shows that branch 3's fault current value is stored in Channel 3.
- The RCMS is set to channel 2 on the RS-485 bus. This is the first portion of the starting address.
- Refer to Section 7.2.1. Locate Channel 3 in the table. The left column is 1, and the first bit for channel 3 is 8. Add together 10 and 8 to get 18 in hexadecimal.
- Concatenate 2 and 18 together to get 218 as the starting address in hexadecimal. If the Modbus master requires a decimal starting address (as the software simulation example shows), convert the number to decimal to obtain 536.

Use the table in Section 6.2.3 to compile the information required for the request string:

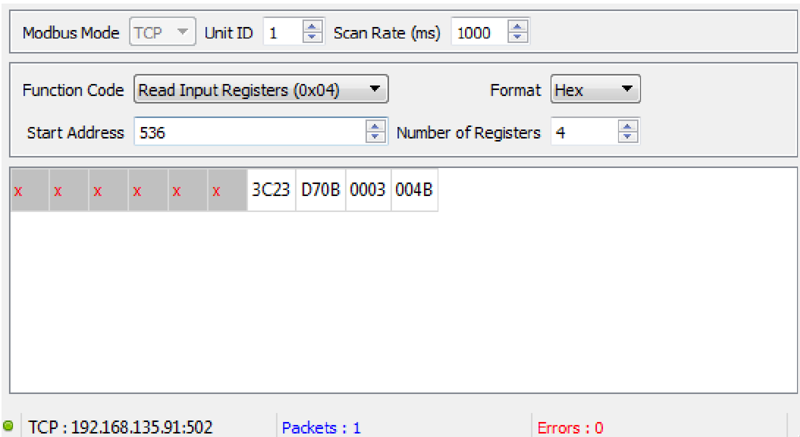
- Transaction ID: 0x0000
- Protocol identifier: 0x0000
- Length: 0x0006
- Unit identifier: 0x01
- Function code: 0x04
- Starting address: 0x0218

Number of registers: 0x0004

Concatenate the values together to create the request string:

00 00 00 00 00 06 01 04 02 18 00 04

Query configuration using Modbus master simulation software is shown below, with response:



The response is broken down in the following sections.

6.4.1 Example - RCMS490 - Response, Part 1 (Value)

The first portion of the response is 3C23 D70B. According to Section 7.2.8, this number is the measured ground fault current for branch number 3, given as a floating point number in hexadecimal format. Use a conversion from hexadecimal to floating point (then decimal if required) to obtain the value.

In this example, converting 3C23 D70B from hexadecimal, to a floating point number, and finally to decimal gives a value of 0.01.

6.4.2 Example - RCMS490 - Response, Part 2 (Alarm State)

The second portion of the response is 00. Refer to Section 7.2.2. This value is a coded response which designates the type of alarm that is active, if the device is in alarm at all. In this example, 00 designates that the RCMS is not in the alarm state.

6.4.3 Example - RCMS490 - Response, Part 3 (Units)

The third portion of the response is 03. This value is a coded response designating the units of measurement for the value. Refer to Section 7.2.3. In this example, 03 designates that the units of measurement are amperes (A).

6.4.4 Example - RCMS490 - Response, Part 4 (Meas. Type)

The final portion of the responser is 004B. This value is a coded response giving more details for the measured value. Refer to Section 7.2.4. In this example, 004B designates that the type of measurement is ground fault current.

7. Annex

7. 1 Data Tables - BCOM-Compatible Devices

7.1.1 Annex Table 1 - Basic Data Points - iso685

This section details commonly used Modbus data points for the iso685 ground fault detector. For a complete list of available data registers, consult the iso685 user manual.

NOTE: *Querying 2 registers provides the value only. Querying 4 registers provides additional information in the last 2 registers, such as alarm status and units of measurement. Refer to iso685 manual for more.*

Starting register (hex)	Starting register (dec))	Number of registers	Description	Type
0x1021	4129	2 / 4	Insulation resistance in Ω	Float
0x1031	4145	2 / 4	Leakage capacitance in F	Float
0x1041	4161	2 / 4	Voltage, L1-L2 in V	Float
0x1051	4177	2 / 4	Voltage, L1-L3 in V	Float
0x1061	4193	2 / 4	Voltage, L2-L3 in V	Float
0x1071	4209	2 / 4	Voltage, L1-G in V	Float
0x1081	4225	2 / 4	Voltage, L2-G in V	Float
0x1091	4241	2 / 4	Voltage, L3-G in V	Float
0x10A1	4257	2 / 4	System frequency in Hz	Float
0x10B1	4273	2 / 4	System connection: 0 = OK, other = error	Float
0x10C1	4289	2 / 4	Ground connection, 0 = OK, other = error	Float
0x10D1	4305	2 / 4	Error code (if applicable)	Float
0x10E1	4321	2 / 4	Device inactive: 0 = active, 1 = inactive	Float
0x1121	4385	2 / 4	DC fault shift in % 0 - 25%: Fault on DC+ 25-75%: Symmetrical fault 75-100%: Fault on DC-	Float

7.1.2 Annex Table 2 - Basic Data Points - PEM735

This section details commonly used Modbus data points for the PEM735 power quality meter. Some values below are only available when using a Wye configuration transformer (i.e. line to neutral voltage). For a complete list of available data registers and use, consult the PEM735 user manual.

Starting register (hex)	Starting register (dec)	Number of registers	Description	Type
0x00	0	2	Voltage, L1-N in V	Float
0x02	2	2	Voltage, L2-N in V	Float
0x04	4	2	Voltage, L3-N in V	Float
0x08	8	2	Voltage, L1-L2 in V	Float
0x0A	10	2	Voltage, L2-L3 in V	Float
0x0C	12	2	Voltage, L1-L3 in V	Float
0x0E	16	2	Load current, L1 in A	Float
0x12	18	2	Load current, L2 in A	Float
0x14	20	2	Load current, L3 in A	Float
0x18	24	2	Real power per phase P_{L1} in W	Float
0x1A	26	2	Real power per phase P_{L2} in W	
0x1C	28	2	Real power per phase P_{L3} in W	
0x1E	30	2	Real power total P_{ges} in W	
0x20	32	2	Reactive power per phase Q_{L1} in var	
0x22	34	2	Reactive power per phase Q_{L2} in var	
0x24	36	2	Reactive power per phase Q_{L3} in var	
0x26	38	2	Reactive power total Q_{ges} in var	
0x28	40	2	Apparent power per phase S_{L1} in VA	
0x2A	42	2	Apparent power per phase S_{L2} in VA	
0x2C	44	2	Apparent power per phase S_{L3} in VA	
0x2E	46	2	Apparent power total S_{ges} in VA	

Starting register (hex)	Starting register (dec)	Number of registers	Description	Type
0x30	48	2	Power factor per phase λ_{L1}	
0x32	50	2	Power factor per phase λ_{L2}	
0x34	52	2	Power factor per phase λ_{L3}	
0x36	54	2	Power factor total λ_{ges}	
0x46	70	1	Phase angle, V_{L1} or V_{L1-L2} in degrees * 100	UINT16
0x47	71	1	Phase angle, V_{L2} or V_{L2-L3} in degrees * 100	UINT16
0x48	72	1	Phase angle, V_{L3} or V_{L3-L1} in degrees * 100	INT16
0x49	73	1	Phase angle, I_{L1} in degrees * 100	INT16
0x4A	74	1	Phase angle, I_{L2} in degrees * 100	INT16
0x4B	75	1	Phase angle, I_{L3} in degrees * 100	INT16

7. 2 Data Tables - RS-485 Devices

This section details the channel memory image common to RS-485 devices. Use this table as a reference for determining the starting address. Additional sections show channel designations for common Bender RS-485 devices. Contact Bender for RS-485 compatible devices not listed in this section.

7.2.1 Annex Table 3 - Channel Memory Image

Use this table to determine the starting address for each channel.

Memory image of a BMS device																
LoByte	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0x00	------------------------- Device type --------------------------										------ Time stamp ------				C D	R.
0x10	Channel 1				Channel 2				Channel 3				Channel 4			
0x20	Channel 5				Channel 6				Channel 7				Channel 8			
0x30	Channel 9				Channel 10				Channel 11				Channel 12			
0x40	Channel 13				Channel 14				Channel 15				Channel 16			
0x50	Channel 17				Channel 18				Channel 19				Channel 20			
0x60	Channel 21				Channel 22				Channel 23				Channel 24			
0x70	Channel 25				Channel 26				Channel 27				Channel 28			
0x80	Channel 29				Channel 30				Channel 31				Channel 32			

7.2.2 Annex Table 4 - Alarm State Codes

Code value	Description
0	No alarm active
1	Prewarning alarm state
2	Internal device error
3	Main alarm active (devices with yellow LEDs)
4	Main alarm active (devices with red LEDs)

7.2.3 Annex Table 5 - Units of Measurement Codes

Code Value (hex)	Code Value (dec)	Description
0x01	1	No units
0x02	2	Ω
0x03	3	A
0x04	4	V
0x05	5	%
0x06	6	Hz
0x07	7	baud
0x08	8	F
0x09	9	H
0x0A	10	degree C
0x0B	11	degree F
0x0C	12	second
0x0D	13	minute
0x0E	14	hour
0x0F	15	day
0x10	16	month

7.2.4 Annex Table 6 - Measurement Detail Codes By Value

This section lists common codes for measurement types. Refer to COM465IP or CP700 user manual for a complete list of codes available.

Code Value (dec)	Code Value (hex)	Description
71	0x47	Insulation resistance in Ω
72	0x48	Current in A
75	0x4B	Ground fault current in A
76	0x4C	Voltage in V
79	0x4F	Frequency in Hz
82	0x52	Capacitance in F
83	0x53	Temperature in degrees C
85	0x55	Digital input (state 0 or 1)
87	0x57	Fault location tracer signal (EDS) in A
88	0x58	Transformer load in %
89	0x59	Total hazard current in A
213	0xD5	Channel disabled

7.2.5 Annex Table 7 - Channel Designations - LIM2010

Models applicable to this section include the LIM2010 line isolation monitor.

Channel	Description	Units	Details code (hex)
1	Total hazard current	A	0x59
2	Transformer load	%	0x58
3	Voltage, L1-L2	V	0x4C
4	Voltage, L1-G	V	0x4C
5	Voltage, L2-G	V	0x4C
6	Insulation impedance	Ω	0x56
7	Insulation resistance	Ω	0x47
8	Leakage capacitance	F	0x52

7.2.6 Annex Table 7 - Channel Designations - IRDH

Models applicable to this section include:

- IRDH275 “B” series (standard models are not compatible)
- IRDH375 “B” series (standard models are not compatible)
- IRDH575 series
- isoPV and isoHR275 series

Channel	Description	Units	Details code (hex)
1	Insulation resistance	Ω	0x47
2	Insulation resistance	Ω	0x47
3	Capacitance	F	0x52

7.2.7 Annex Table 8 - Channel Designations - EDS Series

Models applicable to this section include the EDS460, EDS461, EDS490, and EDS491 series ground fault location modules.

Channel	Description	Units	Details code (hex)
1	Fault tracer signal magnitude, branch 1	A	*
2	Fault tracer signal magnitude, branch 2	A	*
3	Fault tracer signal magnitude, branch 3	A	*
4	Fault tracer signal magnitude, branch 4	A	*
5	Fault tracer signal magnitude, branch 5	A	*
6	Fault tracer signal magnitude, branch 6	A	*
7	Fault tracer signal magnitude, branch 7	A	*
8	Fault tracer signal magnitude, branch 8	A	*
9	Fault tracer signal magnitude, branch 9	A	*
10	Fault tracer signal magnitude, branch 10	A	*
11	Fault tracer signal magnitude, branch 11	A	*
12	Fault tracer signal magnitude, branch 12	A	*

* When the EDS460 is in the normal state, the measurement detail code reported is 004B. When the EDS460 has located a ground fault, the code reported is 0057. This is a special code indicating that the fault has been located on the queried channel. The value returned is the magnitude of the tracer signal used to find the fault, NOT measured ground fault current.

7.2.8 Annex Table 9 - Channel Designations - RCMS Series

Models applicable to this section include the RCMS460 and RCMS490 series multi-channel ground fault monitors.

Channel	Description	Units	Details code (hex)
1	Ground fault current, branch 1	A	0x4B
2	Ground fault current, branch 2	A	0x4B
3	Ground fault current, branch 3	A	0x4B
4	Ground fault current, branch 4	A	0x4B
5	Ground fault current, branch 5	A	0x4B
6	Ground fault current, branch 6	A	0x4B
7	Ground fault current, branch 7	A	0x4B
8	Ground fault current, branch 8	A	0x4B
9	Ground fault current, branch 9	A	0x4B
10	Ground fault current, branch 10	A	0x4B
11	Ground fault current, branch 11	A	0x4B
12	Ground fault current, branch 12	A	0x4B

7.2.9 Annex Table 10 - Channel Designations - RCMA421 / 426

Models applicable to this section include the RCMA421-DCB and RCMA426-DCB GFCI modules.

Channel	Description	Units	Details code (hex)
1	Ground fault current	A	0x4B

8. Special Case - Using iso685-D-P and EDS440

Bender's fault location system using the iso685-D-P and a combination of EDS440 / EDS441 uses a combination of protocols to communicate data between devices. Follow the instructions in this section to obtain data.

8. 1 System Overview

EDS440 / EDS441 devices connect to the iso685-D-P directly using either RS-485 ("BS bus") or a direct PCB connection (BB bus). These connections utilize a special protocol for fast communication between devices which does not connect directly to other equipment The iso685-D-P then connects to the Modbus network using the Ethernet connection.

All Modbus queries are sent directly to the iso685. They are not sent to the EDS devices directly.

8. 2 iso685-D-P - Obtain General System Data

For obtaining general system data, such as the system insulation resistance, follow the instructions as given in Section 5.

8. 3 EDS - Obtain Channel Alarm State

Modbus registers for connected EDS devices are stored on the iso685. Use the IP address for the iso685-D-P as shown in Section 5. 1. Data for EDS devices is stored sequentially in the Modbus map.

Each channel must be queried individually to determine its alarm status.

8.3.1 Obtain Starting Address

To obtain data for a specific device and channel, use the following formula to determine the starting address:

NOTE: Device number does not necessarily correlate to the BS / BB bus address number. It is the sequential number that the device is connected in.

Starting Register (decimal) = 53248 + 12(device- 1) + 4(channel-1)

Starting Register (hex) = 0xD000 + 0xC(device - 1) + 0x4(channel - 1)

Type	Description
Device	Sequential number of EDS to be queried
Channel	Channel number of the EDS to be queried

8.3.2 Create Query

Obtain the following information to build the query string:

Type	No. of bytes	Description
Transaction ID	2	Dictated by Modbus master (i.e. 0x0000)
Protocol identifier	2	0x0000
Length	2	0x0006 (number of bytes following this in the request string)
Unit identifier	1	BCOM address set for the connected iso685-D-P
Function code	1	0x03 (Read Holding Registers)
Starting address	2	Obtained using the formula in Section 8.3.1
Number of registers	2	4

8.3.3 Interpreting Response

Returned values are similar to Bender RS-485 devices. Follow the instructions in Section 6.2.4 to interpret the response.

8. 4 Example

The following is used for the purposes of this example:

- One (1) iso685-D-P with two (2) connected EDS440 devices
- IP address for iso685-D-P configured as 192.168.0.253
- BCOM address for iso685-D-P configured as 1
- BS bus addresses for connected EDS440 devices configured as 2 and 3
- EDS440 device 1 (BS bus address 2) has located a fault on channel 3 (measuring a magnitude of 7 mA for the fault location tracer signal)
- Obtain the alarm status of this channel

The EDS440 device at address 2 is the first sequentially connected device - for the purposes of accessing the Modbus map, it is designated as device 1. Use the formula given in Section 8.3.1 to obtain the starting address:

53248 + 12(1-1) + 4(3-1) = 53256 (decimal) = 0xD008

Use the table in Section 8.3.2 to compile the information required for the request string:

- Transaction ID: 0x0000
- Protocol identifier: 0x0000
- Length: 0x0006
- Unit identifier: 0x04
- Function code: 0x03
- Starting address: 0xD008
- Number of registers: 0x0004

Concatenate the values together to create the request string:

00 00 00 00 00 06 04 03 D0 08 00 04

Responses are broken down in the following sections.

8.4.1 Example - No Fault Located on Specified Channel

If no fault has been located on the queried channel, or the queried channel is inactive, the response will appear as follows:

0000 0000 0001 03FE

8.4.2 Example - Fault Located on Specified Channel

If a fault is located on the queried channel, important values will span across the four returned register values. An example is given below:

3BE5 6041	05	03	0057
1	2	3	4

1 The magnitude of the fault location tracer signal measured, stored as a floating point number. This value should be greater than zero if a fault is located. In this example, converting the number from hexadecimal to floating point to decimal results in a value of 0.007.

2 A code to determine the alarm state of the device. Refer to Section 7.2.2 for a list of codes and their descriptions. In this example, the channel's main alarm is active.

3 A code designating the units of measurement. In fault location, this value will be 0x03, designating units of amperes (A).

4 A code giving a more detailed description of the measured value. For fault location, this value will be 0x0057, designating that the alarm type is the fault location tracer signal.

9. Notes

Use this section to record any relevant notes.

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