# CPA050–CPA300

# COMMUNICATION PROTOCOL

Version 1 Revision 2

December 26th, 2017

# Index

## 1.1 Introduction

The RS485 serial interface supports the MODBUS/JBUS (RTU) protocol. In this document only the information necessary to read/write from/to CPA has been reported (not all the parts of the protocol have been implemented).
For a complete description of the MODBUS protocol please refer to the "Modbus_Application_Protocol_V1_1a.pdf" document that is downloadable from the www.modbus.org web site.

## 1.2 MODBUS functions

These functions are available on CPA:
- Reading of n "Holding Registers" (code 03h)
- Writing of one "Holding Registers" (code 06h)
- Writing of multiple register (code 10h)

**IMPORTANT:**
1) In this document the "Modbus address" field is indicated in two modes:
    1.1) "**Modicom address**": it is the "6-digit Modicom" representation with Modbus function code 03 (Read Holding Registers).
    1.2) "**Physical address**": it is the "word address" value to be included in the communication frame.
2) The communication parameters are to be set according to the configuration of the instrument (refer to CPA instruction manual)

**Function 03h (Read Holding Registers)**

This function is used to read the contents of a contiguous block of holding registers (word). The Request frame specifies the starting register address and the number of registers to be read. It is possible to read maximum 120 registers (words) with a single request, when not differently specified.
The register data in the response message are packed as two bytes per register (word), with the binary contents right justified within each byte. For each register, the first byte contains the high order bits (MSB) and the second contains the low order bits (LSB).

Request frame

| Description | Length | Value | Note |
|---|---|---|---|
| Physical address | 1 byte | 1 to F7h (1 to 247) | |
| Function code | 1 byte | 03h | |
| Starting address | 2 bytes | 0000h to FFFFh | Byte order: MSB, LSB |
| Quantity of registers (**N** word) | 2 bytes | 1 to 10h (1 to 11) | Byte order: MSB, LSB |
| CRC | 2 bytes | | |

Response frame (correct action)

| Description | Length | Value | Note |
|---|---|---|---|
| Physical address | 1 byte | 1 to F7h (1 to 247) | |
| Function code | 1 byte | 03h | |
| Quantity of requested bytes | 1 byte | **N** word * 2 | |
| Register value | **N**\*2 bytes | | Byte order: MSB, LSB |
| CRC | 2 bytes | | |

Response frame (incorrect action)

| Description | Length | Value | Note |
|---|---|---|---|
| Physical address | 1 byte | 1 to F7h (1 to 247) | Possible exception : |
| Function code | 1 byte | 83h | 01h: illegal function |
| Exception code | 1 byte | 01h, 02h, 03h, 04h (see note) | 02h: illegal data address |
| CRC | 2 bytes | | 03h: illegal data value  04h: slave device failure |

**Function 06h (Write Single Holding Register)**

This function code is used to write a single holding register. The Request frame specifies the address of the register (word) to be written and its content.
The correct response is an echo of the request, returned after the register content has been written.

Request frame

| Description | Length | Value | Note |
|---|---|---|---|
| Physical address | 1 byte | 1 to F7h (1 to 247) | |
| Function code | 1 byte | 06h | |
| Starting address | 2 bytes | 0000h to FFFFh | Byte order: MSB, LSB |
| Register value | 2 bytes | 0000h to FFFFh | Byte order: MSB, LSB |
| CRC | 2 bytes | | |

Response frame (correct action)

| Description | Length | Value | Note |
|---|---|---|---|
| Physical address | 1 byte | 1 to F7h (1 to 247) | |
| Function code | 1 byte | 06h | |
| Starting address | 2 bytes | 0000h to FFFFh | Byte order: MSB, LSB |
| Register value | 2 bytes | 0000h to FFFFh | Byte order: MSB, LSB |
| CRC | 2 bytes | | |

**Function 10h (Write multiple register)**

This function code is used to write a block of contiguous registers (maximum 2). The requested values to be written are specified in the request data field. Data is packed as two bytes per register.
The correct response returns the function code, starting address, and the quantity of written registers.

Request frame

| Description | Length | Value | Note |
|---|---|---|---|
| Physical Address | 1 byte | 1 to F7 (1 to 247) | |
| Function code | 1 byte | 10h | |
| Starting Address | 2 bytes | 0000h to FFFFh | Byte order: MSB, LSB |
| Quantity of Registers (**N** word) | 2 bytes | 0001h to 0078h | Byte order: MSB, LSB |
| Byte count | 1 byte | **N** word * 2 | |
| Register value | **N** * 2 bytes | value | Byte order: MSB, LSB |
| CRC | 2 bytes | | |

Response frame (correct action)

| Description | Length | Value | Note |
|---|---|---|---|
| Physical Address | 1 byte | 1 to F7 (1 to 247) | |
| Function code | 1 byte | 10h | |
| Starting Address | 2 bytes | 0000h to FFFFh | Byte order: MSB, LSB |
| Quantity of Registers (**N** word) | 2 bytes | 0001h to 0078h | Byte order: MSB, LSB |
| CRC | 2 bytes | | |

Response frame (incorrect action)

| Description | Length | Value | Note |
|---|---|---|---|
| Physical Address | 1 byte | 1 to F7 (1 to 247) | Possible exception: |
| Function code | 1 byte | 90h | 01h: illegal function |
| Exception code | 1 byte | 01h, 02h, 03h, 04h | 02h: illegal data address |
| CRC | 2 bytes | | 03h: illegal data value |
| | | | 04h: slave device failure |

Response frame (incorrect action)

| Description | Length | Value | Note |
|---|---|---|---|
| Physical address | 1 byte | 1 to F7h (1 to 247) | Possible exception : |
| Function code | 1 byte | 86h | 01h: illegal function |
| Exception code | 1 byte | 01h, 02h, 03h, 04h | 02h: illegal data address |
| CRC | 2 bytes | | 03h: illegal data value |
| | | | 04h: slave device failure |

### 1.3 Application notes

**RS485 general considerations**

1. To avoid errors due to the signal reflections or line coupling, it is necessary to terminate the bus at the beginning and at the end (inserting a 120 ohm 1/2W 5% resistor between line B and A in the last instrument and in the Host interface).
2. The network termination is necessary even in case of point-to-point connection and/or of short distances.
3. For connections longer than 1000m or if in the network there are more than 160 instruments (with 1/5 unit load as used in CPA interface), a signal repeater is necessary.
4. For bus connection it is suggested to use an AWG24 balanced pair cable and to add a third wire for GND connection. Connect GND to the shield if a shielded cable is used.
5. The GND is to be connected to ground only at the host side.
6. 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 is to be considered as not connected, faulty or reached with a wrong address. The same consideration is valid in case of CRC errors or incomplete response frames.

**MODBUS timing**
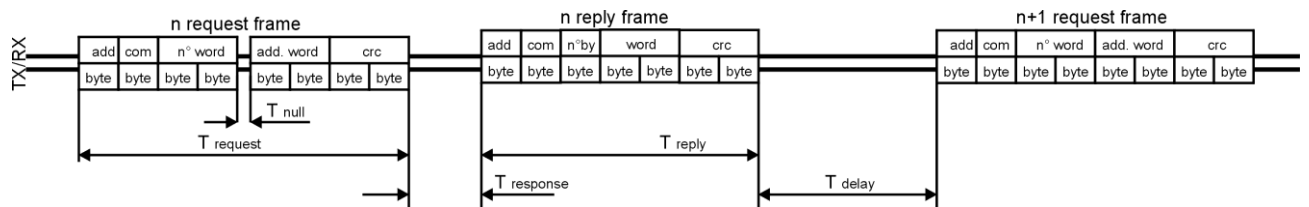


Fig. 1 : 2-wire timing diagram

| Timing characteristics of reading function: | msec |
|---|---|
| T response: Max answering time | 50ms |
| T response: Typical answering time | 7ms |
| T delay: Minimum time before a new query | 3.5char |
| T null: Max interruption time during the request frame | 2.5char |

CPA - Communication Protocol

# 2   TABLES

### 2.1      Data format representation In Carlo Gavazzi instruments

The variables are represented by integers or floating numbers, with 2's complement notation in case of "signed" format, using the following:

| Format | IEC data type | Description | Bits | Range |
|--------|---------------|-------------|------|-------|
| INT16 | INT | Integer | 16 | -32768 .. 32767 |
| UINT16 | UINT | Unsigned integer | 16 | 0 .. 65535 |
| INT32 | DINT | Double integer | 32 | $-2^{31}$ .. $2^{31}$ |
| UINT32 | UDINT | Unsigned double int | 32 | $0 .. 2^{32}-1$ |
| UINT64 | ULINT | Unsigned long integer | 64 | $0 .. 2^{64}-1$ |
| IEEE754 SP | | Single-precision floating-point | 32 | $-(1+[1-2^{-23}])x2^{127} .. 2^{128}$ |

For all the formats the byte order (inside the single word) is MSB->LSB. In INT32, UINT32 and UINT64 formats, the word order is LSW-> MSW.

### 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, according to EN 60253-23:
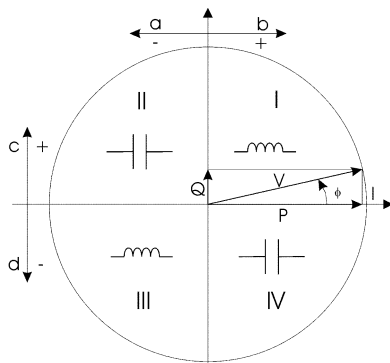


a = Exported active power
b = Imported active power
c = Imported reactive power
d = Exported reactive power

Fig. 2 : Geometric Representation

## 2.2 Instantaneous variables and meters (FLOAT LSW first)

**MODBUS**: read only mode with functions code 03 and 04                    Table 2.2-1

| Modicom address | Physical address | Length (words) | VARIABLE ENG. UNIT | Data Format | Notes |
|---|---|---|---|---|---|
| 40072 | 0047h | 1 | STATUS SW | UINT16 | bit 0: flash settings error; bit1: flash calibration error; bit 2: Voltage Over Range; bit 3: Voltage Under Range; bit [4, 5]: don't care; bit 6: Zero crossing detecting; bit [7, 9]: don't care; bit 10: Energy storing error; bit 11:Energy initialization error; bit 12: don't care; bit 13: Current Over Range; bit 14: Current Under Range |
| 40073 | 0048h | 2 | V L-N | FLOAT (LSW first) | Value weight: Volt |
| 40075 | 004Ah | 2 | A | FLOAT (LSW first) | Value weight: mA |
| 40077 | 004Ch | 2 | W | FLOAT (LSW first) | Value weight: W |
| 40079 | 004Eh | 2 | var | FLOAT (LSW first) | Value weight: var |
| 40081 | 0050h | 2 | VA | FLOAT (LSW first) | Value weight: VA |
| 40083 | 0052h | 2 | PF | FLOAT (LSW first) | Value weight: PF |
| 40085 | 0054h | 2 | Hz | FLOAT (LSW first) | Value weight: Hz |
| 40087 | 0056h | 2 | THD A | FLOAT (LSW first) | Value weight: % |
| 40089 | 0058h | 2 | kWh net | FLOAT (LSW first) | Value weight: kWh |
| 40091 | 005Ah | 2 | kWh (+) TOT | FLOAT (LSW first) | Value weight: kWh |
| 40093 | 005Ch | 2 | kWh (-) TOT | FLOAT (LSW first) | Value weight: kWh |
| 40095 | 005Eh | 2 | V L-N peak | FLOAT (LSW first) | Value weight: Volt |
| 40097 | 0060h | 2 | A peak | FLOAT (LSW first) | Value weight: Ampere |
| 40099 | 0062h | 2 | V L-N max | FLOAT (LSW first) | Value weight: Volt |
| 40101 | 0064h | 2 | V L-N min | FLOAT (LSW first) | Value weight: Volt |
| 40103 | 0066h | 2 | Amax | FLOAT (LSW first) | Value weight:mA |
| 40105 | 0068h | 2 | A min | FLOAT (LSW first) | Value weight: mA |
| 40107 | 006Ah | 2 | W max | FLOAT (LSW first) | Value weight: W |
| 40109 | 006Ch | 2 | W min | FLOAT (LSW first) | Value weight: W |
| 40111 | 006Eh | 2 | var max | FLOAT (LSW first) | Value weight: var |
| 40113 | 0070h | 2 | var min | FLOAT (LSW first) | Value weight: var |
| 40115 | 0072h | 2 | VA max | FLOAT (LSW first) | Value weight: VA |
| 40117 | 0074h | 2 | VA min | FLOAT (LSW first) | Value weight: VA |
| 40119 | 0076h | 2 | PF max | FLOAT (LSW first) | Value weight: PF |
| 40121 | 0078h | 2 | PF min | FLOAT (LSW first) | Value weight: PF |
| 40123 | 007Ah | 2 | Hz max | FLOAT (LSW first) | Value weight: Hz |
| 40125 | 007Ch | 2 | Hz min | FLOAT (LSW first) | Value weight: Hz |
| 40127 | 007Eh | 2 | THD A max | FLOAT (LSW first) | Value weight: % |
| 40129 | 0080h | 2 | THD A min | FLOAT (LSW first) | Value weight: % |

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### 2.3 Instantaneous variables and meters (FLOAT MSW first)

**MODBUS**: read only mode with functions code 03 and 04                                    Table 2.3-1

| | | | | | |
|---|---|---|---|---|---|
| 40132 | 0083h | 1 | STATUS SW | UINT16 | bit 0: flash settings error; bit1: flash calibration error; bit 2: Voltage Over Range; bit 3: Voltage Under Range; bit [4, 5]: don't care; bit 6: Zero crossing detecting; bit [7, 9]: don't care; bit 10: Energy storing error; bit 11: Energy initialization error; bit 12: don't care; bit 13: Current Over Range; bit 14: Current Under Range |
| 40133 | 0084h | 2 | V L-N | FLOAT (MSW first) | Value weight: Volt |
| 40135 | 0086h | 2 | A | FLOAT (MSW first) | Value weight: mA |
| 40137 | 0088h | 2 | W | FLOAT (MSW first) | Value weight: W |
| 40139 | 008Ah | 2 | var | FLOAT (MSW first) | Value weight: var |
| 40141 | 008Ch | 2 | VA | FLOAT (MSW first) | Value weight: VA |
| 40143 | 008Eh | 2 | PF | FLOAT (MSW first) | Value weight: PF |
| 40145 | 0090h | 2 | Hz | FLOAT (MSW first) | Value weight: Hz |
| 40147 | 0092h | 2 | THD A | FLOAT (MSW first) | Value weight: % |
| 40149 | 0094h | 2 | kWh net | FLOAT (MSW first) | Value weight: kWh |
| 40151 | 0096h | 2 | kWh (+) TOT | FLOAT (MSW first) | Value weight: kWh |
| 40153 | 0098h | 2 | kWh (-) TOT | FLOAT (MSW first) | Value weight: kWh |
| 40155 | 009Ah | 2 | V L-N peak | FLOAT (MSW first) | Value weight: Volt |
| 40157 | 009Ch | 2 | A peak | FLOAT (MSW first) | Value weight: Ampere |
| 40159 | 009Eh | 2 | V L-N max | FLOAT (MSW first) | Value weight: Volt |
| 40161 | 00A0h | 2 | V L-N min | FLOAT (MSW first) | Value weight: Volt |
| 40163 | 00A2h | 2 | Amax | FLOAT (MSW first) | Value weight: mA |
| 40165 | 00A4h | 2 | A min | FLOAT (MSW first) | Value weight: mA |
| 40167 | 00A6h | 2 | W max | FLOAT (MSW first) | Value weight: W |
| 40169 | 00A8h | 2 | W min | FLOAT (MSW first) | Value weight: W |
| 40171 | 00AAh | 2 | var max | FLOAT (MSW first) | Value weight: var |
| 40173 | 00ACh | 2 | var min | FLOAT (MSW first) | Value weight: var |
| 40175 | 00AEh | 2 | VA max | FLOAT (MSW first) | Value weight: VA |
| 40177 | 00B0h | 2 | VA min | FLOAT (MSW first) | Value weight: VA |
| 40179 | 00B2h | 2 | PF max | FLOAT (MSW first) | Value weight: PF |
| 40181 | 00B4h | 2 | PF min | FLOAT (MSW first) | Value weight: PF |
| 40183 | 00B6h | 2 | Hz max | FLOAT (MSW first) | Value weight: Hz |
| 40185 | 00B8h | 2 | Hz min | FLOAT (MSW first) | Value weight: Hz |
| 40187 | 00BAh | 2 | THD A max | FLOAT (MSW first) | Value weight: % |
| 40189 | 00BCh | 2 | THD A min | FLOAT (MSW first) | Value weight: % |

### 2.4 Instantaneous variables and meters (INT32)

**MODBUS**: read only mode with functions code 03 and 04                                          Table 2.4-1

| 40192 | 00BEh | 1 | STATUS SW | UINT16 | bit 0: flash settings error; bit1: flash calibration error; bit 2: Voltage Over Range; bit 3: Voltage Under Range; bit [4, 5] don't care; bit 6: Zero crossing detecting; bit [7, 9] don't care; bit 10: Energy storing error; bit 11: Energy initialization error; bit 12: don't care; bit 13: Current Over Range; bit 14: Current Under Range |
|---|---|---|---|---|---|
| 40193 | 00C0h | 2 | V L-N | INT32 (LSW first) | Value weight: Volt*100 |
| 40195 | 00C2h | 2 | A | INT32 (LSW first) | Value weight: mA*100 |
| 40197 | 00C4h | 2 | W | INT32 (LSW first) | Value weight: W*100 |
| 40199 | 00C6h | 2 | var | INT32 (LSW first) | Value weight: var*100 |
| 40201 | 00C8h | 2 | VA | INT32 (LSW first) | Value weight: VA*100 |
| 40203 | 00CAh | 2 | PF | INT32 (LSW first) | Value weight: PF*100 |
| 40205 | 00CCh | 2 | Hz | INT32 (LSW first) | Value weight: Hz*100 |
| 40207 | 00CEh | 2 | THD A | INT32 (LSW first) | Value weight: %*100 |
| 40209 | 00D0h | 2 | kWh net | INT32 (LSW first) | Value weight: kWh*100 |
| 40211 | 00D2h | 2 | kWh (+) TOT | INT32 (LSW first) | Value weight: kWh*100 |
| 40213 | 00D4h | 2 | kWh (-) TOT | INT32 (LSW first) | Value weight: kWh*100 |
| 40215 | 00D6h | 2 | V L-N peak | INT32 (LSW first) | Value weight: Volt*100 |
| 40217 | 00D8h | 2 | A peak | INT32 (LSW first) | Value weight: mA*100 |
| 40219 | 00DAh | 2 | V L-N max | INT32 (LSW first) | Value weight: Volt*100 |
| 40221 | 00DCh | 2 | V L-N min | INT32 (LSW first) | Value weight: Volt*100 |
| 40223 | 00DEh | 2 | Amax | INT32 (LSW first) | Value weight: mA*100 |
| 40225 | 00E0h | 2 | A min | INT32 (LSW first) | Value weight: mA*100 |
| 40227 | 00E2h | 2 | W max | INT32 (LSW first) | Value weight: W*100 |
| 40229 | 00E4h | 2 | W min | INT32 (LSW first) | Value weight: W*100 |
| 40231 | 00E6h | 2 | var max | INT32 (LSW first) | Value weight: var*100 |
| 40233 | 00E8h | 2 | var min | INT32 (LSW first) | Value weight: var*100 |
| 40235 | 00EAh | 2 | VA max | INT32 (LSW first) | Value weight: VA*100 |
| 40237 | 00ECh | 2 | VA min | INT32 (LSW first) | Value weight: VA*100 |
| 40239 | 00EEh | 2 | PF max | INT32 (LSW first) | Value weight: PF*100 |
| 40241 | 00F0h | 2 | PF min | INT32 (LSW first) | Value weight: PF*100 |
| 40243 | 00F2h | 2 | Hz max | INT32 (LSW first) | Value weight: Hz*100 |
| 40245 | 00F4h | 2 | Hz min | INT32 (LSW first) | Value weight: Hz*100 |
| 40247 | 00F6h | 2 | THD A max | INT32 (LSW first) | Value weight: %*100 |
| 40249 | 00F8h | 2 | THD A min | INT32 (LSW first) | Value weight: %*100 |

### 2.5    Firmware version

**MODBUS**: read only mode                                                      Table 2.5-1

| Modicom address | Physical address | Length (words) | VARIABLE ENG. UNIT | Data Format | Notes |
|---|---|---|---|---|---|
| 40002 | 0001h | 1 | Version code | UINT 16 | Value=0: Revision 0 |

### 2.6    Carlo Gavazzi Controls identification code

**MODBUS**: read only mode                                                      Table 2.6-1

| Modicom address | Physical address | Length (words) | VARIABLE ENG. UNIT | Data Format | Notes |
|---|---|---|---|---|---|
| **3**00012 | 0036h | 1 | Carlo Gavazzi Controls identification code | UINT 16 | 95=CPA050 96=CPA300 |

### 2.7    Programming parameter tables

The values are update after the commands 0xC1C0 e 0xC1A0 (see Commands).

**PT and CT configuration menu**

**MODBUS**: read and write mode                                                 Table 2.7-1

| Modicom address | Physical address | Length (words) | VARIABLE ENG. UNIT | Data Format | Notes |
|---|---|---|---|---|---|
| 40009 | 0008h | 2 | Voltage transformer ratio | FLOAT (LSW first) | Default = 1 (VT=1.0) |
| 40011 | 000Ah | 2 | Current transformer ratio | FLOAT (LSW first) | Default = 1 (CT=1.0) |

**Measurement and filters**

**MODBUS:** read and write mode                                                 Table 2.7-2

| Modicom address | Physical address | Length (words) | VARIABLE ENG. UNIT | Data Format | Notes |
|---|---|---|---|---|---|
| 40008 | 0007h | 1 | Flag Measurement | UINT16 | bit 0: 0= TRMS value (without sign) (Default); 1 = DC measurement (with sign); bit 1: 0= Energy storing disable 1= Energy storing enable; bit 2: 0= Freq. detection on Voltage ch (Default); 1= Freq. detection on Current ch. |
| 40007 | 0006h | 1 | Number of tenths of second (1/10) for all RMS calculation in DC | UINT16 | 1…65535 Default: 10 |
| 40014 | 000Dh | 1 | Number of zero crossings for_AC Meas Number of line cycle Zero Crossings for AC measurement RMS. | UINT16 | 1...65535 Default: 50 |

**Serial port configuration menu**

**MODBUS:** read and write mode                                                                 Table 2.7-3

| Modicom address | Physical address | Length (words) | VARIABLE ENG. UNIT | Data Format | Notes |
|---|---|---|---|---|---|
| 40003 | 0002h | 1 | RS485 instrument address | UINT 16 | Value min = 1<br>Value max = 247 |
| 40004 | 0003h | 1 | Machine answer delay (characters) | UINT16 | Value min = 0<br>Value max = 1000<br>Default = 1 |
| 40005 | 0004h | 1 | RS485 baud rate | UINT 16 | Value 0 = 1.2 kbps<br>Value 1 = 2.4 kbps<br>Value 2 = 4.8 kbps<br>Value 3 = 9.6 kbps (Default)<br>Value 4 = 19.2 kbps<br>Value 5 = 38.4 kbps<br>Value 6 = 57.6 kbps<br>Value 7 = 115.2 kbps |
| 40006 | 0005h | 1 | Parity | UINT16 | Value 0 = no parity<br>Value 1 = odd parity<br>Value 2 = even parity |

NOTE: The values are update after switching off and on again

**Commands**

**MODBUS:** read and write mode                                                                 Table 2.7-4

| Modicom address | Physical address | Length (words) | VARIABLE ENG. UNIT | Data Format | Notes |
|---|---|---|---|---|---|
| 40252 | 00FBh | 1 | Command=0xC1A0 | UINT 16 | Reset flash parameters to EEPROM parameters |
| | | | Command= 0XBABA | UINT 16 | Load Energy Net value (energy to load must be written in 00FCh Aux. Register) |
| | | | Command= 0XBABB | UINT 16 | Load Positive Energy value (positive energy to load must be written in 00FCh Aux. Register) |
| | | | Command = 0xBABC | UINT 16 | Load Negative Energy value (negative energy to load must be written in 00FCh Aux. Register) |
| | | | Command= 0xC1C0 | UINT 16 | Save setting parameters from flash memory to EEPROM |
| 40253 | 00FCh | 2 | Auxiliary Register | FLOAT (LSW first) | Energy value to be written (see previous commands) |

CPA - Communication Protocol

# 3  Revisions

**Version 1 Revision 1 3/5/2016:**

- Document created

**Version 1 Revision 2 26/10/2017:**

- Corrected the Current transformer ratio physical address reference (from 0010h to 000Ah)
- Improved the descriptions in Commands table