SERIAL COMMUNICATION PROTOCOL

CPT-DIN
WM14-Advanced

Ver. 1 Rev. 2

27th October 2005

Index

1 COMMUNICATION PROTOCOL

1.1 INTRODUCTION

Only CPT-DIN can be provided with up to two serial interfaces.
The standard version is supplied with one serial interface (defined as auxiliary serial) using a RJ45 plug (see Fig. 1 and Tab. 1-1). The data format , the baud-rate and the address are fixed:

- 1 start bit
- 8 data bit
- 1 stop bit
- Parity: NONE
- 4800 baud
- Address: 255

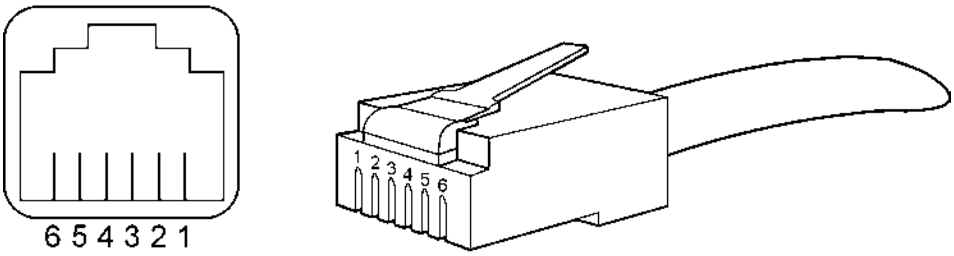


Fig. 1

RJ45 Pin Number	RS232 sub-din 9-pole connector (Female)	Description (PC side)	Physical Level	Logical Level
1	2	RX	…	…
2	3	TX	-	…
3	7	RTS	-10 V	False
4	5	GND	…	-
5	4	DTR	+10 V	True
6	9	Not Connected	…	…

Tab. 1-1 : RJ45 to RS232 pinout

Note: RTS and DTR must be set by the master (PC) to false and true respectively.

On request, CPT-DIN can also be provided with an optional RS485/422 (option S1) or RS232 (option S2) serial interface. WM14a can only be provided with an optional RS485/422 serial interface. The data format is fixed:

- 1 start bit
- 8 data bit
- 1 stop bit
- Parity: NONE

and the baud-rate can be selected among 4800, 9600, 19200 or 38400 baud.
Both the standard and optional interfaces use the MODBUS/JBUS (RTU) protocol.
The host starts the communication by sending the relevant request frame. Each frame is composed of 4 types of information:

- **slave address**: it is a number within the range from 1 to 255 which identifies each instrument connected to the network.
- **function code (command)**: it defines the control type (reading of n words, writing of one word)
- **data field**: it defines the function parameters (e.g. address of the word to write, value of this word, etc.)
- **control word (CRC)**: it is used to detect transmission errors that may occur.

The master calculates the CRC after defining address, function number and data field. When the slave receives the query, it stores the data in a temporary buffer. After that, the CRC is calculated and compared with the one received. If the two CRC values are the same and the address is correct, the slave carries out the command and then sends back its reply.

1.2 FUNCTIONS

These functions are available on the CPT-DIN and WM14a:

- Reading of n words (code 03h).
- Reading of n words (code 04h).
- Writing of one word (code 06h).
- Sub- function diagnostic instrument presence (code 08h).
- Broadcast mode (writing instruction on address 00).

Note: The functions 03h and 04h have exactly the same effect.

1.2.1 FUNCTIONS 03 AND 04

Query

Address	Function (*)	Word address		n° of words (**)		CRC	
1 byte	1 byte	2 bytes		2 bytes		2 bytes	
from 01h to FFh	04h (*)	MSB	LSB	MSB	LSB	MSB	LSB

Reply

Address	Function	n° bytes	Values	CRC	
1 byte	1 byte	1 byte	n° bytes	2 bytes	
from 01h to FFh	04h (*)	(***)	(****)	MSB	LSB

Notes:
(*) The function code can be either 04h or 03h.
(**) **The maximum number of words is 28 (1Ch) for the aux serial and 12 (0Ch) words for the optional RS485/232. For WM14a the maximum number of words is 12 (0Ch).**
(***) Number of bytes returned.
(****) The byte order is MSB-LSB.

1.3 FUNCTION 06

Query

Address	Function	Word address		Word value		CRC	
1 byte	1 byte	2 bytes		2 bytes		2 bytes	
from 01h to FFh	06h	MSB	LSB	MSB	LSB	MSB	LSB

Reply

Address	Function	Word address		Word value		CRC	
1 byte	1 byte	2 bytes		2 bytes		2 bytes	
from 01h to FFh	06h	MSB	LSB	MSB	LSB	MSB	LSB

Note: The answer is an echo of the request, which indicates the correct execution of the command.

1.3.1 FUNCTION 08

Query

Address	Function	Word address		Word value		CRC	
1 byte	1 byte	2 bytes		2 bytes		2 bytes	
from 01h to FFh	08h	00h	00h	AAh	BBh	MSB	LSB

Reply

Address	Function	Word address		Word value		CRC	
1 byte	1 byte	2 bytes		2 bytes		2 bytes	
from 01h to FFh	08h	00h	00h	AAh	BBh	MSB	LSB

Note: The answer is an echo of the request, which indicates the correct execution of the command.

1.3.2 EXCEPTION CODE

If there is a communication error, an exception code is sent by the slave.
The response frame is showed as follows:

Address	Function Code (*)	Exception(**)	CRC	
1 byte	1 byte	1 bytes	2 bytes	
from 01h to FFh	80h + REQUEST FUNCTION	EXCEPTION CODE	MSB	LSB

Notes:
(*) The function code can be either 03h, 04h, 06h or 08h.
(**) Valid values for exception code are 01h, 02h, 03h or 04h.

1.3.2.1 List of exception codes

Code	Description
01	ILLEGAL FUNCTION
02	ILLEGAL DATA ADDRESS
03	ILLEGAL DATA VALUE
04	SLAVE DEVICE FAILURE

1.3.3 EXAMPLES

Here are some examples of the above mentioned functions with query and reply frames. Light grey background boxes are the CRC bytes of the frame (see par. 3).

1.3.3.1 Reading

This example is relevant to the reading of the variable at the cell 60h in RAM, from the instrument which address is 255 (FFh). It is the max value of the system current.

Query	FFh	04h	00h	60h	00h	02h	64h	0Bh	

Reply	FFh	04h	04h	42h	49h	97h	49h	8Eh	23h

The reply is composed of the words 4249h and 9749h, so that the converted decimal value is 50.398 A.

1.3.3.2 Writing

This example shows how to write the current transformer ratio = 18 (12h) on the instrument which address is 237 (EDh).

Query	EDh	06h	01h	9Ah	00h	12h	3Eh	B8h	

Reply	EDh	06h	01h	9Ah	00h	12h	3Eh	B8h	

The reply is an echo of the query.

1.3.3.3 Diagnostic

The diagnostic request shall only be sent by using a rigid-structure frame.
The example below is relevant to a diagnostic request to the instrument which address is 255 (FFh).

Query	FFh	08h	00h	00h	AAh	BBh	CBh	06h	

Reply	FFh	08h	00h	00h	AAh	BBh	CBh	06h	

1.3.3.4 Exception

This example is relevant to an exception code which is sent because the max number of words is exceeded. The instrument address is 200 (C8h).
In this case the number of words requested is 32 (20h), whereas the max admitted for the serial interface on-board is 12.

Query	C8h	04h	00h	00h	00h	20h	E0h	4Bh	

Reply	C8h	84h	03h	D3h	3Fh				

1.4 SERIAL CONNECTIONS

The picture below shows a general structure of a MODBUS RS485 serial line system.

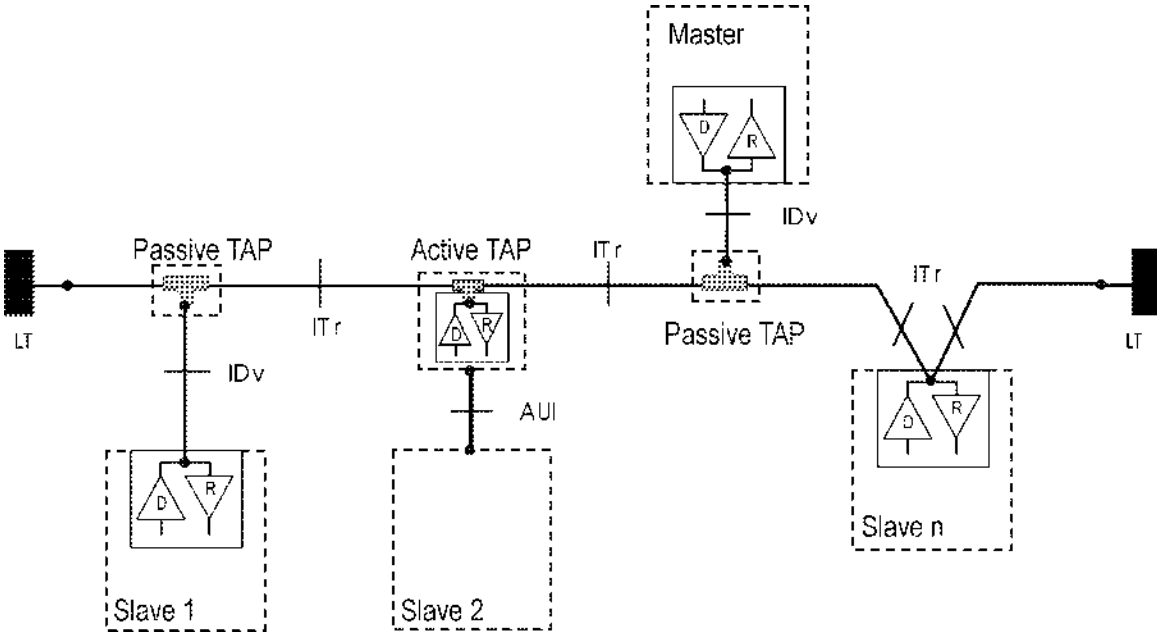


Fig. 2: General MODBUS system structure

1.4.1 RS485 4-WIRE SERIAL CONNECTION

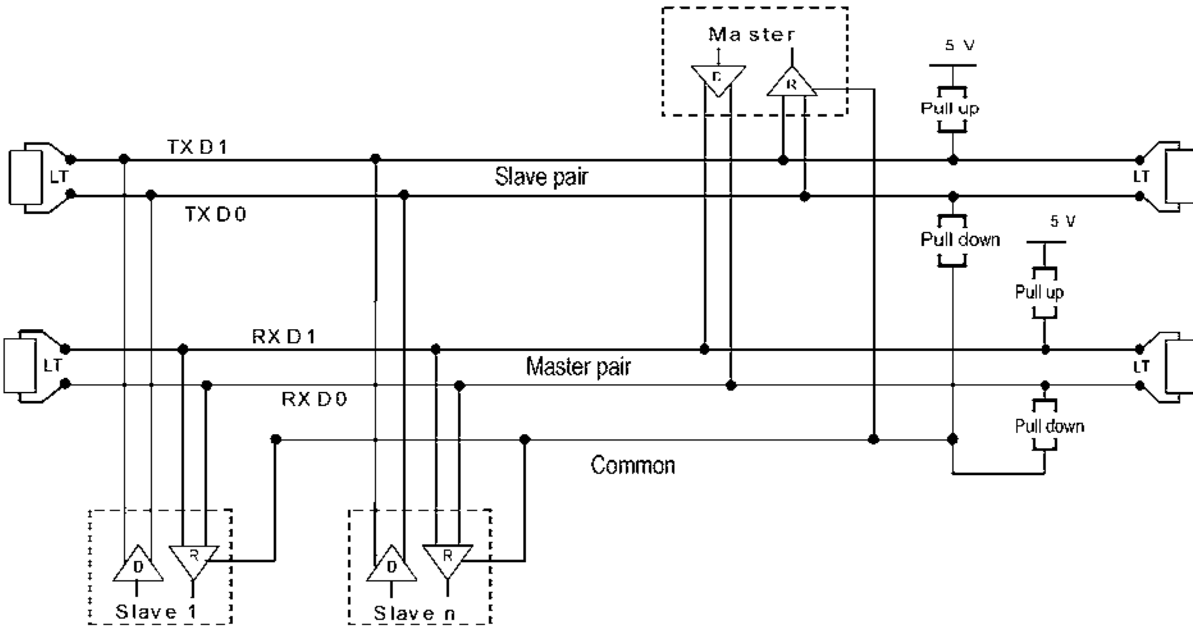


Fig. 3 : general MODBUS 4-wire network

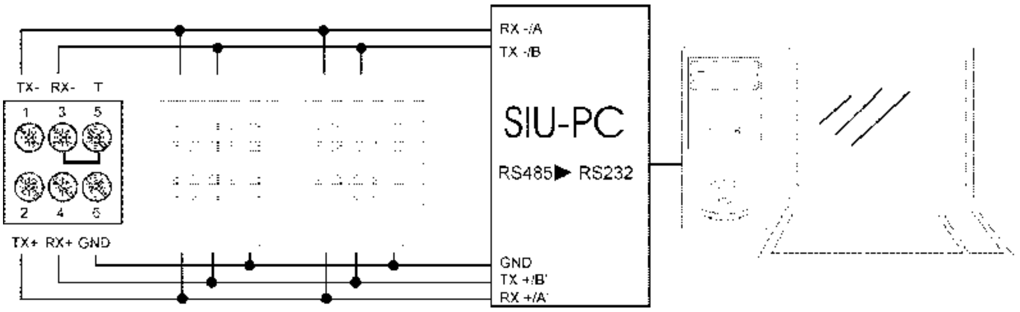


Fig. 4 :CPT-DIN RS485 4-wire (the symbols A, A', B, B' are referred to the standard EIA/TIA-485)

1.4.2 RS485 2-WIRE SERIAL CONNECTION

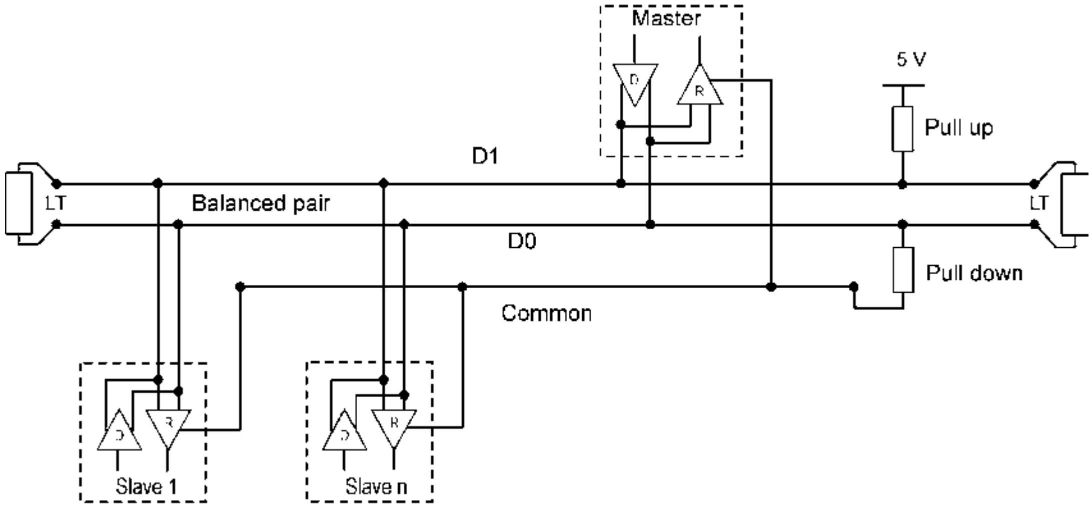


Fig. 5: general MODBUS two-wire network

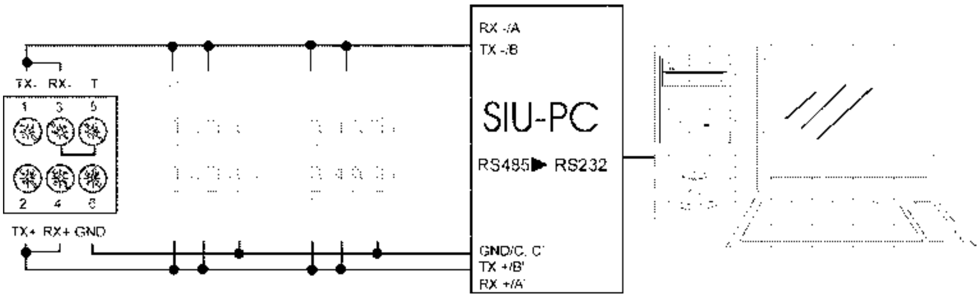


Fig. 6 : CPT-DIN RS485 2-wire (the symbols A, A', B, B' are referred to the standard EIA/TIA-485)

Notes:

1. To avoid errors due to the signal reflections or line coupling, it is necessary to terminate the input of the last instrument on the network, and also the reception of the Host. If this is not enough, it is also possible to bias the Host transmission (in case of 2-wire connection, it is only possible to either terminate or bias the Host, not both). The termination on both the instrument and the host is necessary even in case of point-to-point connection, within short distances.
2. The GND connection is optional if a shielded cable is used.
3. For connections longer than 1000m, a line amplifier is necessary.

1.4.3 RS232 SERIAL CONNECTION

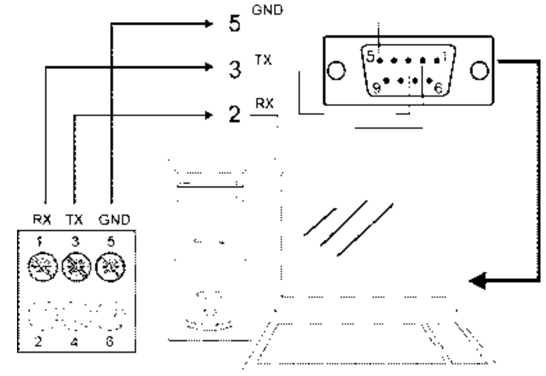


Fig. 7 : RS232

1.4.4 TIMING

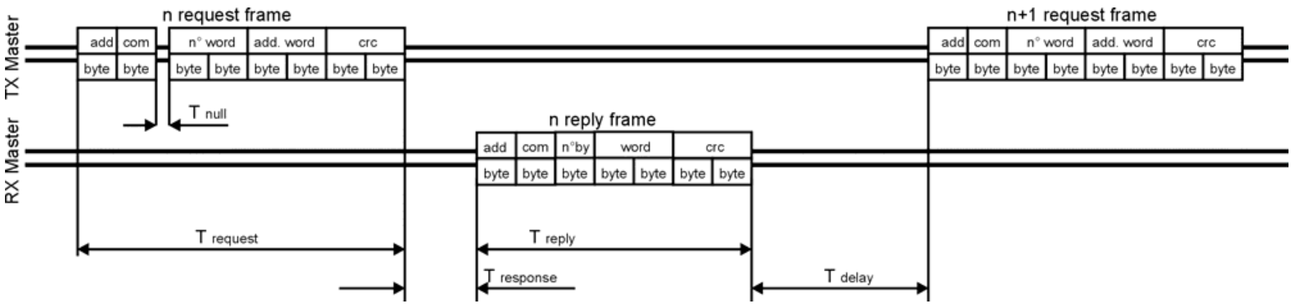


Fig. 8 : 4-wire timing diagram

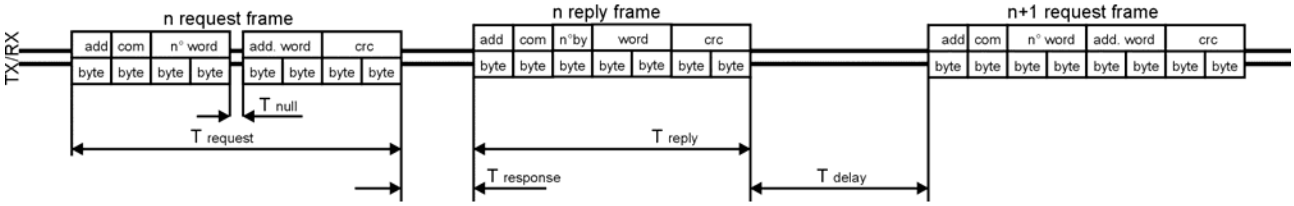


Fig. 9 : 2-wire timing diagram

Timing characteristics of reading function:	msec
T response: Max answering time	500ms
T response: Typical answering time	40ms
T delay: Minimum time for a new query	See Tab. 1-3
T null: Max interruption time on the request frame	See Tab. 1-3

Tab. 1-2 : Timing characteristics

1.4.5 TIMING VALUES

Baud-rate	New request delay (min)	Intercharacter time (max)
4800	3,5 char	2,5 char
9600	3,5 char	2,5 char
19200	3,5 char	2,5 char
38400	1,75 ms	1,75 ms

Tab. 1-3 : Timing values

1.4.6 APPLICATION NOTES

1. If an instrument does not answer within the “max answering time”, it is necessary to repeat the query. If the instrument does not answer after 2 or 3 consecutive queries, it must be considered as not connected, faulty or with wrong address. The same consideration is valid in case of CRC errors or incomplete frames.

2. For the timing calculation, refer to the following formulae:

$$Trequest = \frac{N^\circ bit}{Baud\_rate} * 8$$

$$Treply = \frac{N^\circ bit}{Baud\_rate} * N^\circ char$$

$$TS = T\_request + T\_response + T\_reply + T\_delay1$$

$$TA = TS * N^\circ request$$

$$TM = (TS + Tdelay2) * N^\circ instruments$$

N°bit	10
N°char	(5+N° Word*2) if function 04 o 03, 8 if function 06
N°word	Number of words to be read in an instrument
TS	Execution time of one reading
Tdelay1	Minimum time for new query on the same address
TA	Data acquiring time from one instrument
TM	Monitoring time of all the instruments
N°instruments	Number of instruments connected to the network.
Tdelay2	Minimum time for new query on a different address

Tab. 1-4

2 VARIABLE MAPPING

2.1 RAM MEMORY MAPPING

Address (valid for both functions 03 and 04)	Length (words)	VARIABLE ENG. UNIT	Variable Index	Data Format	Notes
0000h	2	V L1-N	0	IEEE 754	
0002h	2	V L2-N	1	IEEE 754	
0004h	2	V L3-N	2	IEEE 754	
0006h	2	V L1-L2	3	IEEE 754	
0008h	2	V L2-L3	4	IEEE 754	
000Ah	2	V L3-L1	5	IEEE 754	
000Ch	2	A L1	6	IEEE 754	
000Eh	2	A L2	7	IEEE 754	
0010h	2	A L3	8	IEEE 754	
0012h	2	A N	9	IEEE 754	
0014h	2	W L1	10	IEEE 754	
0016h	2	W L2	11	IEEE 754	
0018h	2	W L3	12	IEEE 754	
001Ah	2	VA L1	13	IEEE 754	
001Ch	2	VA L2	14	IEEE 754	
001Eh	2	VA L3	15	IEEE 754	
0020h	2	VAR L1	16	IEEE 754	
0022h	2	VAR L2	17	IEEE 754	
0024h	2	VAR L3	18	IEEE 754	
0026h	2	Phase sequence	19	IEEE 754	See par. 2.1.2 A)
0028h	2	PF L1	20	IEEE 754	See par. 2.1.2 B)
002Ah	2	PF L2	21	IEEE 754	See par. 2.1.2 B)
002Ch	2	PF L3	22	IEEE 754	See par. 2.1.2 B)
002Eh	2	V L-N ∑	23	IEEE 754	
0030h	2	V L-L ∑	24	IEEE 754	
0032h	2	W ∑	25	IEEE 754	
0034h	2	VA ∑	26	IEEE 754	
0036h	2	VAR ∑	27	IEEE 754	
0038h	2	PF ∑	28	IEEE 754	See par. 2.1.2 B)
003Ah	2	Hz	29	IEEE 754	
003Ch	2	Asymmetry L-N %	30	IEEE 754	
003Eh	2	Asymmetry L-L %	31	IEEE 754	
0040h	2	A L1 dmd	32	IEEE 754	
0042h	2	A L2 dmd	33	IEEE 754	
0044h	2	A L3 dmd	34	IEEE 754	
0046h	2	W L1 dmd	35	IEEE 754	
0048h	2	W L2 dmd	36	IEEE 754	
004Ah	2	W L3 dmd	37	IEEE 754	
004Ch	2	VA L1 dmd	38	IEEE 754	
004Eh	2	VA L2 dmd	39	IEEE 754	
0050h	2	VA L3 dmd	40	IEEE 754	
0052h	2	W dmd	41	IEEE 754	
0054h	2	VA dmd	42	IEEE 754	
0056h	2	KWh tot.	43	UINT32	See par. 2.1.2 C)
0058h	2	KVARh tot.	44	UINT32	See par. 2.1.2 C)
005Ah	2	KWh par.	45	UINT32	See par. 2.1.2 C)
005Ch	2	KVARh par.	46	UINT32	See par. 2.1.2 C)
005Eh	2	Hour Counter (1/100h)	47	UINT32	See par. 2.1.2 D)
0060h	2	A MAX	48	IEEE 754	
0062h	2	A MAX dmd	49	IEEE 754	
0064h	2	A L1 MAX	50	IEEE 754	
0066h	2	A L2 MAX	51	IEEE 754	
0068h	2	A L3 MAX	52	IEEE 754	
006Ah	2	W L1 MAX	53	IEEE 754	
006Ch	2	W L2 MAX	54	IEEE 754	
006Eh	2	W L3 MAX	55	IEEE 754	
0070h	2	W MAX dmd	56	IEEE 754	
0072h	2	VA MAX dmd	57	IEEE 754	
0074h	2	PF L1 min	58	IEEE 754	
0076h	2	PF L2 min	59	IEEE 754	
0078h	2	PF L3 min	60	IEEE 754	

007Ah	2	A L1 min	61	IEEE 754	Only for WM14a
007Ch	2	A L2 min	62	IEEE 754	Only for WM14a
007Eh	2	A L3 min	63	IEEE 754	Only for WM14a
0080h	2	V L1 min	64	IEEE 754	Only for WM14a
0082h	2	V L2 min	65	IEEE 754	Only for WM14a
0084h	2	V L3 min	66	IEEE 754	Only for WM14a
0086h	2	V L1 MAX	67	IEEE 754	Only for WM14a
0088h	2	V L2 MAX	68	IEEE 754	Only for WM14a
008Ah	2	V L3 MAX	69	IEEE 754	Only for WM14a
008Ch	2	THD V1	70	IEEE 754	Only for WM14a
008Eh	2	THD V2	71	IEEE 754	Only for WM14a
0090h	2	THD V3	72	IEEE 754	Only for WM14a
0092h	2	THD I1	73	IEEE 754	Only for WM14a
0094h	2	THD I2	74	IEEE 754	Only for WM14a
0096h	2	THD I3	75	IEEE 754	Only for WM14a
00D3h	1	Instrument Code	-	UINT16	
00DEh	1	Firmware Revision	-	UINT16	
00DFh	1	Module Type	-	UINT16	
00F4h	1	Latch Alarm	-	UINT16	See par. 2.2.4.1
00F5h	1	Output state	-	UINT16	
00F7h	1	Locked	-	UINT16	
0103h	1	Out1	-	UINT16	
0104h	1	Out2	-	UINT16	
0105h	1	Remote	-	UINT16	

Tab. 2-1: RAM mapping

The max and min electric values for each variable in Tab. 2-1 are indicated in Tab. 2-2.

VL-N nom : 400V for AV5 model, 100V for AV6 model.
VL-L nom : 690V for AV5 model, 173V for AV6 model.
VTmax = 6000
CTmax = 60000
I nom = 5A

Engineering unit	Input model AV5 (400VL-L)		Input model AV6 (100VL-L)	
	max value	min value	max value	min value
V (L-N)	$2.88 * 10^6$ =VL-Nnom*1.2*VTmax	0	$720 * 10^3$	0
V (L-L)	$4.98 * 10^6$ =VL-Lnom*1.2*VTmax	0	$1.2456 * 10^6$	0
A	$393,21 * 10^3$ =Inom*1.2*CTmax	0	$393,21 * 10^3$	0
W	$1,132 * 10^{12}$	$-1,132 * 10^{12}$	$283.111 * 10^6$	$-283.111 * 10^6$
VA	$1,132 * 10^{12}$	0	$283.111 * 10^6$	0
VAR	$1,132 * 10^{12}$	$-1,132 * 10^{12}$	$283.111 * 10^6$	$-283.111 * 10^6$
Phase sequence (*)	1	-1	1	-1
PF	1	-1	1	-1
Hz	60	48	60	48
Asymmetry (**)	300	0	300	0
KWh	99999999.9	0	99999999.9	0
KVARh	99999999.9	0	99999999.9	0
Hour Counter	$100 * 10^3$	0	$100 * 10^3$	0

Tab. 2-2 : Variables range

Note :
(*) This variable doesn't have any engineering unit. Its value is a pure number.
(**) This variable doesn't have any engineering unit. Its value is a pure number represented in percentage.

2.1.1 VARIABLES REPRESENTATION

The variables are represented by 32-bit floating-point numbers in standard IEEE-754 or UINT16 or UINT32 format. The representation of a 32-bit floating-point number as an integer is:

Bits		
31	30 … 23	22 … 0
sign	Exponent	Mantissa

The value of the number is:

$$(-1)^{sign} * 2^{(Exponent-127)} * 1.Mantissa$$

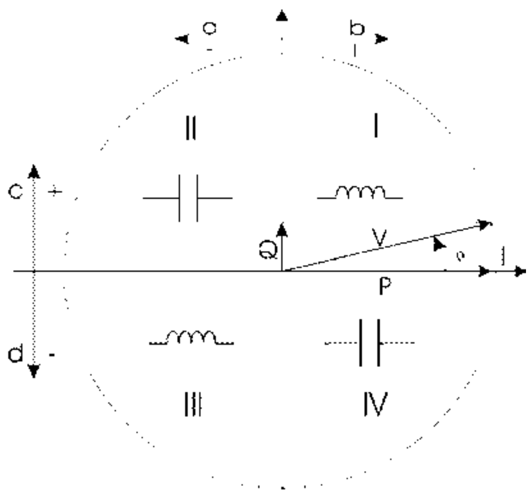
The integer are represented in UINT16 (16 bit) or UINT32 (32 bit) format.

2.1.2 NOTES

A) The value –1 of the variable indicates that all the 3 phases are present and have the correct sequence otherwise +1 indicates a wrong connection.
B) Negative sign of this variable indicates a lead (C) type, positive sign indicates a lag (L) type.
C) This number must be divided by 10 to obtain the correct value of the counter.
D) This value raises when one of the three phase currents is greater than zero. Its step is 36 seconds (1/100 of an hour).

2.1.3 GEOMETRIC REPRESENTATION

According to the signs of the power factor , the active power P and the reactive power Q, it is possible to obtain a geometric representation of the power vector, as indicated in the drawing below:



a = Export active power
b = Import active power
c = Import reactive power
d = Export reactive power

Fig. 10 : Geometric Representation

2.1.4 PARAMETERS

Parameter	Value		Meaning
Instrument Code	33		AV5 three-phase (CPT-DIN)
	34		AV6 three-phase (CPT-DIN)
	35		AV5 single phase (CPT-DIN)
	36		AV6 single phase (CPT-DIN)
	39		AV5 three-phase (WM14a)
	40		AV6 three-phase (WM14a)
Firmware Revision	MSB		-
	LSB		Progressive number
Module Type	MSB	LSB	
	0	0	Standard (no module present).
	0	1	Serial Output RS485 or RS232.
	1	2	One voltage analogue output.
	3	2	Three voltage analogue output.
	1	3	One Current analogue output.
	3	3	Three Current analogue output.
	0	4	Two Digital output.
	0	5	Serial Output RS485 and Two digital output (WM14a)
	0	8	Dupline module output.
Output state (bit15 .... bit0)	bit n		
	0		Alarm condition of the block (n+1) is false. (*)
	1		Alarm condition of the block (n+1) is true. (*)
OutCtrl (**)	MSB	LSB	
	AAh	AAh	Both outputs as alarm.
	AAh	BBh	Out 2 as alarm output, Out 1 as pulse output.
	AAh	CCh	Out 2 as alarm output, Out 1 remote-controlled.
	BBh	AAh	Out 2 as pulse output, Out1 as alarm output.
	BBh	BBh	Both outputs as pulse.
	BBh	CCh	Out 2 as pulse, Out 1 remote-controlled
	CCh	AAh	Out 2 remote-controlled, Out 1 as alarm.
	CCh	BBh	Out 2 remote-controlled, Out 1 as pulse.
	CCh	CCh	Both outputs remote-controlled.
Out1	0		Out 1 isn’t in alarm condition.
	1		Out 1 is in alarm condition.
Out2	0		Out 1 isn’t in alarm condition.
	1		Out 2 is in alarm condition.

Tab. 2-3 : Parameters meaning

Note :
(*) See also Tab. 2-10 and Tab. 2-11 .
(**) This parameter is a RAM copy of the register “OutCtrl_reg” (see Tab. 2-8).

2.1.4.1 Carlo Gavazzi Controls identification code

The identification code can be read by sending a fixed query.
The following example is relevant to this reading on the instrument which address is 255 (FFh).

Query	FFh	04h	00h	0Bh	00h	01h	55	D6

Reply	FFh	04h	02h	00h	23h	D1	3D

In this case the instrument code is 23h (35 decimal), corresponding to the model AV5 single phase.

2.1.4.2 Remote control

When the register “OutCtrl_reg”, which address is 01A6h, is set to the value CCCCh, both digital outputs can be controlled by MODBUS commands, by writing the relevant value on the “Out12_remote” memory address (01A7h). If “OutCtrl_reg” is set to the value xxCCh or CCxxh only output 1 or output 2 will be able to be controlled by MODBUS commands.

2.2 EEPROM MEMORY MAPPING

All the variables stored in EEPROM can be read and written by using Modbus functions 03h or 04h (reading) and 06h (writing).

2.2.1 PROGRAMMING PARAMETERS

Address	Length (words)	Parameter	Description	Min value	MAX value
0199h	1	Password	Programming access password.	0	9999
019Ah	1	Ct_ratio	Current transformer ratio.	1	60000
019Bh	1	Vt_ratio	Voltage transformer ratio.	1 (*)	60000(*)
019Ch	1	Filter_scl	Filter range.	0 (**)	100 (**)
019Dh	1	Filter_coe	Filter coefficient.	1	32
019Eh	1	P_int	Power Integration time (for W dmd).	1 (***)	30 (***)
019Fh	1	A_int	Current Integration time (for A dmd).	1 (***)	30 (***)
01A0h	1	System	System type.	see Tab. 2-5	
01A8h	1	THD_mode	Total harmonics distorsion activation	0	1

Tab. 2-4 : Programming parameters

Notes:
(*) This value is internally divided by 10.
(**) This value is represented in percentage of the full-scale value.
(***) This value is in minutes.

System	3-phase input module	1-phase input module
0	3-ph, 4-wire, unbalanced load	1-ph, 2-wire
1	1-ph, 2-wire	1-ph, 2-wire
2	2-ph, 3-wire	1-ph, 2-wire
3	3-ph, 3-wire, balanced load (3VT + 1CT)	1-ph, 2-wire
4	3-ph, balanced load (1VT + 1CT)	3-ph, balanced load (1VT + 1 CT)
5	3-ph ARON, balanced load (3VT + 2CT)	-

Tab. 2-5 : System type

2.2.2 OPTIONAL SERIAL MODULE PARAMETERS

Both address and baudrate of the optional serial module can be programmed, according to the following table:

Address	Length (words)	Parameter	Description	Value	Meaning
01A1h	1	Address	Address of the optional serial module.	1 to 255	-
01A2h	1	Baudrate	Baudrate of the optional serial module.	0	Baudrate = 4800
				1	Baudrate = 9600
				2	Baudrate = 19200
				3	Baudrate = 32400

Tab. 2-6

2.2.3 ANALOGUE OUTPUT MAPPING (ONLY FOR CPT-DIN)

The analogue parameters can be divided into three blocks.
Each block is associated to a variable, indicated with its index. The parameters showed below in Tab. 2-7 are always linked physically to the output index e.g:

- BLOCK1 ➔ analogue output 1
- BLOCK2 ➔ analogue output 2
- BLOCK3 ➔ analogue output 3

It is necessary to program the out_number parameter once at the sturt up programming.

Address	Length (words)	Parameter	Data Format	Min value	MAX value
BLOCK 1					
01A9h	1	VAR_INDEX_01	UINT16	0	42
01AAh	1	OUT_NUMBER_01	UINT16	0	
01ABh	1	OUT_PERC_MIN_01	UINT16	0	100
01ACh	1	OUT_PERC_MAX_01	UINT16	0	100
01ADh	2	VAL_MIN_01	IEEE 754	see Tab. 2-2	see Tab. 2-2
01AFh	2	VAL_MAX_01	IEEE 754	see Tab. 2-2	see Tab. 2-2
BLOCK 2					
01B1h	1	VAR_INDEX_02	UINT16	0	42
01B2h	1	OUT_NUMBER_02	UINT16	1	
01B3h	1	OUT_PERC_MIN_02	UINT16	0	100
01B4h	1	OUT_PERC_MAX_02	UINT16	0	100
01B5h	2	VAL_MIN_02	IEEE 754	see Tab. 2-2	see Tab. 2-2
01B7h	2	VAL_MAX_02	IEEE 754	see Tab. 2-2	see Tab. 2-2
BLOCK 3					
01B9h	1	VAR_INDEX_03	UINT16	0	42
01BAh	1	OUT_NUMBER_03	UINT16	2	
01BBh	1	OUT_PERC_MIN_03	UINT16	0	100
01BCh	1	OUT_PERC_MAX_03	UINT16	0	100
01BDh	2	VAL_MIN_03	IEEE 754	see Tab. 2-2	see Tab. 2-2
01BFh	2	VAL_MAX_03	IEEE 754	see Tab. 2-2	see Tab. 2-2

Tab. 2-7 : Analogue output parameters

2.2.3.1 ANALOGUE PARAMETERS DESCRIPTION

- VAR_INDEX_0X : variable linked to the output channel (see Tab. 2-1).
- OUT_NUMBER_0X : output channel.
- OUT_PERC_MIN_0X : low output value in percentage.
- OUT_PERC_MAX_0X : high output value in percentage.
- VAL_MIN_0X : low electric value.
- VAL_MAX_0X : high electric value.

2.2.3.2 EXAMPLE ANALOGUE OUTPUT SETTING

Settings:

Variable	Value
Var_index_01	12
out_number_01	0
out_perc_min_01	0
out_perc_max_01	100
val_min_01	0.0
Val_max_01	1000.0

The following example is relevant to the writing instrument which address is 1 (01h). The variable set is W L3 (000Ch).

Set the "**VAR_INDEX_01**" (01A9h) at value 12 (000Ch):

Query	01h	06h	01h	A9h	00h	0Ch	59h	13h
Reply	01h	06h	01h	A9h	00h	0Ch	59h	13h

Set the "**OUT_NUMBER_01**" (01AAh), this instruction is necessary only at start up programming:

Query	01h	06h	01h	AAh	00h	00h	A8h	16h
Reply	01h	06h	01h	AAh	00h	00h	A8h	16h

Set "**OUT_PERC_MIN_01**" at level 0:

Query	01h	06h	01h	ABh	00h	00h	F9h	D6h
Reply	01h	06h	01h	ABh	00h	00h	F9h	D6h

Set "**OUT_PERC_MAX_01**" at level 100:

Query	01h	06h	01h	ACh	00h	64h	49h	FCh
Reply	01h	06h	01h	ACh	00h	64h	49h	FCh

Set "**VAL_MIN_01**" at level 0.0 (HEX representation of this 32-bit floating point value is 00000000h):

Query	01h	06h	01h	ADh	00h	00h	19h	D7h
Reply	01h	06h	01h	ADh	00h	00h	19h	D7h

Query	01h	06h	01h	AEh	00h	00h	E9h	D7h
Reply	01h	06h	01h	AEh	00h	00h	E9h	D7h

Set "**VAL_MAX_01**" at level 1000.0 (HEX representation of this 32-bit floating point value is 0000447Ah in **Intel byte** order):

Query	01h	06h	01h	AFh	00h	00h	B8h	17h
Reply	01h	06h	01h	AFh	00h	00h	B8h	17h

Query	01h	06h	01h	B0h	44h	7Ah	3Bh	32h
Reply	01h	06h	01h	B0h	44h	7Ah	3Bh	32h

2.2.4 DIGITAL OUTPUT MAPPING

CPT-DIN and WM14a are optionally equipped with two digital outputs which can be set as either alarm or pulse outputs.
If an output is set as pulse, only one variable can be linked to it, while up to 16 alarm conditions can be linked to the same output by using the WOUT bit in DIGCR register.
CPT-DIN has a bi-color led, which gives a visual indication of the outputs. The flashing of the green or red led indicates an alarm condition or a pulse generation on the output 1 or 2 respectively.
WM14a has only a red led, which gives a visual indication of the physical outputs when these are set as alarm by “OutCtrl_reg”. It is always possible to set and control all the 16 alarm conditions (set-points) in virtual way : if an alarm condition become active, the relevant bit of “Output State” parameter will be set (see Tab. 2-1 and Tab. 2-3). Physical outputs will be driven if output control register will be properly set (see Tab. 2-8).

Address	Length (words)	Parameter	Description	Min value	MAX value
01A3h	1	Normal_out	Physical output status in normal condition (relevant to the alarm mode)	see Tab. 2-9	
01A6h	1	OutCtrl_reg	Output control register	(*)	
01A7h	1	Out12_remote	Outputs state when remote-controlled	0000h	0101h

Tab. 2-8: Digital output parameters

Note :
(*) MSB and LSB value of “OutCtrl_reg” indicate the type of digital outputs according to Tab. 2-3.

The “**Normal_out**” parameter is structured as follows:

bit 0 : output 1,
bit 4 : output 2,
bit value = 0 → de-energized,
bit value = 1 → energized.

According to this structure, the following table shows the possible configurations

Address	Value (dec)	Value (hex)	Description
01A3h	0	0000h	Both outputs are de-energized.
	1	0001h	Output 1 only is energized.
	2	0010h	Output 2 only is energized.
	3	0011h	Both outputs are energized.

Tab. 2-9 : Normal output status

The “**Out12_remote**” parameter is structured as follows:

value = 0000h → output 1 and output 2 are de-energized,
value = 0001h → output 1 is energized, output 2 is de-energized,
value = 0100h → output 1 is de-energized, output 2 is energized,
value = 0101h → both outputs are energized.

2.2.4.1 ALARMS

There are 16 digital blocks for programming the virtual alarms (for the address of each block see Tab. 2-10). Every time an alarm needs to be programmed or modified, it is necessary to follow the steps below:

- enter the programming mode and write ***locked*** variable (see Tab. 2-1) C0C0h,
- set the ***OutCtrl_reg*** variable (see Tab. 2.7) if necesssary,
- write the correct digital blocks with the new parameters,
- write the output digital state in ***Normal_out*** variable (see Tab. 2.7),
- reset the ***locked*** variable.

Digital Block	Address
1	01C1h
2	01C9h
3	01D1h
4	01D9h
5	01E1h
6	01E9h
7	01F1h
8	01F9h
9	0201h
10	0209h
11	0211h
12	0219h
13	0221h
14	0229h
15	0231h
16	0239h
17 (*)	0241h
18 (**)	0249h

Tab. 2-10 : Digital blocks addresses

Note:
(*) This block can be linked only to pulse output 1.
(**) This block can be linked only to pulse output 2.

When a block is configured as an alarm, there are 4 relevant parameters to be programmed, as shown below.

Parameter	Word	Data Format			Min value	Max value	Description
IND_VAR__DELAY	1	UINT16	LSB	-	0	42	variable linked to the alarm (see Tab. 2-1)
			MSB	-	0	255	activation delay (time in sec)
DIGCR	1	UINT16	LSB	bit 0	0	3	Alarm type: see Tab. 2-13
				bit 1			
				bit 2			
				bit 3	0	1	alarm status
				bit 4	0	1	output selection
				bit 5	0	1	function type
				bit 6	0	1	wait for activation condition
				bit 7	-	-	not used
			MSB	bit 0...7	-	-	not used
THRESHOLD_DOWN	2	IEEE754	-	-	see Tab. 2-2		Low threshold
THRESHOLD _UP	2	IEEE754	-	-	see Tab. 2-2		High threshold

Tab. 2-11 : Alarm Parameters

2.2.4.2 DIGITAL CONTROL REGISTER DIGCR

The Digital Control Register, called DIGCR, contains some further parameters relevant to the alarm

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
-	-	-	-	-	-	-	-	-	ARC	TFUN	WOUT	ALRST	TALR		

Tab. 2-12 : Digital Register

- TALR : the user can set the type of alarm condition according with Tab. 2-13 (see Fig. 11, Fig. 12, Fig. 13 and Fig. 14). UP and DOWN mode have an hysteresis threshold.

bit 2	bit 1	bit 0	Type
0	0	0	UP
0	0	1	DOWN
0	1	0	INT
0	1	1	EXT

Tab. 2-13 : Alarm coding

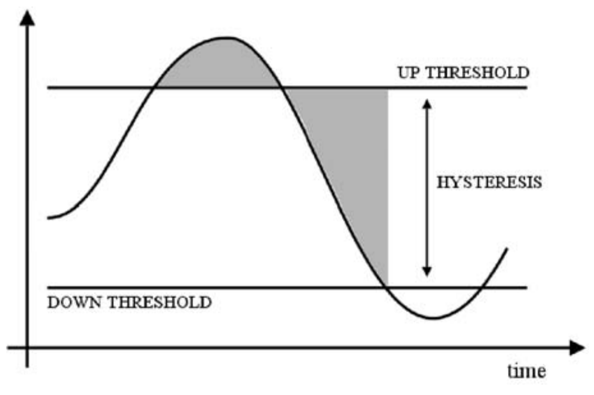


Fig. 11 : UP

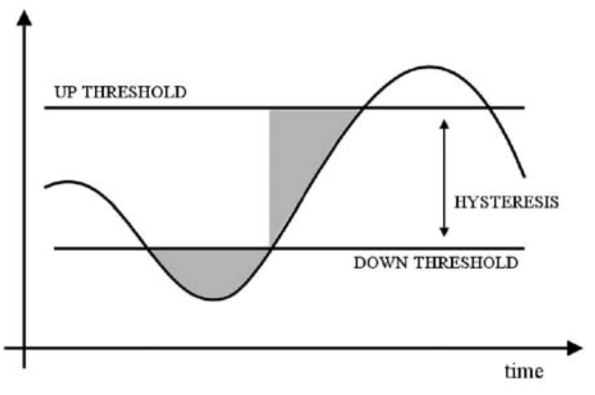


Fig. 12 : DOWN

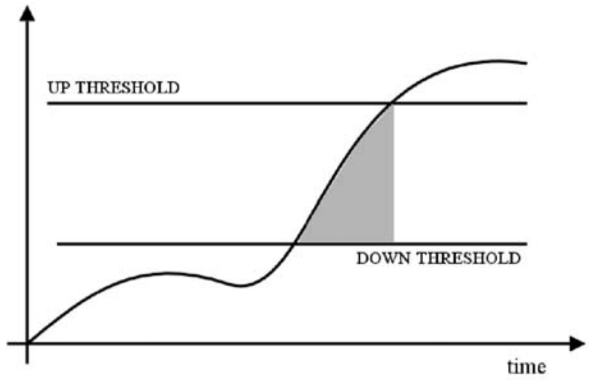


Fig. 13 : INT

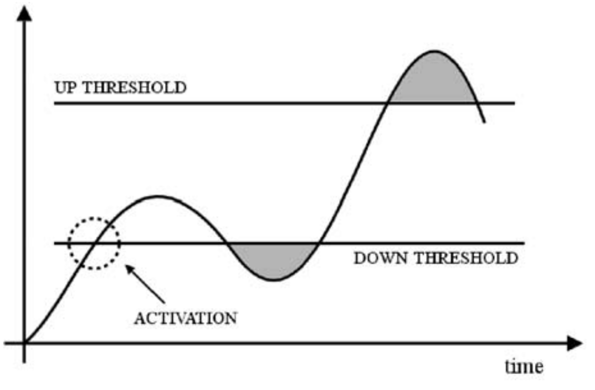


Fig. 14 : EXT with activation

- ALRST : Status of the alarm
  - 0: disabled
  - 1: enabled

- WOUT : Output linked with this digital block
  0: output 1
  1: output 2

- TFUN : Logical function. More alarm conditions can be logically combined (AND or OR) by using this parameter.
  0: AND
  1: OR
  This means that an alarm is activated because of :
  1) One (or more) of the "OR" type variables
  or
  2) All the "AND" type variables together.

- ARC : Wait for the value of the variable to reach a no alarm condition before activating the alarm. When the alarm condition is reset, the "**`Latch Alarm`**" and "**`Output state`**" variables must be cleared (see Tab. 2-1).

2.2.4.3 PULSE OUTPUT

Only energy counters can be linked to pulse outputs (see Tab. 2-1) and only the latest two digital blocks can be linked to pulse output (see Tab. 2-10).
Every time a pulse output needs to be programmed or modified, it is necessary to follow the steps below:

- enter in programming mode and write ***locked*** variable (see Tab. 2-1) C0C0h,
- set the ***OutCtrl_reg*** variable (see Tab. 2.7) if necessary,
- write the correct digital blocks with the new parameters,
- reset the ***locked*** variable.

When a block is configured as a pulse output, there are two relevant parameters to be programmed, as shown in the following table

Parameter	Word	Data Format			Min value	Max value	Description
IND_COUNT	1	UINT16	LSB	-	43	44	variable linked to pulses output (see Tab. 2-1)
			MSB	bit 0	0	1	pulses output 1: 1 = enable
				bit 1	0	1	pulses output 2: 1 = enable
				bit 2	0	1	pulses output selection 0 = out1 1 = out2
				bit 3	-	-	not used
				bit 4	-	-	not used
				bit 5	-	-	not used
				bit 6	-	-	not used
				bit 7	-	-	not used
IMP_FOR	1	UINT16	-	-	see Tab. 2-15		number of pulses for unit (*)

Tab. 2-14 : Pulse Parameters

Note:
(*) This value is internally divided by 100.

Counter	Index	Number of pulses	
		Min value	Max value
KWh TOT	43	0.01	500.00
KVARh TOT	44	0.01	500.00

Tab. 2-15 : Pulses for unit range

2.2.4.4 ALARM CONFIGURATION EXAMPLE

An alarm configuration can be set following the sequence indicated below. The instrument address is 255 (FFh) and the linked variable is "W L1":

- Set the "**locked-out**" variable (00F7h) at C0C0h :

Query	FFh	06h	00h	F7h	C0h	C0h	7Dh	B6h
Reply	FFh	06h	00h	F7h	C0h	C0h	7Dh	B6h

- Set the digital block parameters "**variable linked**" (0Ah) and "**delay time**" (00h).

Query	FFh	06h	01h	C1h	00h	0Ah	4Ch	13h
Reply	FFh	06h	01h	C1h	00h	0Ah	4Ch	13h

- Set the digital block parameters "**alarm status**" (01h), "**output selection**" (01h), "**function type**" (01h) and "**wait for activation condition**" (01h).

Query	FFh	06h	01h	C2h	00h	78h	3Ch	36h
Reply	FFh	06h	01h	C2h	00h	78h	3Ch	36h

- Set "**threshold_down**" at level 0.0 W (HEX representation of this 32-bit floating point value is 00000000h):

Query	01h	06h	01h	C3h	00h	00h	6Dh	D4h
Reply	01h	06h	01h	C3h	00h	00h	6Dh	D4h

Query	01h	06h	01h	C4h	00h	00h	DCh	15h
Reply	01h	06h	01h	C4h	00h	00h	DCh	15h

- Set " **threshold_up**" at level 1000.0 W (HEX representation of this 32-bit floating point value is 0000447Ah in **Intel byte** order):

Query	01h	06h	01h	C5h	00h	00h	8Dh	D5h
Reply	01h	06h	01h	C5h	00h	00h	8Dh	D5h

Query	01h	06h	01h	C6h	44h	7Ah	CFh	36h
Reply	01h	06h	01h	C6h	44h	7Ah	CFh	36h

- Set the "**normal out**" condition: both outputs are energized (11h).

Query	FFh	06h	01h	A3h	00h	11h	ADh	C6h
Reply	FFh	06h	01h	A3h	00h	11h	ADh	C6h

- Reset the "**locked-out**" variable (00F7h) at 0000h :

Query	FFh	06h	00h	F7h	00h	00h	2Dh	E6h
Reply	FFh	06h	00h	F7h	00h	00h	2Dh	E6h

2.3 RESET COMMANDS

The user is allowed to reset all the peak values (dmd max, current max, voltage max, watt max, VAR max etc), the meters (energy meters) and the hour counter. To carry out the reset a write command must be sent (function 06).
Pay attention to follow scrupulously the reset instructions and to send the exact frame, because a different write command could modify some calibration parameters, invalidating the accuracy of the measurements.

The following frame must be sent to execute a reset command.
The value to be sent shall be chosen according to Tab. 2-16.

Request frame

Address	Function	Data address		Value		CRC	
1 byte	1 byte	2 byte		2 byte		2 byte	
From 01h to FFh	06h	20h	EEh	00h	CMD	MSB	LSB

Answer frame

Address	Function	Data address		Value		CRC	
1 byte	1 byte	2 byte		2 byte		2 byte	
From 01h to FFh	06h	20h	EEh	00h	CMD	MSB	LSB

Note : the answer frame is an echo of the request frame, which confirm the execution of the command.

CMD Value	Action
00h	Reset all variables, including instantaneous, min, max, DMD and counters.
01h	Reset DMD value.
02h	Reset energy counters (partial and total) and hour counter.
03h	Reset total energy counters.
04h	Reset partial energy counters.
05h	Reset hour counter.
06h	Reset max and min value.

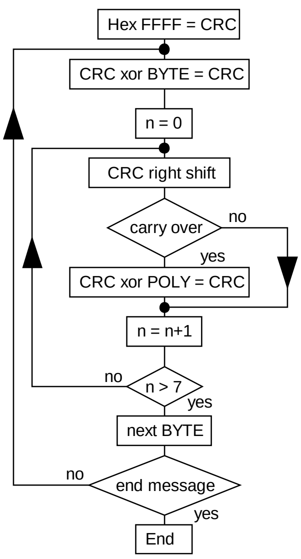
Tab. 2-16 : Reset command

3 CRC CALCULATION

3.1 EXAMPLE OF CRC CALCULATION

Frame = 0207h

Init CRC	1111 1111 1111 1111
Load first character	0000 0010
Execute the XOR with the first char. of the frame	1111 1111 1111 1101
Execute first Shift to the right	0111 1111 1111 1110 1
Carry = 1 , load polynomial	1010 0000 0000 0001
Execute XOR with the polynomial	1101 1111 1111 1111
Execute 2° Shift to the right	0110 1111 1111 1111 1
Carry = 1 , load polynomial	1010 0000 0000 0001
Execute XOR with the polynomial	1100 1111 1111 1110
Execute 3° Shift to the right	0110 0111 1111 1111 0
Execute 4° Shift to the right	0011 0011 1111 1111 1
Carry = 1 , load polynomial	1010 0000 0000 0001
Execute XOR with the polynomial	1001 0011 1111 1110
Execute 5° Shift to the right	0100 1001 1111 1111 0
Execute 6° Shift to the right	0010 0100 1111 1111 1
Carry = 1 , load polynomial	1010 0000 0000 0001
Execute XOR with the polynomial	1000 0100 1111 1110
Execute 7° Shift to the right	0100 0010 0111 1111 0
Execute 8° Shift to the right	0010 0001 0011 1111 1
Carry = 1 , load polynomial	1010 0000 0000 0001
Execute XOR with the polynomial	1000 0001 0011 1110
Load second character of the frame	0000 0111
Execute XOR with the second character of the frame	1000 0001 0011 1001
Execute 1° Shift to the right	0100 0000 1001 1100 1
Carry = 1 , load polynomial	1010 0000 0000 0001
Execute XOR with the polynomial	1110 0000 1001 1101
Execute 2° Shift to the right	0111 0000 0100 1110 1
Carry = 1 , load polynomial	1010 0000 0000 0001
Execute XOR with the polynomial	1101 0000 0100 1111
Execute 3° Shift to the right	0110 1000 0010 0111 1
Carry = 1 , load polynomial	1010 0000 0000 0001
Execute XOR with the polynomial	1100 1000 0010 0110
Execute 4° Shift to the right	0110 0100 0001 0011 0
Execute 5° Shift to the right	0011 0010 0000 1001 1
Carry = 1 , load polynomial	1010 0000 0000 0001
Execute XOR with the polynomial	1001 0010 0000 1000
Execute 6° Shift to the right	0100 1001 0000 0100 0
Execute 7° Shift to the right	0010 0100 1000 0010 0
Execute 8° Shift to the right	0001 0010 0100 0001 0
CRC result	0001 0010 0100 0001 12h 41h



POLY = crc calculation polynominal: A001h

Note: the byte 41h is sent first.