CONTATTO

MCP 4

Programmable Control Module

User's Manual

Release 1.2 – October 2018

DUEMMEGI
HOME AND BUILDING AUTOMATION

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A1- LIST OF REVISIONS OF THIS MANUAL

Rel. 1.0		First emission (MCP 4)
Rel. 1.1	Par. 2.1.4	MODBUS directives better explained
	Par. 5.3	TCP/IP parameter settings better explained
Rel. 1.2	Par. 1.2	Added special virtual points V2020 to V2027 (communication lost on ETH port)
	Par. 2.1.4	Added information about the management of supported MODBUS MASTER functions
	Par. 11.2	Added function 4 to functions supported by MCP 4 in MODBUS MASTER mode (in addition to 3 and 16)

A2- RECOMMENDATIONS

***WARNING:* this manual applies to MCP 4 with the following firmwares:**

***Main microcontroller:* *2.3* or higher**

***Secondary microcontroller:* *1.1* or higher**

The features described in this manual require the program MCP IDE release 3.2.9 or higher.

This manual assumes that the user have an adequate knowledge about the CONTATTO bus system.

Correct disposal of this product

(Waste Electrical & Electronic Equipment)
(Applicable in the European Union and other European countries with separate collection systems). This marking on the product, accessories or literature indicates that the product should not be disposed of with other household waste at the end of their working life. To prevent possible harm to the environment or human health from uncontrolled waste disposal, please separate these items from other types of waste and recycle them responsibly to promote the sustainable reuse of material resources. Household users should contact either the retailer where they purchased this product, or their local government office, for details of where and how they can take these items for environmentally safe recycling. This product and its electronic accessories should not be mixed with other commercial wastes for disposal. Specifically about the battery, check local regulations for correct disposal. Never use municipal waste.

Installation and use restrictions

Standards and regulations

The design and the setting up of electrical systems must be performed according to the relevant standards, guidelines, specifications and regulations of the relevant country. The installation, configuration and programming of the devices must be carried out by trained personnel. The installation and the wiring of the bus line and the related devices must be performed according to the recommendations of the manufacturers (reported on the specific data sheet of the product) and according to the applicable standards. All the relevant safety regulations, e.g. accident prevention regulations, law on technical work equipment, must also be observed.

Safety instructions

Protect the unit against moisture, dirt and any kind of damage during transport, storage and operation. Do not operate the unit outside the specified technical data. Never open the housing. If not otherwise specified, install in closed housing (e.g. distribution cabinet). Earth the unit at the terminals provided, if existing, for this purpose. Do not obstruct cooling of the units. Keep out of the reach of children.

Setting up

The physical address assignment and the setting of parameters (if any) must be performed by the specific softwares provided together the device or by the specific programmer. For the first installation of the device proceed according to the following guidelines:

- Check that any voltage supplying the plant has been removed
- Assign the address to module (if any)
- Install and wire the device according to the schematic diagrams on the specific data sheet of the product
- Only then switch on the 230Vac supplying the bus power supply and the other related circuits

Applied standards

This device complies with the essential requirements of the following directives:
2004/108/CE (EMC)
2006/95/CE (Low Voltage)
2002/95/CE (RoHS)
EN 55022 Class B

Note

Technical characteristics and this data sheet are subject to change without notice.

A3- NEWS OF MCP 4 AGAINST MCP XT AND AVAILABLE VERSIONS

Hardware:

- Fastest processors and memories
- Added one RS485 communication port (COM4)
- Added Ethernet connection
- Removed alarm relay

Functions:

- Integrated weekly Scheduler for management of 16 points ("zones") with 8 time slots each one; each time slot can be individually enabled or disabled
- A new program transferred to MCP 4 is stored in a different memory location and therefore, during the download, the program previously loaded continues to operate without interruption; only when downloading of the new program is completed, and if everything goes well, the automatic switch from the old program to the new one will be performed.
- MODBUS TCP/IP Slave on ETH port
- Integrated Ethernet Bridge, multi-user up to 8 simultaneous connections
- Integrated WEB Server, multi-user up to 8 simultaneous connections, including sceneries management
- Simple Diagnostic through a WEB browser, therefore without need to install MCP IDE program

The available versions are the following:

- ***MCP 4/STD***: 1 RS232 + 2 RS485
- ***MCP 4/ETH***: 1 RS232 + 2 RS485 + ETH

1- MAIN FEATURES

1.1- Required Hardware and Software tools

To use **MCP 4**, the software tools MCP IDE is required, running on a PC (WXP, W7, W8). Minimum hardware required: 1000 MHz processor and 512 Mbytes minimum RAM.
MCP IDE software tools also provides MCP Visio program, allowing to display in a graphical way the status of the field and all parameters of MCP 4, and other programs allowing specific function.

1.2- Main features of MCP 4

- 2032 virtual digital points
- 1024 16-bit registers
- 1024 16-bit counters
- 512 16-bit timers
- 127 real input addresses up to 4-channel 16-bit each one
- 127 real output addresses up to 4-channel 16-bit each one

Special virtual points:

- **V2032**: when set to 1, MCP 4 suspends the equations calculation and the execution of the scripts; when reset to 0, the activity of MCP 4 restarts normally. The point V2032 will be however automatically reset to 0 after a timeout
- **V2020** ÷ **V2027**: it becomes active in case of communication failure for more than 10 seconds on the relative socket 1 ÷ 8 of the ETH port
- **V2019**: the activation of this point causes the reset and the re-initialization of Ethernet interface
- **V2018**: activated when a communication loss on COM4 (RS485) occurs for more than 5 seconds
- **V2017**: activated when one or more MODBUS slaves do not answer to MCP 4 (set in MODBUS master mode) for more than 50 retries; it will be deactivated after a full polling cycle to slave devices without errors
- **V2016**: activated when the communication with WEBS fails
- **V2015**: reserved, new data are present in the NOTIFY buffer
- **V2014**: activated during times from sunrise to sunset
- **V2013**: reserved
- **V2012**: activated when a communication loss on COM2 (RS485) occurs for more than 5 seconds
- **V2011**: activated when a communication loss on COM1 (RS232) occurs for more than 5 seconds
- **V2010**: activated 0.5 seconds after the end of initialization procedure
- **V2009**: the buffer of analog event (LOG or LOGC) is full or old events have been overwritten
- **V2008**: the buffer of binary event (EVENT or EVENTC) is full or old events have been overwritten
- **V2007**: reserved
- **V2006**: reserved
- **V2005**: error during the execution of a script (e.g. not valid instruction)
- **V2004**: timeout during the execution of a script (>500msec)
- **V2003**: 1sec period clock (toggle its status every 0.5 seconds)
- **V2002**: bus failure
- **V2001**: module failure

1.3- Terminology and syntax

In this manual, some symbols and notations will be used; the meaning of these is here bottom explained.

General:

DI	real or virtual digital input
DO	real or virtual digital output
AI	analog input or generic register
AO	analog output or generic register
Ri	generic register

Addresses, channels, points:

O3.1	point 1 of output 3 (channel 1)
O3:1.1	exactly as the previous one
O3:1.2	point 2 of channel 1 of output module 3
AO15:1	channel 1 of output module 15
AI20:2	channel 2 of input module 20
R12	register R12
R14.5	bit 5 of register R14 (for script only)
V100	virtual point 100
V17..V32	all virtual point from V17 to V32
O3:1.1..O4:2.16	all output points from O3:1.1 to O4:2.16

Numbers:

328	decimal number
0b0001010011111011	16-bit binary number
0b11110010	8-bit binary number
0x14FB	16-bit hexadecimal number

Note: the channel of an input or output module, if not specified, will be assumed 1.

2- EQUATIONS: TYPES AND SYNTAX

2.1- Equations for the system configuration

2.1.1- Configuration of the modules

Specify the module installed in the system (see MCP IDE Keyword List).

```
MOD8I/A = (I1)
MOD8I/A = (I2), (I3)
MOD8R   = (O11)
MOD4-4R = (I4, O12)
MOD2DM  = (I13, I14, O13, O14)
MOD2DM  = (I15, I16, O15, O16)
```

2.1.2- Power ON status

Specify the status or value assigned to outputs or registers at power up or at reset.

```
POWERON = ( O3.1 = 1,          \
            O3:1.2 = 1,        \
            AO15:1 = 1000,     \
            AO16..AO17 = 247, \
            R12 = -,           \
            C32 = 1245,        \
            C33..C35 = -,      \
            V100 = 1,          \
            V1..V16 = 1,       \
            V17..V32 = - )
```

R12=- means that R12 maintains the value before the power down (RAM has a battery for back-up)
`AO16..AO17 = 247` means that outputs AO16 channel 1, channel 2, channel 3, channel 4 and AO17 channel 1 will be set to the value 247 at the power ON. To specify all channels of module 16 and all channels of module 17, the correct equation is: **`AO16:1..AO17:4 = 247`**.

2.1.3- Status of fault input modules

The status assumed by MCP 4 for a failed input module; if not specified, MCP 4 assumes the last available value.

```
FAIL = ( I1.1 = 1,             \
         I1:3.2 = 0,           \
         I5:2.1..I5:2.15 = 1, \
         AI15:2 = 2000,        \
         AI12:1 = 0x1234 )
```

2.1.4- Communication Protocol

Set the communication protocols to be used for each port of MCP 4. COM1 is the communication port on the front panel (RS232), COM2 and COM4 are on the terminal block (RS485), COM3 is the special port under the terminal cover on bottom left side (e.g. for WEBS module connected by a flat cable) and LAN1 is the Ethernet port (MCP4/ETH only); on the ETH port, both MODBUS TCP/IP and RTU will be activated (automatic detection). The directives are the followings (FXPXT can be omitted because however activated):

```
COM1 = (FXPXT, MODBUS) // RS232
COM2 = (FXPXT, MODBUS) // RS485
COM3 = (FXPXT, MODBUS) // Dedicated port (WEBS)
COM4 = (FXPXT, MODBUS) // RS485
LAN1 = (FXPXT, MODBUS) // ETH port
```

The available options for all 4 COM ports (COM3 through WEBS module) are the following:

FXPT proprietary protocol, always active even if not specified

MODBUS MODBUS RTU protocol: full correspondence between the number of the Word specified in the Master MODBUS driver and the number of the Words listed in the RAM map in this own manual. This is the preferred option.

MODBUS- MODBUS RTU protocol: the number of the Word specified in the Master MODBUS driver must be increased by 1 in respect to what listed in the RAM map in this own manual. For compatibility only when replacing a MCP Plus with a MCP 4 in old installations.

MODBUS MASTER

MCP 4, by the just described directive, behaves as a SLAVE device in a MODBUS network. Alternatively, the MODBUS **MASTER** mode can be activated for MCP 4, exclusively on COM4, using the following directive:

```
MODBUS a (T, Vm)  = ( Wx, n, Ry,  \
                     ..........  )
```

where:

a is the address (in the range 1 to 31) of the MODBUS SLAVE node to communicate with

T is the communication timeout in milliseconds; if omitted, the default is 1000 (1 second)

Vm is the virtual point that is activated if the slave "a" does not answer to MCP 4; this parameter is optional and can be omitted. The cumulative point V2017 is always available, see paragraph 1.2

x is the number of the first MODBUS Word to be read/written

n is the number of Words to be read/written

y is the starting number of MCP register where the Words have to be stored

The same directive allows the writing of the specified Words when the value of the related register is modified (by program, script, supervisor, etc.). If more blocks of non consecutive Words have to be read/written on the same MODBUS peripheral device, more lines can be added as follows:

```
MODBUS a (T, Vm)  = ( Wx, n, Ry,  \
                      Wj, m, Rk,  \
                      ..........  )
```

Note: if MODBUS MASTER has been activated, all SLAVE protocols (FXPXT included) on COM4 will be deactivated.

To communicate with more MODBUS peripheral devices, add a directive for each SLAVE address as in the following example; the timeout MUST be the same for all nodes.

```
MODBUS 1 (500)  = ( W0,   10, R101, \
                    W100, 10, R111 )
MODBUS 2 (500)  = ( W0,   10, R121, \
                    W100, 10, R131 )
MODBUS 3 (500)  = ( W0,   10, R141, \
                    W100, 10, R151 )
MODBUS 4 (500)  = ( W0,   10, R161, \
                    W100, 10, R171 )
```

Regarding the functions used by MCP4 in MODBUS MASTER mode, the following rules apply:

- If the specified WORD number is in the range 00000 to 30000, MCP4 performs reading via function 3 (Read Holding Registers) and writing via function 16 (Write Multiple Registers). The words read/written are those mapped from WORD 00000 to 30000 in the slave
- If the specified WORD number is in the range 30001 to 39999, MCP4 performs reading via function 4 (Read Input Registers) and no writing (being “Input” registers, thus read only). The words read are those mapped from WORD 0000 to 9998 in the slave
- If the specified WORD number is in the range 40001 to 49999, MCP4 performs reading via function 3 (Read Holding Registers) and writing via function 16 (Write Multiple Registers). The words read/written are those mapped from WORD 0000 to 9998 in the slave
- If the specified WORD number is in the range 50001 to 65535, MCP4 performs reading via function 3 (Read Holding Registers) and writing via function 16 (Write Multiple Registers). The words read/written are those mapped from WORD 9999 to 25534 in the slave

The following table resumes what just listed:

Word in the directive MCP 4	Word in the slave	Used MODBUS function
00000 ÷ 30000	00000 ÷ 30000	3 [R] and 16 [W]
30001 ÷ 39999	0000 ÷ 9998	4 [R]
40001 ÷ 49999	0000 ÷ 9998	3 [R] and 16 [W]
50000 ÷ 65535	9999 ÷ 25534	3 [R] and 16 [W]

Notes:

- *The numbers shown in the previous table are all in decimal format.*
- *The first case (Word 00000 ÷ 30000) may seem redundant because it is already included in the last two, and in fact it is, but allows the back compatibility with FW versions of MCP 4 less than 1.7.*

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2.1.5- Address of MCP 4

Assign an address to MCP 4; allowed values: 1 to 255. It is mandatory when using MODBUS protocol.

```
ADDRESS = (12)
```

2.1.6- Identifier of MCP 4

Assign an identification string to MCP 4 (max 63 characters).

```
ID = (Building 1 controller)
```

2.1.7- Directive for the calculation of sunrise, sunset and sun position

MCP 4 can calculate every day the times of sunrise and sunset and the sun position (azimuth and elevation); the calculated values will be loaded into 4 registers that must be defined through the **LOCALIZE** directive here described. For these calculations, the data related to the position has to be provided to MCP 4 (Longitude and Latitude) together to the related time zone (e.g. for Italy this value is 1).
In addition, MCP 4 handles the virtual point **V2014**, activating it when the current time is inside the range from sunrise to sunset, corrected, if needed, by an amount of minutes that can be declared in the **SUNRISE** and **SUNSET** parameters.

```
LOCALIZE = ( \
            LONGITUDE = 8.8638, \
            LATITUDE = 45.3036, \
            TIMEZONE = 1, \
            SUNRISE = ( 0, R1 ), \
            SUNSET = (0, R2 ), \
            AZIMUTH = R3 , \
            ELEVATION = R4, \
)
```

where:

LONGITUDE	allowed values in the range -180.0000 to +180.0000
LATITUDE	allowed values in the range -90.0000 to +90.0000
TIMEZONE	in respect to Greenwich: allowed values in the range -12 to +12
SUNRISE	minutes to be added or subtracted to the sunrise time (in the range -127 to +127) and the (optional) register reporting the calculated sunrise time
SUNSET	minutes to be added or subtracted to the sunset time (in the range -127 to +127) and the (optional) register reporting the calculated sunset time
AZIMUTH	(optional) register reporting the azimuth of the sun; value in the range 0 to 360 reporting the angular position of the sun in respect to North, measured clockwise in degrees. For instance, azimuth=90 means that the sun is located to East
ELEVATION	(optional) register reporting the elevation of the sun; 2's complement value, the register will contain a value 65446 to 65535 for negative values and 0 to 90 for positive values, corresponding to a value in the range -90 to +90 reporting the position of the sun in respect to the horizon, measured in degrees. A positive value means that the sun is above the horizon, a negative value means that it is under the horizon. Elevation=0 means that the sun is exactly at the horizon line

The times related to sunrise and sunset will be reported by the specified registers as value corresponding to the number of minutes of the day starting from 0:00 (e.g.: 1439 = 23:59).
Note: the 4 registers can be optionally declared; this means that, if the calculation of sunrise, sunset and sun position is not required, these ones can be omitted; in this case the virtual point **V2014** will be however handled.

2.1.8- Publishing on the bus the status of virtual points and value of registers

MCP 4 can be set to send ("publish") on the bus the status of some virtual points and the value of some registers. TO enable the function for the publishing of virtual point and registers, the following instructions has to be added to the MCP 4 configuration:

```
SHARE = ( Vx .. Vy )
SHARE = ( Ri .. Rj )
```

Vx and **Vy** specify respectively a starting and an ending virtual point; for any entered value as **Vx** and **Vy**, these one will be however forced to values multiple of 16 by the compiler of MCP IDE, therefore, specifying for example **V3..V9**, the compiler will force to **V1..V16**.

Ri and **Rj** specify respectively a starting and an ending register; these two value can be freely assigned.

Up to 32 SHARE instruction can be added to the same MCP 4 program; ***each SHARE instruction must contain no more than 128 virtual points or 8 registers***.

The SHARE instruction is useful, for instance, when a ModGSM3 module has been installed in the system and it must manage the information related to the virtual points and registers of MCP 4.

Example. The following instructions will enable the publishing on the bus of virtual points 1025 to 1280 and of the first 32 registers of MCP 4:

```
SHARE = ( V1025 .. V1152 )
SHARE = ( V1153 .. V1280 )
SHARE = ( R0.. R7 )
SHARE = ( R8.. R15)
SHARE = ( R16.. R23)
SHARE = ( R24.. R31)
```

2.1.9- Management of fault modules

Assign a virtual point to the failure condition of one or more modules.

```
MODFAIL(V10) = (I1, I2, O1, O2, O41)
MODFAIL(V11) = (I44)
```

2.1.10- Alignment of the outputs

MCP 4 cyclically executes, in addition its many activities, a status request to the output modules (both digital and analog ones); if MCP 4 detects a mismatch between the status or the value read from the field and the related value stored in the RAM memory of the controller, then it must execute an alignment between the field and the RAM. Two alignment directions are available:

- the status or the value in the RAM will be transferred to the field output
- the status or the value of the field output will be transferred to the RAM memory

As default, MCP 4 executes the first alignment type (from RAM to field); in some cases (depending on the module type and on the specific application) it is instead preferred, if not mandatory, the second alignment type (from field to the RAM). To specify which outputs must be managed according to this alignment type, the equation **FIELDtoRAM** must be used. This equation can include single output points, whole values or point intervals as in the following example.

```
FIELDtoRAM = ( O20.3, \
               O20.4, \
               AO1, AO2:3, \
               O21:1.1..O21:1.8)
```

The alignment from field to RAM, however, is not allowed for all types of modules; when allowed, the related technical sheet of the module will specify this, together to some suggestion on the best setting. Remember that, unless otherwise specified in the **FIELDtoRAM** equation, the alignment will be always executed from RAM to field.

2.1.11- Data exchange between MCP 4 controllers

If more MCP 4 controllers have been installed in a plant, it is possible to activate feature allowing to exchange of data among them. To do this, simply connect each MCP to the other, in order to create a RS485 network (exclusively using COM2 port), and instruct each MCP 4 belonging to this network to "publish" the data well specified by proper directives; therefore, non more components are needed in addition to the RS485 cable connecting the installed MCP 4 controllers.

Moreover, the data exchange mechanism here described also applies between CONTATTO MCP 4 controllers and **Domino** DFCP controller, allowing interactions between the two systems.

The information that can be published on the network are the virtual points and the registers and therefore, since any digital or analog variable can be supported by these ones, almost any information regarding each MCP 4 or the modules connected to it can be transferred.

Each MCP 4 can publish a maximum of 125 Words; since each register takes 1 Word and a Word can contains 16 contiguous virtual points, as an example the following combinations are allowed:

- 2000 virtual points - 0 registers
- 1000 virtual points - 62 registers
- 512 virtual points - 93 registers
- 0 virtual points - 125 registers

In other words, the number of virtual points divided by 16, added to the number of register, must be less or equal to 125:

(nr.V) / 16 + nr.R <=125

As said before, the data exchange feature among more MCP 4 controllers must be activated, during programming step, by one or more configuration directives specifying how many virtual points and/or registers have to be published. These configuration directives are as follows:

```
NETWORK = (Vstart .. Vstop)
NETWORK = (Rstart .. Rstop)
```

Vstart and Vstop means respectively an initial and a final virtual point; any value chosen as Vstart and Vstop will be however forced as multiple of 16 by the compiler of MCP IDE; for instance, choosing `V3..V9`, the compiler will force `V1`..`V16`.

Rstart and Rstop means respectively an initial and a final register; these two values can be set as desired, but remembering that the total number of Words that can be published (virtual points and registers) must be less or equal to 125 as said before.
Each MCP 4 belonging to the network will write in its memory the information published by the other MCP 4 controllers; each Word will be stored in the same position from which it has been originated, therefore the content of register R50 of a MCP 4, for instance, will be stored as R50 by all other MCP 4 controllers. For this reason, of course, the Words published by each MCP 4 must be different from one to the others; in other words, it is mandatory to avoid superimposition of the Words published by the controllers belonging to the same network.

It is also possible to publish non contiguous blocks of virtual points and registers, specifying more **NETWORK** directives, up to a maximum of 8 (as total of V-Words and R-Words). For instance, the following directive may be enclosed in the same MCP 4:

```
NETWORK = (V1 .. V16)
NETWORK = (V513 .. V576)
NETWORK = (V1025 .. V1056)
NETWORK = (R0 .. R8)
NETWORK = (R33 .. R37)
NETWORK = (R50 .. R52)
NETWORK = (R100 .. R100)
NETWORK = (R251 .. R255)
```

To publish only one register, simply specify the same value for Rstart and Rstop (see **R100** in the previous example). Each MCP 4 acquires the information published by the other components of the same network even if it does not contain any **NETWORK** directive; for instance, if only one MCP 4 has to send information to the other components of the networks, but not vice-versa, then the **NETWORK** directive may be activated only for the "master" MCP 4 controller.

Remember:

- if a **NETWORK** directive has been inserted in a MCP 4, then also an **ADDRESS** directive must be insrted too and this last one must be placed **before** any **NETWORK** directive
- the Words published by a MCP 4 must be different from one to the other in order to **avoid superimposition**
- up to 8 **NETWORK** directive can be enabled in each MCP 4 in the network
- Each MCP 4 acquires the information published by the other components of the same network even if it does not contain any **NETWORK** directive
- the data exchange mechanism here described also applies between CONTATTO MCP 4 controllers and **Domino** DFCP controller, allowing interactions between the two systems

Example:

Suppose to have installed 2 MCP 4; also suppose to have connected, to each one of them, 1 MOD8I/A, 1 MOD8R, both with address 1, 1 MOANI and 1 MOANU, both with address 2. Suppose that the application requires to control the outputs of a bus by the input of the other one and vice-versa..
The programs to be written in the two MCP 4 controllers are:

```
// Program for MCP-4 1
      ADDRESS = ( 1 )          // Address of first MCP
      NETWORK = (V1..V16)      // Send 16 virtual points to the other MCP
      NETWORK = (R0..R0)       // Send 1 register to the other MCP
      V1 = I1.1                // Copy the local inputs to first 8 virtual points
      V2 = I1.2
      V3 = I1.3
      V4 = I1.4
      V5 = I1.5
      V6 = I1.6
      V7 = I1.7
      V8 = I1.8
      O1.1 = V17               // Copy the received virtual points to the outputs
      O1.2 = V18
      O1.3 = V19
      O1.4 = V20
      O1.5 = V21
      O1.6 = V22
      O1.7 = V23
      O1.8 = V24
      R0 = AI2                 // Copy the analog input to first register
      AO2 = R1                 // Copy the second register to analog output

// Program for MCP-4 2
      ADDRESS = ( 2 )          // Address of second MCP
      NETWORK = (V17..V32      // Send 16 virtual points to the other MCP
      NETWORK = (R1..R1)       // Send 1 register to the other MCP
      V17 = I1.1               // Copy the local inputs to the virtual points to be sent
      V18 = I1.2
```

```
V19 = I1.3
V20 = I1.4
V21 = I1.5
V22 = I1.6
V23 = I1.7
V24 = I1.8
O1.1 = V1              // Copy the received virtual points to the outputs
O1.2 = V2
O1.3 = V3
O1.4 = V4
O1.5 = V5
O1.6 = V6
O1.7 = V7
O1.8 = V8
R1 = AI2               // Copy the analog input to second register
AO2 = R0               // Copy the first register to analog output
```

In practice, the status of inputs **I1.1..I1.8** of the module connected to the 1st MCP 4 will be copied to **V1..V8** of the same MCP 4 and published on the networks. The 2nd MCP 4 receives the status of these virtual points and it stores them in the same position **V1..V8**, thus transferring the status to output module **O1** connected on its bus. The same thing happens in the reverse way through the virtual points **V17..V24**; the same mechanism also applies to the registers.

2.1.12- Number of nodes in a MCP 4 network

In a network made as described in the previous paragraph, up to 32 MCP 4 may be installed, each one publishing its data in order to make available them to the other components of the network. Since only one MCP 4 at a time can access the RS485 communication line (COM2), being this of serial type, then the publication of the information by all the components (or nodes) of the network needs a sure time.
Due to the particular management of the mechanism to access to the network, this time can be optimized instructing each MCP 4 about how many are the participants to the same network; too do this, the following directive has to be used:

NODESNUM = (num)

where **num** is the number of nodes and must be in the range 1 to 32.
The time required by all the nodes to publish their information, in the worst case of 125 Words to be published, at 115.2 Kbaud, ranges from a minimum of 80 milliseconds, in the case of 2 MCP 4, to a maximum of 1 second in the case of 32 MCP 4.

If the number of nodes has not been specified by the **NODESNUM** directive, this parameter will be set to 32 by default; in this case the network will work anyway but, if for instance the network is made by 2 MCP 4, the time needed for a full cycle will result increased from 80 milliseconds to 340 milliseconds (at 115.2 Kbaud and in the worst case of 125 Words to be published).

The **NODESNUM** directive is thus optional, but it is useful to drastically reduce the time needed to exchange data among MCP 4 controllers when the number of nodes is less than the allowed maximum value.

2.1.13- Scheduler

The Scheduler allows to control a digital output point (exclusively virtual point) as function of the current day and time. MCP 4 includes a timekeeper circuit with back-up battery to avoid the date and time loss when disconnecting the main power supply. The transition from standard to daylight saving time is made automatically by MCP 4.

MCP 4 includes a complete weekly Scheduler: it allows to specify, for each day of the week, in which time slots the specified output must be activated and which are not.
Such programming is repeated identical for all the weeks of the year. The virtual point controlled by the Scheduler must then eventually reported to the desired physical outputs, in combination with other points if required.

The Scheduler integrated in MCP 4 allows the control of 16 different points ("zones") each one with 8 time slots (8 ON-OFF intervals) for each day of the week. The resolution of the Scheduler is 1 minute.

The Scheduler will be activated by the following directive:

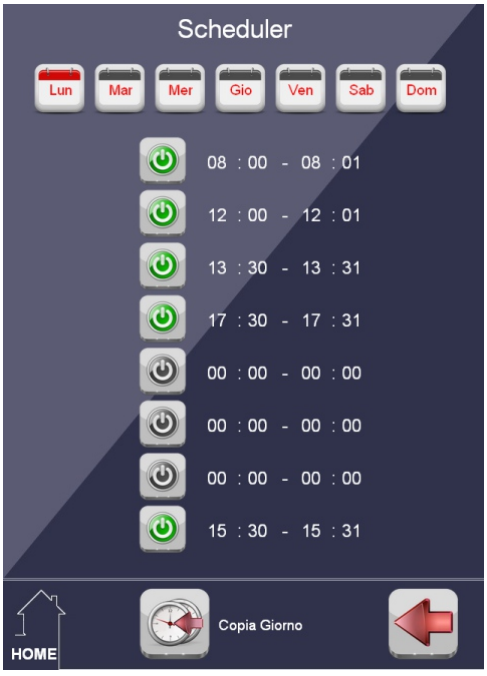
```
SCHEDULER n ( Vx )
```

where:
n is the Scheduler number ("zone") and it must be in the range 1 to 16
Vx is the controlled virtual point

I the points to be controlled are more than one, more directives must be added as in the following example.

```
SCHEDULER 1 ( V100 )
SCHEDULER 2 ( V101 )
SCHEDULER 3 ( V102 )
```

Unlike CLOCK equation which will be described later, where the specified times are set in the user program and then the change these ones requires reprogramming of MCP 4, the Scheduler here described allows easy setting from any supervision program or through the WEB server (optional) integrated in MCP 4. For details on entering and modification of schedules, refer to the specific documentation.
The following figure shows an example of a page that can be developed for the management of the Scheduler.



2.2- Event triggered Equations

2.2.1- Logic equations

Operators: & (AND), | (OR), ! (NOT), ^ (XOR)

(XOR is evaluated by the compiler as follows: **A ^ B = !A & B | A & !B**)

```
O10.3 = I1.1
O2.5 = (I1.1 | I1.2)
V6 = (I4.3 | I8.2) & V4
O1.6 = V100 & I1.7
O1.6 = !I1.3 & I1.7
O1.1 = I2.1 & (I4.3 | I2.4)
O8.1 = V7 ^ I43.2
```

2.2.2- SET – RESET equations

Operators:

S	SET on the edge
SP	SET priority on the edge
SL	SET on the level
SPL	SET priority and on the level
R	RESET on the edge
RP	RESET priority on the edge
RL	RESET on the level
RPL	RESET priority on the level

`O1.1 = SI1.1 & RI1.2` Set/Reset edge triggered.

`O1.1 = SI1.1 & RI1.2` Set/Reset edge triggered

`O1.1 = SI1.1 & RLI1.2` Reset on the level: out is locked OFF if I1.2 is activated.

`O1.1 = SPLI1.1 & RLI1.2` Set/Reset on the level, but out is locked ON if I1.1 is activated (since it is specified to be a priority command).

`O1.5 = I2.3 & RI2.1 & SI4.6` **I2.3** is a consent.

`O1.1 = (SI1.1 | SI1.2) & RI1.3` Parenthesis use: out goes ON activating I1.1 or I1.2.

`O1.1 = SI1.1 & RI1.2 & RI1.3` Out goes OFF activating I1.2 or I1.3.

`O1.1 = SLI1.1 & SLI1.2 & RI1.3` Out goes ON activating BOTH I1.1 and I1.2

2.2.3- TOGGLE equations

Operators:

T	TOGGLE on the edge
S	SET on the edge
SP	SET priority on the edge
SL	SET on the level
SPL	SET priority and on the level
R	RESET on the edge
RP	RESET priority on the edge
RL	RESET on the level
RPL	RESET priority on the level

Terms must be linked by OR operators; no “free” input can be used.

O1.1 = TI6.1 | TV6	Out toggles at every OFF-ON variation of I6.1 or V6.
O1.1 = T!I6.1	Out toggles at the variation ON-OFF of the input.
V100 = TV1 | SV2 | RV3	Set and Reset on the edge.
V100 = TV1 | SV2 | RLV3	Out is locked OFF until V3 is activated (being on the level) .
O1.1 = TI1.1 | TI1.2 | SI1.3 | SI1.4 | RI1.5 | RI1.6	More command inputs.

2.2.4- COUNTER Equations

Counter equation controls a digital output as function of the comparison between the counter value and a threshold. 1024 counters can be defined. Each counter can be controlled by real or virtual inputs, each one with its own specific function:

1. one or more inputs for forward or backward counting (**S(k)**)
2. one or more inputs for the zeroing or to load the counter with a defined value (**P(z)**, **PP(z)**, **PL(z)**, **PPL(z)**)
3. one or more inputs to stop the counting (**H, HP**)

The counter, depending on the variations at its inputs, will be updated and then compared to the threshold value, in order to control the output. Allowed operators are:

<	lower than
<=	lower or equal to
==	equal to
!=	not equal to
>	greater than
>=	greater or equal to

Control operators:

S(k)	Sum k to counter on the edge (k range: -32768 to 32767)
P(z)	Preset counter to z on the edge (z range: 0 to 65535)
PP(z)	Priority Preset counter to z on the edge (z range: 0 to 65535)
PL(z)	Preset counter to z on the level (z range: 0 to 65535)
PPL(z)	Priority Preset counter to z on the level (z range: 0 to 65535)
H	Lock the counter to the current value on the level (Halt)
HP	Priority Lock the counter to the current value on the level (Halt)

All counters of MCP4 are in 16-bit format, thus the content of each counter is in the range 0 to 65535.

For the counter function, the following options can be also specified:

- ***AUTORESET/AUTORELOAD***
- ***MIN***
- ***MAX***
- ***Cn,R*** copy the counter value to a register (with same identifier)
- Variable parameters

The syntax allowing to specify these options is the following (**Vx** may be any allowed point):

```
Vx = Cy,R > 30, AR, MIN, MAX .........
```

where:

- **R** means that the counter value is continuously copied in a register (with the same identifier)
- **AR** is the (optional) value for the autoreset and the autoreload, in order to make possible the automatic zeroing and the automatic loading of the counter: when the forward counting exceeds the value **AR**, then the counter wil be automatically zeroed, while when the backward counting decrease below the value 0, then the counter will be automatically reloaded with the value **AR**. This value can be also the content of a register (see the examples in the following). ***Note****: if the autoreset/autoreload value has not been specified, then the counting will be stopped to 0 (when down counting) and at the maximum allowed value (when up counting), thus avoiding the underflow or the overflow of the counter.*
- **MIN** is the minimum value that can be assumed by the counter; the default value is 0
- **MAX** is the maximum value that can be assumed by the counter; the default value is 65535

The values for the threshold, autoreset, minimum, maximum, step and preset can be also the content of registers (see the examples in the following).

If one of the options **AR**, **MIN** and **MAX** has been omitted, the default value will be assumed. The described options must be however separated by commas as in the following examples.

Examples:

```
V1 = C0>300 S(2)I1.1 & S(-1)I1.2
```
Up counting step 2, Down counting step 1, V1 goes ON when counter is greater than 300.

```
V1 = C0>30,50 S(1)I1.1 & S(-1)I1.2
```
Autoreset/Autoreload: when counter exceeds 50, it is reset to zero; when the counter goes below zero, it is reloaded to 50.

```
V1 = C0>30,,5,50 S(1)I1.1 & S(-1)I1.2
```
MIN and MAX: the up counting is stopped to 50 and the down counting is stopped to 5.

```
V1 = C0>3,5,1 S(1)I1.1 & S(-1)I1.2
```
Autoreset/Autoreload and MIN: when counter exceeds 5, it is reloaded to 1; when the counter goes below 1, it is reloaded to 5.

```
V15 = C10,R > 100 S(1)I1.1 & S(-1)I1.2 \
      & PL(0)I1.3
```
Copy Counter to Reg: the value of C10 is copied to register R10.

```
V10 = C1 > R0,R1,R2,R3 S(R4)I1.1 \
      & P(R4)I1.3
```
Variable parameters.

2.2.5- THRESHOLD Equations

Threshold equation controls a digital output as function of the comparison between an analog value (input module or register) and a Threshold and an Hysteresis. Allowed comparison operators:

<	lower than
<=	lower or equal to
==	equal to
!=	not equal to
>	greater than
>=	greater or equal to

Options:

- Hysteresis
- Variable parameters

The Hysteresis has a different meaning depending on the comparison operator:

< OUT goes ON when **AI<T** and OUT goes OFF when **AI>=(T + H)**
<= OUT goes ON when **AI<=T** and OUT goes OFF when **AI>(T + H)**
== OUT goes ON when **AI==T** and OUT goes OFF when **AI>(T + H)** or when **AI<(T - H)**
!= OUT goes OFF when **AI==T** and OUT goes ON when **AI>(T + H)** or when **AI<(T - H)**. This behavior is complementary to the previous case
> OUT goes ON when **AI>T** and OUT goes OFF when **AI<=(T - H)**
>= OUT goes ON when **AI>=T** and OUT goes OFF when **AI<(T - H)**

Threshold and Hysteresis must be in the range 0 to 65535. Other allowable operators: AND (&) and OR (|).

Examples:

```
O1.1 = AI1 >= 240,2
V2 = AI1 == 40 | AI2 == 30
V2 = AI1 == 40,5
O1.4 = AI1 < 128 & AI1 > 30
O1.5 = AI1 < 600 & R50 >= 30
O1.1 = AI1 > R51,R52 & AI1 < 1000,5
```

2.2.6- TIMER Equations

Timer equation controls a digital output as function of two delay times. 512 timers can be defined. The timer resolution is 0.1s and time range is 0 to 6553.5s (1h:49'). The times specified in the timer equation are intended in second multiplied by 10 (**Te**=100 means 10 seconds).
The input starting the timer is the "trigger" input and it always works on the edge.

Keyword:

TIMER	Standard timer
TIMERP	Non re-triggerable Pulse timer (monostable)
TIMERPR	Re-triggerable Pulse timer (monostable)

E4ended control operators:

H	Lock the timer to the current value on the level (Halt)
Z	Zero, force the expiring of the current timer value (if running) on the edge
ZL	Zero, force the expiring of the current timer value on the level

Note: if the Zero on the level command is activated, the trigger status is transferred to the output without delays. The priority sequence for the timer controls is fixed to Halt, Zero and Trigger.

Options:

- Variable parameters

`O1.1 = TIMER(I2.5, 30, 10)` 3s delay from I2.5 activation to the out activation; 1s delay from I2.5 deactivation to out deactivation.

`V23 = TIMER(!I1.1, 0, 23)` Out is complemented in respect to the trigger input.

`O1.1 = TIMER(I2.5 & HI5.1 & ZI5.2, 90, 50)` Trigger, Halt and Zero: I5.1 halts the timer, I5.2 forces the expiring of the currently running time; if the timer is in stand-by, Halt and Zero controls have not any effect.

`O1.1 = TIMERP(I1.1, 0, 20)` 2s pulse at the activation of the trigger input; no action at the deactivation of the input.

`O1.1 = TIMERP(I1.1, 10, 20)` 2s pulse delayed 1s from the activation of the trigger input.

`O1.1 = TIMERPR(I1.1, 0, 20)` Re-triggerable 2s pulse (computed from last activation of the trigger.

`O1.1 = TIMERPR(I1.1, 10, 20)` Re-triggerable 2s pulse delayed 1s from the first activation of the trigger input.

`O1.1 = TIMER(I1.1, R47, R48)` Variable parameters.

2.2.7- Equations for mathematical and logic calculation

Allowed MATH and LOGIC operators:

MATH		LOGIC	
Symbol	**Function**	**Symbol**	**Function**
+	Sum	&	AND
-	Subtract	I	OR
*	Multiply	^	XOR
/	divide	P()	Preset

Preset options:

`P`	Preset on the edge: load the specified value at the edge of the control input
`PL`	Preset on the level: load the specified value and lock the result to that value

Notes:

- **there is no priority between logical and algebraic operators**: the equation is calculated sequentially from left to right; **brackets are not allowed**
- the Preset on level always takes priority over calculation of the equation and over Preset on edge
- if in the same equation more Presets on level are activated, priority is given to the leftmost one
- when a Preset on level is activated, the result of the equation is frozen to the value determined by that same Preset; if instead the Preset is on the edge, the result of the equation will be the value established by that same Preset until no further changes occur to other terms inside the equation
- each terms involved in a calculation equation is 16-bit number; the partial results are evaluated as 32-bit number, but the final result will be truncated to the less significant 16 bits

Examples:

```
AO1:1 = AI1:4 + 128
R12 = AI1:4 + 12 & 0x00F0 + R1 & P(30)I23.5
R54 = R52 / R53 + R54 * 2
```

A mathematical equation can also be made by one or more Preset terms only; this is useful to load a value in a register or to an output at the activation (or de-activation) of a control input:

```
R0 = P(1527)V1
R1 = P(0x1AB7)I1.8 & P(0)!I1.8
AO23:2 = P(12000)V148 & P(0b11000011)I12.1 & PL(0)!I32.7
```

Exclusively for real outputs (thus registers, counters etc. are excluded), **it is possible to define multiple Presets activated by the same digital point**; in this case, at the activation of the common digital point, the values defined by the Preset will be sent sequentially to the output, in the order in which they have been entered into the equation (from left to right). The following examples show some possibilities.

When V1 goes ON, the values 10, 20 and 30 will be sequentially sent to the output:
```
AO1:1 = P(10)V1 & P(20)V1 & P(30)V1
```

When V1 goes ON, the values 10 and 20 and 30 will be sequentially sent to the output; when V2 goes ON, the values 30 and 40 will be sequentially sent to the output:
```
AO1:1 = PL(10)V1 & P(20)V1 & P(30)V2 & P(40)V2
```

When V1 goes ON, only the value 20 will be sent to the output, because it is a Preset on level:
```
AO1:1 = P(10)V1 & PL(20)V1 & P(30)V1
```

When V1 goes ON, only the value 10 will be sent to the output, because it is the Preset on level placed on the leftmost side in the equation:
```
AO1:1 = PL(10)V1 & PL(20)V1 & P(30)V1
```

2.2.8- Equations for binary code generation

Keyword:

SENDn(Tr)	Send the specified code to output **n** at the activation of the related input (or de-activation if complemented), with refresh time **Tr** seconds (when more inputs are activated)
SENDRn(Tr)	Send the specified code to register **Rn** at the activation of the related input (or de-activation if complemented), with refresh time **Tr** seconds (when more inputs are activated)

The sent code (Bx) must be in the range 0 to 255. If the refresh time has been omitted, then it will be set to 2 seconds. The refresh time must be in the range 1 to 254 seconds; it is possible to disable the refresh by specifying the value 255. In this case the sent code will be always that related to last change of one among the inputs listed in the SEND block.

The input points causing the sending of the related binary code may be real and virtual ones; they can be also complemented.

Up to 16 independent SEND block can be defined.

```
SEND4 (5) = ( I1.1,  B001,    \
              I1.2,  B002,    \
              V354,  B003,    \
             !I4.7,  B006,    \
             !V450,  B129     \
)

SENDR123(2) = ( I5.8,  B001,  \
                V100,  B002,  \
                V101,  B003,  \
               !V470,  B004,  \
               !V480,  B005   \
)
```

Note: commas are mandatory symbols.

2.2.9- Equations for recording status changes (EVENT)

This function allows to store, in chronological order, the status change of the real input points and of the virtual points that have been specified in the EVENT block. Each status change will be stored together to:

Day/Month Hour:Minutes:Seconds

The EVENT function allows to specify if MCP 4 has to store the OFF-ON or the ON-OFF status change or both. The EVENT function will also automatically register the so called “system events”, that are the failure and the restoring of any module and of the bus; the doubled address events will be automatically registered too. Up to 2048 events can be stored in the RAM.

The section of the RAM where these events are stored has the battery back-up feature, therefore the events remain stored even if the main supply voltage fails (at least until the battery does not reach the minimum retaining voltage of the memory).

Keyword:

EVENT	Create the event list (fixed buffer): when the buffer is full, it does not accept any other event (in this way the list contains the first 2048 events from the last cleaning of the buffer)
EVENTC	Create the event list (circular buffer): when the buffer is full, it overwrites the old events (in this way the list contains the last 2048 events)

No more than 1 EVENT block can be declared in the same MCP 4 module. If the buffer is full (case EVENT) or the old events have been overwritten (case EVENTC), then the virtual point **V2008** will be activated to report this occurrence.

```
EVENTC = (          \          Inizio blocco, il buffer è circolare
         V1, ON,    \          Evento 1, alla transizione 0-1 di V1
         V2, OFF,   \          Evento 2, alla transizione 1-0 di V2
         I3.7, ON, OFF \       Evento 3, ad entrambe le transizioni 0-1 e 1-0 di I3.7
)
```

Note: commas are mandatory symbols.

2.2.10- Equations for recording value changes (LOG)

This function allows to store , in chronological order, the change of the value returned by input modules or registers that have been specified in the LOG block. Change in the value means exclusively a change from any value to another one, on condition that the new value is not zero, unless this has not been expressly declared; in other words, any change from zero to any other value, or from any value to another one (but not zero) will be registered, while a change from any value to zero will not be registered, unless not expressly declared in the LOG block. For instance:

1. a change from 0 to 287 will be registered
2. a change from 287 to 584 will be registered
3. a change from 584 to 321 will be registered
4. a change from 321 to 0 will NOT be registered, unless not expressly declared

This function is useful, for instance, to record the codes of the transponders controlling an access to a building. In the LOG block can be specified both real input addresses (specifying the channel if any) and registers. Each value change will be stored together to:

Day/Month Hours:Minutes:Seconds

Up to 1024 16-bit values (or codes) can be stored in the RAM of MCP 4; since the section of the RAM where these events are recorded has the battery back-up feature, the values remain stored even if the main supply voltage fails (at least until the battery does not reach the minimum retaining voltage of the memory).

Keyword:

LOG	Create the value list (fixed buffer): when the buffer is full, it does not accept any other value (in this way the list contains the first 1024 value from the last cleaning of the buffer)
LOGC	Create the value list (circular buffer): when the buffer is full, it overwrites the old values (in this way the list contains the last 1024 values)

Option:

ZERO	Declare that, for the related input or register, also changes from any value to zero has to be recorded

No more than 1 LOG block can be declared in the same MCP 4 module. If the buffer is full (case LOG) or the old events have been overwritten (case LOGC), then the virtual point **V2009** will be activated to report this occurrence.

```
LOGC = (              \        Block start, the buffer is circular type
        AI47:2,       \        changes of input AI47 channel 2, changes to zero excluded
        AI3,  ZERO,   \        changes of input AI3 channel 1, changes to zero included
        R230, ZERO,   \        changes of register R230, changes to zero included
        R321          \        changes of register R321, changes to zero excluded
)
```

Note: commas are mandatory symbols.

2.2.11- Management of the external counter modules (ModCNT)

The counter module (code number ModCNT) **is an external module** (connected to the CONTATTO bus) which counts the pulses applied to its inputs; it stores the total amount of the counting in its non volatile memory. The management of this module by MCP 4 needs a special function, specified by an equation very similar to that one for the management of the internal counters. Each ModCNT counter module features 4 counting channels, thus the equation must specify the channel to be managed.

MCP 4, through a threshold equation, can continuously read the content of each external counter and it can compare it to the threshold value; the result of the comparison controls a digital (real or virtual) output. Allowed comparison operators are:

<	lower than
<=	lower or equal to
==	equal to
!=	not equal to
>	greater than
>=	greater or equal to

It is also possible to specify a real or virtual input which, when activated, reset to the value 0 the counter specified in the equation; this is however an optional input and must be linked by the operator "**&**".
The threshold value also can be the content of a register.

Examples:

`O1.1 = AI10:2 >= 100 & ZI1.1`	The output is controlled by channel 2 of ModCNT module, addressed 10; the output will be activated if the counting is greater or equal to 100. The input **I1.1**, when activated, will reset the counter to 0.
`V10 = AI10:4 > R0`	The virtual point **V10** will be activated if the counting of the channel 4 of ModCNT module addressed 10 is greate than the content of register **R0**.

2.2.12- Management of DALI module (ModDALI)

This equation allows to simplify the management of ModDALI module, especially in systems where the automatic brightness regulation has to be implemented. The syntax of DALI equation is the following:

```
AOUT = DALI (Code, AIN(offset))
```

where:

AOUT	output (address:channel of ModDALI to be managed) or register where the result of equation will be sent
Code	DALI command type (broadcast, single ballast or group)
AIN	analog input whose value must be transferred (typically address:channel of ModLC sensor) or register containing the value to be transferred
offset	value or register containing a value in the range -100 to 100; this value will be algebraically added to **AIN**; this is useful, for instance, when the brightness regulation from a unique sensor must be differentiated between rows of lamps depending on the distance from windows

At every change of one of the **AIN** values inside the **DALI** block, the related value will be transferred to the specified channel of ModDALI module and, by this one, to all ballasts, or to a single ballast, or to a group depending on the value of **Code**.

The allowed **Code**, therefore the DALI destinations, are the following:

Code = 0xXX	direct declaration of the code in hexadecimal format; for instance 0x81 means, according to DALI specifications, that **AIN** must be sent to group 1
Code = B1..B32	equivalent to 0x01..0x20, for commands to single ballast
Code = G1..G16	equivalent to 0x81..0x90, for group commands
Code = ALL	equivalent to 0x00, for broadcast commands

Example:

```
AO1:2 = DALI ( G1, AI44:2,   \  // Send AI44:2 to Group 1
               G2, R1,       \  // Send R1 to Group 2
               G3, R1(10),   \  // Send R1 incremented by 10 to Group 3
               G4, R1(-10),  \  // Send R1 decremented by 10 to Group 4
               B1, AI45:2,   \  // Send AI45:2 to Ballast 1
               B2, R5,       \  // Send R5 to Ballast 2
               B3, R6(10),   \  // Send R6 incremented by 10 to Ballast 3
               B4, R6(-10),  \  // Send R6 decremented by 10 to Ballast 4
               ALL, R100     \  // Send R100 to all Ballasts (broadcast)
)
```

These commands will be sent, in this example, to channel 2 only of DALI module addressed 1 (**AO1:2**).

Note: commas are mandatory symbols.

2.3- Time triggered Equations

2.3.1- Scheduler Equations

Scheduler equation controls a digital output as function of specified ON/OFF time or date. MCP 4 includes a timekeeper with back-up battery to avoid the date and time loss when disconnecting the main power supply. The transition from standard to daylight saving time is made automatically by MCP 4, therefore no intervention of the user is required.

The times specified in the scheduler equations can be daily or weekly times; the scheduled dates can be yearly or absolute dates.

Keyword:

CLOCK	controls the output as function of current time
DATE	controls the output as function of the current date

Options:

- **Variable daily scheduling times** specified in a register (Rx) or in a Word (@WORD x) containing a number in the range 0 to 1439, corresponding to the number of minutes of the day starting from 0:00 (1439 = 23:59); the formula giving the number related to time hh:mm is the following: *(hh x 60) + mm*
- **Variable weekly scheduling times** specified in a register (Rx) or in a Word (@WORD x) containing a number in the range 0 to 10079, corresponding to the number of minutes of the week starting from 0:00 of Monday (10079 = 23:59 of Sunday); the formula giving the number related to time DW:hh:mm, assuming for the days of the week (DW) MON=0…SUN=6, is the following: *(DW x 1440) + (hh x 60) + mm*
- **Variable yearly dates** specified in a register (Rx) or in a Word (@WORD x) containing a number in the range 1 to 372 corresponding to the day of the year starting from January 1 (372 = December 31); the formula giving the number related to the day DD (1÷31) of month MM (1÷12) is the following: *(MM –1) x 31 + DD*
- **Variable absolute dates** specified in a register (Rx) or in a Word (@WORD x) containing a number in the range 1 to 37200 corresponding to the day of the century starting from January 1 00 (37200 = December 31, 99); the formula giving the number related to the day DD (1÷31) of month MM (1÷12) of year YY (0÷99) is the following: *(372 x YY) + (MM –1) x 31 + DD*

Notes:

- the argument x of the notation @WORD x may be in the range 0 to 65535; this is true, unless otherwise specified, for the CLOCK and DATE equations only
- the timing **24:00** is not allowed; use instead the timing **00:00**, taking attention that it is the morning of the specified day.

```
O1.1 = CLOCK(8:15, 17:30)
```
Out is ON everyday from 8:15 to 17:30 (daily scheduling).

```
V3 = CLOCK(MON:8:00, FRI:20:00)
```
Out is on from Monday 8:00 to Friday 20:00 (weekly scheduling).

```
O3.2 = DATE(31/07, 02/09)
```
Out is ON from July 31 to September 9 (yearly scheduling).

```
O3.2 = DATE(31/07/05, 02/09/05)
```
Out is ON from July 31,2005 to September 9, 2005 (absolute scheduling).

```
V4 = CLOCK(TUE:8:00, TUE:12:00) | \
     CLOCK(THU:14:30, SAT:00:00)
```
Out is ON the Tuesday 8:00 to 12:00 and it is also ON from Thursday 14:30 to Saturday 0:00.

```
V6 = DATE(12/01/06, 15/01/06) | \
     DATE(20/01/06, 22/01/06)
```

Out is ON from 12/01/06 to 15/01/06 and from 20/01/06 to 22/01/06.

```
V8 = DATE(12/01/06, 15/01/06) & \
     CLOCK(10:00, 17:00)
```

Out is ON from 10:00 to 17:00 but only in the specified days.

```
O1.1 = CLOCK(XX:R0, XX:R1)
```

Daily switching ON at time specified by R0 and daily switching OFF at the time specified by R1. For example, if R0=675 and R1=1280, then out will be ON everyday from 11:15 to 21:20.

```
O1.1 = CLOCK(XX:@WORD32770, XX:@WORD32771)
```

As the previous equation, but the times are specified by the shown Words.

```
O1.1 = CLOCK(R0, R1)
```

Weekly switching ON at time specified by R0 and weekly switching OFF at time specified by R1. For example, if R0=675 and R1= 6780, then out will be ON every week from Monday 11:15 to Friday 17:00.

```
O1.1 = CLOCK(@WORD32770, @WORD32771)
```

As the previous equation, but time are specified by the shown Words.

```
O1.1 = DATE(R0/XX, R1/XX)
```

Switching ON every year at the date specified by register R0 and switching OFF every year at the date specified by R1. For example, if R0=48 and R1=82, then out will be ON every year from February 17 to March 20.

```
O1.1 = DATE(@WORD32770/XX, @WORD32771/XX)
```

As the previous equation, but the dates are specified by the shown Words.

```
O3.2 = DATE(R3, R4)
```

Switching ON at the absolute date specified by register R3 and switching OFF at the date specified by R4. If R3=675 e R4=6780, the output will be ON from October 24,01 to March 22,18.

```
O3.2 = DATE(@WORD32776, @WORD32777)
```

As the previous equation, but the absolute dates are specified by the shown Words.

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2.4- Macro

A MACRO is a sequence of equations that can be inserted in more points of MCP 4 source program by using a single call to the MACRO itself. The MACRO must first be defined in the Macros TAB of MCP IDE tool software, then it can be referred to in the program as many times as needed (in the Equations TAB of MCP IDE).

Each MACRO can have several arguments (parameters); the number of arguments must be the same in the MACRO definition and in each call. The compiler will link the arguments in the call to the arguments in the MACRO definition, in the same order they were written.
It is important to understand that:

- the MACRO directive only applies to standard MCP 4 equations, it cannot be applied to SCRIPTs
- the MACRO directive is an utility of the compiler, it is not a feature of MCP 4; in other words, the compiler "explodes" each call to a MACRO into the equations specified in the definition of the same MACRO, simply replacing each argument in the definition with the related argument passed by the call

Up to 256 MACROs, each one with up to 32 arguments, can be defined in a MCP 4 program.

The definition of a MACRO is opened by the keyword **MACRO** followed by the name chosen for the MACRO and, inside round brackets, the arguments to be passed to. The definition of a MACRO is closed by the keyword **ENDMACRO**.

The required equations have to included inside this block, taking in account that the arguments in the MACRO definition (that are variable parameters because they change from a call to the other one) cannot have the same names reserved to the parameters or the keywords of MCP 4.

The following example defines a MACRO named DIMMER; this MACRO allow to control a dimmer output (e.g. a MOD2DM module) whose address is OUT; the brightness level is controlled by an UP pushbutton and by a DOWN pushbutton and, to implement the needed equation, a counter CX and a register RX are also used; the argument list is closed by two virtual points VP1 and VP2, needed to realize the wanted function.

The MACRO definition is the following (refer to the technical sheet of MOD2DM module for more details about the meaning of the used equations):

```
MACRO DIMMER (OUT, UP, DOWN, X, VP1, VP2)

VP1 = !(UP | DOWN)
VP2 = CX,R==1 P(129)UP & P(130)DOWN & P(128)VP1
OUT = RX

ENDMACRO
```

If, for instance, 6 dimmer outputs must be controlled in the plant, with identical operation but with different command inputs, the just defined MACRO can be called 6 times as follows:

```
DIMMER (AO1, I1.1, I1.2, 0, V1 , V2)
DIMMER (AO2, I1.3, I1.4, 1, V3 , V4)
DIMMER (AO3, I1.5, I1.6, 2, V5 , V6)
DIMMER (AO4, I1.7, I1.8, 3, V7 , V8)
DIMMER (AO5, I2.1, I2.2, 4, V9 , V10)
DIMMER (AO6, I2.3, I2.4, 5, V11, V12)
```

As it can be seen, a different argument list is passed at each call. The compiler will "explode" this program in a sequence of equations that is more difficult to be interpreted and to be modified. In other words, the compiler will translate the few program lines in the previous example as follows:

```
V1 = !I1.1 & !I1.2
V2 = C0,R == 1 P(129)I1.1 & P(130)I1.2 & P(128)V1
```

```
AO1 = R0

V3 = !I1.3 & !I1.4
V4 = C1,R == 1 P(129)I1.3 & P(130)I1.4 & P(128)V3
AO2 = R1

V5 = !I1.5 & !I1.6
V6 = C2,R == 1 P(129)I1.5 & P(130)I1.6 & P(128)V5
AO3 = R2

V7 = !I1.7 & !I1.8
V8 = C3,R == 1 P(129)I1.7 & P(130)I1.8 & P(128)V7
AO4 = R3

V9 = !I2.1 & !I2.2
V10 = C4,R == 1 P(129)I2.1 & P(130)I2.2 & P(128)V9
AO5 = R4

V11 = !I2.3 & !I2.4
V12 = C5,R == 1 P(129)I2.3 & P(130)I2.4 & P(128)V11
AO6 = R5
```

This example well clarify how to use the MACRO utility to execute block of repetitive equations, where only some parameters change.
In addition, and this is another great advantage in using the MACRO utility, a required change to the operation of the system will be reduced to the modification of the MACRO definition.

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3- SCRIPT

3.1- Summary

Scripts allow to implement sections of program that will be executed in sequential mode by MCP 4. Each Script can be started ("triggered") by an event or it can be executed every a well specified time period. Each defined script must be numbered; up to 127 scripts may be defined.
The scripts ***must be used only to execute functions that cannot be realized by the standard equations of MCP 4***. The duration of a script must be lower than 500msec, on the contrary MCP 4 will interrupt its execution (and it will set the related virtual point V2004). Therefore, be aware of the loops nested into a script.

Keyword	Meaning
SCRIPT… ENDSCRIPT	Enclose the instructions belonging to the script: SCRIPT declares the start and ENDSCRIPT declares the end
TRIGGER	Specify the event that starts the SCRIPT or the time execution period in seconds
EXIT	Force the exit from the script
VAR	Declare a local variable, therefore not shared with the other scripts
GLOBAL VAR	Declare a global variable, therefore shared with all other scripts
EXTERN VAR	The specified variable has been declared as global in another script
&, |, ^, !	logical operators (no parenthesis are allowed and no more than one operation for each line is allowed)
+, -, *, /, =	mathematical operators (no parenthesis are allowed and no more than one operation for each line is allowed)
IF…THEN…ELSE… ENDIF	Condition. IF and ENDIF enclose the block. An IF must be always closed by an ENDIF
>,>=,==,<,<=, !=	Comparison operators (greater than, greater or equal to, equal to, less than, less or equal to, not equal to)
CARRY	Bit (flag) whose value is 1 if the result of the previous operation exceeds the value 65535 (overflow) or if the result of the previous operation is negative (underflow) or if a division by 0 occurred; the value of this bit is 0 in all other cases
ZERO	bit (flag) whose value is 1 if the result of the previous operation is zero; the value of this bit is 0 in all other cases
DEFINE	assign a name to a variable or to a parameter or to a constant
GOTO	unconditional jump
CALL	jump to a subroutine or function (which is a section of a script); from a script, it is possible to call a subroutine contained into another script
SUB…ENDSUB	Enclose a block of instructions as subroutine or as function; the subroutines that have been declared in a script can be "seen" and used by any other script
RET	Exit from a subroutine or function
BIT(x)	Declare that parameter x of a subroutine or function or the value returned by a function is a bit; the declaration BIT(x) applies to subroutines or functions only
WORD(x)	Return the number of the Word where the point x is mapped
[ptr]	Pointer: it returns the content of the Word whose address is the value of the variable inside the square brackets (ptr in this case); in other words, ptr points to the Word address and [ptr] is the content of the "pointed" Word (see examples)
@WORD k	It returns the content of the Word k, where k is a constant value in the range 0 to 32767
@RAM k	It returns the content of the two consecutive bytes starting at address is k, where k is a constant value in the range 0 to 65535
SWAP(x)	exchange the high byte with the low byte of specified Word (x)
RANDOM(0)	Function that returns a 16-bit random number
BMASK(x)	Function that returns a 16 bit number having, in its binary format, only one bit set to 1 at the position of (x-1)%16 (that means (x-1) module 16); this function is useful for bit operations

Quite all notations belonging to the equation syntax of MCP 4 may be used in the scripts. For instance, the following notations are allowed:

```
IF AI1:2 > 230; THEN.....
AO4 = 197
R54.1 = 1
IF I81.1 == 1; THEN.....
O34.7 = 0
V781 = 1
IF V542 == 0; THEN.....
```

Refer to the examples in the following pages for more allowed notations.

Notes:
1. the writing operations on the outputs and on the registers will be executed as a sequential sequence, in the same order as they appear in the script
2. the keywords can be written both in upper and lower case
3. more instruction (statements) on the same line must be separated by the symbol ";"
4. when writing scripts, use the tab in order to enhance the readability of the script itself (e.g. increase the indent of the instructions in the blocks IF…ENDIF); see example for more details.

3.2- Keywords and syntax

3.2.1- Using the TRIGGER

The keywords SCRIPT and ENDSCRIPT "enclose" the script. The keyword SCRIPT must be followed by a number in the range 1 to 127.
The keyword TRIGGER specifies the event triggering the execution of the script or every how many time it must be executed.
The events triggering the scripts can be only real inputs (direct or complemented) or virtual points (direct or complemented). It is allowed, in the same MCP 4 program, to have a script triggered by the a real or virtual point and another script triggered by the same but complemented point; in this way it is possible to execute a script at the activation of a point and another script at the de-activation of the same point.

The following script (SCRIPT 1) will be executed every 1 second (TRIGGER=1):

```
SCRIPT 1
      TRIGGER = 1
      .....
ENDSCRIPT
```

The following script (SCRIPT 2) will be executed at every change OFF to ON of V1:

```
SCRIPT 2
      TRIGGER = v1
      .....
ENDSCRIPT
```

The following script (SCRIPT 3) will be executed at every change ON to OFF of V1:

```
SCRIPT 3
      TRIGGER = !v1
      .....
ENDSCRIPT
```

The following script (SCRIPT 4) will be executed at every change OFF to ON of I2.1:

```
SCRIPT 4
      TRIGGER = I2.1
      .....
ENDSCRIPT
```

3.2.2- VAR, GLOBAL VAR and EXTERN VAR

The scripts allow to use how many variables are required for the execution of the program. The variables used in the scripts must be explicitly declared. Essentially, the variables can be grouped in two classes:

- Local: these variables will not be shared among the several scripts, therefore two variables having the same name, but declared in two different scripts, will be separately handled; a local variable is created at the input of the script and destroyed at the output of the same script
- Global: these variables are shared among the scripts, and therefore they can be used by all the scripts. A global variable, once created, will be kept also at the exit of a script, therefore each script always will read the last value that has been assigned to the variable itself

The VAR instruction in a script defines a local variable, and the GLOBAL VAR instruction defines a global variable. Since all variables in a script must be declared, the instruction EXTERN VAR informs a script that the variable has been declared in another script.
In the following example, the variable TEMP1 is declared as local, both for script 1 and for script 2, while the variable is shared by both script.

```
script 1
      trigger = 2
      var TEMP1
      global var TEMP2
      ……

endscript

script 2
      trigger = 2
      var TEMP1
      extern var TEMP2
      ……

endscript
```

The local variables used by a subroutine must be declared inside the subroutine itself, not in the script containing it; in other words, if a local variable has been declared in a script, the same variable cannot be accessible by a subroutine contained in the same script.

3.2.3- Logic and Mathematical operations

The scripts allow to execute the main logic and mathematical operations. The allowed logic and mathematical operators are:

&	AND
|	OR
^	EXOR
!	NOT
+	Sum
-	Subtract
*	Multiply
/	Divide
=	Equal

No parenthesis are allowed in logic and mathematical operations and no more than one operation for each line is allowed. Keep in mind that the result of the logic and mathematical operations is always a 16-bit integer number. If the result is a negative number, then it will be in the two's complement format.

The following script shows some examples about Logic and mathematical operations.

```
script 1
      trigger = 1
      R0 = R1 + R2
      R0 = R0 + 10
      AO1 = R100 / 2
      R50 = R51 & 0b1111111100000000
endscript
```

An operation of the type VAR = VAR [op] K, where VAR is a variable, K is a constant number and [op] is one of the described logic/mathematical operators (= excluded), the optional notation VAR += 10 can be used.
For instance `R0 = R0 + 10` and `R0 += 10` are absolutely equivalent notations.

3.2.4- IF…THEN…ELSE…ENDIF

The IF…THEN…ENDIF block allows to execute, if the specified condition is true, the instructions included between THEN and ENDIF. If the condition is not true, then the execution will jump to ENDIF or to ELSE if this has been specified (ELSE is an optional keyword). If ELSE has been specified, then the instruction included between ELSE and ENDIF will be executed.
Each IF block must be always closed by an ENDIF which is mandatory (on the contrary to ELSE which is optional).

The condition of the block IF…THEN…ENDIF must be specified using the following comparison operators:

>	Greater than
>=	Greater than or equal to
= =	Equal to
<	Less than
<=	Less than or equal to
!=	Not equal to

The following script includes two IF…THEN…ENDIF blocks; note that the first block is written on the same line, therefore the ";" symbol must be used to split the several instructions. The second IF…THEN…ENDIF block, on the contrary, is written on more lines, therefore the ";" symbol is not required.

```
SCRIPT 1
      TRIGGER = 1

      IF R0>25 THEN; R0=1; ENDIF
      IF R0==0  THEN
            R1=140
            R2=50
            V1=1
      ENDIF
ENDSCRIPT
```

The following script includes an IF block with ELSE.

```
SCRIPT 1
      TRIGGER = 1
      IF I4.7 = 1 THEN
            O1.1 = I1.1
      ELSE
            O1.1 = 0
      ENDIF
ENDSCRIPT
```

Note, in both examples, how tabulations help to better identify the beginning and the end of the IF blocks.
If the argument of the condition is a bit, then the comparison operator can be omitted; for instance the two notations:
`if R0.1==1 then` and `if R0.1 then`
are absolutely equivalent statements.

3.2.5- CARRY and ZERO

CARRY and ZERO are two system bits (also called flags) providing information about the result of the just executed mathematical or logic operation.
The CARRY flag value is 1 if the result of the previous operation exceeds the value 65535 (overflow), or if the result of the previous operation is negative (underflow), or if a division by 0 occurred.

The ZERO flag value is 1 if the result of the previous operation is zero. The following SCRIPT shows the use of these flags.

```
script 1
      trigger = 2
      R0 = R1 + R2      // somma R1 + R2
      if CARRY then
            R0 = 65535  // se risultato >= 65535 allora R0=65535
      endif

      R3 = R4 - R5      // differenza R4 - R5
      if CARRY then
            R3 = 0      // se risultato < 0 allora R0=0
      endif

      R6 = R7 - R8      // differenza R7 - R8
      if ZERO then
            V1 = 1      // se risultato = 0 allora V1=1
      else
            V1 = 0      // altrimenti V1=0
      endif
endscript
```

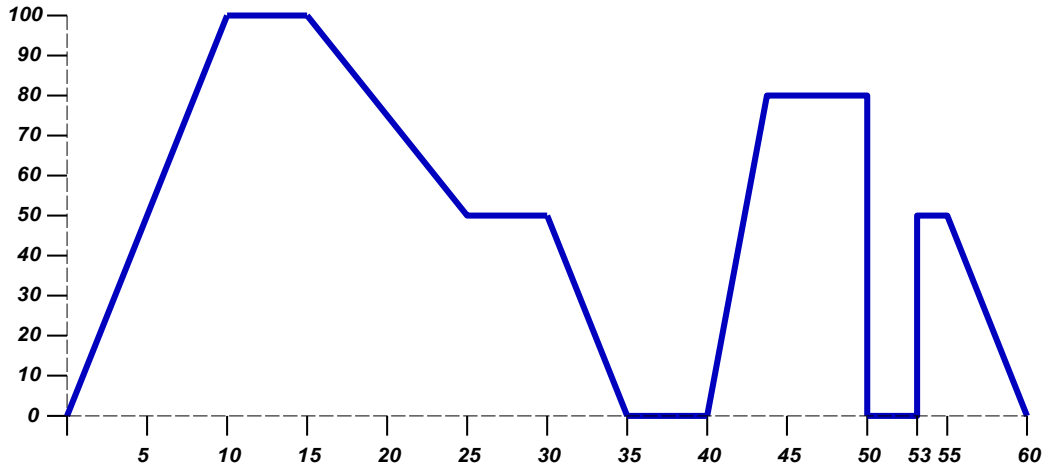
3.2.6- DEFINE

The following script use the `define` keyword to assign a mnemonic name to some points, enhancing in this way the readability of the program.

```
SCRIPT 1
      TRIGGER = 1
      define      Enable      R0.1
      define      Input       I1.1
      define      Lamp        O1.1

      IF Enable = 1 THEN
            Lamp = Input
      ELSE
            Lamp = 0
      ENDIF
ENDSCRIPT
```

The following script shows how is possible to implement quite complex functions. The following SCRIPT implements a single channel Dynamic Light system , that is a light game obtained by a dimmer output module (e.g. MOD2DM). The dynamic light game shown in the following graph has to be implemented (the percentage of brightness is on the vertical axis and the time, in seconds, on the horizontal axis); after 60 seconds, the cycle will be repeated from the beginning.



The SCRIPT will be executed one time per second. First of all, the script declares one local variable (Step) and 2 parameters (two times A01, the reason of this double definition will be explained in the following).
The variable Step represents the amount of seconds elapsed from the beginning of the dynamic light game. At the output from the script, the value of Step will be increased by 1; if the result of this increment is >=60, then Step will be re-initialized to zero.

When the Step value equals one of the moments when the light brightness must be changed, the two instructions **RAMP1=K** and **PERC1=Z** will be executed; the effect of this instructions (that are identical to A01=K and A01=Z) is to transfer to the output A01 the specified values, in the same order they were written. The first value to send to output will be the ramp value, the second one will be the wanted percentage. The use of two different definition for the same output (A01) is only to make the script more readable and intuitive.

For the correspondence between the code and the ramp value, see the MOD2DM technical sheet.

```
SCRIPT 1
      TRIGGER=1
      var    Step
      define RAMP1      AO1
      define PERC1      AO1
      IF Step==0  THEN; RAMP1=150; PERC1=100; ENDIF
      IF Step==15 THEN; RAMP1=160; PERC1=50 ; ENDIF
      IF Step==30 THEN; RAMP1=150; PERC1=0  ; ENDIF
      IF Step==40 THEN; RAMP1=145; PERC1=80 ; ENDIF
      IF Step==50 THEN; RAMP1=140; PERC1=0  ; ENDIF
      IF Step==53 THEN; RAMP1=140; PERC1=50 ; ENDIF
      IF Step==55 THEN; RAMP1=150; PERC1=0  ; ENDIF
      Step = Step+1
      IF Step>=60 THEN; Step=0; ENDIF
ENDSCRIPT
```

Of course, other dimmer outputs may be inserted in the same script, in order to realize a multi-channel dynamic light game.

3.2.7- GOTO

The GOTO instruction causes an unconditional jump to the line of the same script identified by a label. The label used to identify the destination of a jump must be followed by ":" symbol and placed on an empty line. The label on the GOTO line, instead, must not be followed by the ":" symbol (see next example).

```
script 1
      trigger = 1
      if R0 == 1 then
            goto ABC
      endif
      if R0 == 2 then
            goto DEF
      endif
      R10 = 0
      exit
ABC:
      R10 = 101
      exit
DEF:
      R10 = 237
      exit
endscript
```

3.2.8- SUBROUTINES and FUNCTIONS

A Subroutine or a Function is a sequence of instructions that can be executed many times by one or more scripts. The instructions in a subroutine must be surrounded by SUB and ENSUB keywords. All the subroutines of a program, optionally, may be contained in an single script; in this case, the script containing the subroutine does not need the TRIGGER instruction (but only if the same script contains only subroutines).

The definition of a subroutine automatically causes the declaration of a **global** variable having the same name of the subroutine and that can be used to return a value (typically the result of the function).
To "call" a subroutine the CALL instruction can be used, or the function can called in a direct mode. The following rule is always true:

- Use CALL if the subroutine, after the calling, does not return any value
- Call directly the function if, after the calling, it must return a value

At every calling of a Subroutine or Function, **one or more parameters can be passed as inputs** (both variables and constants), specifying them inside round brackets. The variable parameters **can be passed as reference or as value**. The difference among the two cases is the following:

- **Parameters passed as reference**: the *Word address* of the parameter (input, output, register, etc.) will be copied to the related parameter of the subroutine and it will be used as *pointer* inside the subroutine itself. In this way, the parameter passed to the subroutine *can be both read and modified* by the subroutine

- **Parameters passed as value**: *the value of the parameter* (input, output, register, constant, etc.) will be copied to the related parameter of the subroutine and it will be used as *variable* inside the subroutine itself. In this way, the parameter passed to the subroutine *can be read but cannot be modified* by the subroutine. An edit operation on that parameter inside the subroutine will change the value of the local variable created to receive the parameter but it will not change the parameter passed at the calling

The syntax used to specify what method must be applied to each passed parameter is the following:

```
SUB NAMESUB( PAR1, PAR2, [PAR3], [PAR4])
```

Where:

- **PAR1** and **PAR2** are parameters passed as value
- **PAR3** and **PAR4** are parameters passed as reference, being surrounded by square brackets

To specify that a parameter must be interpreted as reference is thus necessary an enough to surround the related parameter by square brackets in the line defining the subroutine (and only in that line).

Note: parameters of bit type (e.g. V1, O3.2, I4.3, etc.) cannot be passed as reference; these parameters can be passed as value only.

The following two examples show each one a calling to subroutine with parameters:

```
call SETUP(R0, AO1, 128)
      .........
sub SETUP(REG, [OUT], K)
      .........
endsub
```

calling to subroutine to which 3 parameters are passed; there is not a value returned by the subroutine.
The parameter **AO1** will be passed as reference, therefore the subroutine can change the value of the parameter itself.
R0, on the contrary, will be passed as value, therefore the subroutine cannot change the original value contained in the parameter itself.
Last parameter is a numerical constant value.

```
R100 = CALCULATE(R10, R11)
      .........
sub CALCULATE(REG1, [REG2])
      .........
endsub
```

function to which 2 parameters are passed and which will return a value copied in R100.
The parameter R11 will be passed as reference, therefore the function can change the value of the parameter itself.
R10, on the contrary, will be passed as value, therefore the function cannot change the original value contained in the parameter itself.

Notes:

- a Subroutine or a Function, when called by a script other than the script where the function was included, must be placed before the calling itself.
- *if a subroutine uses local variables, these ones must be declared inside the subroutine itself.*
- a Subroutine can call another Subroutine for a max total of 16 nested calls.

For the subroutines and the functions without parameters, the following points must be taken in account:

1. if a subroutine or a function does not require input parameters, it **must be however** declared using the parenthesis "()" without the parameters list; for instance: `sub TEMPERATURE()`
2. the calls to subroutines or functions without parameters can be written with or without parenthesis; for instance, the following calls are exactly equivalent:

```
R0 = TEMPERATURE()
R0 = TEMPERATURE
call TEMPERATURE()
call TEMPERATURE
```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Example:
The following script converts to °C the 4 analog values read from a MODNTC (that are normally expressed as Kelvin degrees multiplied by 10). The result of the conversion is written to register from R0 to R3. A function will be used because the mathematical operations to be executed have to be repeated for each channel. The main script passes to the function the Address:Channel information (as value); the result will be returned in the variable CONVERT. Note that the instruction EXIT closes the script (it is like a GOTO to the ENDSCRIPT instruction).

```
script 1
      trigger = 2
      define NTC1 AI1:1
      define NTC2 AI1:2
      define NTC3 AI1:3
      define NTC4 AI1:4

      R0 = CONVERT(NTC1)
      R1 = CONVERT(NTC2)
      R2 = CONVERT(NTC3)
      R3 = CONVERT(NTC4)
      exit

      sub CONVERT(TEMPER)
            CONVERT = TEMPER - 2730
            CONVERT = CONVERT / 10
      endsub
endscript
```

The same result can be achieved also using the following script, where the destination registers will be passed as reference and therefore the subroutine works directly on them. Prefer however the version of the previous example for its efficiency (for reasons going beyond the matter of this manual).

```
script 1
      trigger = 2
      define NTC1 AI1:1
      define NTC2 AI1:2
      define NTC3 AI1:3
      define NTC4 AI1:4

      call CONVERT(R0, NTC1)
      call CONVERT(R1, NTC2)
      call CONVERT(R2, NTC3)
      call CONVERT(R3, NTC4)
      exit

      sub CONVERT([REG], TEMPER)
            TEMPER = TEMPER - 2730
            REG = TEMPER / 10
      endsub
endscript
```

Example:
The following script shows how the **RET instruction** allows to exit from the subroutine (it is like a GOTO to the instruction ENDSUB). This script converts to Celsius degrees the analog value read from a MODNTC and it places the result in the register R1; in addition it switches ON the output O1.1 if the result is in the range 18 to 23 degrees, otherwise it switches OFF the output.

```
script 1
      trigger = 5
      define NTC1 AI100:1

      R1 = CONVERT(NTC1)
      exit

      sub CONVERT(TEMPER)
            CONVERT = TEMPER - 2730
            CONVERT = CONVERT / 10
            if CONVERT >= 23 then
                  O1.1 = 0
                  ret
            endif
            if CONVERT <= 18 then
                  O1.1 = 0
                  ret
            endif
            O1.1 = 1
      endsub
endscript
```

3.2.9- BIT(x)

The parameter passed to a subroutine or function and the optional returned value are, for default, integer 16-bit numbers. If a bit must be passed to a function or if the returned parameter must be a bit, then it must be explicitly declared by the BIT(x) keyword.
BIT(x) declares that parameter x of a subroutine or function, or the returned value, is a bit; the declaration BIT(x) must be used in subroutines or functions only.
The declaration BIT(X) must be placed in the subroutine declaration ONLY.

The following script uses a function having as input parameters a value (REG) and a bit (ENABLE), that therefore has been specified by the declaration BIT(ENABLE); the function returns a value (RSET).

```
script 1
      TRIGGER = 5
      var   RTEMP

      R82 = RSET(R50, V1)
      R83 = RSET(R51, V2)
      R84 = RSET(R52, V3)
      R85 = RSET(R53, V4)

      exit

      sub RSET( REG, BIT(ENABLE) )
            if ENABLE == 1 then
                  RSET = REG / 2
                  RSET = RSET + 128
            else
                  RSET = 0
            endif
      endsub

endscript
```

The following script uses a function having as input parameters two values (REG1 and REG2); the function returns a bit (TEST) that therefore has been specified by the declaration BIT(TEST) (REG1, REG2).

```
script 2
      TRIGGER = 5
      var   RTEMP

      RTEMP.1 = TEST(R0, R1)
      if  RTEMP.1 == 1 then
            R20 = 100
      else
            R20 = 0
      endif
      RTEMP.1 = TEST(R2, R3)
      if  RTEMP.1 == 1 then
            R21 = 200
      else
            R21 = 0
      endif

      exit

      sub BIT(TEST)(REG1, REG2)
            REG1 = REG1 / 2
            REG2 = REG2 / 4
            if REG1 > REG2 then
                  TEST = 1
            else
                  TEST = 0
            endif
      endsub

endscript
```

The following script o script is a combination of the previous two examples. This script uses a function having as input parameters a value (REG) and a bit (ENABLE), therefore declared by BIT(ENABLE); the function returns a bit (TEST), therefore declared by BIT(TEST) (REG1, BIT(ENABLE)).

```
script 3
      TRIGGER = 5

      V17 = TEST(R50, V1)
      V18 = TEST(R51, V2)
      V19 = TEST(R52, V3)
      V20 = TEST(R53, V4)

      exit

      sub BIT(TEST)( REG, BIT(ENABLE) )
            if ENABLE == 1 then
                  REG = REG / 2
                  if REG > 100 then
                        TEST = 1
                  else
                        TEST = 0
                  endif
            else
                  TEST = 0
            endif
      endsub

endscript
```

3.2.10- WORD(x) and pointers

The **WORD(x)** function returns the number (address) of the Word containing the parameter x, where the parameter x is intended to be an input, an output, a virtual point, a register or a counter as in the following examples:

```
A1 = WORD(I18:2)    // returns the number of the Word containing I18 channel 2
A2 = WORD(I18:2.1)  // returns the number of the Word containing I18:2.1
A3 = WORD(O93)      // returns the number of the Word containing O93 channel 1
A4 = WORD(V46)      // returns the number of the Word containing V46
A5 = WORD(R37)      // returns the number of the Word containing R37
A6 = WORD(C42)      // returns the number of the Word containing C42
```

The following script shows how to use the **WORD(x)** function and the pointers. Suppose that the application requires a script that, every 2 seconds, counts how many registers, in the range R0 to R10, contain a value other tan zero; the results (the amount of register !=0) must be placed into register R15.

The function WORD(R0) returns the number of the Word where register R0 is located. The script defines a variable (in this example its name is ptr) that at the beginning is equal to the Word number of register R0. The notation [ptr] (inside square brackets) returns the content of the “pointed” register. In the following script, the R15 value will be increased by 1 every time the content of each register addressed in the loop is other than zero. At each iteration, the value of the pointer will be increased by 1 in order to point to the next Word and therefore to the next register. The notation ptr += 1 is equivalent to ptr = ptr + 1, as R15 = R15 + 1 can be written as R15 +=1.
When the pointer become greater than the address of R10, the loop will be interrupted and the script ends.

```
script 1
      trigger = 2
      var ptr
      ptr = WORD(R0)
      R15 = 0

LOOP:
      if ptr <= WORD(R10) then
                  if [ptr] <> 0 then
                        R15 = R15 + 1
                  endif
            ptr += 1
            goto  LOOP
      endif

endscript
```

Another example: the day of the month is located in the Word 1924 (see RAM map); to copy this value (and therefore the containing of the Word 1924) to register R2, the following instruction can be written:

```
ptr = 1924
R2 = [ptr]
```

On the contrary, it is possible to copy the containing of R2 in the Word 1924 as follows:

```
ptr = 1924
[ptr] = R2
```

The pointer are useful when the Word to be accessed to (both for reading and writing) cannot be identified in other ways (in other words when it cannot be identified by notations as Cx, Ry, etc.).

3.2.11- @RAM k and @WORD k

The functions **@RAM k** and **@WORD k** allow to access to pairs of RAM locations or single Words. The specified value (k) is the starting RAM address or the Word number and **must be a constant value** in the range 0 to 65535 in the first case and 0 to 32767 in the second one.

For instance, the day of the month is mapped in RAM memory at the address 0x0F08-0x0F09, corresponding to Word 1924; to copy this value (therefore the content of the Word 1924), for instance, into register R2, the following notations can be used: `R2 = @RAM0x0F08` or `R2 = @WORD1924`.

On the other hand, the Word content can be also written: `@RAM0x0F08 = R2` or `@WORD1924 = R2`
These functions are useful when the Word to be accessed to (both for reading and writing) cannot be identified in other ways (in other words when it cannot be identified by notations as Cx, Ry, etc.) and they are an option to the pointer method described before.

3.2.12- SWAP(x)

The **SWAP(x)** function exchange the high byte with the low byte of the specified Word (x). The Word can be specified in one of the following ways:

1. directly by its symbolic name (e.g. R34, C48, AI24:3, etc.)
2. directly by @WORD or @RAM
3. by pointer

Examples of the first way:
```
R0 = SWAP(I18:2)
R1 = SWAP(R1)
```

Examples of the second way:
```
R66 = SWAP(@WORD1924)
```

Examples of the third way:
```
ptr = 1924
R45 = SWAP([ptr])
```

3.2.13- RANDOM(0)

The **RANDOM(0)** function returns a random number. The number is generated according to a particular algorithm (Lehmer Random Number Generator) which returns a pseudo random value uniformly distributed. The parameter passed to the RANDOM function must be always zero.

The following script call the RANDOM(0) function every 60 seconds and the returned random value will be copied to R0.

```
script 1
      trigger = 60
      R0 = RANDOM(0)
Endscript
```

3.2.14- BMASK(x)

The **BMASK(x)** function returns a 16-bit number having, in its binary format, only one bit set to 1 at the position of (x-1)%16. This notation means (x-1) module 16 and it is equivalent to the remainder of the division of (x-1) by 16. The **BMASK(x)** function is therefore a mask which can be useful for bit operations.
The script in the following example calls 4 times a subroutine which must set or reset a virtual point if the value of a register is respectively greater or less than a constant value; since both the virtual point and the register and the constant value change at each call, then these parameters have to be passed to the subroutine. **Since the virtual point has to be written**, then this parameter should be passed as reference, but this is not allowed because it is a bit (see paragraph SUBROUTINEs and FUNCTIONs).
This is a typical case requiring the **BMASK(x)** function. Therefore the calling passes to the subroutine the address of the Word containing the virtual point (**WORD(Vn)**) and the mask allowing to identify, in the Word, the position of the bit related to that virtual point (**BMASK(n)**).
To set the virtual point, the subroutine executes the OR between the Word containing the point and the mask (which, as said, contains only one bit set to 1 at the position of the bit related to the desired point).
To reset the virtual point, the subroutine executes the AND between the Word containing the point and the complement of the mask (which therefore will contain only one 0 at the position of the bit related to the desired point).

```
script 1
      trigger = 1
      call TEST(R0,  50, WORD(V49), BMASK(49))
      call TEST(R1, 100, WORD(V50), BMASK(50))
      call TEST(R2, 150, WORD(V51), BMASK(51))
      call TEST(R3, 200, WORD(V52), BMASK(52))
      exit

      sub TEST(REGIN, KAPPA, [WVIRT], MSK)
            if REGIN > KAPPA then
                  WVIRT = WVIRT | MSK     // set virtual point
            else
                  WVIRT = WVIRT & !MSK    // reset virtual point
            endif
      endsub

endscript
```

The **BMASK(x)** function can be applied to any other bit parameter; the following example is very similar to the previous one, but on the contrary the subroutine switch ON and OFF real outputs instead of virtual points.

```
script 1
      trigger = 1
      call TEST(R0,  50, WORD(O1.5), BMASK(5))
      call TEST(R1, 100, WORD(O1.6), BMASK(6))
      call TEST(R2, 150, WORD(O1.7), BMASK(7))
      call TEST(R3, 200, WORD(O1.8), BMASK(8))
      exit

      sub TEST(REGIN, KAPPA, [WOUT], MSK)
            if REGIN > KAPPA then
                  WOUT = WOUT | MSK       // output ON
            else
                  WOUT = WOUT & !MSK      // output OFF
            endif
      endsub

endscript
```

4- PROGRAM WRITING

The program writing is the first step of the MCP 4 controller. The equations, SCRIPTs, and all concerning the operating program, must be written according to the related syntax as described in the previous paragraphs.

To write a program for MCP 4, the software package **MCP IDE** (Integrated Design Environment) has to be used; this package is provided free of charge by **DUEMMEGI** together to MCP 4 module. This program must be installed on a Personal Computer with the following minimum characteristics:

- operative system WINDOWS® XP, 7 or 8
- processor with 1000MHz clock minimum
- 512M RAM memory
- HD with 50MB free space
- Video with graphic resolution 1024x768 pixel minimum
- mouse

MCP IDE, in addition to the program writing support, allows all operation related to the setting up an to the maintenance. ***For more details on the using of this program, refer to the related documentation.***

Essentially, MCP IDE software tool includes:

- a te4 editor to write the program, the SCRIPT, the configuration, MACRO, etc.
- a compiler to allow the translation of an ASCII file, containing the operating information, in a binary file adequate to be transferred in the non volatile memory (FLASH type) of MCP 4 module
- an section to transfer the program from the PC to MCP 4 (or vice-versa)
- MCP VISIO, that is a graphical utility to display the status of the plant (input and output modules, counters, virtual points, registers, etc.)
- a simulator to verify the written program, or a part of it, before to transfer it into MCP 4 memory

The file containing the program is in ASCII format and must have the **.EQU** (or **.EXT**) extension; for instance:

***filename*.EQU**

where *filename* is the name of the program file and may be any name allowed by the WINDOWS® syntax.
The **.EQU** extension is mandatory because the following steps of MCP 4 programming (compiling and transferring) require that the source file have that extension.

MCP 4 controller programming takes place in a 3 sequential steps, through the MCP IDE support:

- building (or editing) of the *filename*.EQU file, containing the operating program in readable format (ASCII)
- compiling of *filename*.EQU, that is the conversion of the ASCII file in the related *filename*.BIN written in a format ready to be transferred into MCP 4 memory
- uploading of *filename*.BIN into MCP 4 memory

If some syntax errors are detected during the step 2, these ones will be reported by the compiler, together to some information about the error type and the line number where the error occurs.

4.1- Rule for program writing

The program must be written according to the syntax described in its relevant paragraph (logic, counter, timer, etc. ...). To write and compile a program, it is not necessary to connect MCP 4 controller to PC.

The following rules have to be observed:

- Spaces and TAB characters have no significance. They will be ignored by the compiler but **the use of some space characters between the terms of an equation or other are strongly recommended for a best readability of the program**
- An equation (but not a line in a SCRIPT) can be broken on several lines using the symbol \ (backslash) at the line end to specify that the equation will continue on the next line
- The equation finishes at the end of the line (if the \ symbol is not specified)
- The `//` symbol (two slashes) declares that the following words, until the line end, are comments, and so they will be ignored by the compiler. **The comments are very useful for best readability and documentation of the program file**. The use of the comment is strongly recommended to describe each equation in the program
- Both upper case and lower case characters can be used during the equation writing

Instead of the input and output symbols (`Ij.k, Ox.y, Vn, Aj`), it is possible to employ some variable names defined by the programmer through the **`define`** directive as here below described:

```
define      Pump1       O1.1  // Output definition
define      Command     I1.1  // Input definition

Pump1 = Command       // Equation
```

The previous equation is fully equivalent to:

```
      O1.1 = I1.1
```

but it can be easily interpreted. The variable names defined through the **`define`** directive cannot contain spacing characters. In addition, the compiler will ignore upper or lower case.

The following example shows a possible and simple program using the **`define`**:

```
//////////////////////
// Definitions /////////
//////////////////////
define            StairLight        O1.1
define            Floor1Button      I1.1
define            Floor2Button      I1.2
define            Floor3Button      I1.3

// Define a virtual point as OR of each button (parallel connection)
V1 = Floor1Button | Floor2Button | Floor3Button

// Light Output
StairLight = TIMER (V1, 0, 450)
```

In the above example there are 3 buttons, one per each floor of a building; the pressing of a button switches on the stair light. This light will remain on during 45 seconds after the button release, then it will be automatically switched off thanks to the TIMER function. The same program may be written without using the definition of variable names as follows:

```
// Command by the buttons
V1 = I1.1 | I1.2 | I1.3

// Light output
O1.1 = TIMER (V1, 0, 450)
```

Note that using the **`define`** directive, the program has a best and mnemonic readability.
About the using of the **`define`** directive in the SCRIPT, refer to the related chapter.

4.2- Compiling the program

The compiling is the second step of MCP 4 programming process. **The file containing the program (.EQU extension) must be compiled through the proper menu item of MCP IDE utility**.
The compiler processes the written equations, checks the syntax and the congruence, warns the errors if any and links the data in a binary file which name is the same as the .EQU file but with .BIN extension. The binary file is not in a printable format but it is adequate to be transferred in the MCP 4 memory.

To write and compile a program, it is not necessary to connect MCP 4 controller to PC.

If during the compiling process one or more errors occur, they will be displayed on the screen of the PC in a proper window and the program continues to check all other equations.

The compiler may also reports some WARNINGs: this means that no errors have been detected but there are some points to be verified before to upload the program to MCP 4 memory.

4.3- Uploading the program to MCP 4 memory

Last step of MCP 4 programming process is the **uploading to its flash MEMORY of the binary file** containing the system configuration and the program code. This is the third and last step after having written and copiled the program.

The uploading is made by the proper menu item of MCP IDE utility trough the RS232 port of PC connected to the MCP 4 serial port. The program can be however transferred also through the RS485 port or through the LAN network (using, for instance, the WEBS module in bridge mode).

The uploading of the program requires that MCP 4 controller be supplied and connected to PC, normally by means of the proper cable provided with MCP 4.

A new program transferred to MCP 4 is stored in a different memory location and therefore, during the download, the program previously loaded continues to operate without interruption; only when downloading of the new program is completed, and if everything goes well, the automatic switch from the old program to the new one will be performed.

5- SETTING UP

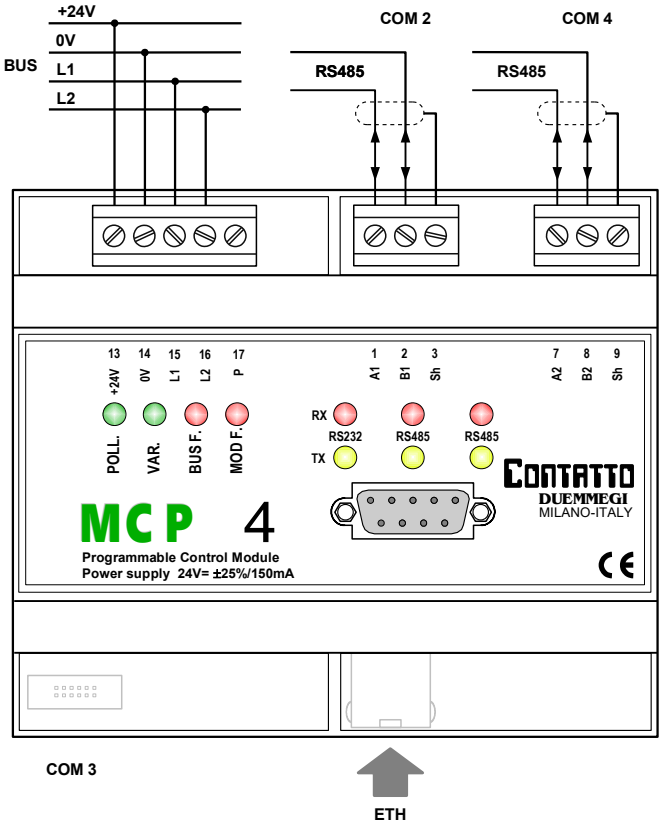
5.1- Connections

MCP 4 module is available in DIN modular housing (6 modules size) and it provides a 5 poles removable terminal block for the connection to the bus.

MCP 4 features a serial RS232 port (COM1), two RS485 ports (COM2 and COM4), a dedicated port for special modules (COM3) and an Ethernet port (optional).

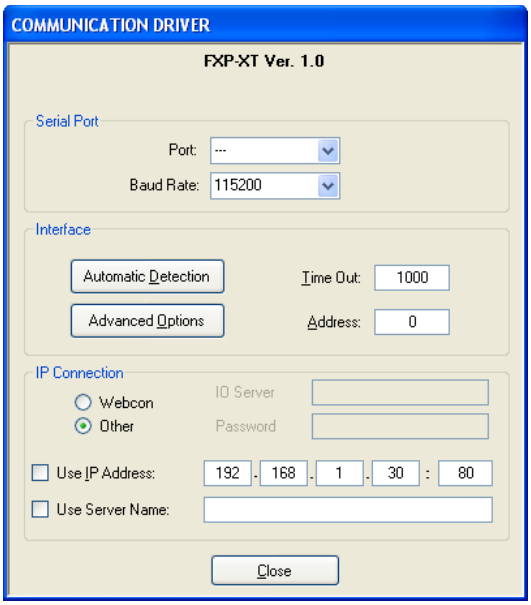
Following figures show the proper connections to be made and the description of the terminals; note that terminal 17 must be left unconnected.

Connections of MCP module

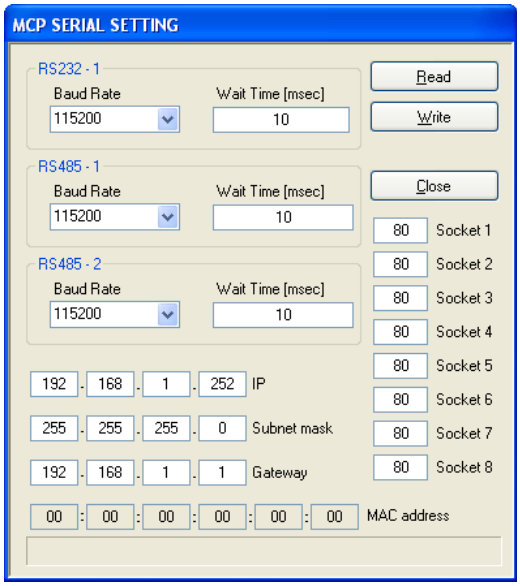


5.2- Baud Rate selection

MCP 4 Baud Rate factory settings is fixed to 115200 Baud both for RS232 and the two RS485 ports; if for any reasons this speed has to be changed, use the software tool MCP IDE . Connect MCP 4 to the PC, supply it, and launch MCP IDE. Select from the menu “Communication”, “Enable”. The following window will appear:



Select the port (e.g. COM1) or press the button Automatic Detection to execute the automatic search of MCP 4 on the serial ports. Press then Advanced Options button; the following window will appear:

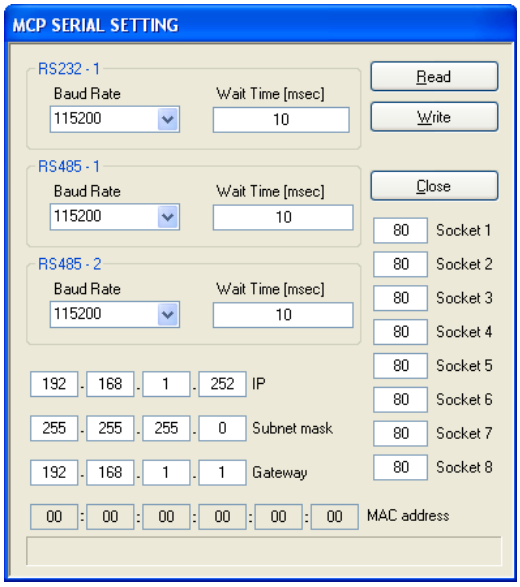


Press Read to read the current MCP 4 setting for the Baud Rate on RS 232 and RS485 ports. The other three parameters (Wait Time) are the delay time before the answer of MCP 4 to a Host request; these wait times are suggested to be not changed, if not really needed.
Choose the wanted Baud Rate for each port and then press the Write button to transfer the new setting to MCP 4. Finally, press the Close button; take in account that, when changing the Baud Rate of the port to which the PC is currently connected to, a new communication enable procedure at the new Baud Rate is needed. The allowed Baud Rates are: 2400, 4800, 9600, 19200, 38400, 57600, 115200.

5.3- TCP/IP parameters settings (Ethernet)

For configuring TCP/IP parameters it is possible to proceed in several ways, two of which are here below described.

1- Through RS232 serial connection between the PC and MCP4/ETH
This is the preferred method because it does not depend on the configuration of the network where MCP4/ETH has to be installed.
Connect the PC to the RS232 port of MCP4/ETH (if required via a USB-RS232 converter). Open the configuration panel by selecting, from MCP Ide menu, *Communication*, *Enable Communication* and open the communication with MCP4/ETH; then select *Advanced Options*: the following window will be shown:



The shown values are the default ones. Enter the desired parameters (IP address, Subnet mask, Gateway and ports for the different sockets), then push the Write button. At this point MCP4/ETH will be visible on the network with the set parameters, provided that they are compatible with the network configuration. The Read button allows to report the MCP4/ETH current configuration and its MAC address.

2- Via LAN network and browser
MCP4/ETH has the factory settings as shown in the figure above, particularly IP address 192.168.1.252, ports number 80 for all sockets, Subnet mask 255.255.255.0 and Gateway 192.168.1.1.
If the network is already compatible with this set of parameters, it is possible to connect MCP4/ETH directly to the local network (making sure that the default IP address is not already used by another device on the network) and change these settings as desired using the “Contatto Web Server” integrated in MCP4/ETH. The “Contatto Web Server” of MCP4/ETH can be accessed by using any browser (Firefox, Internet Explorer, Google Chrome, etc.). Enter into the current IP address of MCP4/ETH in the bar address of the browser (the default is 192.168.1.252) followed by /webmenu.htm, for example:

192.168.1.252/webmenu.htm

The main page of “Contatto Web Server” will be shown. Select LAN Configuration to access the sub-page of TCP/IP parameters setting.

5.4- RS232 and RS485 serial ports of MCP 4

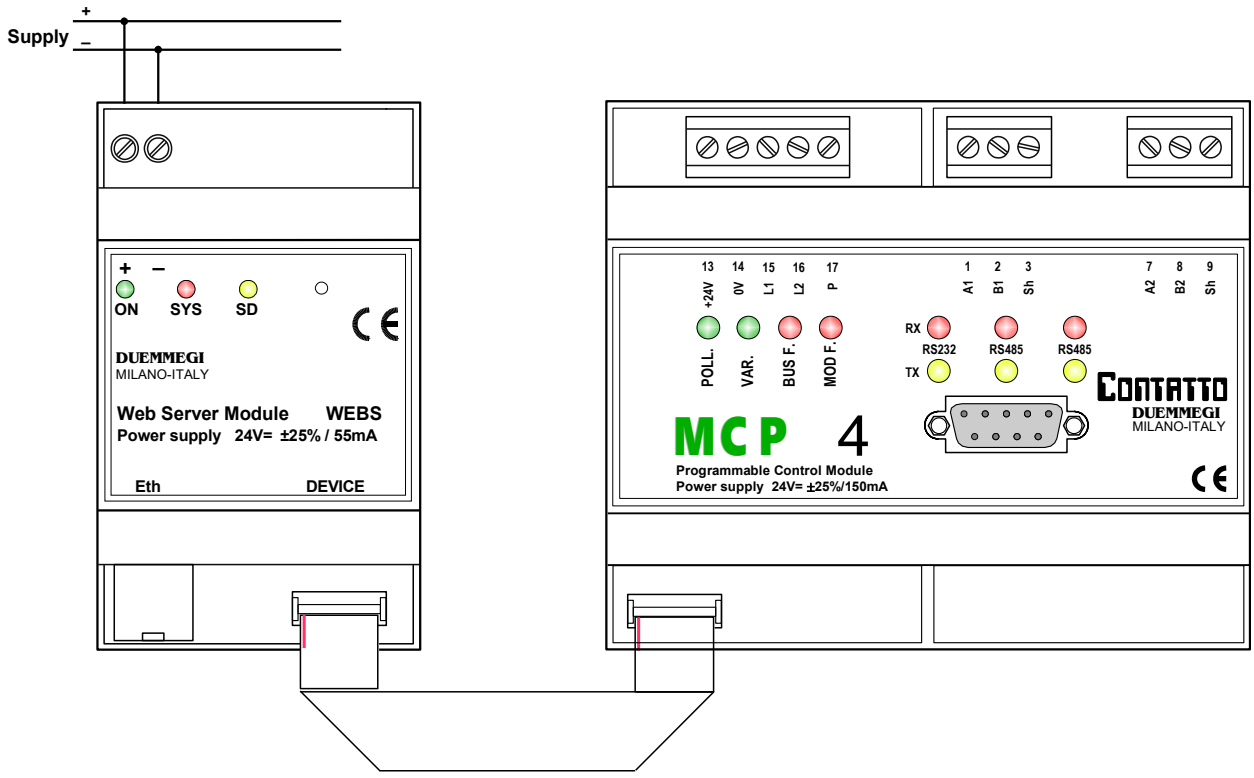
MCP 4 provides both RS232 (COM1, on the front panel) and RS485 serial ports (COM2 and COM4, terminals 1-2-3 and 7-8-9). These ports are **electrically insulated from the bus** by means of some internal opto-couplers and a dc/dc converter (no additional external power supply is required).

However, RS232 and RS485 ports **are not insulated each one to the other**.

WARNING: as for all RS485 networks, ***radial connections must be avoided***; in addition, RS485 line ***must be loaded, both at the beginning and at the end, by a 120 Ohm 1/2W resistor*** between terminals A and B. The maximum number of device that can be connected on RS485 line must be limited to 32.

5.5- WEBS communication port

MCP 4 features a special communication port (COM3, under the terminal cover on the bottom left side, see following figure) for the connection to WEBS module, providing both Web Server functions and bridge function to interface MCP 4 to a LAN network (Ethernet). For more details refer to the technical sheet of WEBS module.



6- DIAGNOSTICS

6.1- Diagnostics of CONTATTO system through MCP 4

MCP 4 module provides the failure warning through two red LEDs on the front panel.
The red LEDs report the alarms related to module failure (**MOD.F**) and bus failure (**BUS.F**). The MOD.F signaling occurs after 5 seconds delay time in respect to the moment of the failure of a module. The search of fault modules may be done using the MCP IDE software package, primarily displaying the map of the plant on MCP VISIO.
If both **MOD.F and BUS.F LEDs lights in continuous mode**, this means that MCP 4 memory is not correctly programmed.

If a BUS FAILURE occurs, the bus connections have to be checked. This failure appears when MCP 4 is not able to transmit on the bus (L1 and L2).

Two green LEDs on MCP 4 panel report the bus activity: the **POLL** led shows the start of the polling cycle and it blinks at a frequency inversely proportional to the number of configured modules (with few connected modules this LED may seem to be fixed ON).
The **VAR** led shows, through a flsh, the occurrence of a status change on one or more input modules.

If the VAR LED remains ON for a long time (greater then 2 seconds), then two or more modules of the same type (IN or OUT) have the same address; in this case use MCP VISIO utility to find the doubled addresses (the doubled modules are displayed on the screen in yellow color). The doubled addresses signaling, however, cannot be assured, because if the answer of the two modules is exactly superimposed each one to the other, then MCP 4 cannot detect the anomaly.

During the firmware update of the main microcontroller inside MCP 4 the two red LEDs flash alternately, while during the firmware update of the secondary microcontroller the two green LEDs flash alternately.

Three pairs of LEDs (red and yellow) on the front panel of MCP 4 allow to monitor the activity, if any, on the related serial ports RS232 and RS485.

The following table resumes the signaling in the various operating status:

Operating status	POLL	VAR	BUS.F	MOD.F
Normal	Periodic blinking	Flash at the occurrence of a change on an input module	Fixed OFF	Fixed OFF
Module failure	Periodic blinking	Flash at the occurrence of a change on an input module	Fixed OFF	Fixed ON
Double address	Periodic blinking	ON for long time	Fixed OFF	X
Bus failure	Fixed OFF	Fixed OFF	Fixed ON	Fixed OFF
FLASH not programmed	Simultaneous periodic blinking		Fixed ON	Fixed ON
Update of main microc. or FW not valid	Simultaneous periodic blinking		Alternate blinking	
Update of secondary microc. or FW not valid	Alternate blinking		X	X

Note: The frequency of periodic blinking of POLL may be so high that LED seems to be fixed ON.
X = don't care.

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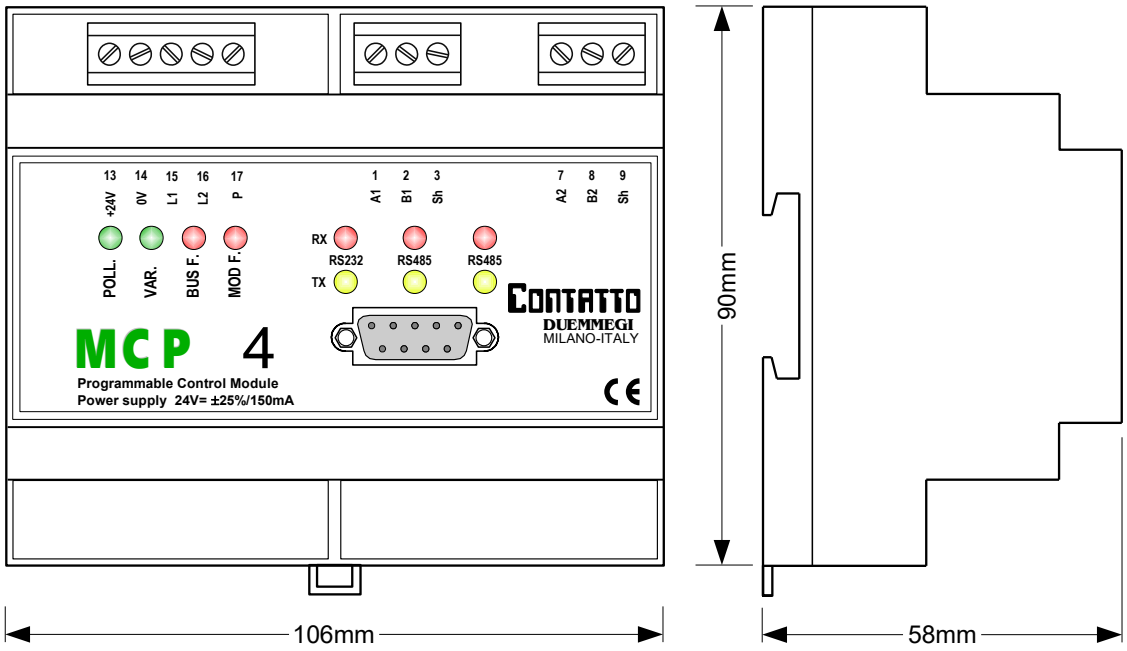
7- TECHNICAL CHARACTERISTICS

Power supply voltage	24V⎓ ± 25%
Max current consumption	150mA
Number of internal processors	2
Automatic switch standard/daylight saving time	Yes
Typical input to output reaction time	25msec
User program memory size	FLASH type 16 MBytes
RAM Memory size	256 KWords
Allowable virtual points	2032
Allowable registers	1024, 16-bit each one
Allowable timers	512 with times 0 to 6553 seconds, resolution 0.1 sec.
Allowable counters	1024, 16-bit each one
Programming clock	Daily, Weekly, Yearly
Integrated advanced scheduler	Weekly
Integrated WEB Server	Yes (if Ethernet port installed)
Allowable input addresses	127 addresses, 4 channel for address, 16-bit for channel
Allowable output addresses	127 addresses, 4 channel for address, 16-bit for channel
Available communication ports	1 x RS232 opto-coupled 2 x RS485 opto-coupled 1 x dedicated port 1 x Ethernet port (optional)
Peripheral devices handling	- Touch screen video terminals - Bus display with alarm handling - SCADA Supervision systems on PC
Interfacing to other systems	Through MODBUS RTU and MODBUS TCP/IP protocols
Housing	Modular box 6M for DIN rail mounting
Operating temperature	-5 ÷ 50 °C
Storage temperature	-20 ÷ 70 °C
Protection degree	IP20

Warning: MCP 4 module contains a rechargeable battery: remove this battery if throwing out the device. The battery must be eliminated in a safe way according to current laws.

8- OUTLINE DIMENSIONS



9- FXP-XT COMMUNICATION PROTOCOL

9.1- Messages format ad meaning

The proprietary protocol implemented into MCP 4 is named **FXP-XT** protocol; this protocol, has been specifically developed to interface MCP 4 to external world (PC, PLC, etc.) and it is **NRZ with 1 start bit, 8 data bit, no parity, 1 stop bit**. The baud rate can be selected as follows: 2400, 4800, 9600, 19200, 38400, 57600, 115200 baud. **MCP acts as a slave unit**, then it only answers to the requests of a HOST device.
In the following, the numerical data represented with the **0x** notation are intended to be in the hexadecimal format.

The messages between MCP 4 and HOST have the following format:

Address	Code	#Byte	Data 1	.....	Data N	ChkSum H	ChkSum L

Where:

- **Address**: 1 byte, node address of MCP 4; the address 0x00 is valid for any node address
- **Code**: 1 byte, it specifies the function of the message
- **# Byte**: 1 byte, number of bytes in the following data field
- **Data 1 ÷ N** N data bytes
- **ChkSum**: 2 bytes (high, low) of checksum, equal to the complemented sum of the message bytes, including the address, the code and the number of bytes.

The available messages are:

HOST to MCP requests

Code	# Byte	Data Bytes	Description
0x7F	4	Add_U, Add_H, Add_L, N	Reading from RAM memory of N bytes (1÷255), starting from address specified by the first 3 data bytes. N=0 means reading of 256 bytes.
0x7E	5 ÷ 256	Add_U, Add_H, Add_L, N, Data1… DataN	Writing to RAM memory of N bytes (1÷252) starting from address specified by the first 3 data bytes. (Note 1)
0x7D	4	Add_U, Add_H, Add_L, N	Reading from microcontroller memory of N bytes (1÷255) starting from address specified by the first 3 data bytes. N=0 means reading of 256 bytes. (Note 2)
0x7C	5 ÷ 256	Add_U, Add_H, Add_L, N, Data1… DataN	Writing to microcontroller memory of N bytes (1÷252) starting from address specified by the first 3 data bytes. (Note 2)
0x7B	2	Mod_Add, N	Reading of N (1÷32) output modules starting from module address Mod_Addr.
0x7A	2	Mod_Add, N	Reading of N (1÷32) input modules starting from module address Mod_Addr.
0x79	6	Mod_Addr, Ch, Status_H, Status_L, Mask_H, Mask_L	Writing of a channel (Ch = 1÷4) of an output module (Mod_Addr=1÷127). The mask (bit set to 1) identifies which output points have to be modified.
0x78	3	V_H, V_L, Status	Virtual point writing. V_H-V_L is the point number (1÷2032), Status can be 0x00 (for Vx=0) or 0x01 (for Vx=1).
0x70	2	'ID'	ID request. The data field contains the ASCII code of the two characters 'I' and 'D' (therefore 0x49 and 0x44).

Note 1: If a writing operation modifies an output, a virtual point, a register, a counter, etc., then the command will be executed when the less significant byte of the Word is written, while no command is executed when writing the most significant byte of the Word.
Note 2: To read/write the EEPROM memory of MCP4, the messages 0x7D/0x7C with address starting from 0x7FF000 have to be used.

MCP to HOST answers

Code	# Byte	Data Bytes	Description
0x7F	1 ÷ 256	Data1…DataN	Answer to reading message of N bytes from RAM memory.
0x7E	1	0xFF if writing OK 0x00 se writing KO	Answer to writing message of N bytes to RAM memory.
0x7D	1 ÷ 256	Data1…DataN	Answer to reading message of N bytes from microcontroller memory.
0x7C	1	0xFF if writing OK 0x00 if writing KO	Answer to writing message of N bytes to microcontroller memory.
0x7B	8 ÷ 256	Data1…Data(Nx8)	Answer to reading message of N (1÷32) output modules starting from address module Mod_Addr. The answer contains Nx8 bytes in the data field. The meaning of each block of 8 bytes is the following: Data1-Data2: CH1 of module Mod_Addr Data3-Data4: CH2 of module Mod_Addr Data5-Data6: CH3 of module Mod_Addr Data7-Data8: CH4 of module Mod_Addr
0x7A	8 ÷ 256	Data1…Data(Nx8)	Answer to reading message of N (1÷32) input modules starting from address module Mod_Addr. The answer contains Nx8 bytes in the data field. The meaning of each block of 8 bytes is the following: Data1-Data2: CH1 of module Mod_Addr Data3-Data4: CH2 of module Mod_Addr Data5-Data6: CH3 of module Mod_Addr Data7-Data8: CH4 of module Mod_Addr
0x79	1	0xFF if writing OK 0x00 if writing KO	Answer to channel writing (Ch = 1÷4) of an output module (Mod_Addr=1÷127).
0x78	1	0xFF if writing OK 0x00 if writing KO	Answer to writing message of a virtual point.
0x70	68	FV1_H, FV1_L, FV2_H, FV2_L, ID1….ID64	Answer to the identification code request. Bytes FV1_H ÷FV2_L return the version number of the firmware loaded into MCP 4. ID1÷ID64 are the ASCII codes of the 64 characters of the identification string.

9.2- RAM memory mapping

The following table describes the RAM mapping of MCP 4 for the commonly used parameters.

Notes: Unspecified RAM locations in the following table are intended to be reserved or not used.
When using ***MODBUS RTU*** protocol, the number of each Word in the table of next paragraph must be increased by 1 IF AND ONLY IF the **MODBUS-** option was used (see 2.1.4).

9.2.1- Main RAM memory mapping

Byte (HEX)	Word (DEC)	Description	Comments
0002÷00FF	1÷127	Status or value of CH1 of input modules	Each status or value takes 1 Word. The input modules are 127. (Note 1)
0102÷01FF	129÷255	Status or value of CH2 of input modules	Each status or value takes 1 Word. The input modules are 127. (Note 1)
0202÷02FF	257÷383	Status or value of CH3 of input modules	Each status or value takes 1 Word. The input modules are 127. (Note 1)
0302÷03FF	385÷511	Status or value of CH4 of input modules	Each status or value takes 1 Word. The input modules are 127. (Note 1)
0402÷04FF	513÷639	Status or value of CH1 of output modules	Each status or value takes 1 Word. The output modules are 127. (Note 1)
0502÷05FF	641÷767	Status or value of CH2 of output modules	Each status or value takes 1 Word. The output modules are 127. (Note 1)
0602÷06FF	769÷895	Status or value of CH3 of output modules	Each status or value takes 1 Word. The output modules are 127. (Note 1)
0702÷07FF	897÷1023	Status or value of CH4 of output modules	Each status or value takes 1 Word. The output modules are 127. (Note 1)
0902÷09FF	1153÷1279	Map of the virtual points	2032 virtual points (digital only) organized as block of 16 points for each Word (8 points for per byte). (Note 2)
0A00÷0A27	1280÷1299	Scheduler management	See paragraph 9.2.2 for details
0F00÷0F01	1920	Hours in BCD format	Read from the MCP 4 timekeeper chip. (Note 3)
0F02÷0F03	1921	Minutes in BCD format	Read from the MCP 4 timekeeper chip. (Note 3)
0F04÷0F05	1922	Seconds in BCD format	Read from the MCP 4 timekeeper chip. (Note 3)
0F06÷0F07	1923	Day of the week in BCD format	Read from the MCP 4 timekeeper chip. 1=Monday, 2=Tuesday, ….7 (or 0)=Sunday. (Note 3)
0F08÷0F09	1924	Day of the month in BCD format	Read from the MCP 4 timekeeper chip. (Note 3)
0F0A÷0F0B	1925	Month in BCD format	Read from the MCP 4 timekeeper chip. (Note 3)
0F0C÷0F0D	1926	Year in BCD format	Read from the MCP 4 timekeeper chip. (Note 3)
0F10÷OF11	1928	Amount of binary events in the queue	Read only.
0F12÷0F13	1929	Amount of binary events to be deleted	How many consecutive events must be deleted in the queue.
0F14÷0F15	1930	Pointer to the first binary event	It is the address of the first event after last deleting.
0F16÷OF17	1931	Amount of analog event in the queue	Read only.
0F18÷0F19	1932	Amount of analog events to be deleted	How many consecutive events must be deleted in the queue.
0F1A÷0F1B	1933	Pointer to the first analog event	It is the address of the first event after last deleting.
1000÷17FF	2048÷3071	Map of the general purpose registers	R0÷R1023. 1 Word for each register.
1800÷1FFF	3072÷4095	Map of the counters	C0÷C1023. 1 Word for each counter.
2000÷2FFF	4096÷6143	Map of the timer	TIMER0÷TIMER511. 4 Words for each timer, the first containing the current time and the other three reserved.
3000÷3FFF	6144÷8191	Scheduler data	See paragraph 9.2.2 for details
4000÷7FFF	8192÷16383	List of binary events	2048 events, 8 bytes for each event, total 16384 bytes. (Note 4)
A000÷BFFF	20480÷24575	List of analog events	1024 events, 8 bytes for each event, total 8192 byte. (Note 5)
E800÷E9FF	29696÷29951	Information about configured modules	2 bytes for each modules, offset = 2 x (Module_ Address). (Note 6)
EA00÷EAFF	29952÷30079	Diagnostic information	1 byte for each modules, offset = (Module_ Address). (Note 7)
EB00÷EB7F	30080÷30143	Reset of 16-bit external counter modules MODCNT	1 byte for each modules, offset = (Module_ Address). (Note 8)

Note 1: Generally, for digital inputs and outputs, bit=1 means active status and bit=0 means non-active status. For analog modules, the Word contains the value referred to that channel. The less significant bit of a Word refers to point 1, the most significant bit refers to point 16.

Note 2: The less significant bit of the first Word in the map of virtual points (Word 1153) is the status of virtual point V1, the most significant bit of the same Word is the status of the virtual point V16, and so on for the next Words. Bit=1 means active status and bit=0 means non-active status. The virtual point n is the bit (n-1)%16 (n-1 module 16) of the Word 1153 + INT[(n-1)/16].

Note 3: These Words contain the current status of MCP 4 internal timekeeper chip; in addition to reading, these cells may be written and in this case the timekeeper chip will be updated with new passed parameters (also in MODBUS protocol). All Words related to the timekeeper information have the MSByte always set to zero, while the LSByte contains the related information (hh, mm, ss, day of the week, day, month, year) in BCD format.

Note 4: The binary event list can store up to 2048 events, and it is organized in blocks of 8 bytes for each event. Each 8-byte block (related to an event) is coded as follows:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

VIRT	Module_Address (1÷127)						
STATUS	SYS. F	Channel (0 – 3)		Point (0÷15)			
-							
-	-	-	Hours				
-	-	Minutes					
-	-	Seconds					
-	-	-	Day of the month				
-	-	-	-	Month			

1. If the bit VIRT is =1, then the specified address is referred to a virtual point
2. For virtual point Vn, n = ((Module_Address) - 1) x 16) + Point + 1
3. (SYS.F = 1) & (Module_Address = 0) & (STATUS=1) means BUS.F
4. (SYS.F = 1) & (Module_Address = 0) & (STATUS=0) means BUS. OK
5. (SYS.F = 1) & (Module_Address <> 0) & (STATUS=1) means MOD.F
6. (SYS.F = 1) & (Module_Address <> 0) & (STATO=0) means MOD.OK
7. The symbol – means “not used”

Note 5: The list of analog events (values or codes) can store up to 1024 events, and it is organized in blocks of 8 bytes for each event. Each 8-byte block (related to an event) is coded as follows:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0

-	Module_Address (1÷127)						
Value or Code (Byte_H)							
Value or Code (Byte_L)							
-	-	-	Hours				
-	-	Minutes					
Channel (0 – 3)	Seconds						
-	-	-	Day of the month				
-	-	-	-	Month			

The symbol – means “not used”.

Note 6: The configuration map (bytes 0xE800÷0xE9FF) contains the information related to the bus modules included in the polling cycle of MCP 4. The information is organized in two bytes for each module with offset = 2x(Module_Address) as follows:

offset 0 (Bytes 0xE800÷0xE801): not used
offset 2 (Bytes 0xE802÷0xE803): input module 1
offset 4 (Bytes 0xE804÷0xE805): input module 2
……
offset 254 (Bytes 0xE8FE÷0xE8FF): input module 127
offset 256 (Bytes 0xE900÷0xE901): not used
offset 258 (Bytes 0xE902÷0xE903): output module 1
……
offset 510 (Bytes 0xE9FD÷0xE9FF): output module 127

On the contrary of other cases, the first byte (that with even address) must be interpreted as low byte of the Word and the second one (that with odd address) as high byte of the Word; in other words, the bits of each Word in this map must be interpreted as follows:
Bit7 Bit6 Bit5 Bit4 Bit3 Bit2 Bit1 Bit0 Bit15 Bit14 Bit13 Bit12 Bit11 Bit10 Bit9 Bit8

The meaning of the bits is the following:

Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Nr of chann.(*)		Type of module (**)			Virtual point for module failure information (***)										

(*) bit15÷14: Number of channels (0÷3 means 1÷4)
(**) bit 13÷11: Type of module:
0 = No module
1 = 8-bit module, 1st generation
2 = 16-bit module, 1st generation
3 = 1-channel 16-bit module, 2nd generation
4 = multiple channels 16-bit module, 2nd generation

(***) bit 10÷0: virtual point (if needed) for module failure information, in the format Point/Address. Bits 6÷0 show the address, bits 10÷7 shows the point. The virtual point will be Vn, where n = ((bit6÷bit0) - 1) x 16) + (bit10÷bit7) + 1

Note 7: The map of diagnostic (bytes 0xEA00÷0xEAFF) contains the information related to the fault modules or related to modules with doubled address. The information are organized in one byte for each module with offset = Module_Address as follows:

offset 0 (Byte 0xEA00): not used
offset 1 (Byte 0xEA01): input module 1
offset 2 (Byte 0xEA02): input module 2
……
offset 127 (Byte 0xEA7F): input module 127
offset 128 (Byte 0xEA80): not used
offset 129 (Byte 0xEA81): output module 1
……
offset 255 (Byte 0xEAFF): output module 127

The meaning of the bits is the following:
bit 7: not used
bit 6: not used
bit 5: doubled address
bit 4: module failure
bit 0÷3: counter of the consecutive loss answers

Note 8: This map (bytes 0xEB00÷0xEB7F) can be used to reset the external counter modules MODCNT (if installed). The information are organized in one byte for each MODCNT module, with offset = Module_Address as follows:

offset 0 (Byte 0xEB00): not used
offset 1 (Byte 0xEB01): input module MODCNT 1
offset 2 (Byte 0xEB02): input module MODCNT 2
……
offset 127 (Byte 0xEB7F): input module MODCNT 127

The meaning of the bits of each byte in this map is the following:
bit 7÷4: not used
bit 3: reset channel 4
bit 2: reset channel 3
bit 1: reset channel 2
bit 0: reset channel 1

9.2.2- RAM mapping of the Scheduler

The Scheduler uses two blocks of RAM memory inside MCP4: Words 1280÷1299 and Words 6144÷8191. The first block is used to make parametric (and therefore easier) the reading and writing of a given day Dy of a given scheduler Sx (Dy= 1 (MON) to 7 (SUN) and Sx= 1 to 16). The second block contains instead all 8 ON and OFF times of all 7 days all of all 16 schedulers.
For the management by a supervisor or a WEB SERVER, it is advisable to act only on the first RAM block, leaving out where they are actually mapped the information of each scheduler: this approach greatly simplifies the work and makes it parameterizable through the specification of two values: the number of the scheduler (Sx = 1÷16) and the day of the week (Dy = 1÷7). When writing one of these two values, MCP 4 will copy the data related to the day Dy of the scheduler Sx in the first RAM block. Conversely, writing a value (eg. a time) in a Word of the first RAM block, MCP 4 will copy the data related to the day Dy of the scheduler Sx from this block RAM to its actual position in the second RAM block.

Byte (HEX)	Word (DEC)	Contenuto	Commenti
		BEGINNING OF BLOCK 1	
0A00÷0A01	1280	1st ON scheduling time	1st Byte: hour (0÷24), 2° Byte: minutes (0÷59) if hour=24, the minutes must be = 0; also see (Note 1) and (Note 2). Writing a value in these Words, MCP will update the related scheduler data, pointed by Word 1297 (Scheduler nr. Sx) and 1298 (Day nr. Dy)
0A02÷0A03	1281	1st OFF scheduling time	Same as above
0A04÷0A05	1282	2nd ON scheduling time	Same as above
0A06÷0A07	1283	2nd OFF scheduling time	Same as above
...	...	...	...
0A1C÷0A1D	1294	8th ON scheduling time	Same as above
0A1E÷0A1F	1295	8th OFF scheduling time	Same as above
0A20÷0A21	1296	Scheduling times enabling	The first 8 bits represent the enabling of the related scheduling time (Bit=0: sched. disabled, Bit=1: sched. enabled). Bit0 = 1st scheduling time Bit1 = 2nd scheduling time Bit2 = 3rd scheduling time Bit3 = 4th scheduling time Bit4 = 5th scheduling time Bit5 = 6th scheduling time Bit6 = 7th scheduling time Bit7 = 8th scheduling time
0A22÷0A23	1297	Scheduler number Sx	Writing a value 1 to 16 in this Word, MCP 4 will copy the data of the day Dy of the schedule Sx in the Words 1280÷1296 (8 scheduling times ON-OFF + Enabling)
0A24÷0A25	1298	Day number Dy	Writing a value 1 (MON) to 7 (SUN) in this Word, MCP 4 will copy the data of the day Dy of the scheduler Sx in the Words 1280÷1296 (8 scheduling times ON-OFF + Enabling)
0A26÷0A27	1299	Copy scheduler	Writing any value in this Word, MCP 4 will copy the data of the current day to the next one (of the same scheduler Sx) and the day number Dy will be increased by 1 or, if it was 7, it will be set to 1
		END OF BLOCK 1	
...	...	...	...
		BEGINNING OF BLOCK 2	
3000÷30FF	6144÷6271	Data of scheduler 1	128 Words
3100÷31FF	6272÷6399	Data of scheduler 2	128 Words
...	...	...	...
3F00÷3FFF	8064÷8191	Data of scheduler 16	128 Words
		END OF BLOCK 2	

Note:
(1) It is possible to specify the time 24:00 if the controlled point must be ON across midnight, in order to avoid the switching OFF during a minute between 23:59 and 00:00.
(2) Hour values greater than 24 and/or minutes greater than 59 mean a not valid time.

10- MCP IDE: INTEGRATED DEVELOPMENT ENVIRONMENT FOR APPLICATIONS USING MCP 4

10.1- Description of the software package

MCP IDE (Rel 3.2.3 or higher) is an Integrated Development Environment to support the program development for CONTATTO MCP 4 controller. The MCP IDE package comes complete with an Editor, Compiler, Transfer utility, Simulator and Supervisor of the operation status of MCP 4 and of the plants.
The package is made by several tool programs, as described here in the following.

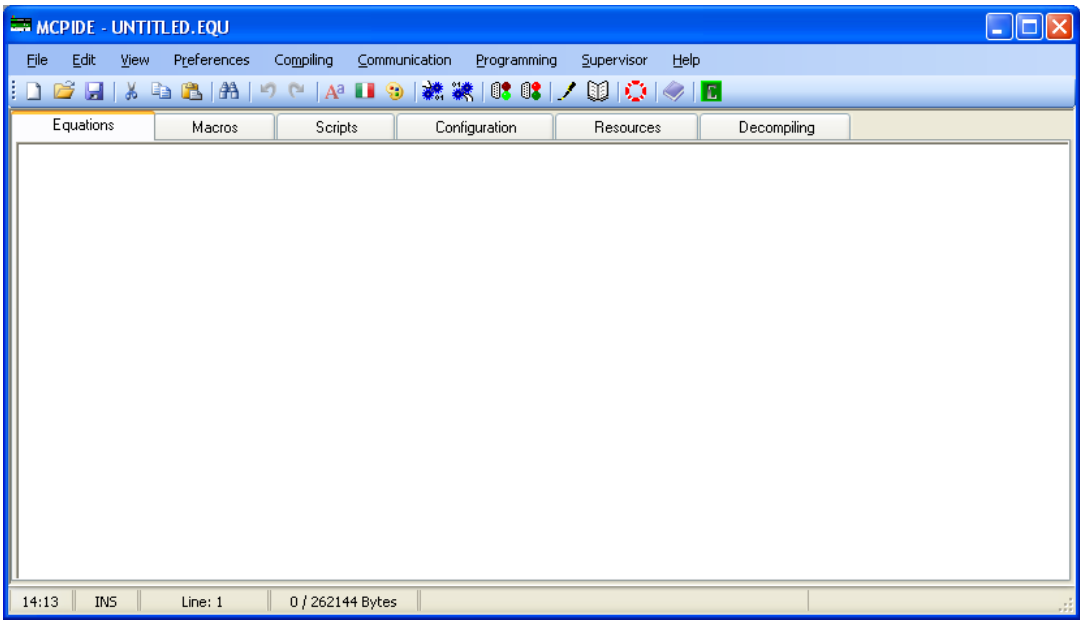
- **MCP IDE** is the MCP 4 program editor, integrating the compiler, the configuration tools for special modules (e.g. ModTPD transponder reader module, ModHT room controller for hotel applications and so on) and the "write to / read from" MCP 4 utilities.
- **MCP VISIO** is a tool allowing the supervision of input and output modules and all other MCP 4 parameters (counters, registers, virtual points, etc.). This tool can work connected to MCP 4 through the serial port or it can simulate the program written by MCP IDE, in order to debug it before the writing into MCP 4 FLASH memory.
- **MCP MAP** is an advanced tool allowing to access to the "heart" of MCP 4; the use of this tool is reserved to expert user only.
- **Controtto XT** is an utility for the control of CONTATTO through the PC.

To perform a firmware update of MCP 4 microcontrollers (other than all other **Duemmegi** devices), use the software package named **BootTools** which can be downloaded from **Duemmegi** site.

The ease of use of MCP IDE and its many features and utilities allow quick development and configuration of MCP 4 controller, according to the requirements of the plant where it will be installed. The intuitive operation and the clear menu items allow to start using MCP IDE immediately, allowing to save more time in developing applications and requiring less time reading user manuals.

10.2- MCP IDE

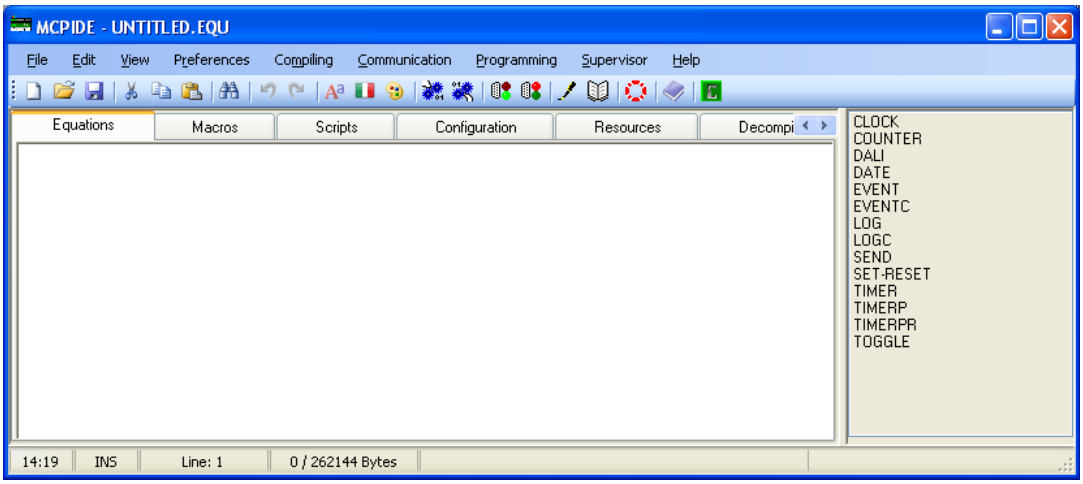
MCP IDE looks like the following figure:



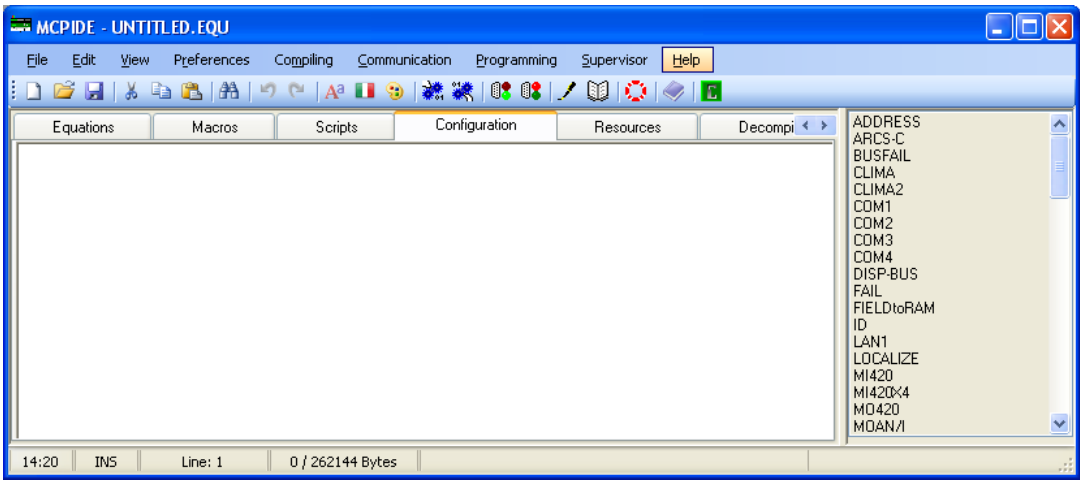
The main window of the program has 6 TABs (Workspaces): Equations, Macros, Scripts, Configuration, Resources and Decompiling. Each button on the button bar shows the description of its function simply placing the mouse cursor on the button itself.

The majority of the buttons and menu items are so intuitive that no more explanations are needed.

The button  (or the menu item View – Show Keywords List) is the "life belt" and it allows to switch ON or OFF the opening of a space, on the right side, containing all the keywords allowed in the related TAB:

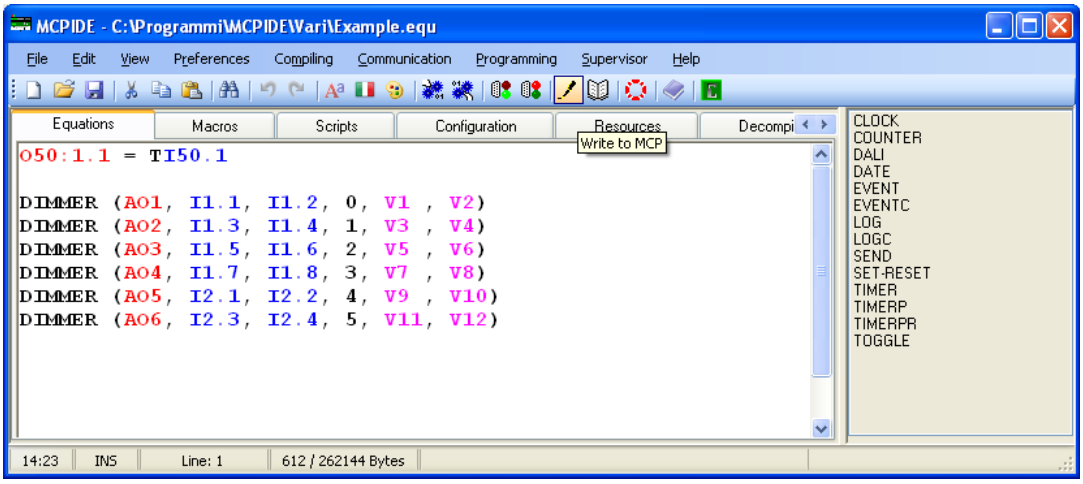


When Configuration TAB is selected, then also a list of all available CONTATTO modules will be shown:

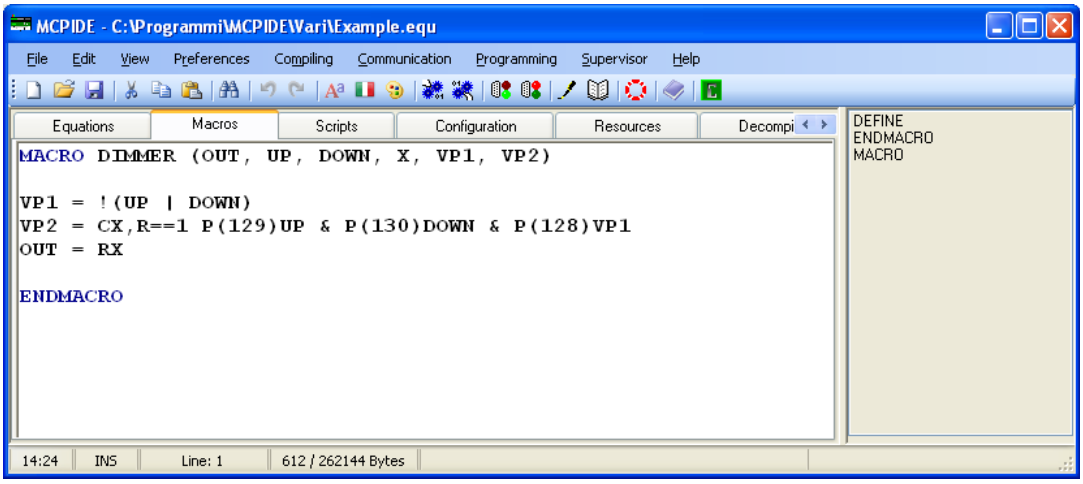


Double-clicking on one of the keywords in the life belt, the related example will be placed in the opened workspace; the inserted example must be completed as required.

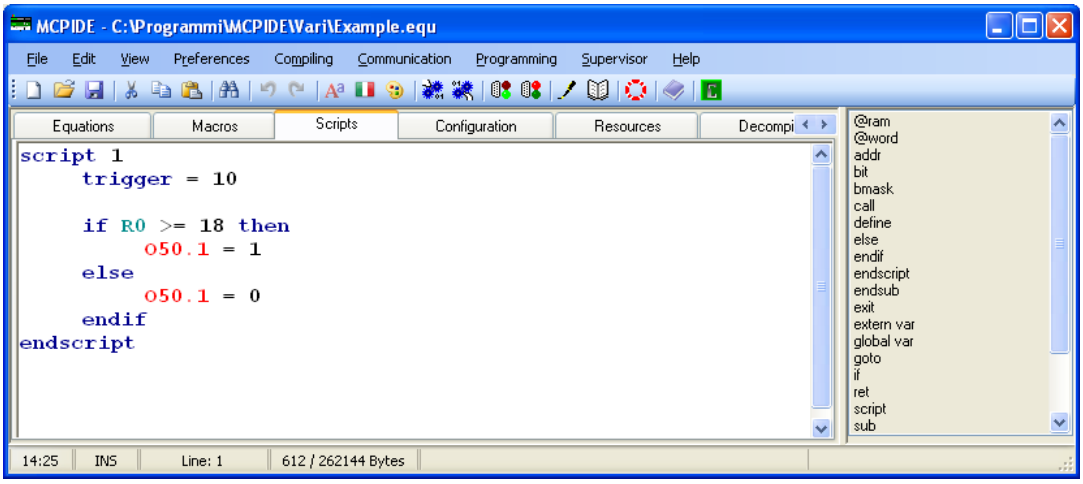
The Equations workspace allows writing the standard equation of MCP 4:



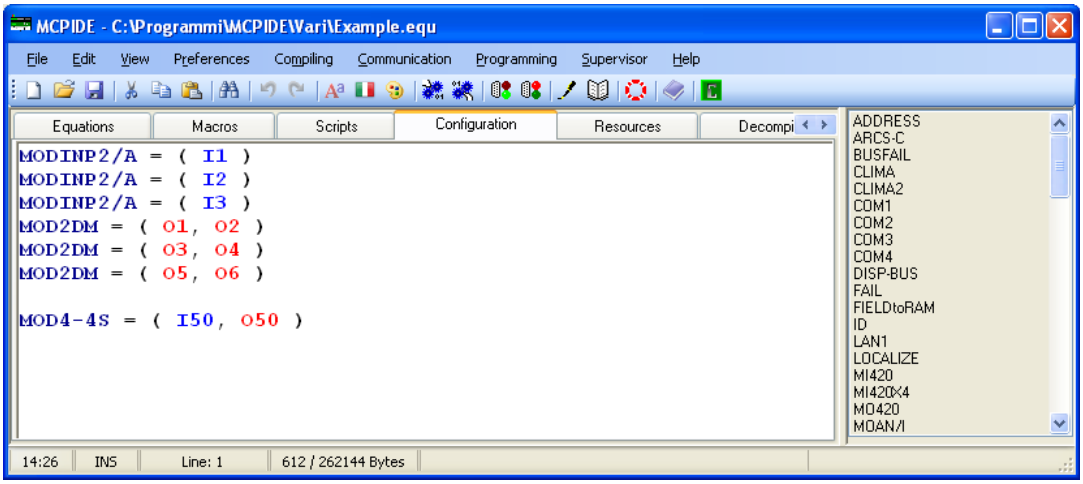
The Macros workspace allows writing the Macro definitions:



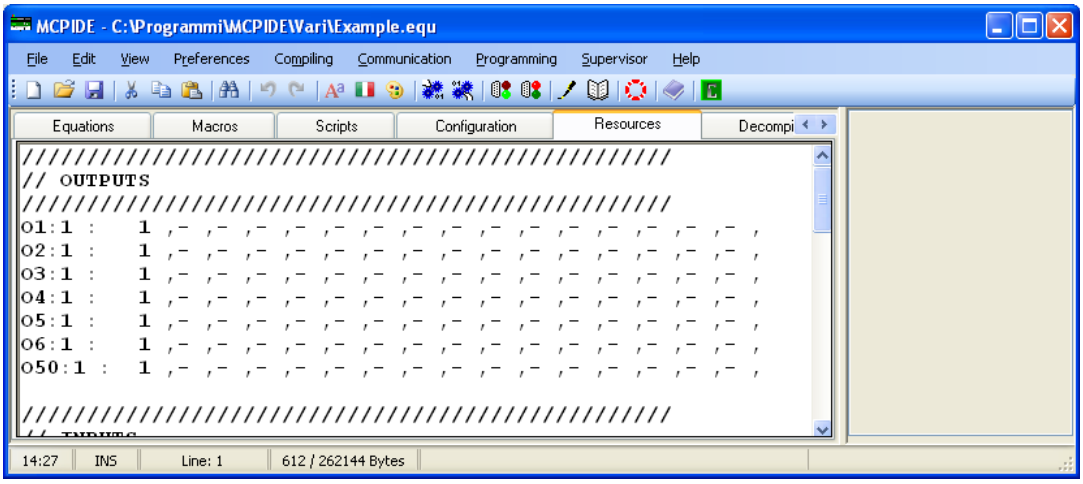
The Script workspace allows writing the Scripts:



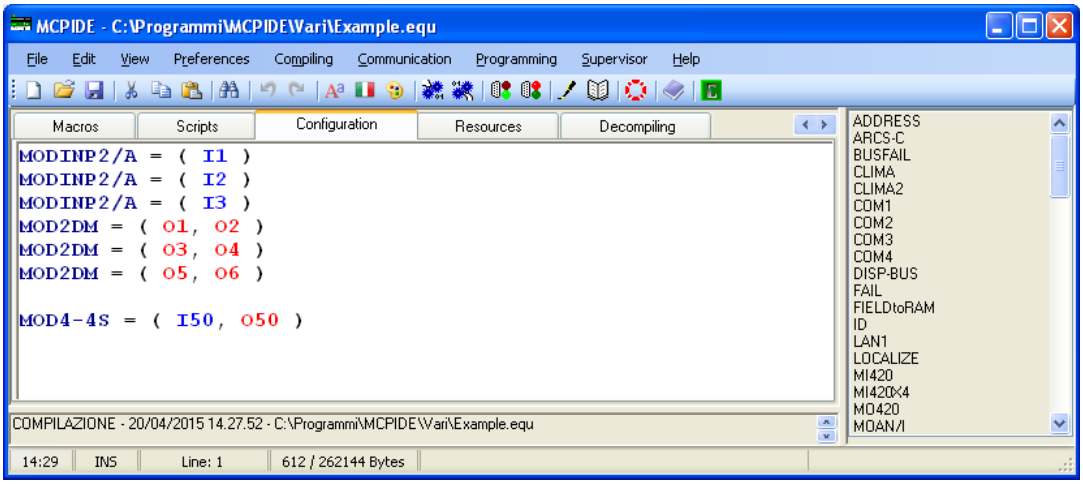
The Configuration workspace allows writing the module list and other information (e.g. ADDRESS):



The Resources workspace (read only) contains, after compiling, information about the resources used in the just compiled program:

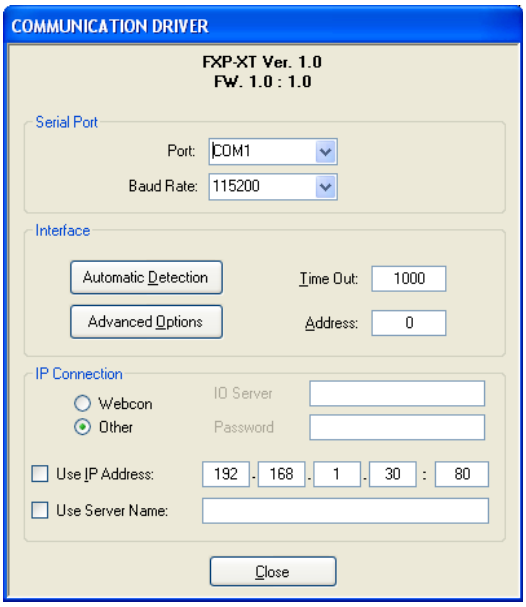


The Decompiling workspace (read-only) is reserved to expert user and contains, after de-compiling, information about how the compiler has interpreted the written program:



10.2.1- MCP IDE

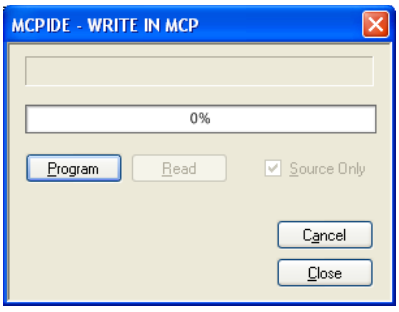
The button  open the serial communication with MCP 4, while the button  closes it. The window appearing at the communication opening is that shown here. Once the communication has been enabled by the button Detect, an information similar to "FW – 1.0 : 1.0" will be shown; the first number on the left side is the FW version of the main microcontroller of MCP 4 (1.0 in this example), while the number on the right side is the FW version of the secondary microcontroller (1.0 in this example).



The label "FXP-XT Ver. 1.0" in the shown window is the version of the communication driver included in the MCP IDE package.
The "Time Out" is the maximum time that MCP IDE wait for an answer from MCP 4 and "Address" is the address assigned to the MCP 4 to be polled (take in account that specifying address zero the communication will take place regardless of the address assigned to MCP 4).

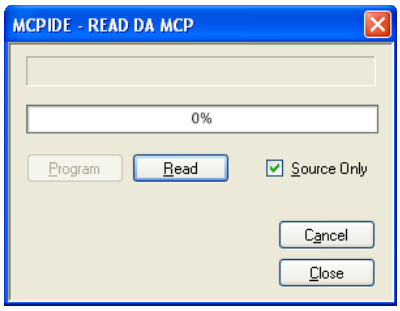
MCP IDE can also communicate with MCP 4 through the Ethernet network. In this case the communication can be enabled specifying "Other" and the IP address and the port of MCP4 (or another device interfacing MCP 4 to the netwotk) and then clicking in the "Use IP Address" check box. In this way MCP IDE will send the messages on the Ethernet port of the PC where it has been installed, instead to RS232 port. The answer of MCP 4, afterward, will follow the reverse way.
"Use Server Name" allows to specify an address provided by a DNS service (e.g. when accessing from WAN and MCP 4 is installed in a LAN that communicates to the WAN through a dynamic IP).
Another connection possibility is through Webcon: in this case, after having selected the related item, enter the IO Server name (generally Contatto) and the password, then enter the IP address and the port of Webcon and finally select "Use IP Address" (or enter the DNS service address and then select "Use Server Name"); for details, refer to Webcon user's manual.

10.2.2- Program transferring



Pushing the button  or selecting the Write to MCP menu item, the window on this left side will be shown.

Push program to begin the transfer of current program to MCP 4.

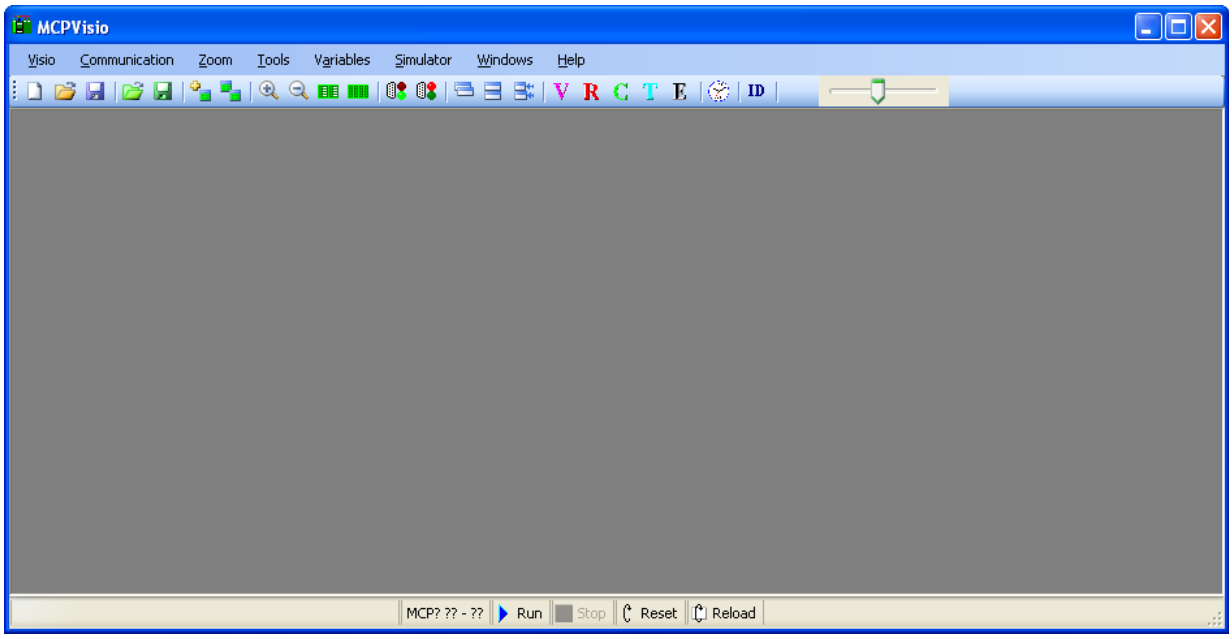


Pushing the button  or selecting Read from MCP, the reversed process will start; the window will on this left side appear.

Enabling the "Source Only" option, the source program will be transferred as it has been created, including the comments; on the contrary, the whole FLASH contents will be downloaded to the PC. This last procedure requires many time and it is needed for specific reasons only (e.g. diagnostic).

10.3- MCP VISIO

MCP VISIO looks like the following figure:



Each button on the button bar shows the description of its function simply placing the mouse cursor on the button itself.

The majority of the buttons and menu items are so intuitive that no more explanations are needed.

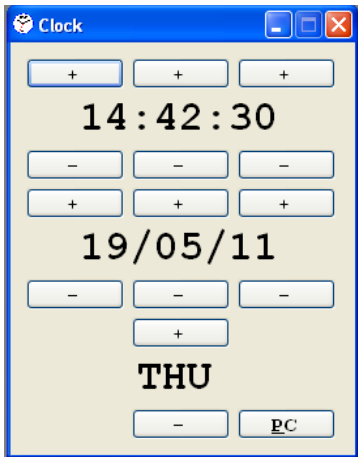
The button  open the serial communication with MCP 4, while the button  closes it.

Note: since the communication driver it the same for all the software package, if the serial communication has been opened from MCP IDE, then the communication results to be opened in MCP VISIO too and vice versa.

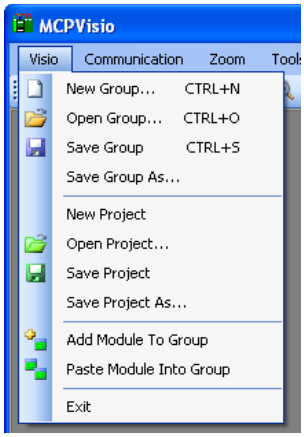
The buttons 

allow to display, respectively, the window of virtual points, registers, counters, timers and events (both digital and analog ones).

The reading/setting window (opened by the butto  n) looks like in the figure on this right side. The clock panel shows Hours:Minutes:Seconds on the first line, Day/Month/Year on the second one and the Day of the Week on the third line.
If the serial communication with MCP 4 is opened, the related current time and date setting will be shown. If, on the contrary, the serial communication with MCP 4 is closed, then a sequence of dashes will be shown. The buttons + and – will increment and decrement the related item.
At every change in the setting using the buttons + and -, the setting of MCP 4 will be automatically updated.
The button PC transfers the date and time setting of the PC to MCP 4.



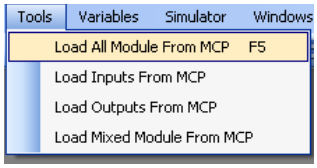
The button ID will show on the status bar, on the bottom side of MCP VISIO window, the firmware version of the connected MCP 4.



The Visio menu item allows the following operations:

New Group: open a new group (see in the following)
Open Group: load a saved group from file
Save Group: save the current group to file
Save Group As: save the current group with different file name
New Project: open a new project (see in the following)
Open Project: load a saved project from file (see in the following)
Save Project: save the current project to file
Save Project As: save the current project with different file name
Add module To Group: add a module to the current group
Paste Module Into Group: paste a module into the current group
Exit: quit the program

The Tools menu allows the following functions:



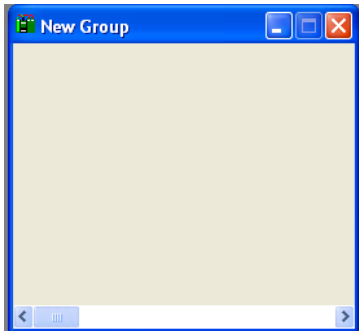
Load All Modules From MCP: create 3 groups (Inputs, Outputs and Mixed Modules)
Load Inputs From MCP: create a group for all configured Input Modules
Load Outputs From MCP: create a group for all configured Output Modules
Load Mixed Module from MCP: create a group for all configured Mixed Modules

Through these functions, the module configured in MCP 4 will be shown, provided that MCP 4 has been connected or the simulator has been activated (see in the following). As option, it is possible to create customized groups including input and output modules and virtual points; the procedure to create the groups will be now described.

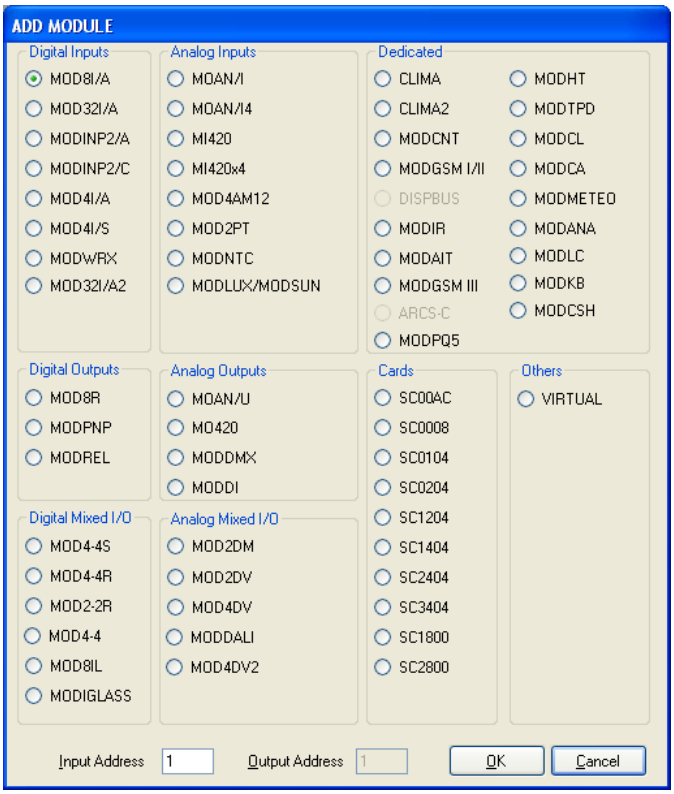
The slider  on the button bar allows to change the polling period from PC to MCP 4 (if connected). Moving the slider at left side, the period is lower (so the updating of the objects in the windows is fast). Moving it at right side the period increase (so the updating of the objects in the windows is slow).

10.3.1- The Groups of MCP VISIO

Select New Group from the Visio menu. A new window will be opened as in the following figure:

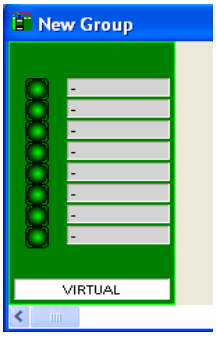


The input and output modules and the virtual points can be included in this window as desired. Press the button to  add a module. The following window will appear:

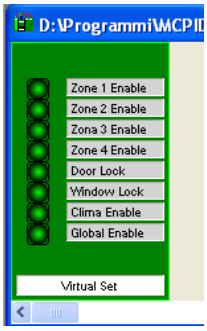


Select one of the listed modules and specify the address in the related te4 box (for mixed and some special modules, both input and output address has to be specified).

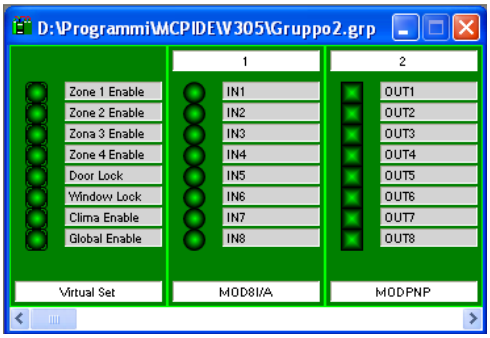
To insert a virtual module (made by 8 points, assigned in any order) select VIRTUAL in the Others column; in this case, of course, no address is required. The number of each virtual point will be assigned as follow. After having selected the VIRTUAL option, press OK. The group window will look like the following:



Now hold down the Shift button on the keyboard and double click with the mouse on the virtual LED to be assigned to a virtual point (be sure to click ON the LED).
A yellow label will be shown at the place of the clicked LED: type in a number in the range 1 to 2032 to assign that LED to the desired virtual point.
Click on the right side of each LED while holding down the Shift button on the keyboard to assign a label to the related point. Finally, click on the white band on the lower side of the virtual module (always holding down Shift button) to assign a name to it.



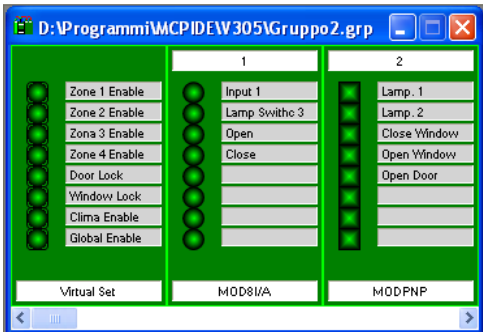
To check or to edit the virtual point assigned to a virtual LED, simply click again on the LED itself holding down Shift Key. The same operation allow to edit the other fields.
The result may be like the figure here on the right side.
For instance, add now a MOD8I/A and a MODPNP module to the same group as in the following figure. The write and edit operations described before (click while holding down the Shift key) can be performed on any kind of module in the group window. So use it to change the name assigned to each module (the white band on the lower side) or to change the address (the white band on the upper side).



The color of the module symbols included in the groups can be:

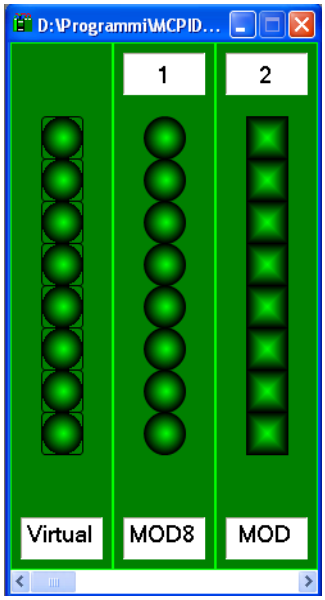
GREY: that module was not configured in the current program
RED: the module does not answer to MCP 4
YELLOW: two or more modules have the same address

The 4 buttons  in the group window allow to change the graphic mode. The first two modes will zoom in and zoom out; 4 zoom levels are available. The other two buttons act on the labels, showing or hiding them respectively.



The names of each input and output point were assigned in the same way described before (double click on the label on the right side of each LED).

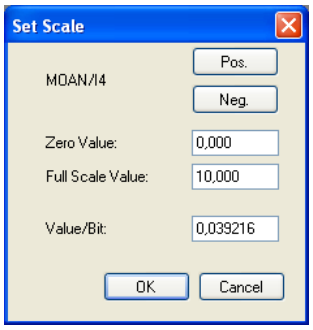
The figure on this right side shows the option related to the graphical mode without labels and applied zoom level 3:



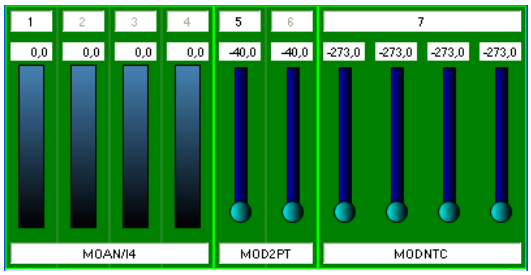
To remove a real or virtual module from a group, click on any area of the module itself while holding down the Alt button on the keyboard; a confirmation will be required before the deleting.

It is also possible to Copy and Paste a module in the same group or from a group to another one. To copy a module in the Clipboard, Click on any area of the module itself while holding down the Ctrl button on the keyboard. To paste the module from the Clipboard to a group, press the button  in the destination group.

Each group can be saved (or updated) in a file by the button  or by the related menu item and then reloaded by the button  .



For analog modules, MCP VISIO allows the setting of the measurement scale. The figure on this right side shows 3 analog modules (MOAN/I4, MOD2PT e MODNTC) inside a group of MCP VISIO.

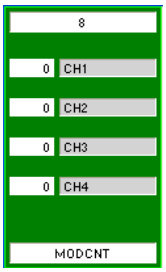


Each te4 box inside the graphic representation of the module is the values read from the field (or the simulated value). Clicking on these te4 boxes with the right button of the mouse, a window allowing to change the measurement scale setting appears; the values shown in this window depend on the considered module. For instance, clicking with right button on a te4 box of MOAN/I4 module, the window shown on this left side will appear; the zero value and the full scale value can be set in this window.

The Value/Bit is the achieved resolution using the currently setting of zero and full scale values. As shown, the default settings for this module are Zero Value = 0 and Full scale Value = 10.

If the module is used to measure a pressure (through a proper transducer with 0÷10V output) in the range 1 bar (at 0V output) to 15 bar (at 10V output), then the settings required by MCP VISIO to show the read value in bar unit will be:

Zero Value = 1
Full scale Value = 15



The Value/Bit will be updated by the program according to the other two values.

For the “special” analog modules (e.g. MOD2PT and MODNTC) the scale setting should be left to the default value, because the measured parameters are well defined.

Regarding the counter modules MODCNT (see figure on this right side), it is possible to reset each one of the 4 counting values clicking on the related box te4 while holding down the Shift button on the keyboard.

10.3.2- The Projects of MCP VISIO

MCP VISIO allows to save all its current settings, intended as opened groups, windows, positions and dimensions of the windows, zoom levels and graphic levels, etc..

To create a project, press the button  of MCP VISIO, or select the menu item Save project from the Visio menu.

To recall a previously saved project, press the button  of MCP VISIO, or select the menu item Open Project from the Visio menu.

10.3.3- The Simulator of MCP VISIO

MCP VISIO features a simulator allowing to test and debug the MCP 4 program (or part of it). The simulator is a fully software tool, therefore no serial connection to MCP 4 is required.
The simulator shows the behavior of the output parameters of a program (e.g. real and virtual output points, registers, counters, etc.) as result of some stimulus on input parameters.
To activate the simulator select Run in the Simulator menu; select the file containing the program to be simulated (the file must have .BIN extension and it is automatically created by the compiling process of MCP IDE). Once loaded, the name of the file under simulation, together its path, will be shown in the status bar on the bottom side of MCP VISIO, together to the related controls Run, Stop, Reset and Reload.

While the simulation is running, its possible to change values, status of input modules, virtual points and so on; to do this, simply click on the object to be changed. For digital points (input modules, virtual points, etc.) the left button of the mouse performs the switching on, while the right button performs the switching off.

The Stop button stops the simulation while the Reset button restores all the parameters at their power up value (this is similar to the power up of MCP 4).
The Reload button reloads the file shown in the control panel; when changing anything in a program, it must be complied again and it must be reload in the simulator.

11- MODBUS COMMUNICATION PROTOCOL

11.1- Abstract

MCP Plus can interface to external world through MODBUS RTU protocol. This protocol is integrated into MCP 4 and coexist, if enabled by the PROTOCOL directive (see related paragraph), together to the FXP XT proprietary protocol as described previously; this means:

- MCP Plus will answer according to the MODBUS protocol, if enabled, to any MODBUS requests
- MCP Plus will answer according to the proprietary FXP XT protocol to any FXP XT requests

This chapter will describe some traces about using of MODBUS protocol.
The communication parameters for MODBUS protocol implemented into MCP 4 are the followings:

- **1 start bit**
- **8 data bits**
- **no parity**
- **1 or 2 stop bits (automatic detection)**

The baud rate may be set as previously described to the following values: 2400, 4800, 9600, 19200, 38400, 57600, 115200 baud. **MCP 4 always acts as slave (it is a MODBUS peripheral unit)**; this means that it only answers to the requests of a MASTER MODBUS DEVICE.

In a MODBUS networks each peripheral device must its own address (normally named “station address”); the address of MCP 4 has to be set by the ADDRESS function as described in the related paragraph.

To localize the input and output points, virtual points, registers, etc., refer to the external RAM memory described in a previous chapter or, better, refer to the tables listed in the following pages.

11.2- Supported MODBUS functions

MCP 4 supports, in SLAVE mode, the following MODBUS functions:

Function code	Description
1	Read output table
2	Read input table
3	Read registers (RAM memory)
4	Read analog input
5	Force single digital output point
6	Preset single register
16	Preset multiple registers
17	Report device type

In MASTER mode, MCP 4 uses MODBUS functions 3, 4 and 16 only.

11.3- Example of MODBUS functions

This paragraph shows some examples of MODBUS functions (request and answer) among the most used; in these paragraphs it is meant that MCP 4, in a MODBUS system, is a SLAVE device, thus it answers to the queries of a MASTER device.

The following examples are useful to identify the MODBUS functions to be used when communicating with MCP 4; the current MODBUS drivers implemented in many common devices (PLC, supervision software for PC, videoterminals, etc.) normally provide a development platform and a user interface which dramatically simplify the setting up in respect of the description that will be made in the following paragraphs. In practice

the setting up of the communication between the MASTER system and MCP 4 will be reduced to the configuration of the communication driver provided by the manufacturer of the MASTER system, therefore refer to the user's manual of the same system.

The following notations, unless otherwise specified, have to be intended in decimal format.

11.3.1- Function 1: Reading the digital output status

The MODBUS function 1 allows to read the output status; the following parameters must be specified:

- **a start point (Start)**; this value **must be multiple of 16**. This value identifies the number of the digital output (normally called coil) starting from 16 and arranged by channel as follows:

Output	Number of the output (coil)
Non usato	0
O1:1.1	16
O2:1.1	32
...	...
O127:1.1	2032
Non usato	2048
O1:2.1	2064
O2:2.1	2080
...	...
O127:2.1	4080
Non usato	4096
O1:3.1	4112
O2:3.1	4128
...	...
O127:3.1	6128
Non usato	6144
O1:4.1	6160
O2:4.1	6176
...	...
O127:4.1	8176

  The general formula is: said **Add** the address of the real module of CONTATTO system, starting from which the status of the outputs has to be read and **CH** the channel, then the value of Start will be:

  (Add x 16) + 2048 x (CH – 1)

  Allowed values: **from 0 to 8176**.

- **how many output points have to be read (Number)**; in practice, how many modules having consecutive address have to be read. To avoid confusion, this value is suggested to be **multiple of 16** and equal to the number of modules to be read multiplied by 16. Allowed values: **from 16 to 8176**.

MCP 4 will answer with a number of bytes equal to Number divided by 8.

Example:
Read the output status of module 25, for instance a MOD8R that, as known, features 8 output points and a single channel (1). The parameters to be passed to MODBUS driver are:

Start: **400**
Number: **16**

MCP 4 will answer with 2 bytes containing the status of the output points of module 25, according to the binary code (1=out ON, 0=out OFF). The less significant bit of the lower byte is related to the output point 1, the most significant bit is related to the output point 8; the higher byte will be, in this case always 0x00 (zero).

11.3.2- Function 2: Reading the digital input status

The MODBUS function 2 allows to read the input status; the following parameters has to be specified:

- **a start point (Start)**; this value **must be multiple of 16**. This value identifies the number of the digital input starting from 16 and arranged by channel as follows:

Input	Number of the input
Non usato	0
I1:1.1	16
I2:1.1	32
...	...
I127:1.1	2032
Non usato	2048
I1:2.1	2064
I2:2.1	2080
...	...
I127:2.1	4080
Non usato	4096
I1:3.1	4112
I2:3.1	4128
...	...
I127:3.1	6128
Non usato	6144
I1:4.1	6160
I2:4.1	6176
...	...
I127:4.1	8176

  The general formula is: said **Add** the address of the real module of CONTATTO system, starting from which the status of the inputs has to be read and **CH** the channel, then the value of Start will be:

  (Add x 16) + 2048 x (CH – 1)

  Allowed values: **from 0 to 8176**.

- **how many input points have to be read (Number)**; in practice, how many modules having consecutive address have to be read. To avoid confusion, this value is suggested to be **multiple of 16** and equal to the number of modules to be read multiplied by 16. Allowed values: **from 16 to 8176**.

MCP 4 will answer with a number of bytes equal to Number divided by 8.

Example 1:
Read the input status of module 43, for instance a MOD8I/A that, as known, features 8 input points and a single channel (1). The parameters to be passed to MODBUS driver are:

Start: **688**
Number: **16**

MCP 4 will answer with 2 bytes containing the status of the input points of module 43, according to the binary code (1=input ON, 0=input OFF). The less significant bit of the lower byte is related to the input point 1, the most significant bit is related to the input point 8; the higher byte will be, in this case always 0x00 (zero).

Example 2:
Read the input status of modules 57, 58, 59, and 60, for instance all MOD8I/A modules that, as known, features 8 input points each one. The parameters to be passed to MODBUS driver are:

Start: **912**
Number: **64**

MCP 4 will answer with 8 bytes containing the status of the input points of modules from 57 to 60 included.

11.3.3- Function 3: Reading the registers (RAM memory)

The MODBUS function 3 **is the most used**, because of general use, and it allows to read the content of the RAM memory of MCP 4 with all information about the status of the system.
The following parameters have to be specified:

- **a starting point (Start)**; this value **is the address of the Word into the RAM** starting from which the registers have to be read. Allowed values: **from 1 to 30143** (in hexadecimal from 0x0001 to 0x75BF)
- **how many Words have to be read (Number)**; allowed values: **from 1 to 125**.

MCP 4 will answer with a number of Words equal to the specified Number (that means **a number of bytes equal to the double of the specified Number**).

The MODBUS function 3 can be used to read the status of the real inputs and outputs, the status of virtual points, the content of counters, etc.; in practice, any information mapped into the MCP 4 RAM can be required, included the current date and time of the internal timekeeper.

Example 1:
Read the **output status** of module 25, for instance a MOD8R; alternatively to function 1, the function 3 can be used. The location of the Word in the RAM containing the status of the output module **i** (channel 1) is **i+512**, therefore, concerning the module 25, the following parameters will be passed to MODBUS driver:

Start: **537**
Number: **1**

MCP 4 will answer with a Word whose most significant byte is zero and the less significant byte is contains the status of the output points of module 25, in binary code (1=out ON, 0=out OFF). The less significant bit is related to the output point 1, the most significant bit is related to output point 8.

Example 2:
Read the **input status** of module 43, for instance a MOD8I/A; alternatively to function 2, the function 3 can be used. The location of the Word in the RAM containing the status of the input module **i** (channel 1) is **i**, therefore, concerning the module 43, the following parameters will be passed to MODBUS driver:

Start: **43**
Number: **1**

MCP 4 will answer with a Word whose most significant byte is zero and the less significant byte is contains the status of the input points of module 43, in binary code (1=input ON, 0=input OFF). The less significant bit is related to the input point 1, the most significant bit is related to input point 8.

Example 3:
Read the **input status** of module 57, 58, 59 and 60, for instance all MOD8I/A modules, using the function 3. The following parameters will be passed to MODBUS driver:

Start: **57**
Number: **4**

MCP 4 will answer with 4 Words (8 bytes), each one having the most significant byte equal to zero and the less significant byte containing the status of the input points of modules 57, 58, 59 and 60, in binary code (1=input ON, 0=input OFF). The less significant bit is related to the input point 1, the most significant bit is related to input point 8.

Example 4:
Read the **status of virtual point** V328 using the function 3. The Word containing the status of virtual point **Vx** is given by:

1153 + INT[(x - 1) / 16]

Since a virtual point takes only one bit of the Word, the bit number must be also specified; this is given by:

(x – 1)%16

where the notation %16 means “module 16” and it is equivalent to the remainder of the division of x by 16; the notation INT[ ] means the integer part of the result of the operation inside the parenthesis.
To calculate y module 16 proceed as follows:
•divide y by 16
•subtract the integer part of the result of point 1 to the result itself
•multiply by 16 the result of point 2: the resultant value is the module 16 of the starting number; this result is always an integer number in the range 0 to 7.

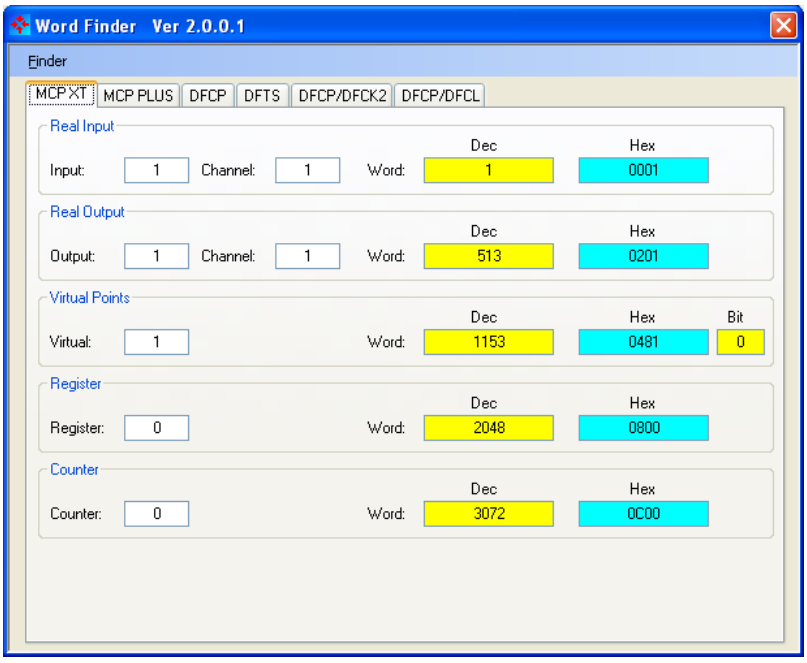
The parameters to be passed to the MODBUS driver, for virtual point V328, are:

Start: **1173**
Number: **1**
Bit: **7**

MCP 4 will answer with a Word (2 bytes) containing the status of the virtual points from V321 (less significant bit) to V336 (most significant bit). The virtual points are binary coded (1=point ON, 0=point OFF).

Example for the calculation of 327%16:
•327 : 16 = 20.4375
•20.4375 – 20 = 0.4375
•0.4375 x 16 = 7

Alternatively, the paragraph 11.4 reports some tables to easily locate the RAM address and the bits related to a given virtual point. As further possibility, use the program WordFinder (see the following figure) that can be free of charge from the site www.duemmegi.it.



11.3.4- Function 4: Reading analog inputs

The MODBUS function 4 is substantially equivalent to the function 3, therefore refer to this last one.

11.3.5- Function 5: Command of a single output digital point

The function 5 allows to force the status of a single output digital point, both real and virtual one; it is necessary to specify:

- ***REAL OUTPUT:*** **the number of the real output point to be forced (Number)**; said **i** the address of the real module of CONTATTO system, a point of which has to be changed and said **p** the output point to be changed, then Number must be set to **[(i –1) x 64 + p – 1] + (CH – 1) x 16**. Allowed values for **i** range from 1 to 127, for **p** they range from 1 to 16 and for **CH** they range from 1 to 4.
- ***VIRTUAL OUPUT:*** **the number of the output virtual point to be forced (Number)**; said **n** the number of the virtual point to be changed, then Number must be set to **16384 + n - 1**. Allowed values for **n** range from 1 to 2032.
- **new status of the output point** (0xFF00=ON, 0x0000=OFF).

Example:
Switch on the point 3 (channel 1) of the output module addressed 29. The parameters to be passed to the MODBUS driver are:

Number: **1794**
Status: **0xFF00**

11.3.6- Function 6: Writing a single register (RAM memory)

The function 6 allows to write a value into a single Word of the RAM memory of MCP 4, that contains all information about the status of the system. The function 16 is more used than the function 6.
The following parameters have to be specified:

- **Number**: this value **is the Word address** where the new value has to be written. Allowed values for Number: **from 0 to 30143** (in hexadecimal from 0x0000 to 0x75BF).
- **Data: the value to be written** into the specified Word.

11.3.7- Function 16: Writing multiple registers (RAM memory)

The function 16 allows to write into the external RAM memory of MCP 4, that contains all information about the status of the system. This function, together to function 3, **is the most used**.
The following parameters have to be specified:

- **a starting point (Start)**; this value **is the address of the RAM Word** starting from which the new values have to be written. Allowed values for Start: **from 0 to 30143** (in hexadecimal from 0x0000 to 0x75BF). The **internal memory** of the microcontroller MUST NOT BE MODIFIED.
- **how many registers have to be written (Number)**; in practice, how many consecutive Words have to be written. Allowed values: from **1 to 125**.
- **the values to be written (Data)** in the specified Words; each data (the amount is specified by Number) must be made by 2 bytes (1 WORD).

The MODBUS drivers normally provide the possibility to write one or more whole Words (useful for instance to change the content of a counter or to change an analog output), or to change a single bit of the Word (for instance to control a single real output or to change the status of a virtual point).

The MODBUS function 16 can thus be used to change the status of whole output module (both digital or analog type), the status of a single output point of a module, the status of virtual points, the content of counters, registers, etc.

To change a single bit of a register using the function 16, the status of the other bits of the same register has to be taken in account, because the writing takes place on the whole Word; in practice, the MODBUS driver automatically take in account this, because, when the writing must be at bit level, they execute the following steps:

1. reading, through the function 3, of the Word containing the bit to be changed
2. writing, through the function 16, of the just read Word read but with the wanted byte changed

The MODBUS function 16 can be also used to set the date and time of the internal timekeeper of MCP 4 as shown in one of the following examples.

Example 1:
Switch on the point 3 of the output module 29. Instead of function 5, the function 16 can be used. From the memory map of MCP 4 at paragraph 9.2.1 (or using WordFinder program, available free of charge on the site www.duemmegi.it) the Word containing the status of output module 29 is the 541, therefore, regarding the module 29, the following parameters have to be passed to the MODBUS driver:

Start: **541**
Number: **1** (normally, in this case, this parameter is not required by the driver)
Bit: **2**
Value: **1** (or ON, it depends on the used driver)

Note: the point 3 of an output module correspond to bit 2 of the Word, because the real output points of the CONTATTO system are numbered from 1 to 8, while the MODBUS driver "works" on the bits from 0 to 7.

The execution of this function, as described before, implies that the MODBUS driver read the Word 541 using the function 3, then it changes the bit 2 to the read value and finally it sends the resulting value to the Word 541 using the function 16. This procedure, normally, is automatically executed by the MODBUS driver of the MASTER system (PLC, supervision software, video-terminal, etc.).

Example 2:
Switch on all outputs of the output module 29. Use the function 16. The Word into MCP 4 RAM related to output module 29 (channel 1) is the 541, therefore the following parameters have to be passed to the MODBUS driver:

Start: **541**
Number: **1**
Value: **255**

In this case the value 255 will be directly written into the Word 541. In addition, the MODBUS drivers allow to execute both mathematical and logical operations between the current value of the Word and a fixed value (for instance an EXOR between the current value of an output module and the value 255 to complement the status of each output of the same module) and then to write the result in the same Word.

Example 3:
Switch on the virtual point V751 using the function 16. As said before for the function 3, the Word containing the status of virtual point **Vx** is given by:

1153 + INT[(x - 1) / 16]

while the bit is:

(x – 1)%16

As option, see the tables at the end of this manual or use the already mentioned program WordFinder.

The virtual point V751 is the bit 14 of the Word 1199; the following parameters have to be passed to the MODBUS driver:

Start: **1199**
Number: **1** (normally, in this case, this parameter is not required by the driver)
Bit: **14**
Value: **1** (or ON, it depends on the used driver)

The execution of this function, as described before, implies that the MODBUS driver read the Word 1199 using the function 3, then it changes the bit 14 to the read value and finally it sends the resulting value to the same Word 1199 using the function 16. This procedure is mandatory, because the Word 1199 contains the status of the virtual points from V737 to V752; since the status of the other virtual points does not be changed, then the preliminary reading of this Word is needed. This procedure, however, is normally executed automatically by the MODBUS driver of the MASTER system.

Example 4:
Write the value 157 into counter C22 (remember that, for the CONTATTO system, the counter are numbered from 0 to 1023). Use the function 16. The address of the Word containing the value of the counter **Cn** is given by **3072+n** (see RAM map or the tables at the end of this manual or use WordFinder); thus, concerning the counter C22 , the following parameters have to be passed to the MODBUS driver:

Start: **3094**
Number: **1**
Value: **157**

In this case the value 157 will be directly written into the Word 3094.

Example 5:
Set to 36 the minutes of the MCP 4 timekeeper; from the RAM map of MCP, the Word related to the minutes is the 1921. the following parameters have to be passed to the MODBUS driver:

Start: **1921**
Number: **1**
Value: **54**

In this case the value 54 will be directly written into the Word 1921. The timekeeper will be updated with the new minutes value.

Note that the passed value is 54 (decimal), because the register of the minutes, as for all registers related to the timekeeper parameters, needs the BCD format; in facts, 36 in BCD format corresponds to 54 in decimal format.

11.4- Tables for relationship Words-Parameters of MCP 4

The following tables allow to quickly find the number of the MODBUS Word containing the wanted parameter. The following tables are valid if the directive PROTOCOL = (MODBUS) and not PROTOCOL = (MODBUS-) has been used (see description of the PROTOCOL directive). All numbers in the tables are in decimal format. As option, **DUEMMEGI** provides, free of charge, a small program named **WordFinder** which immediately gives the address of the MODBUS Word and the bit (if required) of the wanted parameter. This program can be downloaded fro the site www.duemmegi.it , section Software Support.

11.4.1- Physical inputs

Channel 1:

IN	000	010	020	030	040	050	060	070	080	090	100	110	120
000	-	010	020	030	040	050	060	070	080	090	100	110	120
001	001	011	021	031	041	051	061	071	081	091	101	111	121
002	002	012	022	032	042	052	062	072	082	092	102	112	122
003	003	013	023	033	043	053	063	073	083	093	103	113	123
004	004	014	024	034	044	054	064	074	084	094	104	114	124
005	005	015	025	035	045	055	065	075	085	095	105	115	125
006	006	016	026	036	046	056	066	076	086	096	106	116	126
007	007	017	027	037	047	057	067	077	087	097	107	117	127
008	008	018	028	038	048	058	068	078	088	098	108	118	-
009	009	019	029	039	049	059	069	079	089	099	109	119	-

Channel 2:

IN	000	010	020	030	040	050	060	070	080	090	100	110	120
000	-	138	148	158	168	178	188	198	208	218	228	238	248
001	129	139	149	159	169	179	189	199	209	219	229	239	249
002	130	140	150	160	170	180	190	200	210	220	230	240	250
003	131	141	151	161	171	181	191	201	211	221	231	241	251
004	132	142	152	162	172	182	192	202	212	222	232	242	252
005	133	143	153	163	173	183	193	203	213	223	233	243	253
006	134	144	154	164	174	184	194	204	214	224	234	244	254
007	135	145	155	165	175	185	195	205	215	225	235	245	255
008	136	146	156	166	176	186	196	206	216	226	236	246	-
009	137	147	157	167	177	187	197	207	217	227	237	247	-

Channel 3:

IN	000	010	020	030	040	050	060	070	080	090	100	110	120
000	-	266	276	286	296	306	316	326	336	346	356	366	376
001	257	267	277	287	297	307	317	327	337	347	357	367	377
002	258	268	278	288	298	308	318	328	338	348	358	368	378
003	259	269	279	289	299	309	319	329	339	349	359	369	379
004	260	270	280	290	300	310	320	330	340	350	360	370	380
005	261	271	281	291	301	311	321	331	341	351	361	371	381
006	262	272	282	292	302	312	322	332	342	352	362	372	382
007	263	273	283	293	303	313	323	333	343	353	363	373	383
008	264	274	284	294	304	314	324	334	344	354	364	374	-
009	265	275	285	295	305	315	325	335	345	355	365	375	-

Channel 4:

IN	000	010	020	030	040	050	060	070	080	090	100	110	120
000	-	394	404	414	424	434	444	454	464	474	484	494	504
001	385	395	405	415	425	435	445	455	465	475	485	495	505
002	386	396	406	416	426	436	446	456	466	476	486	496	506
003	387	397	407	417	427	437	447	457	467	477	487	497	507
004	388	398	408	418	428	438	448	458	468	478	488	498	508
005	389	399	409	419	429	439	449	459	469	479	489	499	509
006	390	400	410	420	430	440	450	460	470	480	490	500	510
007	391	401	411	421	431	441	451	461	471	481	491	501	511
008	392	402	412	422	432	442	452	462	472	482	492	502	-
009	393	403	413	423	433	443	453	463	473	483	493	503	-

11.4.2- Physical outputs

Channel 1:

OUT	000	010	020	030	040	050	060	070	080	090	100	110	120
000	-	522	532	542	552	562	572	582	592	602	612	622	632
001	513	523	533	543	553	563	573	583	593	603	613	623	633
002	514	524	534	544	554	564	574	584	594	604	614	624	634
003	515	525	535	545	555	565	575	585	595	605	615	625	635
004	516	526	536	546	556	566	576	586	596	606	616	626	636
005	517	527	537	547	557	567	577	587	597	607	617	627	637
006	518	528	538	548	558	568	578	588	598	608	618	628	638
007	519	529	539	549	559	569	579	589	599	609	619	629	639
008	520	530	540	550	560	570	580	590	600	610	620	630	-
009	521	531	541	551	561	571	581	591	601	611	621	631	-

Channel 2:

OUT	000	010	020	030	040	050	060	070	080	090	100	110	120
000	-	650	660	670	680	690	700	710	720	730	740	750	760
001	641	651	661	671	681	691	701	711	721	731	741	751	761
002	642	652	662	672	682	692	702	712	722	732	742	752	762
003	643	653	663	673	683	693	703	713	723	733	743	753	763
004	644	654	664	674	684	694	704	714	724	734	744	754	764
005	645	655	665	675	685	695	705	715	725	735	745	755	765
006	646	656	666	676	686	696	706	716	726	736	746	756	766
007	647	657	667	677	687	697	707	717	727	737	747	757	767
008	648	658	668	678	688	698	708	718	728	738	748	758	-
009	649	659	669	679	689	699	709	719	729	739	749	759	-

Channel 3:

OUT	000	010	020	030	040	050	060	070	080	090	100	110	120
000	-	778	788	798	808	818	828	838	848	858	868	878	888
001	769	779	789	799	809	819	829	839	849	859	869	879	889
002	770	780	790	800	810	820	830	840	850	860	870	880	890
003	771	781	791	801	811	821	831	841	851	861	871	881	891
004	772	782	792	802	812	822	832	842	852	862	872	882	892
005	773	783	793	803	813	823	833	843	853	863	873	883	893
006	774	784	794	804	814	824	834	844	854	864	874	884	894
007	775	785	795	805	815	825	835	845	855	865	875	885	895
008	776	786	796	806	816	826	836	846	856	866	876	886	-
009	777	787	797	807	817	827	837	847	857	867	877	887	-

Channel 4:

OUT	000	010	020	030	040	050	060	070	080	090	100	110	120
000	-	906	916	926	936	946	956	966	976	986	996	1006	1016
001	897	907	917	927	937	947	957	967	977	987	997	1007	1017
002	898	908	918	928	938	948	958	968	978	988	998	1008	1018
003	899	909	919	929	939	949	959	969	979	989	999	1009	1019
004	900	910	920	930	940	950	960	970	980	990	1000	1010	1020
005	901	911	921	931	941	951	961	971	981	991	1001	1011	1021
006	902	912	922	932	942	952	962	972	982	992	1002	1012	1022
007	903	913	923	933	943	953	963	973	983	993	1003	1013	1023
008	904	914	924	934	944	954	964	974	984	994	1004	1014	-
009	905	915	925	935	945	955	965	975	985	995	1005	1015	-

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11.4.3- Virtual points

W/bit	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168
Bit 0	V1	V17	V33	V49	V65	V81	V97	V113	V129	V145	V161	V177	V193	V209	V225	V241
Bit 1	V2	V18	V34	V50	V66	V82	V98	V114	V130	V146	V162	V178	V194	V210	V226	V242
Bit 2	V3	V19	V35	V51	V67	V83	V99	V115	V131	V147	V163	V179	V195	V211	V227	V243
Bit 3	V4	V20	V36	V52	V68	V84	V100	V116	V132	V148	V164	V180	V196	V212	V228	V244
Bit 4	V5	V21	V37	V53	V69	V85	V101	V117	V133	V149	V165	V181	V197	V213	V229	V245
Bit 5	V6	V22	V38	V54	V70	V86	V102	V118	V134	V150	V166	V182	V198	V214	V230	V246
Bit 6	V7	V23	V39	V55	V71	V87	V103	V119	V135	V151	V167	V183	V199	V215	V231	V247
Bit 7	V8	V24	V40	V56	V72	V88	V104	V120	V136	V152	V168	V184	V200	V216	V232	V248
Bit 8	V9	V25	V41	V57	V73	V89	V105	V121	V137	V153	V169	V185	V201	V217	V233	V249
Bit 9	V10	V26	V42	V58	V74	V90	V106	V122	V138	V154	V170	V186	V202	V218	V234	V250
Bit 10	V11	V27	V43	V59	V75	V91	V107	V123	V139	V155	V171	V187	V203	V219	V235	V251
Bit 11	V12	V28	V44	V60	V76	V92	V108	V124	V140	V156	V172	V188	V204	V220	V236	V252
Bit 12	V13	V29	V45	V61	V77	V93	V109	V125	V141	V157	V173	V189	V205	V221	V237	V253
Bit 13	V14	V30	V46	V62	V78	V94	V110	V126	V142	V158	V174	V190	V206	V222	V238	V254
Bit 14	V15	V31	V47	V63	V79	V95	V111	V127	V143	V159	V175	V191	V207	V223	V239	V255
Bit 15	V16	V32	V48	V64	V80	V96	V112	V128	V144	V160	V176	V192	V208	V224	V240	V256

W/bit	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184
Bit 0	V257	V273	V289	V305	V321	V337	V353	V369	V385	V401	V417	V433	V449	V465	V481	V497
Bit 1	V258	V274	V290	V306	V322	V338	V354	V370	V386	V402	V418	V434	V450	V466	V482	V498
Bit 2	V259	V275	V291	V307	V323	V339	V355	V371	V387	V403	V419	V435	V451	V467	V483	V499
Bit 3	V260	V276	V292	V308	V324	V340	V356	V372	V388	V404	V420	V436	V452	V468	V484	V500
Bit 4	V261	V277	V293	V309	V325	V341	V357	V373	V389	V405	V421	V437	V453	V469	V485	V501
Bit 5	V262	V278	V294	V310	V326	V342	V358	V374	V390	V406	V422	V438	V454	V470	V486	V502
Bit 6	V263	V279	V295	V311	V327	V343	V359	V375	V391	V407	V423	V439	V455	V471	V487	V503
Bit 7	V264	V280	V296	V312	V328	V344	V360	V376	V392	V408	V424	V440	V456	V472	V488	V504
Bit 8	V265	V281	V297	V313	V329	V345	V361	V377	V393	V409	V425	V441	V457	V473	V489	V505
Bit 9	V266	V282	V298	V314	V330	V346	V362	V378	V394	V410	V426	V442	V458	V474	V490	V506
Bit 10	V267	V283	V299	V315	V331	V347	V363	V379	V395	V411	V427	V443	V459	V475	V491	V507
Bit 11	V268	V284	V300	V316	V332	V348	V364	V380	V396	V412	V428	V444	V460	V476	V492	V508
Bit 12	V269	V285	V301	V317	V333	V349	V365	V381	V397	V413	V429	V445	V461	V477	V493	V509
Bit 13	V270	V286	V302	V318	V334	V350	V366	V382	V398	V414	V430	V446	V462	V478	V494	V510
Bit 14	V271	V287	V303	V319	V335	V351	V367	V383	V399	V415	V431	V447	V463	V479	V495	V511
Bit 15	V272	V288	V304	V320	V336	V352	V368	V384	V400	V416	V432	V448	V464	V480	V496	V512

W/bit	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200
Bit 0	V513	V529	V545	V561	V577	V593	V609	V625	V641	V657	V673	V689	V705	V721	V737	V753
Bit 1	V514	V530	V546	V562	V578	V594	V610	V626	V642	V658	V674	V690	V706	V722	V738	V754
Bit 2	V515	V531	V547	V563	V579	V595	V611	V627	V643	V659	V675	V691	V707	V723	V739	V755
Bit 3	V516	V532	V548	V564	V580	V596	V612	V628	V644	V660	V676	V692	V708	V724	V740	V756
Bit 4	V517	V533	V549	V565	V581	V597	V613	V629	V645	V661	V677	V693	V709	V725	V741	V757
Bit 5	V518	V534	V550	V566	V582	V598	V614	V630	V646	V662	V678	V694	V710	V726	V742	V758
Bit 6	V519	V535	V551	V567	V583	V599	V615	V631	V647	V663	V679	V695	V711	V727	V743	V759
Bit 7	V520	V536	V552	V568	V584	V600	V616	V632	V648	V664	V680	V696	V712	V728	V744	V760
Bit 8	V521	V537	V553	V569	V585	V601	V617	V633	V649	V665	V681	V697	V713	V729	V745	V761
Bit 9	V522	V538	V554	V570	V586	V602	V618	V634	V650	V666	V682	V698	V714	V730	V746	V762
Bit 10	V523	V539	V555	V571	V587	V603	V619	V635	V651	V667	V683	V699	V715	V731	V747	V763
Bit 11	V524	V540	V556	V572	V588	V604	V620	V636	V652	V668	V684	V700	V716	V732	V748	V764
Bit 12	V525	V541	V557	V573	V589	V605	V621	V637	V653	V669	V685	V701	V717	V733	V749	V765
Bit 13	V526	V542	V558	V574	V590	V606	V622	V638	V654	V670	V686	V702	V718	V734	V750	V766
Bit 14	V527	V543	V559	V575	V591	V607	V623	V639	V655	V671	V687	V703	V719	V735	V751	V767
Bit 15	V528	V544	V560	V576	V592	V608	V624	V640	V656	V672	V688	V704	V720	V736	V752	V768

W/bit	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216
Bit 0	V769	V785	V801	V817	V833	V849	V865	V881	V897	V913	V929	V945	V961	V977	V993	V1009
Bit 1	V770	V786	V802	V818	V834	V850	V866	V882	V898	V914	V930	V946	V962	V978	V994	V1010
Bit 2	V771	V787	V803	V819	V835	V851	V867	V883	V899	V915	V931	V947	V963	V979	V995	V1011
Bit 3	V772	V788	V804	V820	V836	V852	V868	V884	V900	V916	V932	V948	V964	V980	V996	V1012
Bit 4	V773	V789	V805	V821	V837	V853	V869	V885	V901	V917	V933	V949	V965	V981	V997	V1013
Bit 5	V774	V790	V806	V822	V838	V854	V870	V886	V902	V918	V934	V950	V966	V982	V998	V1014
Bit 6	V775	V791	V807	V823	V839	V855	V871	V887	V903	V919	V935	V951	V967	V983	V999	V1015
Bit 7	V776	V792	V808	V824	V840	V856	V872	V888	V904	V920	V936	V952	V968	V984	V1000	V1016
Bit 8	V777	V793	V809	V825	V841	V857	V873	V889	V905	V921	V937	V953	V969	V985	V1001	V1017
Bit 9	V778	V794	V810	V826	V842	V858	V874	V890	V906	V922	V938	V954	V970	V986	V1002	V1018
Bit 10	V779	V795	V811	V827	V843	V859	V875	V891	V907	V923	V939	V955	V971	V987	V1003	V1019
Bit 11	V780	V796	V812	V828	V844	V860	V876	V892	V908	V924	V940	V956	V972	V988	V1004	V1020
Bit 12	V781	V797	V813	V829	V845	V861	V877	V893	V909	V925	V941	V957	V973	V989	V1005	V1021
Bit 13	V782	V798	V814	V830	V846	V862	V878	V894	V910	V926	V942	V958	V974	V990	V1006	V1022
Bit 14	V783	V799	V815	V831	V847	V863	V879	V895	V911	V927	V943	V959	V975	V991	V1007	V1023
Bit 15	V784	V800	V816	V832	V848	V864	V880	V896	V912	V928	V944	V960	V976	V992	V1008	V1024

W/bit	1217	1218	1219	1220	1221	1222	1223	1224	1225	1226	1227	1228	1229	1230	1231	1232
Bit 0	V1025	V1041	V1057	V1073	V1089	V1105	V1121	V1137	V1153	V1169	V1185	V1201	V1217	V1233	V1249	V1265
Bit 1	V1026	V1042	V1058	V1074	V1090	V1106	V1122	V1138	V1154	V1170	V1186	V1202	V1218	V1234	V1250	V1266
Bit 2	V1027	V1043	V1059	V1075	V1091	V1107	V1123	V1139	V1155	V1171	V1187	V1203	V1219	V1235	V1251	V1267
Bit 3	V1028	V1044	V1060	V1076	V1092	V1108	V1124	V1140	V1156	V1172	V1188	V1204	V1220	V1236	V1252	V1268
Bit 4	V1029	V1045	V1061	V1077	V1093	V1109	V1125	V1141	V1157	V1173	V1189	V1205	V1221	V1237	V1253	V1269
Bit 5	V1030	V1046	V1062	V1078	V1094	V1110	V1126	V1142	V1158	V1174	V1190	V1206	V1222	V1238	V1254	V1270
Bit 6	V1031	V1047	V1063	V1079	V1095	V1111	V1127	V1143	V1159	V1175	V1191	V1207	V1223	V1239	V1255	V1271
Bit 7	V1032	V1048	V1064	V1080	V1096	V1112	V1128	V1144	V1160	V1176	V1192	V1208	V1224	V1240	V1256	V1272
Bit 8	V1033	V1049	V1065	V1081	V1097	V1113	V1129	V1145	V1161	V1177	V1193	V1209	V1225	V1241	V1257	V1273
Bit 9	V1034	V1050	V1066	V1082	V1098	V1114	V1130	V1146	V1162	V1178	V1194	V1210	V1226	V1242	V1258	V1274
Bit 10	V1035	V1051	V1067	V1083	V1099	V1115	V1131	V1147	V1163	V1179	V1195	V1211	V1227	V1243	V1259	V1275
Bit 11	V1036	V1052	V1068	V1084	V1100	V1116	V1132	V1148	V1164	V1180	V1196	V1212	V1228	V1244	V1260	V1276
Bit 12	V1037	V1053	V1069	V1085	V1101	V1117	V1133	V1149	V1165	V1181	V1197	V1213	V1229	V1245	V1261	V1277
Bit 13	V1038	V1054	V1070	V1086	V1102	V1118	V1134	V1150	V1166	V1182	V1198	V1214	V1230	V1246	V1262	V1278
Bit 14	V1039	V1055	V1071	V1087	V1103	V1119	V1135	V1151	V1167	V1183	V1199	V1215	V1231	V1247	V1263	V1279
Bit 15	V1040	V1056	V1072	V1088	V1104	V1120	V1136	V1152	V1168	V1184	V1200	V1216	V1232	V1248	V1264	V1280

W/bit	1233	1234	1235	1236	1237	1238	1239	1240	1241	1242	1243	1244	1245	1246	1247	1248
Bit 0	V1281	V1297	V1313	V1329	V1345	V1361	V1377	V1393	V1409	V1425	V1441	V1457	V1473	V1489	V1505	V1521
Bit 1	V1282	V1298	V1314	V1330	V1346	V1362	V1378	V1394	V1410	V1426	V1442	V1458	V1474	V1490	V1506	V1522
Bit 2	V1283	V1299	V1315	V1331	V1347	V1363	V1379	V1395	V1411	V1427	V1443	V1459	V1475	V1491	V1507	V1523
Bit 3	V1284	V1300	V1316	V1332	V1348	V1364	V1380	V1396	V1412	V1428	V1444	V1460	V1476	V1492	V1508	V1524
Bit 4	V1285	V1301	V1317	V1333	V1349	V1365	V1381	V1397	V1413	V1429	V1445	V1461	V1477	V1493	V1509	V1525
Bit 5	V1286	V1302	V1318	V1334	V1350	V1366	V1382	V1398	V1414	V1430	V1446	V1462	V1478	V1494	V1510	V1526
Bit 6	V1287	V1303	V1319	V1335	V1351	V1367	V1383	V1399	V1415	V1431	V1447	V1463	V1479	V1495	V1511	V1527
Bit 7	V1288	V1304	V1320	V1336	V1352	V1368	V1384	V1400	V1416	V1432	V1448	V1464	V1480	V1496	V1512	V1528
Bit 8	V1289	V1305	V1321	V1337	V1353	V1369	V1385	V1401	V1417	V1433	V1449	V1465	V1481	V1497	V1513	V1529
Bit 9	V1290	V1306	V1322	V1338	V1354	V1370	V1386	V1402	V1418	V1434	V1450	V1466	V1482	V1498	V1514	V1530
Bit 10	V1291	V1307	V1323	V1339	V1355	V1371	V1387	V1403	V1419	V1435	V1451	V1467	V1483	V1499	V1515	V1531
Bit 11	V1292	V1308	V1324	V1340	V1356	V1372	V1388	V1404	V1420	V1436	V1452	V1468	V1484	V1500	V1516	V1532
Bit 12	V1293	V1309	V1325	V1341	V1357	V1373	V1389	V1405	V1421	V1437	V1453	V1469	V1485	V1501	V1517	V1533
Bit 13	V1294	V1310	V1326	V1342	V1358	V1374	V1390	V1406	V1422	V1438	V1454	V1470	V1486	V1502	V1518	V1534
Bit 14	V1295	V1311	V1327	V1343	V1359	V1375	V1391	V1407	V1423	V1439	V1455	V1471	V1487	V1503	V1519	V1535
Bit 15	V1296	V1312	V1328	V1344	V1360	V1376	V1392	V1408	V1424	V1440	V1456	V1472	V1488	V1504	V1520	V1536

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W/bit	1249	1250	1251	1252	1253	1254	1255	1256	1257	1258	1259	1260	1261	1262	1263	1264
Bit 0	V1537	V1553	V1569	V1585	V1601	V1617	V1633	V1649	V1665	V1681	V1697	V1713	V1729	V1745	V1761	V1777
Bit 1	V1538	V1554	V1570	V1586	V1602	V1618	V1634	V1650	V1666	V1682	V1698	V1714	V1730	V1746	V1762	V1778
Bit 2	V1539	V1555	V1571	V1587	V1603	V1619	V1635	V1651	V1667	V1683	V1699	V1715	V1731	V1747	V1763	V1779
Bit 3	V1540	V1556	V1572	V1588	V1604	V1620	V1636	V1652	V1668	V1684	V1700	V1716	V1732	V1748	V1764	V1780
Bit 4	V1541	V1557	V1573	V1589	V1605	V1621	V1637	V1653	V1669	V1685	V1701	V1717	V1733	V1749	V1765	V1781
Bit 5	V1542	V1558	V1574	V1590	V1606	V1622	V1638	V1654	V1670	V1686	V1702	V1718	V1734	V1750	V1766	V1782
Bit 6	V1543	V1559	V1575	V1591	V1607	V1623	V1639	V1655	V1671	V1687	V1703	V1719	V1735	V1751	V1767	V1783
Bit 7	V1544	V1560	V1576	V1592	V1608	V1624	V1640	V1656	V1672	V1688	V1704	V1720	V1736	V1752	V1768	V1784
Bit 8	V1545	V1561	V1577	V1593	V1609	V1625	V1641	V1657	V1673	V1689	V1705	V1721	V1737	V1753	V1769	V1785
Bit 9	V1546	V1562	V1578	V1594	V1610	V1626	V1642	V1658	V1674	V1690	V1706	V1722	V1738	V1754	V1770	V1786
Bit 10	V1547	V1563	V1579	V1595	V1611	V1627	V1643	V1659	V1675	V1691	V1707	V1723	V1739	V1755	V1771	V1787
Bit 11	V1548	V1564	V1580	V1596	V1612	V1628	V1644	V1660	V1676	V1692	V1708	V1724	V1740	V1756	V1772	V1788
Bit 12	V1549	V1565	V1581	V1597	V1613	V1629	V1645	V1661	V1677	V1693	V1709	V1725	V1741	V1757	V1773	V1789
Bit 13	V1550	V1566	V1582	V1598	V1614	V1630	V1646	V1662	V1678	V1694	V1710	V1726	V1742	V1758	V1774	V1790
Bit 14	V1551	V1567	V1583	V1599	V1615	V1631	V1647	V1663	V1679	V1695	V1711	V1727	V1743	V1759	V1775	V1791
Bit 15	V1552	V1568	V1584	V1600	V1616	V1632	V1648	V1664	V1680	V1696	V1712	V1728	V1744	V1760	V1776	V1792

W/bit	1265	1266	1267	1268	1269	1270	1271	1272	1273	1274	1275	1276	1277	1278	1279
Bit 0	V1793	V1809	V1825	V1841	V1857	V1873	V1889	V1905	V1921	V1937	V1953	V1969	V1985	V2001	V2017
Bit 1	V1794	V1810	V1826	V1842	V1858	V1874	V1890	V1906	V1922	V1938	V1954	V1970	V1986	V2002	V2018
Bit 2	V1795	V1811	V1827	V1843	V1859	V1875	V1891	V1907	V1923	V1939	V1955	V1971	V1987	V2003	V2019
Bit 3	V1796	V1812	V1828	V1844	V1860	V1876	V1892	V1908	V1924	V1940	V1956	V1972	V1988	V2004	V2020
Bit 4	V1797	V1813	V1829	V1845	V1861	V1877	V1893	V1909	V1925	V1941	V1957	V1973	V1989	V2005	V2021
Bit 5	V1798	V1814	V1830	V1846	V1862	V1878	V1894	V1910	V1926	V1942	V1958	V1974	V1990	V2006	V2022
Bit 6	V1799	V1815	V1831	V1847	V1863	V1879	V1895	V1911	V1927	V1943	V1959	V1975	V1991	V2007	V2023
Bit 7	V1800	V1816	V1832	V1848	V1864	V1880	V1896	V1912	V1928	V1944	V1960	V1976	V1992	V2008	V2024
Bit 8	V1801	V1817	V1833	V1849	V1865	V1881	V1897	V1913	V1929	V1945	V1961	V1977	V1993	V2009	V2025
Bit 9	V1802	V1818	V1834	V1850	V1866	V1882	V1898	V1914	V1930	V1946	V1962	V1978	V1994	V2010	V2026
Bit 10	V1803	V1819	V1835	V1851	V1867	V1883	V1899	V1915	V1931	V1947	V1963	V1979	V1995	V2011	V2027
Bit 11	V1804	V1820	V1836	V1852	V1868	V1884	V1900	V1916	V1932	V1948	V1964	V1980	V1996	V2012	V2028
Bit 12	V1805	V1821	V1837	V1853	V1869	V1885	V1901	V1917	V1933	V1949	V1965	V1981	V1997	V2013	V2029
Bit 13	V1806	V1822	V1838	V1854	V1870	V1886	V1902	V1918	V1934	V1950	V1966	V1982	V1998	V2014	V2030
Bit 14	V1807	V1823	V1839	V1855	V1871	V1887	V1903	V1919	V1935	V1951	V1967	V1983	V1999	V2015	V2031
Bit 15	V1808	V1824	V1840	V1856	V1872	V1888	V1904	V1920	V1936	V1952	V1968	V1984	V2000	V2016	V2032

11.4.4- Registers

R	000	010	020	030	040	050	060	070	080	090	100	110	120	130	140	150
000	2048	2058	2068	2078	2088	2098	2108	2118	2128	2138	2148	2158	2168	2178	2188	2198
001	2049	2059	2069	2079	2089	2099	2109	2119	2129	2139	2149	2159	2169	2179	2189	2199
002	2050	2060	2070	2080	2090	2100	2110	2120	2130	2140	2150	2160	2170	2180	2190	2200
003	2051	2061	2071	2081	2091	2101	2111	2121	2131	2141	2151	2161	2171	2181	2191	2201
004	2052	2062	2072	2082	2092	2102	2112	2122	2132	2142	2152	2162	2172	2182	2192	2202
005	2053	2063	2073	2083	2093	2103	2113	2123	2133	2143	2153	2163	2173	2183	2193	2203
006	2054	2064	2074	2084	2094	2104	2114	2124	2134	2144	2154	2164	2174	2184	2194	2204
007	2055	2065	2075	2085	2095	2105	2115	2125	2135	2145	2155	2165	2175	2185	2195	2205
008	2056	2066	2076	2086	2096	2106	2116	2126	2136	2146	2156	2166	2176	2186	2196	2206
009	2057	2067	2077	2087	2097	2107	2117	2127	2137	2147	2157	2167	2177	2187	2197	2207

R	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310
000	2208	2218	2228	2238	2248	2258	2268	2278	2288	2298	2308	2318	2328	2338	2348	2358
001	2209	2219	2229	2239	2249	2259	2269	2279	2289	2299	2309	2319	2329	2339	2349	2359
002	2210	2220	2230	2240	2250	2260	2270	2280	2290	2300	2310	2320	2330	2340	2350	2360
003	2211	2221	2231	2241	2251	2261	2271	2281	2291	2301	2311	2321	2331	2341	2351	2361
004	2212	2222	2232	2242	2252	2262	2272	2282	2292	2302	2312	2322	2332	2342	2352	2362
005	2213	2223	2233	2243	2253	2263	2273	2283	2293	2303	2313	2323	2333	2343	2353	2363
006	2214	2224	2234	2244	2254	2264	2274	2284	2294	2304	2314	2324	2334	2344	2354	2364
007	2215	2225	2235	2245	2255	2265	2275	2285	2295	2305	2315	2325	2335	2345	2355	2365
008	2216	2226	2236	2246	2256	2266	2276	2286	2296	2306	2316	2326	2336	2346	2356	2366
009	2217	2227	2237	2247	2257	2267	2277	2287	2297	2307	2317	2327	2337	2347	2357	2367

R	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470
000	2368	2378	2388	2398	2408	2418	2428	2438	2448	2458	2468	2478	2488	2498	2508	2518
001	2369	2379	2389	2399	2409	2419	2429	2439	2449	2459	2469	2479	2489	2499	2509	2519
002	2370	2380	2390	2400	2410	2420	2430	2440	2450	2460	2470	2480	2490	2500	2510	2520
003	2371	2381	2391	2401	2411	2421	2431	2441	2451	2461	2471	2481	2491	2501	2511	2521
004	2372	2382	2392	2402	2412	2422	2432	2442	2452	2462	2472	2482	2492	2502	2512	2522
005	2373	2383	2393	2403	2413	2423	2433	2443	2453	2463	2473	2483	2493	2503	2513	2523
006	2374	2384	2394	2404	2414	2424	2434	2444	2454	2464	2474	2484	2494	2504	2514	2524
007	2375	2385	2395	2405	2415	2425	2435	2445	2455	2465	2475	2485	2495	2505	2515	2525
008	2376	2386	2396	2406	2416	2426	2436	2446	2456	2466	2476	2486	2496	2506	2516	2526
009	2377	2387	2397	2407	2417	2427	2437	2447	2457	2467	2477	2487	2497	2507	2517	2527

R	480	490	500	510	520	530	540	550	560	570	580	590	600	610	620	630
000	2528	2538	2548	2558	2568	2578	2588	2598	2608	2618	2628	2638	2648	2658	2668	2678
001	2529	2539	2549	2559	2569	2579	2589	2599	2609	2619	2629	2639	2649	2659	2669	2679
002	2530	2540	2550	2560	2570	2580	2590	2600	2610	2620	2630	2640	2650	2660	2670	2680
003	2531	2541	2551	2561	2571	2581	2591	2601	2611	2621	2631	2641	2651	2661	2671	2681
004	2532	2542	2552	2562	2572	2582	2592	2602	2612	2622	2632	2642	2652	2662	2672	2682
005	2533	2543	2553	2563	2573	2583	2593	2603	2613	2623	2633	2643	2653	2663	2673	2683
006	2534	2544	2554	2564	2574	2584	2594	2604	2614	2624	2634	2644	2654	2664	2674	2684
007	2535	2545	2555	2565	2575	2585	2595	2605	2615	2625	2635	2645	2655	2665	2675	2685
008	2536	2546	2556	2566	2576	2586	2596	2606	2616	2626	2636	2646	2656	2666	2676	2686
009	2537	2547	2557	2567	2577	2587	2597	2607	2617	2627	2637	2647	2657	2667	2677	2687

R	640	650	660	670	680	690	700	710	720	730	740	750	760	770	780	790
000	2688	2698	2708	2718	2728	2738	2748	2758	2768	2778	2788	2798	2808	2818	2828	2838
001	2689	2699	2709	2719	2729	2739	2749	2759	2769	2779	2789	2799	2809	2819	2829	2839
002	2690	2700	2710	2720	2730	2740	2750	2760	2770	2780	2790	2800	2810	2820	2830	2840
003	2691	2701	2711	2721	2731	2741	2751	2761	2771	2781	2791	2801	2811	2821	2831	2841
004	2692	2702	2712	2722	2732	2742	2752	2762	2772	2782	2792	2802	2812	2822	2832	2842
005	2693	2703	2713	2723	2733	2743	2753	2763	2773	2783	2793	2803	2813	2823	2833	2843
006	2694	2704	2714	2724	2734	2744	2754	2764	2774	2784	2794	2804	2814	2824	2834	2844
007	2695	2705	2715	2725	2735	2745	2755	2765	2775	2785	2795	2805	2815	2825	2835	2845
008	2696	2706	2716	2726	2736	2746	2756	2766	2776	2786	2796	2806	2816	2826	2836	2846
009	2697	2707	2717	2727	2737	2747	2757	2767	2777	2787	2797	2807	2817	2827	2837	2847

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R	800	810	820	830	840	850	860	870	880	890	900	910	920	930	940	950
000	2848	2858	2868	2878	2888	2898	2908	2918	2928	2938	2948	2958	2968	2978	2988	2998
001	2849	2859	2869	2879	2889	2899	2909	2919	2929	2939	2949	2959	2969	2979	2989	2999
002	2850	2860	2870	2880	2890	2900	2910	2920	2930	2940	2950	2960	2970	2980	2990	3000
003	2851	2861	2871	2881	2891	2901	2911	2921	2931	2941	2951	2961	2971	2981	2991	3001
004	2852	2862	2872	2882	2892	2902	2912	2922	2932	2942	2952	2962	2972	2982	2992	3002
005	2853	2863	2873	2883	2893	2903	2913	2923	2933	2943	2953	2963	2973	2983	2993	3003
006	2854	2864	2874	2884	2894	2904	2914	2924	2934	2944	2954	2964	2974	2984	2994	3004
007	2855	2865	2875	2885	2895	2905	2915	2925	2935	2945	2955	2965	2975	2985	2995	3005
008	2856	2866	2876	2886	2896	2906	2916	2926	2936	2946	2956	2966	2976	2986	2996	3006
009	2857	2867	2877	2887	2897	2907	2917	2927	2937	2947	2957	2967	2977	2987	2997	3007

R	960	970	980	990	1000	1010	1020
000	3008	3018	3028	3038	3048	3058	3068
001	3009	3019	3029	3039	3049	3059	3069
002	3010	3020	3030	3040	3050	3060	3070
003	3011	3021	3031	3041	3051	3061	3071
004	3012	3022	3032	3042	3052	3062	-
005	3013	3023	3033	3043	3053	3063	-
006	3014	3024	3034	3044	3054	3064	-
007	3015	3025	3035	3045	3055	3065	-
008	3016	3026	3036	3046	3056	3066	-
009	3017	3027	3037	3047	3057	3067	-

11.4.5- Counters

C	000	010	020	030	040	050	060	070	080	090	100	110	120	130	140	150
000	3072	3082	3092	3102	3112	3122	3132	3142	3152	3162	3172	3182	3192	3202	3212	3222
001	3073	3083	3093	3103	3113	3123	3133	3143	3153	3163	3173	3183	3193	3203	3213	3223
002	3074	3084	3094	3104	3114	3124	3134	3144	3154	3164	3174	3184	3194	3204	3214	3224
003	3075	3085	3095	3105	3115	3125	3135	3145	3155	3165	3175	3185	3195	3205	3215	3225
004	3076	3086	3096	3106	3116	3126	3136	3146	3156	3166	3176	3186	3196	3206	3216	3226
005	3077	3087	3097	3107	3117	3127	3137	3147	3157	3167	3177	3187	3197	3207	3217	3227
006	3078	3088	3098	3108	3118	3128	3138	3148	3158	3168	3178	3188	3198	3208	3218	3228
007	3079	3089	3099	3109	3119	3129	3139	3149	3159	3169	3179	3189	3199	3209	3219	3229
008	3080	3090	3100	3110	3120	3130	3140	3150	3160	3170	3180	3190	3200	3210	3220	3230
009	3081	3091	3101	3111	3121	3131	3141	3151	3161	3171	3181	3191	3201	3211	3221	3231

C	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310
000	3232	3242	3252	3262	3272	3282	3292	3302	3312	3322	3332	3342	3352	3362	3372	3382
001	3233	3243	3253	3263	3273	3283	3293	3303	3313	3323	3333	3343	3353	3363	3373	3383
002	3234	3244	3254	3264	3274	3284	3294	3304	3314	3324	3334	3344	3354	3364	3374	3384
003	3235	3245	3255	3265	3275	3285	3295	3305	3315	3325	3335	3345	3355	3365	3375	3385
004	3236	3246	3256	3266	3276	3286	3296	3306	3316	3326	3336	3346	3356	3366	3376	3386
005	3237	3247	3257	3267	3277	3287	3297	3307	3317	3327	3337	3347	3357	3367	3377	3387
006	3238	3248	3258	3268	3278	3288	3298	3308	3318	3328	3338	3348	3358	3368	3378	3388
007	3239	3249	3259	3269	3279	3289	3299	3309	3319	3329	3339	3349	3359	3369	3379	3389
008	3240	3250	3260	3270	3280	3290	3300	3310	3320	3330	3340	3350	3360	3370	3380	3390
009	3241	3251	3261	3271	3281	3291	3301	3311	3321	3331	3341	3351	3361	3371	3381	3391

C	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470
000	3392	3402	3412	3422	3432	3442	3452	3462	3472	3482	3492	3502	3512	3522	3532	3542
001	3393	3403	3413	3423	3433	3443	3453	3463	3473	3483	3493	3503	3513	3523	3533	3543
002	3394	3404	3414	3424	3434	3444	3454	3464	3474	3484	3494	3504	3514	3524	3534	3544
003	3395	3405	3415	3425	3435	3445	3455	3465	3475	3485	3495	3505	3515	3525	3535	3545
004	3396	3406	3416	3426	3436	3446	3456	3466	3476	3486	3496	3506	3516	3526	3536	3546
005	3397	3407	3417	3427	3437	3447	3457	3467	3477	3487	3497	3507	3517	3527	3537	3547
006	3398	3408	3418	3428	3438	3448	3458	3468	3478	3488	3498	3508	3518	3528	3538	3548
007	3399	3409	3419	3429	3439	3449	3459	3469	3479	3489	3499	3509	3519	3529	3539	3549
008	3400	3410	3420	3430	3440	3450	3460	3470	3480	3490	3500	3510	3520	3530	3540	3550
009	3401	3411	3421	3431	3441	3451	3461	3471	3481	3491	3501	3511	3521	3531	3541	3551

C	480	490	500	510	520	530	540	550	560	570	580	590	600	610	620	630
000	3552	3562	3572	3582	3592	3602	3612	3622	3632	3642	3652	3662	3672	3682	3692	3702
001	3553	3563	3573	3583	3593	3603	3613	3623	3633	3643	3653	3663	3673	3683	3693	3703
002	3554	3564	3574	3584	3594	3604	3614	3624	3634	3644	3654	3664	3674	3684	3694	3704
003	3555	3565	3575	3585	3595	3605	3615	3625	3635	3645	3655	3665	3675	3685	3695	3705
004	3556	3566	3576	3586	3596	3606	3616	3626	3636	3646	3656	3666	3676	3686	3696	3706
005	3557	3567	3577	3587	3597	3607	3617	3627	3637	3647	3657	3667	3677	3687	3697	3707
006	3558	3568	3578	3588	3598	3608	3618	3628	3638	3648	3658	3668	3678	3688	3698	3708
007	3559	3569	3579	3589	3599	3609	3619	3629	3639	3649	3659	3669	3679	3689	3699	3709
008	3560	3570	3580	3590	3600	3610	3620	3630	3640	3650	3660	3670	3680	3690	3700	3710
009	3561	3571	3581	3591	3601	3611	3621	3631	3641	3651	3661	3671	3681	3691	3701	3711

C	640	650	660	670	680	690	700	710	720	730	740	750	760	770	780	790
000	3712	3722	3732	3742	3752	3762	3772	3782	3792	3802	3812	3822	3832	3842	3852	3862
001	3713	3723	3733	3743	3753	3763	3773	3783	3793	3803	3813	3823	3833	3843	3853	3863
002	3714	3724	3734	3744	3754	3764	3774	3784	3794	3804	3814	3824	3834	3844	3854	3864
003	3715	3725	3735	3745	3755	3765	3775	3785	3795	3805	3815	3825	3835	3845	3855	3865
004	3716	3726	3736	3746	3756	3766	3776	3786	3796	3806	3816	3826	3836	3846	3856	3866
005	3717	3727	3737	3747	3757	3767	3777	3787	3797	3807	3817	3827	3837	3847	3857	3867
006	3718	3728	3738	3748	3758	3768	3778	3788	3798	3808	3818	3828	3838	3848	3858	3868
007	3719	3729	3739	3749	3759	3769	3779	3789	3799	3809	3819	3829	3839	3849	3859	3869
008	3720	3730	3740	3750	3760	3770	3780	3790	3800	3810	3820	3830	3840	3850	3860	3870
009	3721	3731	3741	3751	3761	3771	3781	3791	3801	3811	3821	3831	3841	3851	3861	3871

C	800	810	820	830	840	850	860	870	880	890	900	910	920	930	940	950
000	3872	3882	3892	3902	3912	3922	3932	3942	3952	3962	3972	3982	3992	4002	4012	4022
001	3873	3883	3893	3903	3913	3923	3933	3943	3953	3963	3973	3983	3993	4003	4013	4023
002	3874	3884	3894	3904	3914	3924	3934	3944	3954	3964	3974	3984	3994	4004	4014	4024
003	3875	3885	3895	3905	3915	3925	3935	3945	3955	3965	3975	3985	3995	4005	4015	4025
004	3876	3886	3896	3906	3916	3926	3936	3946	3956	3966	3976	3986	3996	4006	4016	4026
005	3877	3887	3897	3907	3917	3927	3937	3947	3957	3967	3977	3987	3997	4007	4017	4027
006	3878	3888	3898	3908	3918	3928	3938	3948	3958	3968	3978	3988	3998	4008	4018	4028
007	3879	3889	3899	3909	3919	3929	3939	3949	3959	3969	3979	3989	3999	4009	4019	4029
008	3880	3890	3900	3910	3920	3930	3940	3950	3960	3970	3980	3990	4000	4010	4020	4030
009	3881	3891	3901	3911	3921	3931	3941	3951	3961	3971	3981	3991	4001	4011	4021	4031

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C	960	970	980	990	1000	1010	1020
000	4032	4042	4052	4062	4072	4082	4092
001	4033	4043	4053	4063	4073	4083	4093
002	4034	4044	4054	4064	4074	4084	4094
003	4035	4045	4055	4065	4075	4085	4095
004	4036	4046	4056	4066	4076	4086	-
005	4037	4047	4057	4067	4077	4087	-
006	4038	4048	4058	4068	4078	4088	-
007	4039	4049	4059	4069	4079	4089	-
008	4040	4050	4060	4070	4080	4090	-
009	4041	4051	4061	4071	4081	4091	-