M2M/DMTME Instruments

Communication protocol

Technical specification V.2.0
2CSG445011D0201

1 Setting up M2M/DMTME serial communication

1.1 Serial network ID programming

Enter setup menu on the instrument and scroll options until the display shows, for DMTME "id Adr" (see DMTME instruction manual for detailed instructions), or for M2M[a] "Menu communication" → "Address" (see M2M 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. RS-485 interface allows multi-drop connection with several devices in the same network. Maximum recommended length of a RS485 line is 1200m. For longer distances use low attenuation cables or ABB CUS repeater. On the same RS485 bus a maximum of 32 units can be installed; over this number a repeater must be inserted. The higher the number of devices, the higher will be the response delay.

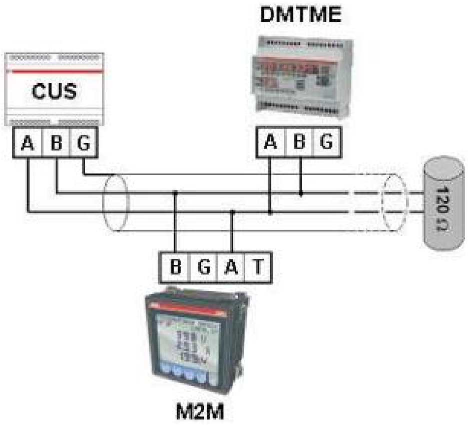
Communication parameters

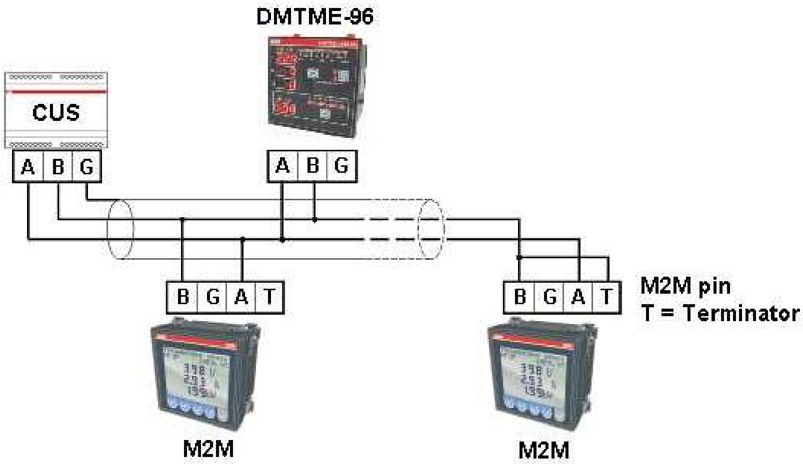
Baud rate	2400 ÷ 19200 (for DMTME) 4800 ÷ 19200 (for M2M)
Data bit	8
Stop bit	1, 2 (only with parity = none) or 1 (with parity = odd, even or none)
Parity	Even, odd, none

1.3 Serial line connection

As reported in the scheme below, 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. For lines longer than 500m connect a terminal resistor Rt=120W to the twisted cables pair; the resistor has to be connected between serial interface and the last connected instrument. When using a shielded twisted pair, shield shall be grounded. For a safe and stable connection use 22 AWG twisted pair cables with capacity lower than 60pF/m (e.g. Belden EIA RS485 ref. 3105A). For further information see also ABB CUS instructions manual.

[a] M2M models where the serial interface is available are: M2M MODBUS, M2M ALARM, M2M I/O. For simplicity, if not specified, all the models will be listed in the document with M2M.





In the previous figure, if the M2M is the last instrument installed in the RS485 network, is possibile to avoid the terminal resistor connecting pin T with pin B.

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.

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.

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 24 consecutive measures. Below are described the read request format (from master to slave) and the reply format (from slave to master).

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.

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".

Memory map

The following table indicates 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.

Address	Word	Measurement description	Unit	Format
1000h	2	3-PHASE SYSTEM VOLTAGE	Volt	Unsigned Long
1002h	2	PHASE VOLTAGE L1-N	Volt	Unsigned Long
1004h	2	PHASE VOLTAGE L2-N	Volt	Unsigned Long
1006h	2	PHASE VOLTAGE L3-N	Volt	Unsigned Long
1008h	2	LINE VOLTAGE L1-2	Volt	Unsigned Long
100Ah	2	LINE VOLTAGE L2-3	Volt	Unsigned Long
100Ch	2	LINE VOLTAGE L3-1	Volt	Unsigned Long
100Eh	2	3-PHASE SYSTEM CURRENT	mA	Unsigned Long
1010h	2	LINE CURRENT L1	mA	Unsigned Long
1012h	2	LINE CURRENT L2	mA	Unsigned Long
1014h	2	LINE CURRENT L3	mA	Unsigned Long
1016h	2	3-PHASE SYS. POWER FACTOR [I]	* 1000	Signed Long
1018h	2	POWER FACTOR L1[I]	* 1000	Signed Long
101Ah	2	POWER FACTOR L2[I]	* 1000	Signed Long
101Ch	2	POWER FACTOR L3[I]	* 1000	Signed Long
101Eh	2	3-PHASE SYSTEM COS φ[I]	* 1000	Signed Long
1020h	2	PHASE COS φ1[I]	* 1000	Signed Long
1022h	2	PHASE COS φ2[I]	* 1000	Signed Long
1024h	2	PHASE COS φ3[I]	* 1000	Signed Long
1026h	2	3-PHASE S. APPARENT POWER	VA	Unsigned Long
1028h	2	APPARENT POWER L1	VA	Unsigned Long
102Ah	2	APPARENT POWER L2	VA	Unsigned Long
102Ch	2	APPARENT POWER L3	VA	Unsigned Long
102Eh	2	3-PHASE SYS. ACTIVE POWER	Watt	Signed Long (S)
1030h	2	ACTIVE POWER L1	Watt	Signed Long (S)
1032h	2	ACTIVE POWER L2	Watt	Signed Long (S)
1034h	2	ACTIVE POWER L3	Watt	Signed Long (S)
1036h	2	3-PHASE S. REACTIVE POWER	VAr	Signed Long (S)
1038h	2	REACTIVE POWER L1	VAr	Signed Long (S)
103Ah	2	REACTIVE POWER L2	VAr	Signed Long (S)
103Ch	2	REACTIVE POWER L3	VAr	Signed Long (S)
103Eh	2	3-PHASE SYS. ACTIVE ENERGY	Wh * 100	Unsigned Long
1040h	2	3-PHASE S. REACTIVE ENERGY	VArh * 100	Unsigned Long
1046h	2	FREQUENCY	mHz	Unsigned Long
1060h	2	MAX LINE CURRENT L1	mA	Unsigned Long
1062h	2	MAX LINE CURRENT L2	mA	Unsigned Long
1064h	2	MAX LINE CURRENT L3	mA	Unsigned Long
1066h	2	MAX 3-PHASE SYS. ACTIVE POWER	Watt	Signed Long (S)
1068h	2	MAX 3-PHASE S. APPARENT POWER	VA	Unsigned Long
1070h	2	3-PHASE SYS. ACTIVE POWER 15' AVER	Watt	Signed Long (S)
1072h[II]	2	3-PHASE SYS. APPARENT POWER 15' AVER	VA	Unsigned Long
1074h[II]	2	ACTIVE ENERGY L1	Wh * 100	Unsigned Long
1076h[II]	2	ACTIVE ENERGY L2	Wh * 100	Unsigned Long
1078h[II]	2	ACTIVE ENERGY L3	Wh * 100	Unsigned Long
107Ah[II]	2	REACTIVE ENERGY L1	VArh * 100	Unsigned Long
107Ch[II]	2	REACTIVE ENERGY L2	VArh * 100	Unsigned Long
107Eh[II]	2	REACTIVE ENERGY L3	VArh * 100	Unsigned Long
1080h[II]	2	MAX 3-PHASE SYS. ACTIVE POWER 15' AVER	Watt	Signed Long (S)
1082h[II]	2	VOLTAGE ThdF L1 (NORMAL VISUALISATION) [IV]	* 100	Unsigned Long
1084h[II]	2	VOLTAGE ThdF L2 (NORMAL VISUALISATION) [IV]	* 100	Unsigned Long
1086h[II]	2	VOLTAGE ThdF L3 (NORMAL VISUALISATION) [IV]	* 100	Unsigned Long
1088h[II]	2	CURRENT ThdF L1 (NORMAL VISUALISATION) [IV]	* 100	Unsigned Long
108Ah[II]	2	CURRENT ThdF L2 (NORMAL VISUALISATION) [IV]	* 100	Unsigned Long
108Ch[II]	2	CURRENT ThdF L3 (NORMAL VISUALISATION) [IV]	* 100	Unsigned Long
108Eh[II]	2	MAX ACTIVE POWER 15' AVER L1	Watt	Signed Long (S)
1090h[II]	2	MAX ACTIVE POWER 15' AVER L2	Watt	Signed Long (S)
1092h[II]	2	MAX ACTIVE POWER 15' AVER L3	Watt	Signed Long (S)
1094h[II]	2	MAX 3-PHASE SYS. APPARENT POWER 15' AVER	VA	Unsigned Long
1096h[II]	2	MAX APPARERENT POWER 15' AVER L1	VA	Unsigned Long
1098h[II]	2	MAX APPARERENT POWER 15' AVER L2	VA	Unsigned Long
109Ah[II]	2	MAX APPARERENT POWER 15' AVER L3	VA	Unsigned Long

109Ch[III]	2	AVER. ACTIVE POWER from PULSES INPUT (CH1)	Watt	Unsigned Long
109Eh[III]	2	AVER. REACT. POWER from PULSES INPUT (CH2)	Var	Unsigned Long
10A0h[III]	2	ACTIVE ENERGY from PULSES INPUT (CH1)	Wh * 100	Unsigned Long
10A2h[III]	2	REACTIVE ENERGY from PULSES INPUT (CH2)	VArh * 100	Unsigned Long
10A4h[II]	2	CURRENT THRESHOLD for TIMER-2 ACTIVATION	mA	Unsigned Long
10A6h[II]	2	3-PHASE SYS. APPARENT ENERGY	VAh * 100	Unsigned Long
10A8h[II]	2	APPARENT ENERGY L1	VAh * 100	Unsigned Long
10AAh[II]	2	APPARENT ENERGY L2	VAh * 100	Unsigned Long
10ACh[II]	2	APPARENT ENERGY L3	VAh * 100	Unsigned Long
10AEh[II]	2	3-PHASE SYS. GENERATED ACTIVE ENERGY	Wh * 100	Unsigned Long
10B0h[II]	2	GENERATED ACTIVE ENERGY L1	Wh * 100	Unsigned Long
10B2h[II]	2	GENERATED ACTIVE ENERGY L2	Wh * 100	Unsigned Long
10B4h[II]	2	GENERATED ACTIVE ENERGY L3	Wh * 100	Unsigned Long
10B6h[II]	2	3-PHASE S. GENERATED REACTIVE ENERGY	VArh * 100	Unsigned Long
10B8h[II]	2	GENERATED REACTIVE ENERGY L1	VArh * 100	Unsigned Long
10BAh[II]	2	GENERATED REACTIVE ENERGY L2	VArh * 100	Unsigned Long
10BCh[II]	2	GENERATED REACTIVE ENERGY L3	VArh * 100	Unsigned Long
10BEh[II]	2	3-PHASE S. GENERATED APPARENT ENERGY	VAh * 100	Unsigned Long
10C0h[II]	2	GENERATED APPARENT ENERGY L1	VAh * 100	Unsigned Long
10C2h[II]	2	GENERATED APPARENT ENERGY L2	VAh * 100	Unsigned Long
10C4h[II]	2	GENERATED APPARENT ENERGY L3	VAh * 100	Unsigned Long
11A0h	2	CURRENT TRANSFORM RATIO (CT)	1 – 1250[V] (DMTME) 1 – 2000[V] (M2M)	Unsigned Long
11A2h	2	VOLTAGE TRANSFORM RATIO (VT)	1 – 500[VI] (DMTME) 1 – 600[VI] (M2M)	Unsigned Long
11A4h	2	PULSE ENERGY WEIGHT	1 – 4[VII]	Unsigned Long

Unsigned Long is a 2-words (32 bit) value without sign
Signed Long is a 2-words (32-bit) value expressed in 2's complement format; for example the integer value "-7" is FFFF FFF9h

[S] This value is Signed only in M2M (unsigned in MTME).

[I] When the power factor or cos φ is undefined (e.g. in case of no current) the instrument places the value "cos φ = 2" (value = 2000 on this registry) to indicate unavailability of the measure

[II] Only for M2M instruments

[III] Only for M2M I/O model

[IV] When ThdF is undefined (e.g. in case of no current) the related reading register yelds the value 0.

[V] For M2M instruments the maximum selectable value is 2000; the reading register yelds the CT "ratio" programmed in the instrument. For example if in the instrument the CT value is set as 100/5A, this register will yeld 20.

[VI] For M2M instruments the maximum selectable value is 600; the reading register yelds the VT "ratio" programmed in the instrument.

[VII] Possible values:
1. each pulse weight 10 Wh/VArh
2. each pulse weight 100 Wh/VArh
3. each pulse weight 1000 Wh/VArh
4. each pulse weight 10000 Wh/VArh

2.3 Function 10h: "Write parameters"

This function allows the setup of some instrument parameters or the execution of commands. It is possible to set up more than one parameter using this function. If the writing buffer is bigger than the memory space an error is generated in response. If the writing buffer is more than one register and some values are out of range an error is generated in response.

Frame format

ADDRESS FIELD	FUNCTION CODE 10h	START ADDRESS	# OF REGs	No. OF SEND BYTES	D0, D1, .., Dn	ERROR CHECK

Memory map

Address	Word	Measurement description	Min	Max
11A0h	2	CURRENT TRANSFORM RATIO (CT)	1	1250[VII] (DMTME) 2000[VII] (M2M)
11A2h	2	VOLTAGE TRANSFORM RATIO (VT)	1	500[VIII] (DMTME) 600[VIII] (M2M)
11A4h	2	PULSE ENERGY WEIGHT	1	4[VI]

[VII] For M2M instruments the maximum selectable value is 2000; the command sets in the instrument simultaneously the value of CT's secondary current to 5A and the value of CT's primary current to CT*5A. For example to setting CT=50 will result in CT = 250/5 in the M2M instrument configuration.

[VIII] For M2M instruments the maximum selectable value is 600; the command sets in the instrument simultaneously the value of VT's secondary voltage to 100V and the value of VT's primary voltage to VT*100V

Example:

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

ADDRESS FIELD	=	1Fh
FUNCTION CODE	=	10h
Reg H	=	11h
Reg L	=	A0h
# Reg H	=	00h
# Reg L	=	02h
BYTE COUNT	=	04h
Data 0 H	=	00h
Data 0 L	=	00h
Data 1 H	=	00h
Data 1 L	=	64h
CRC H	=	58h
CRC L	=	44h

In this example will be set value 100 (64h) for CT ratio.

Command map

Add.	Word	Measurement description	MSB Word	LSB Word
11B0h	2	Reset Energy counters	11B0h	55AAh
11B2h	2	Reset Max Values	11B2h	55AAh
11B4h	2	Reset Average Values	11B4h	55AAh

For the execution of the command the buffer must contain, as value, the two words indicated on the table.

2.4 Function 11h: "Report slave ID"

This function makes it possible to read the instrument identifier.

Read request (Master)

ADDRESS FIELD	FUNCTION CODE	ERROR CHECK

ADDRESS FIELD	=	02h
FUNCTION CODE	=	11h
CRC H	=	C0h
CRC L	=	DCh

In this example the id request is sent using Func = 11h to the slave with address Addr = 02h; the CRC C0DCh ends the frame.

Reply (Slave)

ADDRESS FIELD	FUNCTION CODE	No. OF BYTES	INSTRUMENT TYPE	FW release	ERROR CHECK

ADDRESS FIELD	=	02h
FUNCTION CODE	=	11h
No. OF BYTES	=	04h
INST. TYPE	=	50h
FW REL H	=	00h
FW REL L	=	70h
///		00h
CRC H	=	FEh
CRC L	=	81h

The answer contains address and function, the number of data bytes Len = 04h, the analyser description Instrument type = 50h, the high byte of firmware version Fw rel. H = 00h and the low byte of firmware version Fw rel. L = 70h. In this case FW rel. = 0070h (112): this value must be divided by 100 (V1.12). CRC FE81h ends the frame.

INSTRUMENT MODEL	*INSTRUMENT TYPE*
DMTME – I – 485	80 (50h)
M2M MODBUS	57 (39h)
M2M ALARM	58 (3Ah)
M2M I/O	59 (3Bh)

2.5 Exceptions on the Bus

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

Exception	Description
01 ILLEGAL FUNCTION	An unsupported function code has been sent
02 ILLEGAL DATA ADDRESS	Illegal address
03 ILLEGAL DATA VALUE	A setup datum is outside of the acceptable limits