M2M Basic

Communication protocol

Technical specification V1.0
2CSG445012D0201

Contents

1 Setting up M2M Basic serial communication

1.1 Serial network ID programming

Enter the device password, enter setup menu on the instrument and scroll options until the display shows “Addr” (see M2M Basic instruction manual for detailed instructions). Insert a value for the ID address, from 1 to 247, according to RS-485. Confirm and exit from setup.

1.2 RS-485 communication interface

By means of the asynchronous RS-485 serial interface, the instrument can share information with PC, PLC or other compatible systems. Maximum recommended length of a RS485 line is 1200m. It is recommended to use a twisted pair cable with shielding and terminator of 120Ω at the beginning and the end of the network.
RS-485 interface allows multi-drop connection with several devices in the same network. The higher the number of devices, the higher will be the delay.

Communication parameters

Baud rate	4800 ÷ 38400
Data bit	8
Stop bit	1, 2
Parity	Even, odd, none

If the device to which the instrument have to be connected is not equipped with RS485 serial port, a serial RS232/RS485 interface converter should be used between PC and the instruments.

2 Communication frame in RTU mode

2.1 Modbus RTU protocol

Modbus is a master-slave communication protocol able to support up to 247 slaves organized as a multidrop bus. The communication is half-duplex. The network messages can be Query-Response or Broadcast type. The Query-Response command is transmitted from the Master to an established Slave and generally it is followed by an answering message. The Broadcast command is transmitted from the Master to all Slaves and it is never followed by an answer.

2.1.1 Communication frame structure

A Modbus frame is composed of:

T1 T2 T3
ADDRESS FIELD = 8 bits
FUNCTION CODE = 8 bits
DATA FIELD = N x 8 bits
ERROR CHECK = 16 bit CRC
T1 T2 T3

in which:

a) the Address field contains the address of the Slave to which the message is sent

b) the Function field contains the code of the function that must be carried out by the Slave

c) the Data field contains the information needed by the Slave to carry out a specific function or contains data collected from the Slave in response to a question

d) the CRC field allows both the Master and the Slave to check a message in order to detect any errors in transmission. Sometimes, due to electrical “noise” or other interference, a message may be changed during the transmission from one unit to another. The error check ensures that neither the Master nor the Slave react to messages that have been haltered

e) the T1 T2 T3 sequence represents the time that separates one frame from another, and corresponds to at least 3 and a half characters: during this period no one is allowed to talk on the bus, to let the instruments detect that a frame is over and another one is starting

In RTU mode, the synchronisation of the frame can be maintained only by simulating a synchronous message. The receiving device measures the time that separates the reception of one character and the reception of the subsequent one (for example, between address and function). If this time is longer than the time needed to transmit three and a half characters, then the message is considered lost and the next character arriving is considered to be an address, in other words the beginning of a new frame.

2.1.2 CRC generation

The CRC used in Modbus follows the standard CRC-16 defined by CCITT.

Many algorithms are ready off-the-shelf; an algorithm written in C, using a look-up table, is reported below:

```
word crc16_rev_table[256] =
{ 0x0000, 0xC0C1, 0xC181, 0x0140, 0xC301, 0x03C0, 0x0280, 0xC241,
0xC601, 0x06C0, 0x0780, 0xC741, 0x0500, 0xC5C1, 0xC481, 0x0440,
0xCC01, 0x0CC0, 0x0D80, 0xCD41, 0x0F00, 0xCFC1, 0xCE81, 0x0E40,
0x0A00, 0xCAC1, 0xCB81, 0x0B40, 0xC901, 0x09C0, 0x0880, 0xC841,
0xD801, 0x18C0, 0x1980, 0xD941, 0x1B00, 0xDBC1, 0xDA81, 0x1A40,
0x1E00, 0xDEC1, 0xDF81, 0x1F40, 0xDD01, 0x1DC0, 0x1C80, 0xDC41,
0x1400, 0xD4C1, 0xD581, 0x1540, 0xD701, 0x17C0, 0x1680, 0xD641,
0xD201, 0x12C0, 0x1380, 0xD341, 0x1100, 0xD1C1, 0xD081, 0x1040,
0xF001, 0x30C0, 0x3180, 0xF141, 0x3300, 0xF3C1, 0xF281, 0x3240,
0x3600, 0xF6C1, 0xF781, 0x3740, 0xF501, 0x35C0, 0x3480, 0xF441,
0x3C00, 0xFCC1, 0xFD81, 0x3D40, 0xFF01, 0x3FC0, 0x3E80, 0xFE41,
0xFA01, 0x3AC0, 0x3B80, 0xFB41, 0x3900, 0xF9C1, 0xF881, 0x3840,
0x2800, 0xE8C1, 0xE981, 0x2940, 0xEB01, 0x2BC0, 0x2A80, 0xEA41,
0xEE01, 0x2EC0, 0x2F80, 0xEF41, 0x2D00, 0xEDC1, 0xEC81, 0x2C40,
0xE401, 0x24C0, 0x2580, 0xE541, 0x2700, 0xE7C1, 0xE681, 0x2640,
0x2200, 0xE2C1, 0xE381, 0x2340, 0xE101, 0x21C0, 0x2080, 0xE041,
0xA001, 0x60C0, 0x6180, 0xA141, 0x6300, 0xA3C1, 0xA281, 0x6240,
0x6600, 0xA6C1, 0xA781, 0x6740, 0xA501, 0x65C0, 0x6480, 0xA441,
0x6C00, 0xACC1, 0xAD81, 0x6D40, 0xAF01, 0x6FC0, 0x6E80, 0xAE41,
0xAA01, 0x6AC0, 0x6B80, 0xAB41, 0x6900, 0xA9C1, 0xA881, 0x6840,
0x7800, 0xB8C1, 0xB981, 0x7940, 0xBB01, 0x7BC0, 0x7A80, 0xBA41,
0xBE01, 0x7EC0, 0x7F80, 0xBF41, 0x7D00, 0xBDC1, 0xBC81, 0x7C40,
0xB401, 0x74C0, 0x7580, 0xB541, 0x7700, 0xB7C1, 0xB681, 0x7640,
0x7200, 0xB2C1, 0xB381, 0x7340, 0xB101, 0x71C0, 0x7080, 0xB041,
0x5000, 0x90C1, 0x9181, 0x5140, 0x9301, 0x53C0, 0x5280, 0x9241,
0x9601, 0x56C0, 0x5780, 0x9741, 0x5500, 0x95C1, 0x9481, 0x5440,
0x9C01, 0x5CC0, 0x5D80, 0x9D41, 0x5F00, 0x9FC1, 0x9E81, 0x5E40,
0x5A00, 0x9AC1, 0x9B81, 0x5B40, 0x9901, 0x59C0, 0x5880, 0x9841,
0x8801, 0x48C0, 0x4980, 0x8941, 0x4B00, 0x8BC1, 0x8A81, 0x4A40,
0x4E00, 0x8EC1, 0x8F81, 0x4F40, 0x8D01, 0x4DC0, 0x4C80, 0x8C41,
0x4400, 0x84C1, 0x8581, 0x4540, 0x8701, 0x47C0, 0x4680, 0x8641,
0x8201, 0x42C0, 0x4380, 0x8341, 0x4100, 0x81C1, 0x8081, 0x4040};
unsigned fast_crc16( unsigned char *ucpBuf, int nSize){
register word x;
register word crc;
int i;
crc = 0xFFFF; /* start with all 1's for a reverse CRC */
for( i = 0; i < nSize; ++i) {
/* process each character in the message - 2 steps per char only! */ x = crc ^ ucpBuf[i];
crc = (crc >> 8) ^ crc16_rev_table[x & 0x00FF];
}
return( crc);
}
```

2.2 Function 03h: "Read holding registers"

This function reads one or more memory adjacent locations, each one being 2-word sized. It is possible to read up to 125 registers. Below are described the read request format (from master to slave) and the reply format (from slave to master).

2.2.1 Read request (Master)

ADDRESS FIELD	FUNCTION CODE	START ADDRESS	No. OF REGISTERS	ERROR CHECK

ADDRESS FIELD = 1Fh
FUNCTION CODE = 03h
START ADDRESS H = 10h
START ADDRESS L = 00h
No. OF REGS H = 00h
No. OF REGS L = 14h
CRC H = 42h
CRC L = BBh

In the example above, the master sends the 'read function' Func = 03h to the slave with address Addr = 1Fh, starting from base register address Data Start Register = 1000h for Data Regs = 14h consecutive registers. So the command reads all registers from address 1000h a 1013h. The CRC = 42BBh closes the data stream.

2.2.2 Reply (Slave)

ADDRESS FIELD	FUNCTION CODE	No. OF SEND BYTES	D0, D1, …, Dn	ERROR CHECK

ADDRESS FIELD = 1Fh
FUNCTION CODE = 03h
BYTE COUNT = 28h
Data Reg 1000 H = 10h
Data Reg 1000 L = EFh
…….
CRC H = Xxh
CRC L = Yyh

The table above shows the fields in the instrument reply, which are:

- Addressed Slave Addr = 1Fh
- Function code request Func = 03
- Number of data byte following Byte Count = 28h
- Data byte fields requested by the master (Data Out Reg)
- CRC closes the reply data stream (CRC)

There are three particular cases that can happen using this command; the first is related to the quantity of requested memory, the second is related to the beginning of the requested segment and the last is related to the quantity of the requested words.

In particular, if the quantity of the requested bytes is greater than the instrument's memory extension, the instrument will answer an "INVALID DATA" for the not available values; for example, if are requested 20 bytes from the last fourth valid address, a part of the request overflows in the non available memory. The exceeded bytes will be filled with the value 00, indicating a non-managed value for those memory cells.

The second particular case is related to a request starting from a non-valid address, when the request starts from an address not present in the following table. In this case the instrument will answer with an exception "02 ILLEGAL DATA ADDRESS".

The last particular case is the request of a number of words greater than the maximum for the instrument: in this case the instrument will answer with an exception "02 ILLEGAL DATA address".

2.2.3 Memory maps

The following 3 tables indicate the correspondence between the address of the location, the number of accessible words beginning with that address, the description of the measurement value, the unit of measurement of the measurement value and the binary format. They differentiate each other for the data format.

- *Integer 32 bits*

Reg [Dec]	Reg [Hex]	Measurement description	Unit	Format
4096	1000	3-PHASE SYSTEM VOLTAGE	V	Unsigned integer 32 bits
4098	1002	PHASE VOLTAGE L1-N	V	Unsigned integer 32 bits
4100	1004	PHASE VOLTAGE L2-N	V	Unsigned integer 32 bits
4102	1006	PHASE VOLTAGE L3-N	V	Unsigned integer 32 bits
4104	1008	LINE VOLTAGE L1-2	V	Unsigned integer 32 bits
4106	100A	LINE VOLTAGE L2-3	V	Unsigned integer 32 bits
4108	100C	LINE VOLTAGE L3-1	V	Unsigned integer 32 bits
4110	100E	3-PHASE SYSTEM CURRENT	mA	Unsigned integer 32 bits
4112	1010	LINE CURRENT L1	mA	Unsigned integer 32 bits
4114	1012	LINE CURRENT L2	mA	Unsigned integer 32 bits
4116	1014	LINE CURRENT L3	mA	Unsigned integer 32 bits
4118	1016	3-PHASE SYS. POWER FACTOR	/1000	Signed integer 32 bits
4120	1018	POWER FACTOR L1	/1000	Signed integer 32 bits
4122	101A	POWER FACTOR L2	/1000	Signed integer 32 bits
4124	101C	POWER FACTOR L3	/1000	Signed integer 32 bits
4126	101E	3-PHASE SYSTEM COS Phi	/1000	Signed integer 32 bits

4128	1020	PHASE COS Phi1	/1000	Signed integer 32 bits
4130	1022	PHASE COS Phi2	/1000	Signed integer 32 bits
4132	1024	PHASE COS Phi3	/1000	Signed integer 32 bits
4134	1026	3-PHASE S. APPARENT POWER	VA	Unsigned integer 32 bits
4136	1028	APPARENT POWER L1	VA	Unsigned integer 32 bits
4138	102A	APPARENT POWER L2	VA	Unsigned integer 32 bits
4140	102C	APPARENT POWER L3	VA	Unsigned integer 32 bits
4142	102E	3-PHASE SYS. ACTIVE POWER	W	Signed integer 32 bits
4144	1030	ACTIVE POWER L1	W	Signed integer 32 bits
4146	1032	ACTIVE POWER L2	W	Signed integer 32 bits
4148	1034	ACTIVE POWER L3	W	Signed integer 32 bits
4150	1036	3-PHASE S. REACTIVE POWER	VAr	Signed integer 32 bits
4152	1038	REACTIVE POWER L1	VAr	Signed integer 32 bits
4154	103A	REACTIVE POWER L2	VAr	Signed integer 32 bits
4156	103C	REACTIVE POWER L3	VAr	Signed integer 32 bits
4158	103E	3-PHASE SYS. ACTIVE ENERGY	Wh*100	Unsigned integer 32 bits
4160	1040	3-PHASE S. REACTIVE ENERGY	Varh*100	Unsigned integer 32 bits
4162	1042	Neutral current	mA	Unsigned integer 32 bits
4166	1046	FREQUENCY	mHz	Unsigned integer 32 bits
4168	1048	3-Phase sys. angle between current and voltage	m Degrees	Signed integer 32 bits
4170	104A	Phase 1 angle between current and voltage	m Degrees	Signed integer 32 bits
4172	104C	Phase 2 angle between current and voltage	m Degrees	Signed integer 32 bits
4174	104E	Phase 3 angle between current and voltage	m Degrees	Signed integer 32 bits
4176	1050	Phase 1 Voltage Angle	m Degrees	Signed integer 32 bits
4178	1052	Phase 2 Voltage Angle	m Degrees	Signed integer 32 bits
4180	1054	Phase 3 Voltage Angle	m Degrees	Signed integer 32 bits
4182	1056	Phase 1 Current Angle	m Degrees	Signed integer 32 bits
4184	1058	Phase 2 Current Angle	m Degrees	Signed integer 32 bits
4186	105A	Phase 3 Current Angle	m Degrees	Signed integer 32 bits
4202	106A	Unbalance phase voltage	% /100	Unsigned integer 32 bits
4204	106C	Unbalance line voltage	% /100	Unsigned integer 32 bits
4206	106E	Unbalance current	% /100	Unsigned integer 32 bits
4208	1070	3-PHASE SYS. ACTIVE POWER 15’ AVER	W	Signed integer 32 bits
4210	1072	3-PHASE SYS. APPARENT POWER 15’ AVER	VA	Unsigned integer 32 bits
4226	1082	VOLTAGE ThdF L1 (NORMAL VISUALISATION)	% /100	Unsigned integer 32 bits
4228	1084	VOLTAGE ThdF L2 (NORMAL VISUALISATION)	% /100	Unsigned integer 32 bits
4230	1086	VOLTAGE ThdF L3 (NORMAL VISUALISATION)	% /100	Unsigned integer 32 bits

4232	1088	CURRENT ThdF L1 (NORMAL VISUALISATION)	% /100	Unsigned integer 32 bits
4234	108A	CURRENT ThdF L2 (NORMAL VISUALISATION)	% /100	Unsigned integer 32 bits
4236	108C	CURRENT ThdF L3 (NORMAL VISUALISATION)	% /100	Unsigned integer 32 bits
4262	10A6	3-PHASE SYS. APPARENT ENERGY	Vah*100	Unsigned integer 32 bits
4270	10AE	3-PHASE SYS. GENERATED ACTIVE ENERGY	Wh*100	Unsigned integer 32 bits
4278	10B6	3-PHASE S. GENERATED REACTIVE ENERGY	Varh*100	Unsigned integer 32 bits
4294	10C6	Current Demand L1	mA	Unsigned integer 32 bits
4296	10C8	Current Demand L2	mA	Unsigned integer 32 bits
4298	10CA	Current Demand L3	mA	Unsigned integer 32 bits
4512	11A0	CURRENT TRANSFORM RATIO (CT)	A/A	Unsigned integer 32 bits
4514	11A2	VOLTAGE TRANSFORM RATIO (VT)	V/V	Unsigned integer 32 bits
4516	11A4	PULSE ENERGY WEIGHT	1/kW	Unsigned integer 32 bits

- *Float 32 bits*

Reg [Dec]	Reg [Hex]	Measurement description	Unit	Format
12288	3000	Voltage L1 and Neutral	V	Float 32 bits
12290	3002	Voltage L2 and Neutral	V	Float 32 bits
12292	3004	Voltage L3 and Neutral	V	Float 32 bits
12294	3006	Voltage L1 and L2	V	Float 32 bits
12296	3008	Voltage L2 and L3	V	Float 32 bits
12298	300A	Voltage L3 and L1	V	Float 32 bits
12300	300C	Three phase system voltage	V	Float 32 bits
12302	300E	Reserved		
12304	3010	Current phase 1	A	Float 32 bits
12306	3012	Current phase 2	A	Float 32 bits
12308	3014	Current phase 3	A	Float 32 bits
12310	3016	Neutral current	A	Float 32 bits
12312	3018	Three phase system current	A	Float 32 bits
12314	301A	Reserved		
12316	301C	Active power phase 1	W	Float 32 bits
12318	301E	Active power phase 2	W	Float 32 bits
12320	3020	Active power phase 3	W	Float 32 bits
12322	3022	Active power total	W	Float 32 bits
12324	3024	Reactive power phase 1	Var	Float 32 bits
12326	3026	Reactive power phase 2	Var	Float 32 bits
12328	3028	Reactive power phase 3	Var	Float 32 bits
12330	302A	Reactive power total	Var	Float 32 bits
12332	302C	Apparente power fase 1	VA	Float 32 bits

12334	302E	Apparente power fase 2	VA	Float 32 bits
12336	3030	Apparente power fase 3	VA	Float 32 bits
12338	3032	Apparente power total	VA	Float 32 bits
12340	3034	Reserved		
12342	3036	Power factor phase 1		Float 32 bits
12344	3038	Power factor phase 2		Float 32 bits
12346	303A	Power factor phase 3		Float 32 bits
12348	303C	Power factor phase total		Float 32 bits
12350	303E	Displacement factor phase 1		Float 32 bits
12352	3040	Displacement factor phase 2		Float 32 bits
12354	3042	Displacement factor phase 3		Float 32 bits
12356	3044	Displacement factor phase total		Float 32 bits
12358	3046	Angle Phi1		Float 32 bits
12360	3048	Angle Phi2		Float 32 bits
12362	304A	Angle Phi3		Float 32 bits
12364	304C	Angle Phi total		Float 32 bits
12366	304E	Frequency	Hz	Float 32 bits
12368	3050	Current demand phase 1	A	Float 32 bits
12370	3052	Current demand phase 2	A	Float 32 bits
12372	3054	Current demand phase 3	A	Float 32 bits
12374	3056	Active power demand	W	Float 32 bits
12376	3058	Reactive power demand	Var	Float 32 bits
12378	305A	Apparent power demand	VA	Float 32 bits
12380	305C	Voltage angle phase 1		Float 32 bits
12382	305E	Voltage angle phase 2		Float 32 bits
12384	3060	Voltage angle phase 3		Float 32 bits
12386	3062	Currente angle phase 1		Float 32 bits
12388	3064	Currente angle phase 2		Float 32 bits
12390	3066	Current angle phase 3		Float 32 bits
12392	3068	THD U1	%	Float 32 bits
12394	306A	THD U 2	%	Float 32 bits
12396	306C	THD U 3	%	Float 32 bits
12398	306E	THD I1	%	Float 32 bits
12400	3070	THD I2	%	Float 32 bits
12402	3072	THD I3	%	Float 32 bits
12404	3074	Phase voltage unbalance	%	Float 32 bits
12406	3076	Line voltage unbalance	%	Float 32 bits
12408	3078	Current unbalance	%	Float 32 bits
12410	307A	Direct active energy kWh in *100	kWh	Unsigned integer 32 bits
12412	307C	Reverse active energy kWh in *100	kvarh	Unsigned integer 32 bits
12414	307E	Direct reactive energy kWh in *100	kWh	Unsigned integer 32 bits

12416	3080	Reverse reactive energy kWh in *100	kvarh	Unsigned integer 32 bits
12418	3082	Apparent energy kVAh *100	kVAh	Unsigned integer 32 bits

- *Integer 16 bits*

Reg [Dec]	Reg [Hex]	Measurement description	Conversion factor	Format
80	50	Primary of the CT	Integer value	Unsigned word*
81	51	Number of decimal places for primary of CT	0,1,2 or 3	Unsigned word*
82	52	Magnitude of the CT	0 (A),3 (kA)	Unsigned word*
83	53	Primary of the VT	Integer value	Unsigned word*
84	54	Number of decimal places for primary of VT	0,1,2 or 3	Unsigned word*
85	55	Magnitude of the VT	0 (V),3 (kV)	Unsigned word*
86	56	Nominal power	Integer value	Unsigned word*
87	57	Number of decimal places for power	0,1,2 or 3	Unsigned word*
88	58	Magnitude of the power	0 (W),3 (kW) or 6 (MW)	Unsigned word*
100	64	Voltage L1 and Neutral	16384 = Rated Value	Unsigned word*
101	65	Voltage L2 and Neutral	16384 = Rated Value	Unsigned word*
102	66	Voltage L3 and Neutral	16384 = Rated Value	Unsigned word*
103	67	Voltage L1 and L2	16384 = Rated Value	Unsigned word*
104	68	Voltage L2 and L3	16384 = Rated Value	Unsigned word*
105	69	Voltage L3 and L1	16384 = Rated Value	Unsigned word*
106	6A	Current I1	16384 = Rated Value	Unsigned word*
107	6B	Current I2	16384 = Rated Value	Unsigned word*
108	6C	Current I3	16384 = Rated Value	Unsigned word*
109	6D	Neutral current	16384 = Rated Value	Unsigned word*
110	6E	Active Power P1	16384 = Rated Value	Signed word*
111	6F	Active Power P2	16384 = Rated Value	Signed word*
112	70	Active Power P3	16384 = Rated Value	Signed word*
113	71	Total Active Power PT	16384 = Rated Value	Signed word*
114	72	Reactive Power Q1	16384 = Rated Value	Signed word*
115	73	Reactive Power Q2	16384 = Rated Value	Signed word*
116	74	Reactive Power Q3	16384 = Rated Value	Signed word*
117	75	Total Reactive Power QT	16384 = Rated Value	Signed word*
118	76	Apparent Power S1	16384 = Rated Value	Unsigned word*
119	77	Apparent Power S2	16384 = Rated Value	Unsigned word*
120	78	Apparent Power S3	16384 = Rated Value	Unsigned word*

121	79	Total Apparent Power ST	16384 = Rated Value	Unsigned word*
122	7A	Power Factor 1	16384 = Rated Value	Signed word*
123	7B	Power Factor 2	16384 = Rated Value	Signed word*
124	7C	Power Factor 3	16384 = Rated Value	Signed word*
125	7D	Power Factor T	16384 = Rated Value	Signed word*
126	7E	Frequency	2000H = 50 Hz	Unsigned word*
127	7F	Imported active energy in MWh	1 = 1 MWh	Unsigned word*
128	80	Imported active energy in kWh	1 = 1 kWh	Unsigned word*
129	81	Imported active energy in Wh	1 = 1 Wh	Unsigned word*
130	82	Imported reactive energy in Mvarh	1 = 1 Mvarh	Unsigned word*
131	83	Imported reactive energy in kvarh	1 = 1 kvarh	Unsigned word*
132	84	Imported reactive energy in varh	1 = 1 varh	Unsigned word*
133	85	Exported active energy in MWh	1 = 1 MWh	Unsigned word*
134	86	Exported active energy in kWh	1 = 1 kWh	Unsigned word*
135	87	Exported active energy in Wh	1 = 1 Wh	Unsigned word*
136	88	Exported reactive energy in Mvarh	1 = 1 Mvarh	Unsigned word*
137	89	Exported reactive energy in kvarh	1 = 1 kvarh	Unsigned word*
138	8A	Exported reactive energy in varh *1	1 = 1 varh	Unsigned word*
139	8B	Angle Phi 1	16384 = 360	Unsigned word*
140	8C	Angle Phi 2	16384 = 360	Unsigned word*
141	8D	Angle Phi 3	16384 = 360	Unsigned word*
142	8E	Angle Phi t	16384 = 360	Unsigned word*
143	8F	Demand of Current I1	16384 = Rated Value	Unsigned word*
144	90	Demand of Current I2	16384 = Rated Value	Unsigned word*
145	91	Demand of Current I3	16384 = Rated Value	Unsigned word*
146	92	Demand of Real Power	16384 = Rated Value	Signed word*
147	93	Demand of Reactive Power	16384 = Rated Value	Signed word*
148	94	Demand of Apparent Power	16384 = Rated Value	Unsigned word*
149	95	Phase 1 Voltage Angle	16384 = Rated Value	Unsigned word*
150	96	Phase 2 Voltage Angle	16384 = Rated Value	Unsigned word*
151	97	Phase 3 Voltage Angle	16384 = Rated Value	Unsigned word*
152	98	Phase 1 Current Angle	16384 = Rated Value	Unsigned word*
153	99	Phase 2 Current Angle	16384 = Rated Value	Unsigned word*
154	9A	Phase 3 Current Angle	16384 = Rated Value	Unsigned word*
155	9B	Cos Phi 1	16384 = Rated Value	Signed word*
156	9C	Cos Phi 2	16384 = Rated Value	Signed word*

157	9D	Cos Phi 3	16384 = Rated Value	Signed word*
158	9E	Cos Phi T	16384 = Rated Value	Signed word*
159	9F	THD U1	16384 = Rated Value	Unsigned word*
160	A0	THD U2	16384 = Rated Value	Unsigned word*
161	A1	THD U3	16384 = Rated Value	Unsigned word*
162	A2	THD I1	16384 = Rated Value	Unsigned word*
163	A3	THD I2	16384 = Rated Value	Unsigned word*
164	A4	THD I3	16384 = Rated Value	Unsigned word*
165	A5	Apparent energy in MVAh	1 = 1 MVAh	Unsigned word*
166	A6	Apparent energy in kVAh	1 = 1 kVAh	Unsigned word*
167	A7	Apparent energy in VAh	1 = 1 VAh	Unsigned word*
168	A8	Phase voltage unbalance	16384 = Rated Value	Unsigned word
169	A9	Line voltage unbalance	16384 = Rated Value	Unsigned word
170	AA	Current unbalance	16384 = Rated Value	Unsigned word

2.3 Exceptions on the Bus

Below is a table of the exceptions handled for errors regarding access to the bus:

Exception	**Description**
01	Illegal function
02	Illegal data address
03	Illegal data value