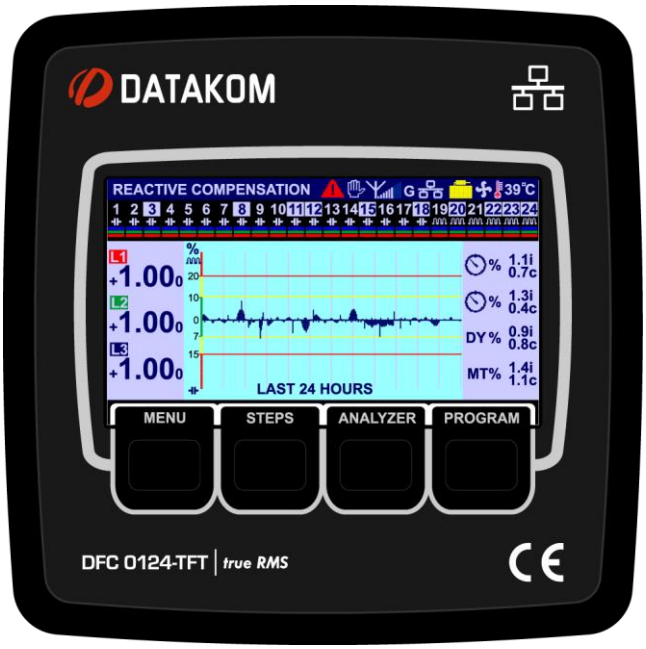
MODBUS APPLICATION MANUAL

DFC-0124



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ABOUT THIS DOCUMENT

This document describes minimum required details for the successfull interfacing of the DFC-0124 family units to 3rd party Modbus and Modbus-TCP/IP based applications.

Follow carefully advices given in the document. These are often good practices for the installation of the unit which reduce future issues.

For all technical queries please contact Datakom at below e-mail address:

datakom@datakom.com.tr

SCOPE OF THIS DOCUMENT

This document will apply to both Modbus through RS-485 and Modbus-TCP/IP communications.

RELATED DOCUMENTS

FILENAME	DESCRIPTION
0124_DATA	DFC0124 Brochure
0124_TFT_DATA	DFC0124-TFT Brochure
0124_PRESENTATION	DFC0124 Power Factro Controller and Remote Monitoring Presentation

REVISION HISTORY

REVISION	DATE	AUTHOR	DESCRIPTION
01	05.02.2017	TO	First release. Firmware V4.7

TERMINOLOGY

CAUTION: Potential risk of injury or death.

WARNING: Potential risk of malfunction or material damage.

ATTENTION: Useful hints for the understanding of device operation.

MODBUS COMMUNICATION BASICS

The Modbus communication is widely used in the connection of industrial control units to various management systems for remote monitoring and control. It has begun the basic industry standard in the last decades.

The unit offers the possibility of MODBUS communication through below carriers:

-RS485 serial port, with adjustable baud rate between 2400 and 115200 bauds

-MODBUS-TCP/IP through Ethernet port (10/100Mb)

-MODBUS-TCP/IP through GSM-GPRS modem. (84/42kb)

Detailed description about the MODBUS protocol is found in the document "**Modicon Modbus Protocol Reference Guide"**. This document may be downloaded at: www.modbus.org/docs/PI_MBUS_300.pdf

Detailed description about the MODBUS-TCP/IP protocol is found in the document "**MODBUS APPLICATION PROTOCOL SPECIFICATION"**. This document may be downloaded at:

http://www.modbus.org/docs/Modbus_Application_Protocol_V1_1b.pdf

The MODBUS properties of the unit are:

-Data transfer mode: RTU

-Serial data: selectable baud rate, 8 bit data, no parity, 1 bit stop

-Modbus-TCP/IP: Ethernet 10/100Mb or GPRS Class 10.

-Supported functions:

-Function 3 (Read multiple registers)

-Function 6 (Write single register)

-Function 16 (Write multiple registers)

Each register consists of 2 bytes (16 bits). A larger data structure will contain multiple registers.

MODBUS CONFIGURATION

The Modbus communications requires a slave address to be assigned to each device in the Modbus network. This address ranges between 1 and 240 and allows the addressing of different slave devices in the same network.

Each device in the same RS-485 serial network must be assigned a different slave address. Otherwise the Modbus communications will not be performed.

Devices using Modbus-TCP/IP with different IP or port addresses may use any slave address. It is advised to set these slave addresses to the default setting which is 1.

Parameters required for RS-485 Modbus operation

Modbus Slave Address: may be set between 1 and 240

RS-485 Enable: must be set to 1 (or checkbox enabled)

RS-485 Baud Rate: selectable between 2400 and 115200 bauds. All devices in the same network must use the same Baud Rate.

Selecting a higher baud rate will allow faster communication, but will reduce the communication distance. Selecting a lower baud rate will increase the communication distance, but will cause slower response times.

Typically 9600 bauds will allow 1200m distance with special balanced 120 ohms cable.

Parameters required for Modbus-TCP/IP through Ethernet port

Modbus Slave Address: may be set between 1 and 240. If only one unit is available in the same IP address, it is advised to keep the default address (1).

Ethernet Enable: This parameter should be set to 1 (or checked) in order to enable the ethernet port.

Modbus TCP/IP Port: The usual setting is 502. However the unit is able to work on any port address.

User IP Mask: There are 3 mask registers available. The use of the registers are emphasized in the D-500/700 User Manual. Please set the first mask as 255.255.255.0 for the proper operation.

Ethernet Network IP: May be left as 0.0.0.0 for automatic address claim or set to a value in order to claim a defined address.

Ethernet Gateway IP: Should be set in accordance with your local switch configuration.

Ethernet Subnet Mask: Should be set in accordance with your local switch configuration.

Parameters required for Modbus-TCP/IP through GSM_GPRS Modem

Modbus Slave Address: may be set between 1 and 240. If only one unit is available in the same IP address, it is advised to keep the default address (1).

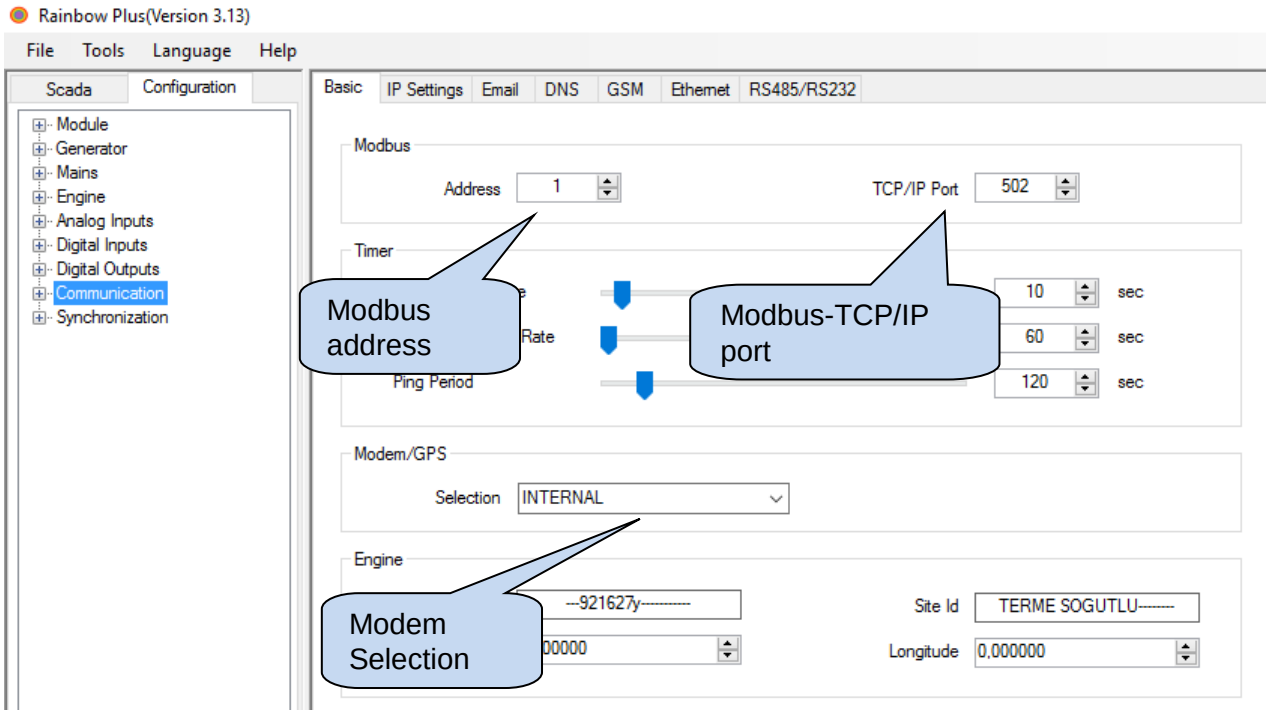
Modem Selection: Internal or external following your configuration.

Modem Baud Rate: Selectable only for external modem. 115200 bauds advised. Selecting a lower baud rate will slow down communication between the controller and the modem.

GPRS Connection Enable: This parameter should be set to 1 (or checked).

Modbus TCP/IP Port: Set this value to 80.

User IP Mask: There are 3 mask registers available. The use of the registers are emphasized in the DFC-0124 User Manual. Please set the first mask as 255.255.255.0 for the proper operation.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502
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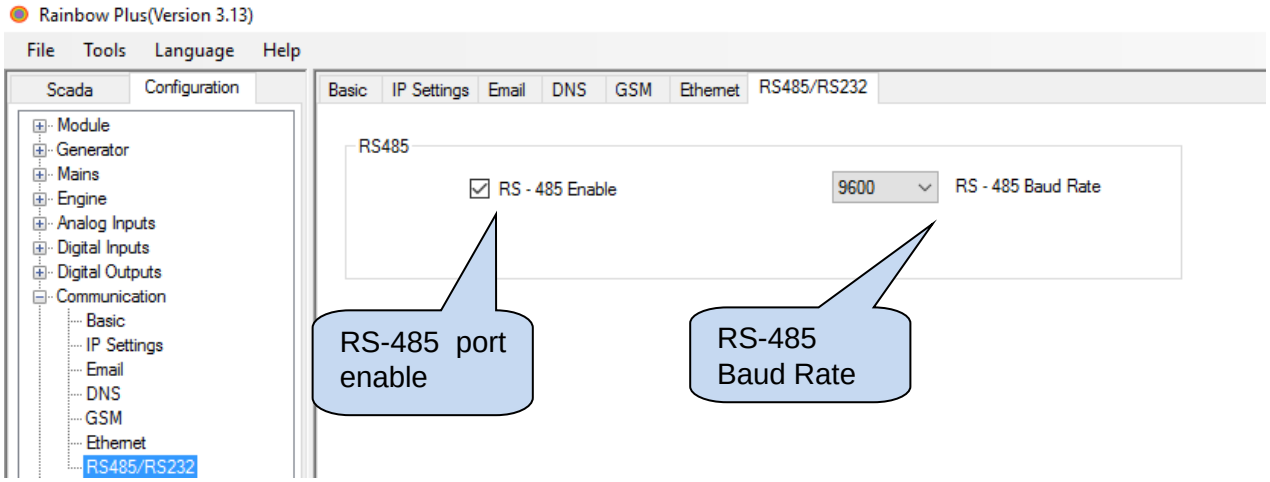
Modbus address
Modbus-TCP/IP port
Modem Selection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9600
RS - 485 Baud Rate
RS-485 port enable
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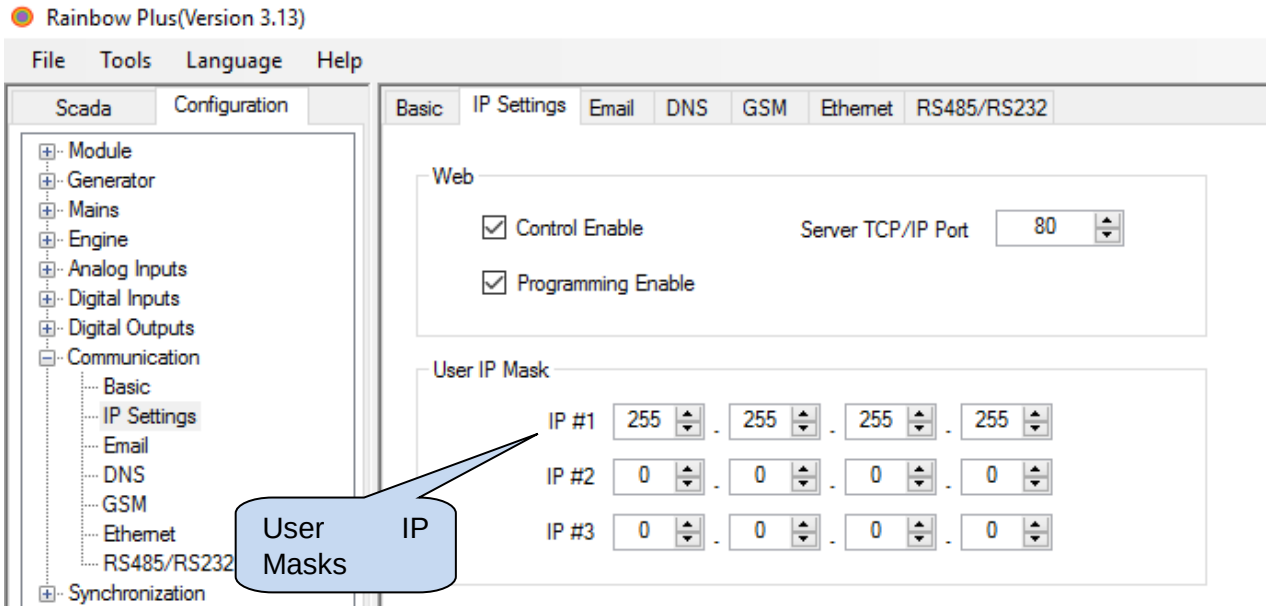
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Basic IP Settings Email DNS GSM Ethernet RS485/RS232
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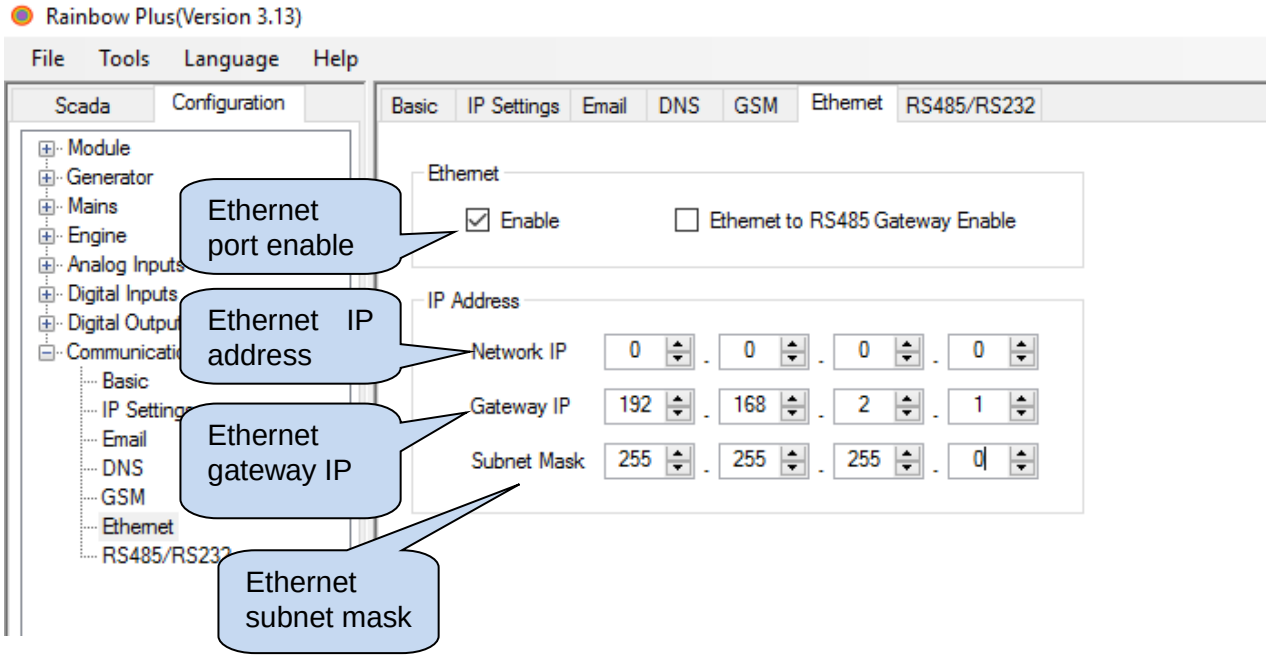
Control Enable
Server TCP/IP Port 80
Programming Enable
User IP Mask
IP #1 255 255 255 255
IP #2 0 0 0 0
IP #3 0 0 0 0
User IP Masks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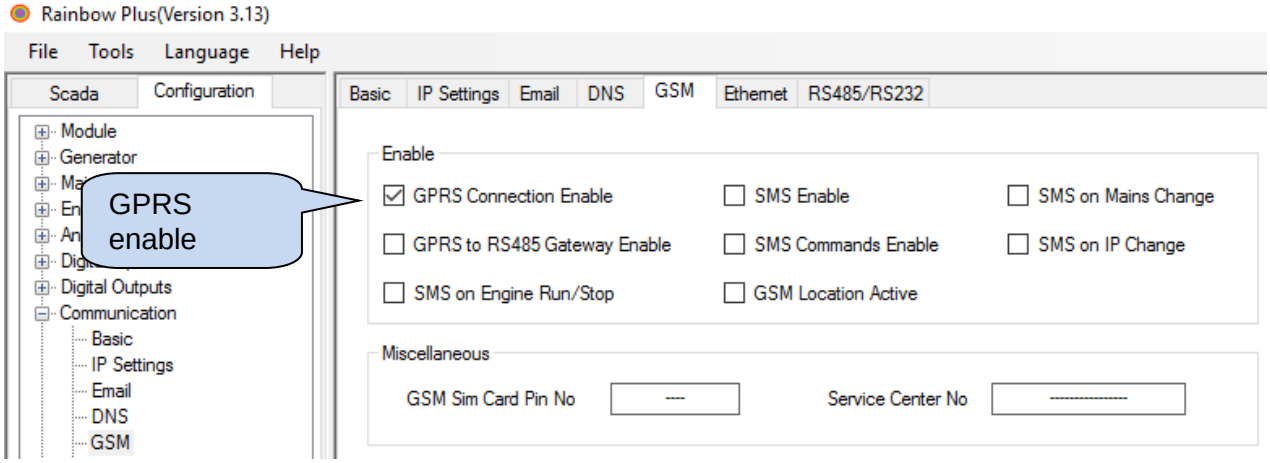
IP Address
Network IP 0 0 0 0
Gateway IP 192 168 2 1
Subnet Mask 255 255 255 0
Ethernet port enable
Ethernet IP address
Ethernet gateway IP
Ethernet subnet mask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GPRS Connection Enable
SMS Enable
SMS on Mains Change
GPRS to RS485 Gateway Enable
SMS Commands Enable
SMS on IP Change
SMS on Engine Run/Stop
GSM Location Active
Miscellaneous
GSM Sim Card Pin No
Service Center No
GPRS enable

DATA READING

The function 03 (read multiple registers) will be used for data reading. The MODBUS master will send a query. The answer will be one of the below:

-A response containing the requested data

-An exceptional response indicating a read error.

The maximum number of registers read in one message is 16. If more registers are requested, the unit will send only the first 16 registers.

The query message specifies the starting register and quantity of registers to be read. The message structure is below:

Byte	Description	Value
0	Controller address	1 to 240
1	Function code	3
2	Starting address high	See below the description of available registers
3	Starting address low	
4	Number of registers high	always 0
5	Number of registers low	max 10h (16 decimal)
6	CRC low byte	See below for the checksum calculation
7	CRC high byte	

Here is the sequence to read 16 registers starting from address 20h (32 decimal):

01 03 00 20 00 10 45 CC (each byte is expressed as 2 hexadecimal characters)

The checksum value in the above message may be used for the verification of checksum calculation algorithm.

The normal response will be:

Byte	Description	Value
0	Controller address	same as in the query
1	Function code	3
2	Data lenght in **bytes** (L)	number of registers * 2
3	High byte of 1st register	
4	Low byte of 1st register	
5	High byte of 2nd register	
6	Low byte of 2nd register	
....		
L+1	High byte of the last register	
L+2	Low byte of the last register	
L+3	CRC low byte	See below for the checksum calculation
L+4	CRC high byte	

The exceptional response will be:

Byte	Description	Value
0	Controller address	same as in the query
1	Function code	131 (function code + 128)
2	Exception code	2 (illegal address)
3	CRC low byte	See below for the checksum calculation
4	CRC high byte	

DATA WRITING (SINGLE REGISTER)

The function 06 (write single register) and the function 16 (write multiple registers) are used for data writing.
The MODBUS master will send a query containing data to be written. The answer will be one of the below:

-A normal response confirming successful write,
-An exceptional response indicating a write error.

Only some of the available registers are authorized to be written. An attempt to write a write protected register will result to the exceptional response.

The query message specifies the register address and data. The message structure is below:

Byte	Description	Value
0	Controller address	1 to 240
1	Function code	6
2	Register address high	See below the description of available registers
3	Register address low	
4	Data high byte	
5	Data low byte	
6	CRC low byte	See below for the checksum calculation
7	CRC high byte	

Here is the sequence to write the value 0010h to the register 40h (64 decimal):

01 06 00 40 00 10 89 D2 (each byte is expressed as 2 hexadecimal characters)

The checksum value in the above message may be used for the verification of checksum calculation algorithm

The normal response will be the same as the query:

Byte	Description	Value
0	Controller address	1 to 240
1	Function code	6
2	Register address high	See below the description of available registers
3	Register address low	
4	Data high byte	
5	Data low byte	
6	CRC low byte	See below for the checksum calculation
7	CRC high byte	

The exceptional response will be:

Byte	Description	Value
0	Controller address	same as in the query
1	Function code	134 (function code + 128)
2	Exception code	2 (illegal address) or 10 (write protection)
3	CRC low byte	See below for the checksum calculation
4	CRC high byte	

DATA WRITING (MULTIPLE REGISTERS)

The function 06 (write single register) and the function 16 (write multiple registers) are used for data writing.
The MODBUS master will send a query containing data to be written. The answer will be one of the below:

-A normal response confirming successful write,
-An exceptional response indicating a write error.

Only some of the available registers are authorized to be written. An attempt to write a write protected register will result to the exceptional response.

The query message specifies the register address and data. The message structure is below:

Byte	Description	Value
0	Controller address	1 to 240
1	Function code	16
2	Starting address high	See below the description of available registers
3	Starting address low	
4	Number of registers high	always 0
5	Number of registers low	max
6	Data lenght in **bytes** (L)	number of registers * 2
7	High byte of 1st register	
8	Low byte of 1st register	
9	High byte of 2nd register	
10	Low byte of 2nd register	
....		
L+5	High byte of the last register	
L+6	Low byte of the last register	
L+7	CRC low byte	See below for the checksum calculation
L+8	CRC high byte	

The normal response is below:

Byte	Description	Value
0	Controller address	1 to 240
1	Function code	16
2	Starting address high	See below the description of available registers
3	Starting address low	
4	Number of registers high	always 0
5	Number of registers low	max
6	CRC low byte	See below for the checksum calculation
7	CRC high byte	

The exceptional response will be:

Byte	Description	Value
0	Controller address	same as in the query
1	Function code	144 (function code + 128)
2	Exception code	2 (illegal address) or 10 (write protection)
3	CRC low byte	See below for the checksum calculation
4	CRC high byte	

CRC CALCULATION

Here is a procedure for generating a CRC:

1) Load a 16–bit register with FFFF hex (all 1's). Call this the CRC register.

2) Exclusive OR the first 8–bit byte of the message (the function code byte) with the low–order byte of the 16–bit CRC register, putting the result in the CRC register.

3) Shift the CRC register one bit to the right (toward the LSB), zero–filling the MSB. Extract and examine the LSB. The LSB is the least significant bit of the CRC **before** the shift operation.

4) If the LSB is 1: Exclusive OR the CRC register with the polynomial value A001 hex.

5) Repeat Steps 3 and 4 until 8 shifts have been performed. Thus, a complete 8–bit byte will be processed.

6) Repeat Steps 2 through 5 for the next 8–bit byte of the message. Continue doing this until all bytes have been processed.

7) The final contents of the CRC register is the CRC value.

8) Place the CRC into the message such that the low byte is transmitted first. The algorithm should give the correct CRC for below messages:

01 03 00 20 00 10 45 CC
01 06 00 40 00 10 89 D2

Error codes

Only 3 error codes are used:
01: illegal function code
02: illegal address
10: write protection (attempt to write a read_only register)

Data types

Each register consists of 16 bits (2 bytes)

If the data type is a byte, only the low byte will contain valid data. High byte is don't care.

For data type longer than 16 bits, consecutive registers are used. The least significant register comes first.

DATA FORMATS

16bit variables: These variables are stored in a single register. Bit_0 denotes the LSB and bit 15 denotes the MSB.

32 bit variables: These variables are stored in 2 consecutive registers. The high order 16 bits are in the first register and the low order 16 bits are in the second register

Bit arrays: Arrays larger than 16 bits are stored in multiple registers. The LSB of the first register is bit_0. The MSB of the first register is bit_15. The LSB of the second register is bit_16. The MSB of the second register is bit_31, and so on.

REGISTER DEFINITIONS

BANKS

ADDRESS (decimal)	R / W	DATA SIZE	COEFF.	DESCRIPTION
1225 ...	R	48bit 3x16	x10	Bank 1 kVAr
1228 ...	R	48bit 3x16	x10	Bank 2 kVAr
1231 ...	R	48bit 3x16	x10	Bank 3 kVAr
1234 ...	R	48bit 3x16	x10	Bank 4 kVAr
1237 ...	R	48bit 3x16	x10	Bank 5 kVAr
1240 ...	R	48bit 3x16	x10	Bank 6 kVAr
1243 ...	R	48bit 3x16	x10	Bank 7 kVAr
1246 ...	R	48bit 3x16	x10	Bank 8 kVAr
1249 ...	R	48bit 3x16	x10	Bank 9 kVAr
1252 ...	R	48bit 3x16	x10	Bank 10 kVAr
1255 ...	R	48bit 3x16	x10	Bank 11 kVAr
1258 ...	R	48bit 3x16	x10	Bank 12 kVAr
1261 ...	R	48bit 3x16	x10	Bank 13 kVAr
1264 ...	R	48bit 3x16	x10	Bank 14 kVAr
1267 ...	R	48bit 3x16	x10	Bank 15 kVAr
1270 ...	R	48bit 3x16	x10	Bank 16 kVAr
1273 ...	R	48bit 3x16	x10	Bank 17 kVAr
1276 ...	R	48bit 3x16	x10	Bank 18 kVAr
1279 ...	R	48bit 3x16	x10	Bank 19 kVAr
1282 ...	R	48bit 3x16	x10	Bank 20 kVAr
1285 ...	R	48bit 3x16	x10	Bank 21 kVAr
1288 ...	R	48bit 3x16	x10	Bank 22 kVAr

1291 ...	R	48bit 3x16	x10	Bank 23 kVAr
1294 ...	R	48bit 3x16	x10	Bank 24 kVAr
1321 ...	R	48bit 3x16	x10	SVC kVAr

BANKS STRUCTURE

ADDRESS (decimal)	R / W	DATA SIZE	COEFF.	DESCRIPTION
BASE+0	R	16bit	x10	Phase L1
BASE+1	R	16bit	x10	Phase L2
BASE+2	R	16bit	x10	Phase L3

DATE & TIME

ADDRESS (decimal)	R / W	DATA SIZE	COEFF.	DESCRIPTION
8192	R / W	16bit	-	Year (0-4095)
8193	R / W	16bit	-	Month (1-12)
8194	R / W	16bit	-	Date (1-31)
8195	R	16bit	-	Day of Week (0-6)
8196	R / W	16bit	-	Hours (0-23)
8197	R / W	16bit	-	Minutes (0-59)
8198	R / W	16bit	-	Seconds (0-59)
8199	R / W	16bit	-	Year (0-4095) (UTC)
8200	R / W	16bit	-	Month (1-12) (UTC)
8201	R / W	16bit	-	Date (1-31) (UTC)
8202	R	16bit	-	Day of Week (0-6) (UTC)
8203	R / W	16bit	-	Hours (0-23) (UTC)
8214	R / W	16bit	-	Minutes (0-59) (UTC)
8215	R / W	16bit	-	Seconds (0-59) (UTC)

COUNTERS

ADDRESS (decimal)	R / W	DATA SIZE	COEFF.	DESCRIPTION
12288	R / W	32bit	x10	kWh_1 Import
12290	R / W	32bit	x10	kWh_1 Export
12292	R / W	32bit	x10	kVArh_1 Inductive
12294	R / W	32bit	x10	kVArh_1 Capacitive
12296	R / W	32bit	x10	Group_1 Hour Counter
12298	R / W	32bit	x10	kWh_2 Import
12300	R / W	32bit	x10	kWh_2 Export
12302	R / W	32bit	x10	kVArh_2 Inductive
12304	R / W	32bit	x10	kVArh_2 Capacitive
12306	R / W	32bit	x10	Group_2 Hour Counter

DEMAND MIN MAX & PUSHBUTTON SIMULATION

ADDRESS (decimal)	R / W	DATA SIZE	COEFF.	DESCRIPTION
12460	R	32bit	x10	Demand I1
12462	R	32bit	x10	Demand I2
12464	R	32bit	x10	Demand I3
12466	R	32bit	x10	Demand In
12468	R	32bit	x100	Demand kW
12470	R	32bit	x100	Demand kVAr
12472	R	32bit	x10	Minimum V1
12474	R	32bit	x10	Minimum V2
12476	R	32bit	x10	Minimum V3
12478	R	32bit	x10	Minimum U12
12480	R	32bit	x10	Minimum U23
12482	R	32bit	x10	Minimum U31
12484	R	32bit	x10	Minimum I1
12486	R	32bit	x10	Minimum I2
12488	R	32bit	x10	Minimum I3

12490	R	32bit	x10	Minimum In
12492	R	32bit	x100	Minimum Frequency
12494	R	32bit	x100	Minimum kW import
12496	R	32bit	x100	Minimum kW export
12498	R	32bit	x100	Minimum kVAr inductive
12500	R	32bit	x100	Minimum kVAr capacitive
12502	R	32bit	x10	Maximum V1
12504	R	32bit	x10	Maximum V2
12506	R	32bit	x10	Maximum V3
12508	R	32bit	x10	Maximum U12
12510	R	32bit	x10	Maximum U23
12512	R	32bit	x10	Maximum U31
12514	R	32bit	x10	Maximum I1
12516	R	32bit	x10	Maximum I2
12518	R	32bit	x10	Maximum I3
12520	R	32bit	x10	Maximum In
12522	R	32bit	x100	Maximum Frequency
12524	R	32bit	x100	Maximum kW Import
12526	R	32bit	x100	Maximum kW Export
12528	R	32bit	x100	Maximum kVAr Inductive
12530	R	32bit	x100	Maximum kVAr Capacitive
16385	W	16bit	-	Pushbutton Simulation BIT 0: Simulate Down Arrow Button BIT 1: Simulate Left Arrow Button BIT 2: Simulate Right Arrow Button BIT 3: Simulate Up Arrow Button
16386	W	16bit	-	Return to Factory Settings
16387	W	16bit	-	Reset Counters. (Value should set to 0)

MEASUREMENTS

ADDRESS (decimal)	R / W	DATA SIZE	COEFF.	DESCRIPTION
20480	R	32bit	x10	Phase L1 Voltage
20482	R	32bit	x10	Phase L2 Voltage
20484	R	32bit	x10	Phase L3 Voltage
20486	R	32bit	x10	Phase L1-L2 Voltage
20488	R	32bit	x10	Phase L2-L3 Voltage
20490	R	32bit	x10	Phase L1-L3 Voltage
20492	R	32bit	x10	Phase L1 Current
20494	R	32bit	x10	Phase L2 Current
20496	R	32bit	x10	Phase L3 Current
20498	R	32bit	x10	Neutral Current
20500	R	32bit	x10	Phase L1 Active Power
20502	R	32bit	x10	Phase L2 Active Power
20504	R	32bit	x10	Phase L3 Active Power
20506	R	32bit	x10	Total Active Power
20508	R	32bit	x10	Phase L1 Reactive Power
20510	R	32bit	x10	Phase L2 Reactive Power
20512	R	32bit	x10	Phase L3 Reactive Power
20514	R	32bit	x10	Total Reactive Power
20516	R	32bit	x10	Phase L1 Apparent Power
20518	R	32bit	x10	Phase L2 Apparent Power
20520	R	32bit	x10	Phase L3 Apparent Power
20522	R	32bit	x10	Total Apparent Power
20524	R	16bit	x1000	Phase L1 Power Factor
20525	R	16bit	x1000	Phase L2 Power Factor
20526	R	16bit	x1000	Phase L3 Power Factor
20527	R	16bit	x1000	Total Power Factor
20528	R	16bit	x100	Frequency
20529	R	16bit	x10	Temperature
20530	R	16bit	x10	Generator Input Voltage

20531	-	-	-	-
20532	R	32bit	x10	Average Ph-N Voltage
20534	R	32bit	x10	Average Ph-Ph Voltage
20536	R	32bit	x10	Average Current
20538	R	16bit	x10	Phase L1 Tangent
20539	R	16bit	x10	Phase L2 Tangent
20540	R	16bit	x10	Phase L3 Tangent
20541	R	16bit	x10	Total Tangent

ALARM, OUTPUT BITS & STATISTICS

ADDRESS (decimal)	R / W	DATA SIZE	COEFF.	DESCRIPTION	
23325	R	16bit	-	Alarms	
				BIT 0: Not Three Phase BIT 1: First Banks Not Three Phase BIT 2: Current Transformer Error BIT 3: High Voltage BIT 4: Low Voltage BIT 5: High Frequency BIT 6: Low Frequency BIT 7: High kW	BIT 8: Low kW BIT 9: High kVAr BIT 10: Low kVAr BIT 11: High Cos BIT 12: Low Cos BIT 13: High Current BIT 14: High THDV BIT 15: High THDI
23326	R	16bit	-	Alarms	
				BIT 0: Reserved BIT 1: Voltage Unbalance BIT 2: Current Unbalance BIT 3: Reserved BIT 4: Reserved BIT 5: Phase Sequence BIT 6: Capacitor Error BIT 7: High Temp Alarm	BIT 8: High Temp Warning BIT 9: Low Temp Alarm BIT 10: Temp Fail Alarm BIT 11: Current Transformer Error BIT 12: Daily Ind/Cap Alarm BIT 13: Monthly Ind/Cap Alarm BIT 14: Internal Alarm BIT 15: SVC Error

23340	R	16bit	x10	Daily Inductive %	
23341	R	16bit	x10	Daily Capacitive %	
23342	R	16bit	x10	Monthly Inductive %	
23343	R	16bit	x10	Monthly Capacitive %	
23914	R	16bit	-	Output States (Out1-Out12)	
23915	R	16bit	-	Output States (Out13-Out24)	

HARMONICS AND WAVEFORM INFORMATION

ADDRESS (decimal)	R / W	DATA SIZE	COEFF.	DESCRIPTION
20594 ...	R	4368bit 273x16	-	Phase L1 voltage, harmonics and waveform buffer
20867 ...	R	4368bit 273x16	-	Phase L2 voltage, harmonics and waveform buffer
21140 ...	R	4368bit 273x16	-	Phase L3 voltage, harmonics and waveform buffer
21415 ...	R	4368bit 273x16	-	Phase L1-2 voltage, harmonics and waveform buffer
21413 ...	R	4368bit 273x16	-	Phase L2-3 voltage, harmonics and waveform buffer
21686 ...	R	4368bit 273x16	-	Phase L3-1 voltage, harmonics and waveform buffer
22959 ...	R	4368bit 273x16	-	Phase L1 current, harmonics and waveform buffer
22232 ...	R	4368bit 273x16	-	Phase L2 current, harmonics and waveform buffer
22505 ...	R	4368bit 273x16	-	Phase L3 current, harmonics and waveform buffer

BUFFER STRUCTURE

The buffer consists of 273 x 16 bit registers. The structure is below.

ADDRESS (decimal)	R / W	DATA SIZE	COEFF.	DESCRIPTION
BASE+0	R	16bit	x10	THD of this channel
BASE+1	R	256bit 16x16	x10	This string of 16 registers carry individual harmonics of the selected channel, staring from H#01 until H#31. The first register represents the fundamental and is always set to 100.0%.
BASE+17	R	4096bit 256x16	x1	Scopemeter dataof the channel. Each register represents one point in the X axis of the scopemeter. The complete waveform is represented with 256 horizontal points. The register value is a signed integer. The sampling rate is 122us. Thus the buffer length is 256x122us, namely 31ms, presenting more than 1 cycle of the waveform. By representing these values in graphical form, a software oscilloscope can be made.