

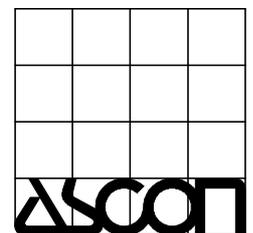
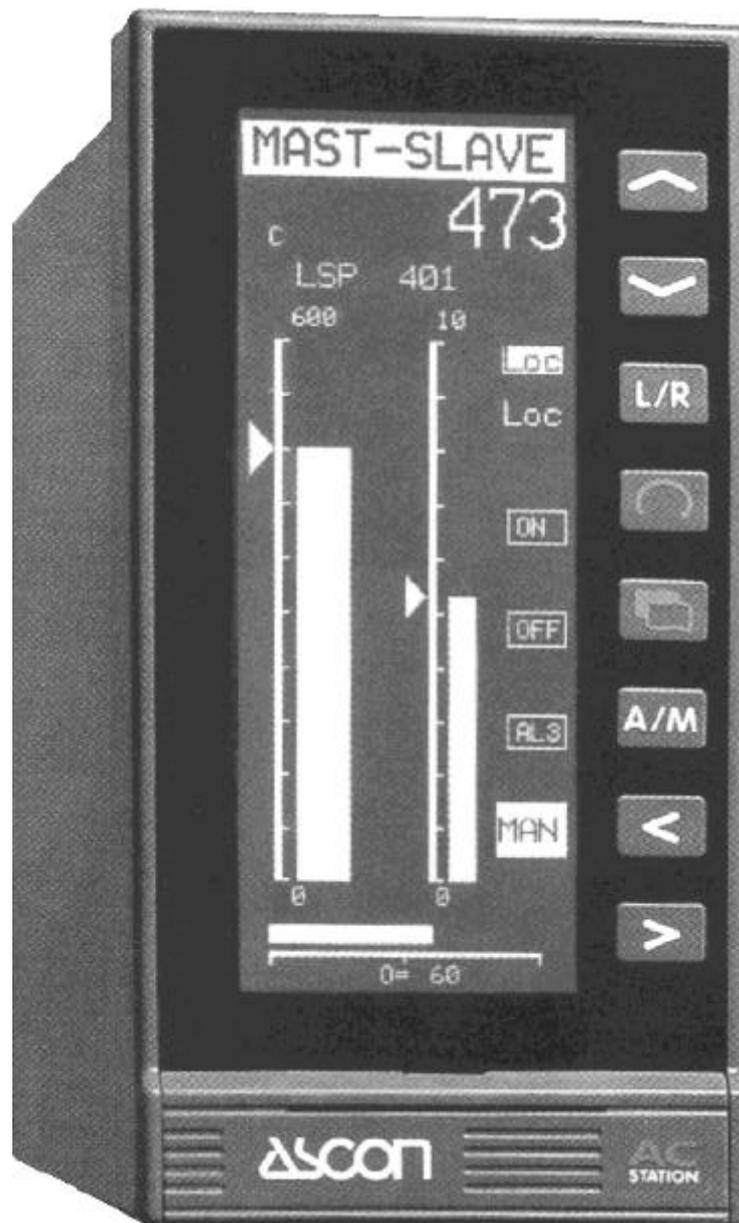
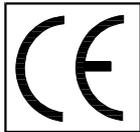


# Multifunction Programmable Controller Installation and User manual of the AC10 - AC20 - AC30 controller

USER MANUAL  
M.I.U. ACMO – 11 / 00 - 03  
Cod. J30 - 304 - 1AMIAC-ING



UNI EN ISO 9001



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# *I N T R O D U C T I O N*

Congratulation for having chosen an ASCON instruments.

This instruction manual is dedicated to the Multifunction Controllers:

Model AC 10 - with 4 loops, preconfigured, with simple functionality.

Model AC 20 - with 4 loops, custom configurable by mean of a PC.

Model AC 30 - Programmer, with Real Time Clock, 4 loops, custom configurable by mean of a PC.

## *N O T E :*

- A)** Be sure that this manual is available to the user of the instrument.
- B)** The manual refers to a family of multifunction controllers, suitable for panel mounting and supplied with high innovative graphic display. This effective user interface provides a huge amount of quality information, the user perceive more immediately than other technologies.
- C)** The configuration software for the AC20 and AC30 controllers, is supplied on floppy disks. You must keep the original disks in a safe place. Any copy of this software for purposes different than the configuration of the ASCON AC series controllers, is forbidden. The use of the software is regulated by the licence agreement provided by the Supplier.
- D)** Package contents verification. When you open the package of an AC10, AC20 o AC30 multifunction controller, check that all the items correspond to the packing list below. If an item is missed or damaged, you must contact the nearest ASCON sales office.
  - 1) AC station
  - 2) Mounting clamps
  - 3) User and Installation manual (consisting of this book)
  - 4) Communication manual

# MULTIFUNCTION PROGRAMMABLE CONTROLLER

## 1. General information

### 1.1 Main differences between AC10, AC20 and AC30

The AC series controllers are supplied in the following 3 versions:

**AC10** 4 control loops, 4 analog inputs, 4 analog outputs, 8 digital I/O, with 12 control strategies, stored in the instrument memory and executed upon command from the front panel.

The parametrisation of the controller is performed through one of the following 3 ways: directly from the instrument panel, through the serial comm Main Com and by mean of the AC-Prograph/AC-Edit running on Windows.

**AC20** 4 control loops, 8 analog inputs, 4 analog outputs, 8 digital I/O, with 12 control strategies, stored in the instrument memory and recalled from the front panel.

The parametrisation of the controller is performed through one of the following 3 ways: directly from the instrument panel, through the serial comm Main Com and by mean of the AC-Prograph/AC-Edit running on Windows. Beyond the AC10 characteristics, this version offers the feature of custom defined strategies, defined by mean of the AC\_PROGRAPH software, running on a Windows PC.

**AC30** 4 control loops, 8 analog inputs, 4 analog outputs, 8 digital I/O and Real Time Clock with 12 control strategies, stored in the instrument memory and recalled from the front panel.

The parametrisation of the controller is performed through one of the following 3 ways: directly from the instrument panel, through the serial comm Main Com and by mean of the AC-Prograph/AC-Edit running on Windows. Beyond the AC20 characteristics, this version offers the feature of Setpoints Programmers, generating time dependant setpoint profiles and time sequenced digital outputs.

### 1.2 Technical specification

#### 1.2.1 I/O maximum capabilities

Analog Inputs(AI)	N° 8 ( N° 4 only for AC10 )
Analog Outputs (AO)	N° 4
Logic Inputs (DI)	N° 8
Frequency Input	N° 1 ( AC20 and AC30 )
Logic Outputs(DO)	N° 8
Main Comm RS 485	N° 1
Aux Comm RS 485	N° 1 ( only for AC20 and AC30 )
Serial port RS 232	N° 1
ARCNET LAN	N° 1 ( only for AC20 and AC30 )

*Analog Inputs(AI)* Voltage input, with range 0-5 V or 1-5 V cc, software selectable.  
Current input, with range AI 0-20 mA or 4-20 mA, with external 250  $\Omega$  burden resistors. 16 bit A/D conversion resolution.  
Input impedance (DC)  $\geq$  1000 M $\Omega$ .

*Frequency Input* This feature is provided on the D1 input of the AC20 and AC30 controllers, only.  
Minimum input signal amplitude: 8Vpp. Input

	<p>ranges: 0.01 - 200 Hz, 0.1 - 2000 Hz, 1 - 20 KHz.</p> <p>When the range 0.01-200 Hz is selected, an antibounce filter of 1.5 ms. is automatically inserted on the input signal.</p>
<i>Analog Output (AO)</i>	<p>Ranges: 0-5 V, 1-5 V, 0- 20 mA, 4-20 mA, software selectable.</p> <p>Output load drive:</p> <ul style="list-style-type: none"> <li>- 500 <math>\Omega</math> minimum for voltage output.</li> <li>- 500 <math>\Omega</math> maximum for current output.</li> </ul> <p>Resolution <math>\cong</math> 13 bit.</p>
<i>Logic Inputs (DI)</i>	<p>Input range: 24 VDC ( min 8 VDC, max. 36 VDC, for logic "1" ).</p> <p>Optoisolated , current sinking, 4700 <math>\Omega</math> input impedance.</p> <p>bidirectional (no polarity), driven both by positive and negative voltages.</p>
<i>Logic Outputs (DO)</i>	<p>Output level: 24 V cc/ca, max. 36 V cc/ca, Maximum current: 300 mA.</p> <p>Normally open output.</p> <p>Protection against surges and short circuits through automatically armed fuses.</p>
<i>Serial Communication</i>	<p>RS485 port (Main Com) to a Supervisory Computer.</p> <p>Protocol supported: MODBUS RTU.</p> <p>Line length: 1200 metres maximum.</p> <p>Units per line: 32 controllers with twisted pair cable and 120 <math>\Omega</math> termination resistors.</p> <p>Transmission rate:19200 baud.</p> <p>RS485 Port (Aux Com) to Expansion Units or to a computer for the backup of the data. Galvanic isolated from the controller I/O signal (AC20 and AC30 only).</p> <p>RS232 Port (programming Port) to a computer, running the AC-Prograph (AC20 and AC30), for the design and the test of control strategies, or running AC_EDIT, for saving of the strategy parameters (AC10, AC20 and AC30).</p>
<i>Failure Digital Output (DO)</i>	<p>Configurable.</p>
<i>Accuracy Class</i>	<p>Inputs: 0 - 5 V ; 0,1 % of the span.</p> <p>Outputs: 0 - 20 mA, 0 - 5 V; 0,1 % of the span.</p>
<i>Temperature Drift</i>	<p>Inputs 0.005 % / <math>^{\circ}</math>C maximum.</p> <p>Outputs 0.01 % / <math>^{\circ}</math>C maximum.</p>
<i>Display</i>	<p>LCD graphic display, backlighted by EL (cool cathode) lamp.</p> <p>128 x 320 pixel resolution.</p> <p>Control of the contrast from the keyboard, with automatic environmental temperature compensation.</p> <p>Duration of the lamp &gt; 20.000 hours.</p>

<i>Keyboard</i>	8 multifunction keys.
<i>Supply</i>	90 - 264 Vac, 48 - 63 Hz, optionally 24 Vac/VDC $\pm$ 20 %.
<i>Maximum Power consumption</i>	20 VA.
<i>Transmitter Power Supply</i>	24 V cc $\pm$ 5 % regulated, 300 mA maximum, with short circuit protection.
<i>Isolation</i>	EN 61010
<i>Electromagnetic compatibility</i>	EN 55011, EN 50081-2, EN 50082-2 IEC801-2, 801-3, 801-4, 801-5 Level IV
<i>Operating Conditions</i>	KWF for DIN 40040
<i>Environmental Conditions</i>	Temperature 0 - 50 °C. Relative Humidity 10 to 90 % (without condensation).
<i>Protection</i>	IP30 for the case. IP20 for the termination unit. IP54 front panel protection
<i>Material</i>	Self-extinguishing 94VI.
<i>Dimension</i>	DIN standard 72 x 144 x 260 mm.
<i>Panel mounting</i>	Through adjustable mounting clamps, fitted on the top and the bottom of the controller.
<i>Weight</i>	1,7 Kg approximately.

### 1.3 Hardware Description

The AC10, AC20 and AC30 controllers, consists of:

#### *FRONT PANEL*

- LCD graphic display with automatic and manual adjustment of the contrast.
- Keyboard, for issuing commands and for changing parameters.
- Plug in connector for programming the controller.

#### *ELECTRONIC BOARD*

- CPU board with analog and digital inputs.
- LAN Board with the serial interface to the LAN (optional for AC20 and AC30).
- Power supply board.
- Output board, with digital and analog outputs.
- Display board with intelligent graphic display controller.
- LCD supply board with the LCD lamp voltage booster circuit.

#### *REAR UNIT*

- Termination unit with M3 terminals and connectors.
- Transparent terminal cover with connections indication.

## 1.4 Resident Strategies Description

The multifunction AC controllers are supplied with the following resident configurations, already stored in the memory:

1 Loop A	(Simple loop with Remote Setpoint and Controlled Variable retransmission)
1 Loop B	(Loop with Remote Setpoint and predefined stored Setpoints, Feedforward, PV retransmission)
1 Loop C	( Typical Heat/Cool Loop)
2 Loops A	(2 simple Loops with Remote Setpoint and PV retransmission)
2 Loops B	( 2 Loops, one complex and the other simpler)
2 Loops C	( Heat Cool Loop plus 1 simple Loop)
Ratio	( 1 Ratio Loop plus 1 simple Loop)
Cascade	(Cascade loop with Remote Setpoint and PV retransmission)
Override	( 2 Loops interconnected as override controllers)
4 Loops	( 4 simple Loops independent each other)
4 Indicators	( 4 measure indication, with retransmission and alarms)
2 A/M Station	( 2 A/M stations, with alarms and retransmission)

*More information about this strategies are illustrated in Annex A: Resident configurations.*

## 1.5 Library of the functional modules of the AC10, AC20 and AC30 controllers

### *Input/Output and Display*

Description	Mnemonic Code	Information displayed on the controller panel
Analog Input	AI	A. Inputs
Digital Input	DI	D. Inputs
Frequency Input	FI	Freq. Input
Analog Output	AO	A. Outputs
Digital Output	DO	D. Outputs
Time proport. Output	TPO	T. Prop. Out
Bargraph Display	1BP	1 Bar Panel
Bargraph Display	2BP	2 Bar Panel
Bargraph Display	4BP	4 Bar Panel
Trend Display	TRP	Trend Panel
Trend Display	2TP	2 Tr. Panel
Trend Display	4TP	4 Trend Panel
Alarms Display	ALP	-
Control Panel	SELP	Sel. Panel
Analog meas. display	ADP	12AD Panel
Analog meas. display	4ADP	4AD Panel
Analog values Setting	4WAD	4WAD Panel
Multiswitch	16SW	-

### *Control and Processing*

Description	Mnemonic Code	Information displayed on the controller panel
Setpoint and Deviation calculation	SDV	Set & Deviation
PID algorithm	PID	PID Block
Output	MV	Outs Mgt.
Heat/Cool output	HCMV	H&C Out Mgt.
Motor positioner	SRV	Servo Motor
Setpoint Programmer	PRG	Programmer
Time Clock	RTC	Clk Program
Range Change	SCH	Sc. Changer
Filter	FILT	Dig. Filter
Analog signal delay	ADLY	Analog Delay
Digital signal delay	DDL	Dig. Delay
Rate limiter	MSL	Slope Limit
Characterisation	CHAR	Linearizator.
Minimum or Maximum	MAX	Min or Max
Analog Soft. Multiplexer	AMUX	Analog Mux
Analog Hard. Multiplexer	AMX8	-
Sample and Hold	HLD	-
Digital Soft. Multiplexer	DMUX	Dig. Select
Digital Hard. Multiplexer	DMX8	-
Mass flow compensation	AGA	-
Flow compensation	MFL	-
Totaliser	TOT	Totalizers
Signal Limiter	LMT	Limit Block
Alarms	ALM	Alarm Block
Rate alarm	SALM	Speed Alarm
Analog Software Demux	ASEL	Analog Demux
Set page	SETP	-
Timer	TMR	-
Servomotor Open/Closed Loop	SRV2	-

### Control and Processing

Description	Mnemonic Code	Information displayed on the controller panel
Analog Hardw.Demux	AS8	-
Digital Software Demux	DSEL	Dig. DeSel
Digital Hardware Demux	DS8	-
Digital decoder	DEC8	-

### Math and Logic

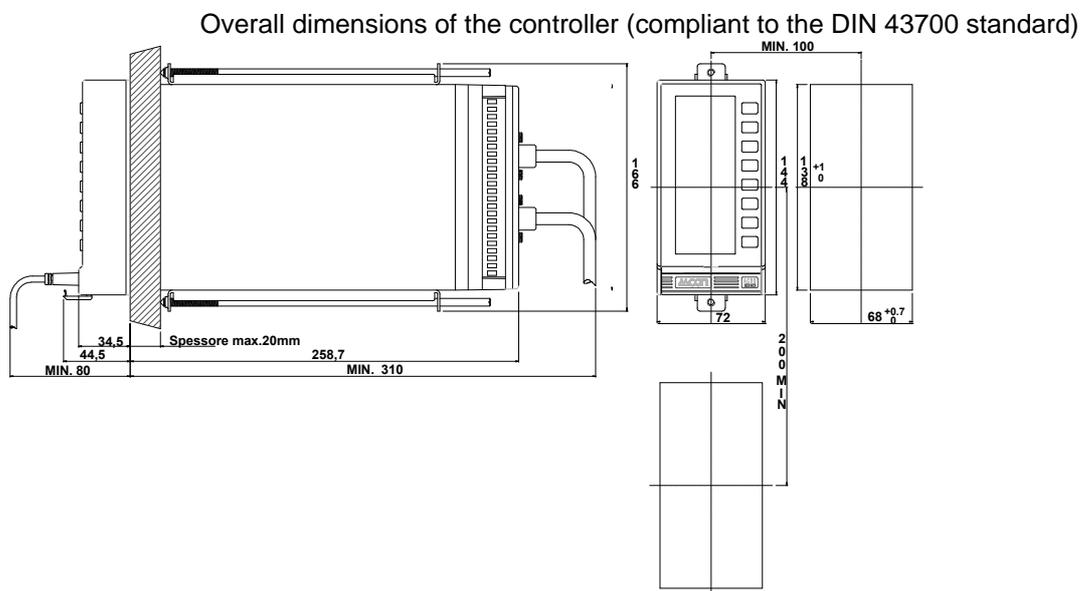
Description	Mnemonic Code	Information displayed on the controller panel
Analog var. to Computer	CAIO	-
Digital var. to Computer	CDIO	-
Key activation	KEY	-
Failure of the controller	FAIL	-
Delay	DLY	Dig. Delay
Computer time out	CALM	Comp. Alarm
Aux. Units time out	AALM	Aux. U. Alarm
LAN time out	LALM	LAN Alarm
System Configuration	SYS	-
Setpoint Control Key Lock	SPKL	-
Output Control Key Lock	OPKL	-

### Math and Logic Functions

Description	Mnemonic Code	Information displayed on the controller panel
Expression	EXP	-
Arithmetic operation	OPR	Math Operat.
Math operation	FN	Math Funct.
Single Constant	CNS	-
And	AND	-
Or	OR	-
Eor	EOR	-
Not	NOT	-
Flip-Flop J-K Latch	JKF	
Monostable	MST	Monostable
Counter	CNT	-
OR 8 inputs	OR_8	-
Analog predefined constants	MCNS	Constants
Digital predefined constants	MDCN	D. Constants
AND_8	AND_8	-
Shift	SHIFT	-

## 2. Installation

### 2.1 Dimensions



### 2.2 Panel Mounting

1. Insert the instrument in the aperture on the panel. (fig. 2.1)
2. Fit the two mounting clamps, fixing them in the slots of the instrument case, on the top and on the bottom of the instrument walls. To hook firmly the clamps, slide them away from the panel, in the direction of the termination unit. (fig. 2.2)
3. Rotate clockwise the clamps screws up to when the instrument front panel sticks completely on the panel wall. Do not tight the screws too strongly, to avoid panel distortion.

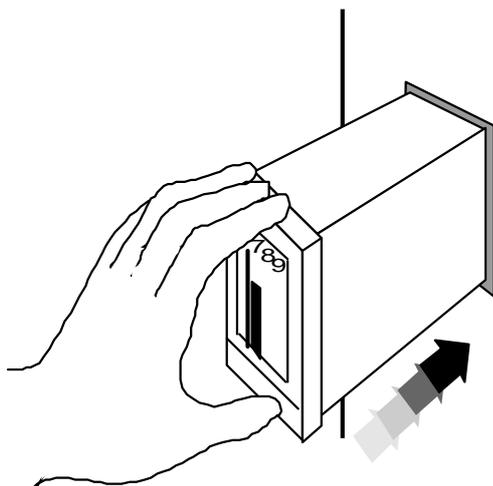


Figure 2.1 Insertion into the panel aperture

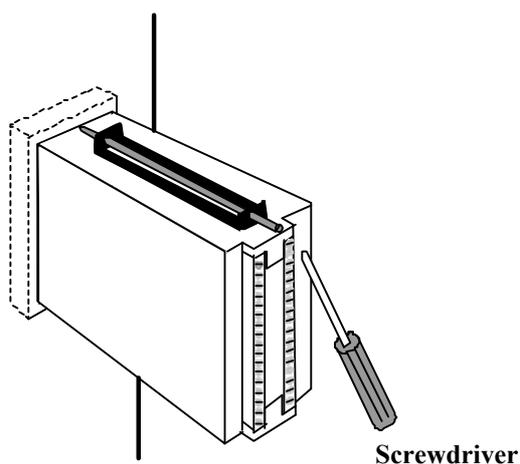


Figure 2.2 Hooking the clamps and blocking with the screws

## 2.3 Connections and terminations

The screw terminals, located at the rear of the controller, can be accessed by removing the transparent protective terminal cover. This cover is secured in position by two screws.

On the transparent cover all the terminals are labelled, together with some functional information, as shown in figure 2.3.

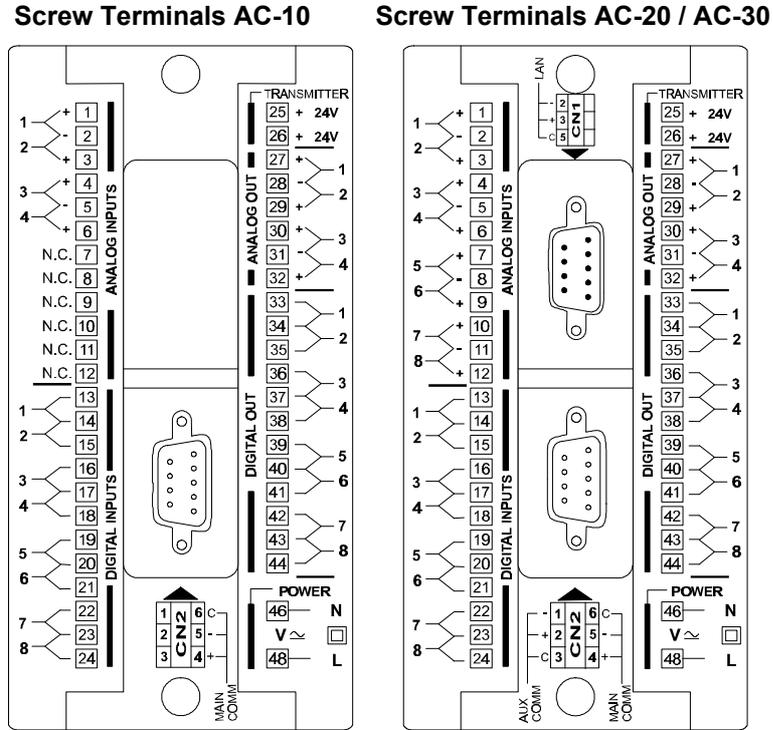


Figure 2.3 Termination Units

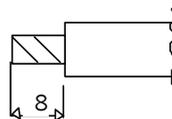
To avoid misunderstanding, the input and output terminals are functionally grouped. Therefore, the left side of the termination unit houses the input signals, while the outputs are on the right side.

This organisation facilitates the installation of the signal cable, because inputs and outputs have different cable paths. In the central part of the termination unit, the following connectors, for the serial communication, are located:

- in the upper part, the connector to the LAN network is located
  - in the lower part, the RS485 Aux and Main Comm connector is located.
- Through the controller has been designed to work in the worst conditions, typical of the industrial environment, the following suggestions must be followed:
- Keep separate the cable to the controller power supply from the other power cables to the plant.
  - Avoid to install the controller near to power switches, electromagnetic contactors, high power motors and others power sources.
  - Avoid to install the controller near static power units, especially if they are based on phase angle control.

The terminals are build up according to the UL-CSA standard.

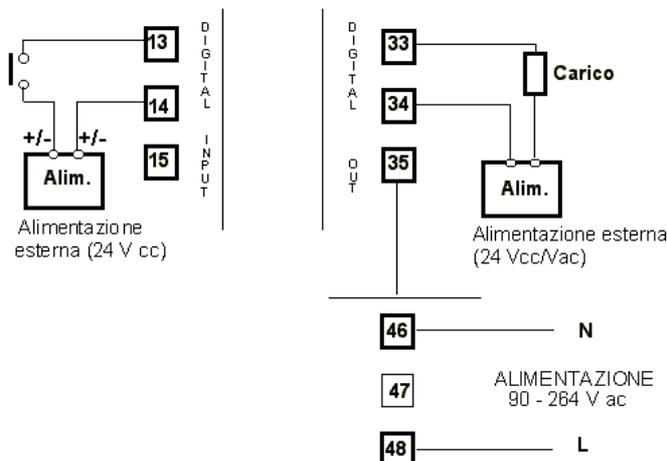
For proper connections, it is recommended to use cable with maximum size of 12AWG (2.5 mm<sup>2</sup>), to remove the cable insulation cover for approximately 8mm and to insert it completely in the terminal hole, before tightening the screw (Use an edge screwdriver 0.4 x 2.5 x 75 mm).



## 2.4 Electrical Connections

The following pages illustrate the most common examples of connection between the instrument and the field.

### 2.4.1 Passive Transmitter

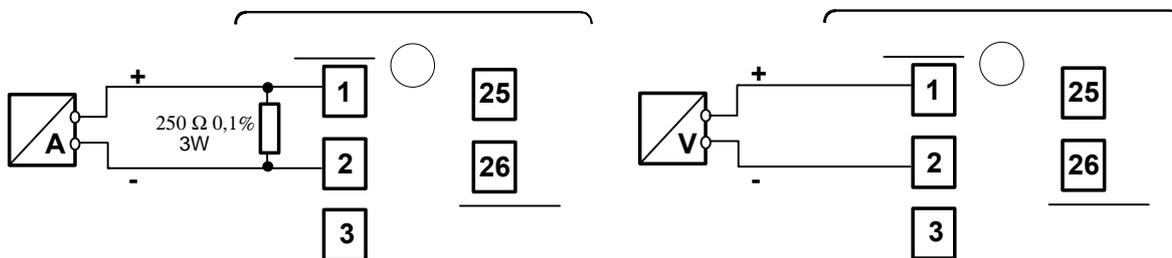


**Note**

Use the 24 VDC power supply, on the terminals 25 and 26 only for powering the passive transmitter. Do not use this power supply for the digital inputs and outputs of the AC controller.

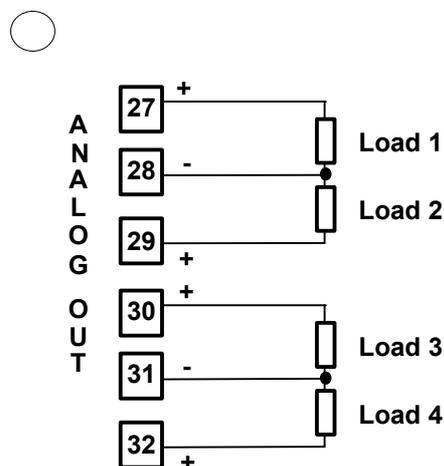
### 2.4.2 Active transmitter

The shunt resistor, shown in the figure below, is not required if the output of the transmitter is already in voltage. In case of transmitter with output in current ( 0-20mA or 4-20mA), a shunt resistor, of 250Ω 0,1% 3W must be installed on the terminal unit of the AC controller



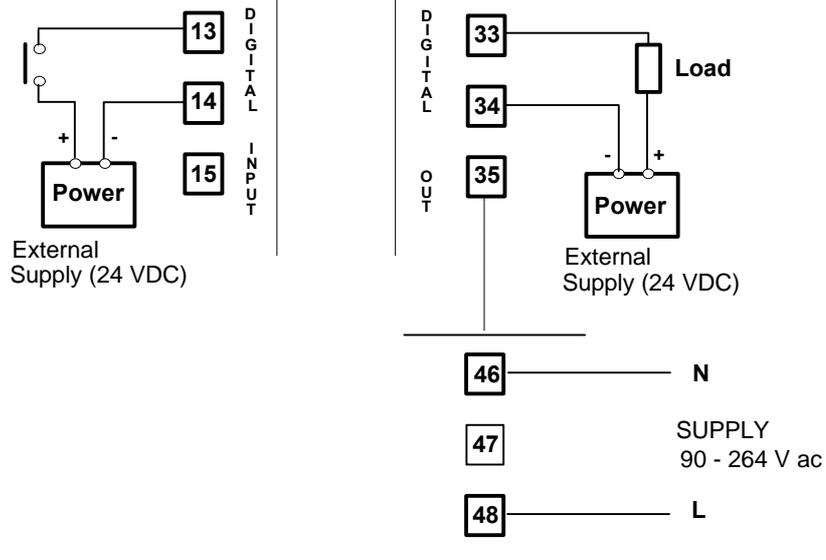
### 2.4.3 Analog output

The setting of the output type ( between 0-5 V or 1-5 V voltage and 0-20 mA or 4-20 mA current ) is performed by the AO (Analog Output) module.



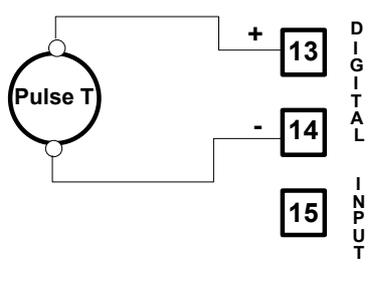
### 2.4.4 Digital Inputs and Outputs

The power is provided by an external power supply, with range 8-36 VDC.

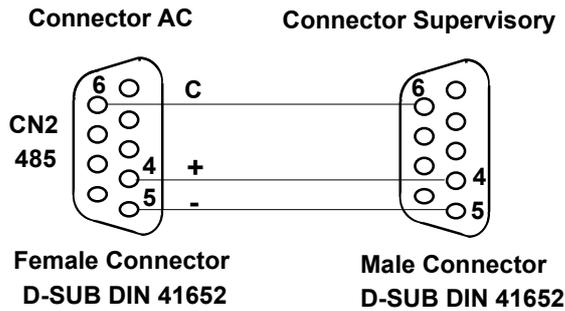


### 2.4.5 Frequency Input

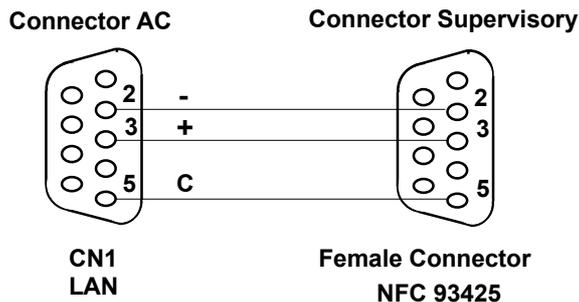
The frequency input signal must not exceed the range 8-36 V



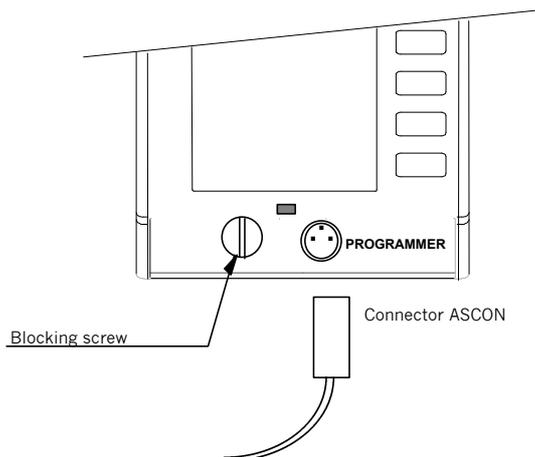
### 2.4.6 RS485 Serial Port Main Comm



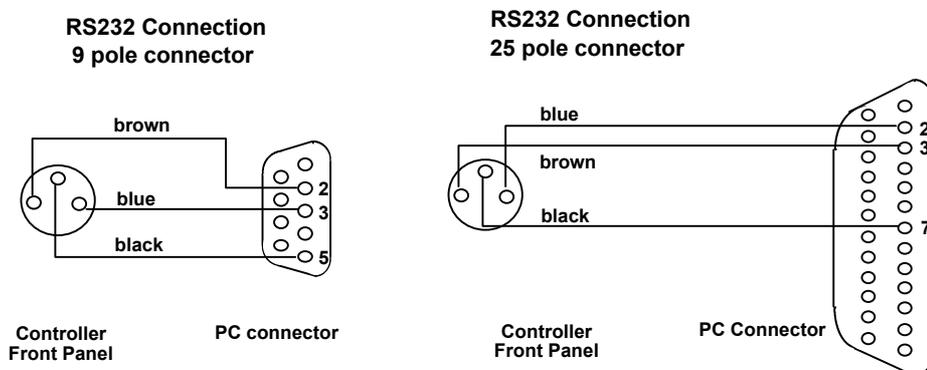
### 2.4.7 ARCNET Network



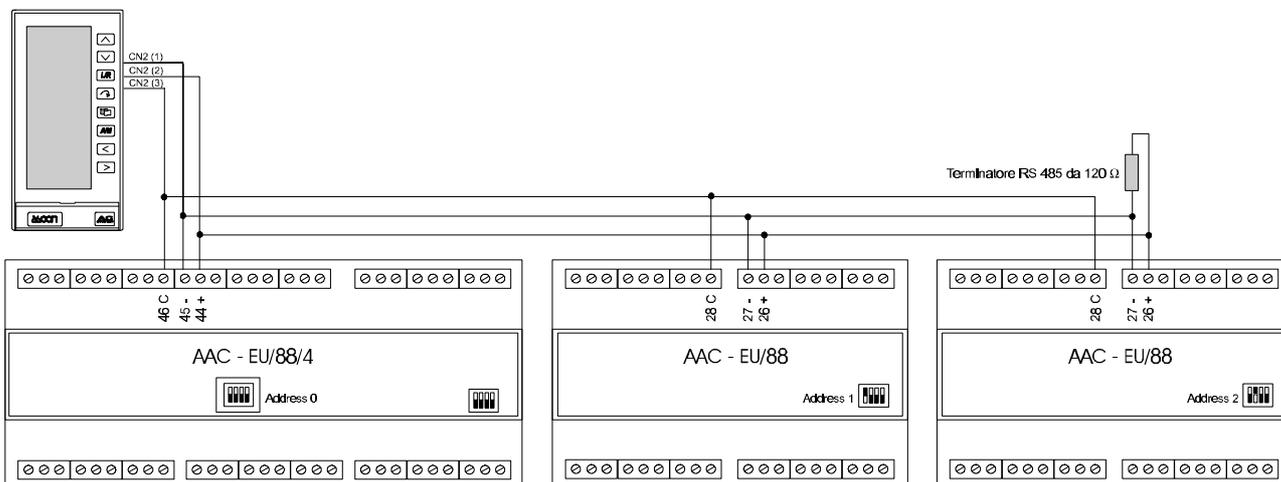
### 2.4.8 Connection to a PC via the programming port



In the figure below, the details of the connection to a 9 and a 25 pole connector, are shown.



### 2.4.9 Connection to the Expansion Unit, via the RS485 port AUX Comm



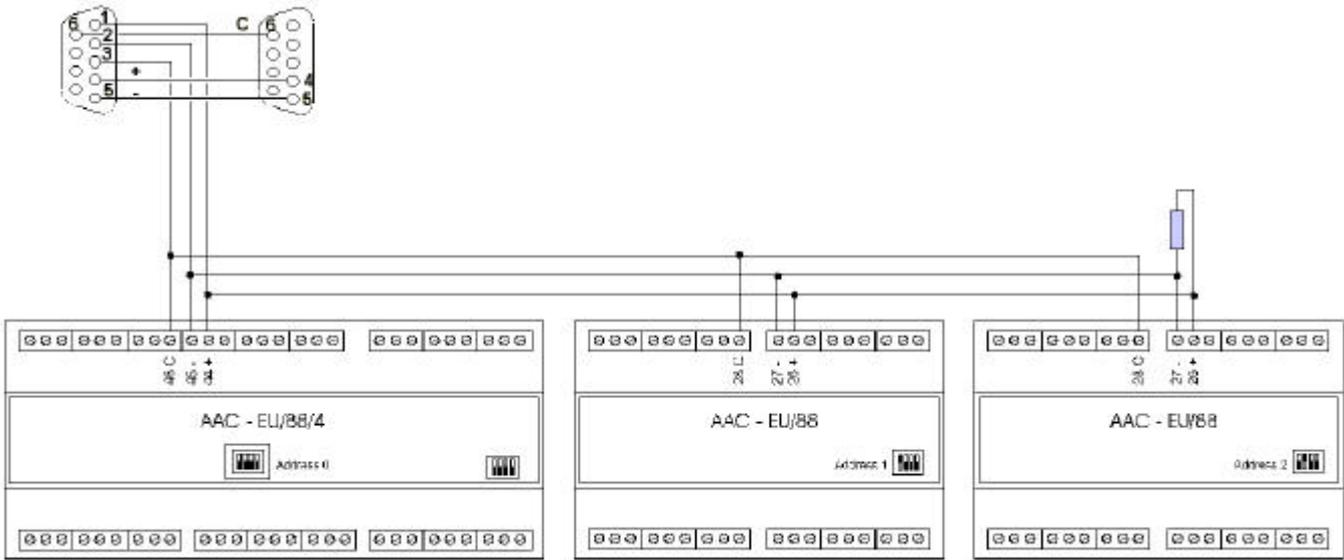
**Note:**

The figure above illustrates a controller with the maximum number of Expansion Units connected to it. If there is an Expansion Unit model AAC-EU/88/4 (the one supporting analog signals) it must have assigned the address "0" while the others the addresses "1" and "2". If there is only one Expansion Unit, it must have assigned always the address "0". Furthermore, the last unit in the serial link must have a termination resistor of 120Ω 1/4W.

### 2.4.10 RS485 Main Comm serial connection + expansion unit

CN1 AC

SUPERVISOR



## 3. Startup

### STARTUP PROCEDURE

The flowchart of Figure 3.1 lists all the steps you must carry out to have your AC10, AC 20 and AC30 controller, installed on the plant and properly controlling the Customer process.

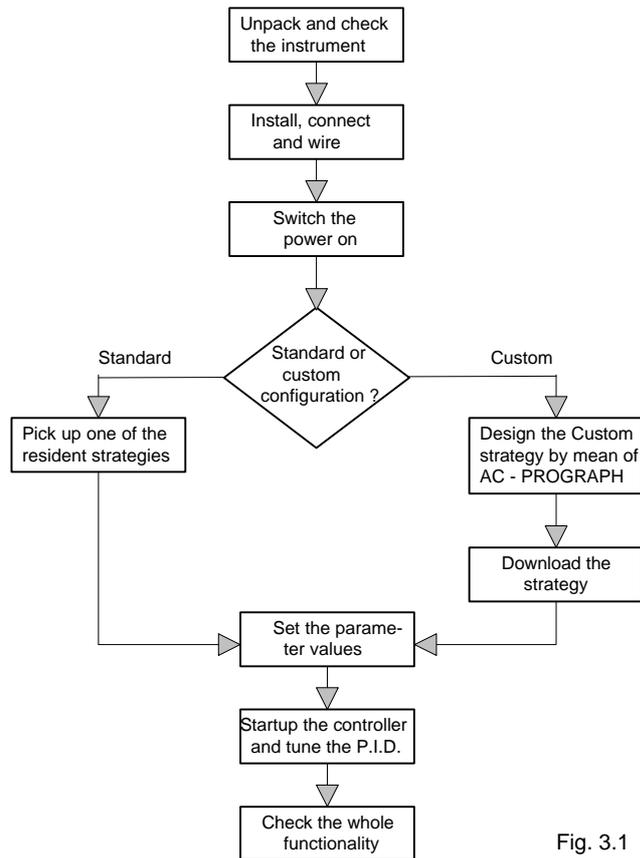


Fig. 3.1

### 3.1 Keyboard

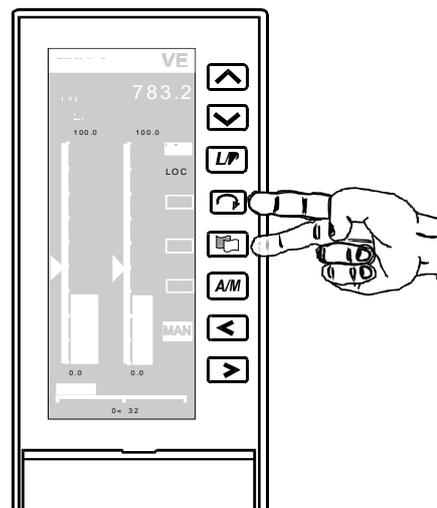


Fig. 3.2

The keyboard is located on the right side of the front panel. It consists of 8 pushbuttons, whose functionality is described in the following pages.

## 3.2 Pushbuttons Functionality

-  Increases the value of the selected variable, i.e. the Local Setpoint.
-  Lowers the value of the selected variable, i.e. the Local Setpoint.
-  Changes the Setpoint operating mode.
-  Selects the next variable of the scrolled variable list and displays it in the corresponding field in the upper part of the panel.
-  Forces the controller to present, on the display, the next display panel configured in the strategy.
-  Selects the Out station, operating mode between AUTO and MAN.
-  When the controller is in MAN, it decreases the value of the output.
-  When the controller is in MAN, it increases the value of the output.

The usual functionality of these 8 pushbuttons is described above. In some peculiar circumstances, they perform differently. This occurs with some panel (i.e. Selector, System Clock, Dual Trend, etc.), where the operator has to set specific parameters. In this case, in order to clearly flag that the functionality of the key has been changed, an icon of a button, with the mnemonic of the new functionality, is displayed on the display panel, close to the pushbutton. When the display panel changes, the icon disappears and the pushbutton returns back to its original functionality.

The following ones are these new buttons, as they appear on the various panels.

-  **Enter** It allows to input a value in a variable or, simply, to proceed with the next step in a parameter definition procedure.
-  **Page** It allows to go to the next page, when the values of parameters are listed on more than one page.
-  **Return or Reject** It allows, in any step of a parameter definition procedure, to abort the current entry and go back to the previous display, without changing any value.
-  Scroll keys. They allow picking up a choice from a list of various possibilities.

**NOTE** During the calibration procedure, the following buttons are displayed:

*Input Calibration.*

-  N -> Proceeds to the next step.
-  C -> Performs the calibration and stores the calibration coefficients.

*Output Calibration.*

-  S -> Select: Selects/Deselects the output.
-  R -> Return: Returns back to the previous display panel

### 3.3 Display

The display panel consists of a graphic LCD display, backlighted, with high resolution (128 x 320 pixels).

On the AC controller, there are several types of active panels, each one corresponding to a functional module of the strategy. These panel displays have a complete user interface, allowing you to have detailed informations about process variables, to issue commands and to set parameters. The definition of the types and the quantities of these display panels are set in the selected or designed strategy.

When the pushbutton  is pressed, the panels will be displayed in the order set in the Tools – Edit Modules menu of the AC Prograph / AC Edit programme.

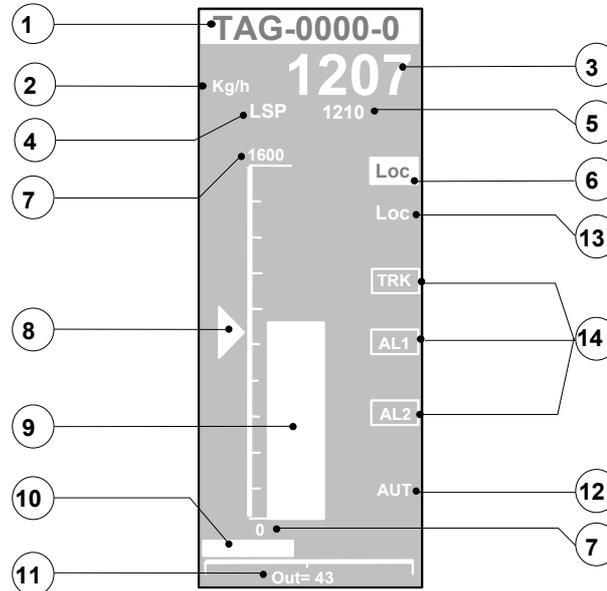
*For the above refer to section 7.6.2. of the manual.*

The active panels are the following:

- **1 Bar Panel:** front panel of a control loop, with numeric indication of the relevant variables, bargraph display for the main ones (process variable, setpoint, output) and status display of logical signals or alarms.
- **2 Bar Panel:** front panel of two control loops, usually connected in cascade, with numeric and bargraph indication of the most relevant variables and status display of logical signals or alarms.
- **4 Bar Panel:** front panel of four control loops, with bargraph indication of the process variable and setpoint, numeric indication of the relevant variables and a cumulative alarms display, common to all the 4 loops. This panel automatically omits the display of the signals not connected to its functional module, in order to avoid meaningless information. Therefore, it is a suitable display from 2 to 4 loops.
- **Trend Panel:** It is the front panel of a single loop. It provides all the numeric and bargraph displays of the 1 Bar Panel, with the addition of a trend chart, reporting, graphically, the recent trend of an analog signal, like the Process Variable. The user selects the time span of the chart between the following 8 choices: 1, 2, 5, 10, 30 minutes- 1, 2, 5 hours.
- **2 Trend Panel:** It is the front panel of a Setpoint Programmer. It provides a trend chart, with the recent trend of 2 variables (usually, the Setpoint and the Process variable), together with the display of the status of 2 digital signals and the visualization and the command of the various operating modes of the Programmer. It is available only on the AC30 controller, where the Programmer module is supported. The time span of the chart is selected by the user, between the following 8 choices: 1, 2, 5, 10, 30 minutes- 1, 2, 5 hours.
- **4 Trend Panel:** This panel provides 2 trend chart, with the recent trend of 2 variables each, the real time display of the values of the trended variables and the visualization of the status of 4 digital signals. The time span of the chart is selected by the user, between the following 8 choices: 1, 2, 5, 10, 30 minutes- 1, 2, 5 hours.
- **Alarm Panel:** Alarm annunciator, displaying the status of 12 alarm signals. Each alarm is displayed with a message of 12 alphanumeric characters maximum, in reverse or normal according to the status of the corresponding digital input.
- **Selector Panel:** Control panel allowing the user to set the pattern of 4 digital outputs, by choosing from a list of predefined patterns. Each pattern performs a predefined operation on the process and is labeled with a symbolic name for an immediate understanding.
- **12 Analog Display:** Indicator panel, displaying the value of up to 12 analog signal inputs. Each input is identified by a 6-character label for an immediate understanding.
- **4 Analog Display:** Indicator panel displaying the value of up to 4 analog inputs. Compared to the 12 Analog Display module, this module provides more informations (longer tag and engineering units) and the visualization of the variables with big size characters (apx 1 cm. high), that can be seen far away.

- **4 Writable Analog Display:** This display panel allows the display or generation of 4 analog variables directly from the front panel. For each generated variable it will be possible to define an identification tag with its own engineering unit of measurement.

### 3.3.1 1 Bar Panel



#### 1) Tag

This tag is the identifier of the panel and consists of up to 10 alphanumeric characters. It is assigned automatically when the module is created and can be modified through AC\_Edit/AC-Prograph.

#### 2) Engineering Units

Engineering units mnemonic, consisting of a string of 3 characters maximum. It is entered and modified through AC\_Edit/AC-Prograph.

#### 3) Main Variable Value

Numerical visualization of the main variable, consisting of 6 characters, including the sign and the decimal point.

#### 4) Scrolled Variable Tag

This 3-character label, specified by the Customer, identifies the scrolled variable displayed.

The following ones are some examples of tags, as already defined in the resident configurations. In the custom strategies, these tags are almost defined by the user, but the ones related to general variables, like the Working Setpoint etc.:

TSP : Target Set Point; value of the Setpoint.

WSP : Working Set Point; value of the Set to the PID module.

RSP : Remote Set Point; value of the Setpoint input signal.

CSP : Computer Set Point; value set by the Computer.

PV1 : Process Variable 1; value of the main variable n°1.

PV2 : Process Variable 2; value of the main variable n.2.

WSR : Working Set Ratio; value of the ratio setpoint.

#### 5) Scrolled Variable Value

Numerical display of the selected scrolled variable. The list of the variables includes the Local Setpoint and other analog input signals of the module. It consists of 6 characters, including the sign and the decimal point.

#### 6) Setpoint Operating Mode

This short mnemonic reports the current Setpoint operating mode of the loop. The various modes are: Loc, Rem, Com.

**7) Scale high/low Limits**

They define the values of upper and lower limits of the scale. Each value consists of 6 characters, including the sign and the decimal point.

**8) Set point Slider**

Graphic representation, through a moving slider, of the real time value of the Setpoint. The slider is moved in steps of 0,5 %.

**9) Bargraph**

Bargraph indication of the process variable. The bargraph shows the process variable value in 200 steps, providing a resolution of 0,5 %.

**10) Output bargraph**

Horizontal bargraph, showing the loop control output value in steps of 1 %.

**11) Output Value**

Numerical display of the loop control output, in percentage.

**12) Auto/Man**

Display of the Out station operating mode. The possible modes are AUT or MAN.

**13) Loc/Rem/Com**

Display of the Setpoint operating mode that the user has requested from the controller keyboard. The mode is indicated by the mnemonics Loc, Rem and Com.

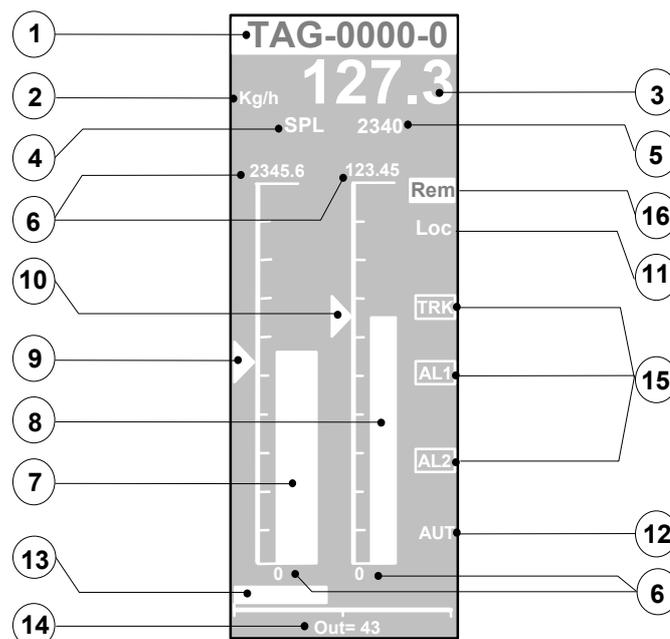
**14) Alarms and Digital**

Display, by mean of user defined, 3 characters mnemonic, of the status of the 3 digital inputs of the module. These inputs are used for representing alarms or simple logic status.

**3.3.2 2 Bar Panel**

The main purpose of this display is to provide the front panel for a cascade loop (Master and Slave).

In this case, the setpoint and the measured variable of the Master loop is on the left (Loop1), while the ones of the Slave are on the right (Loop2). The control output (manipulated variable) displayed belongs to the Slave, while the output of the Master, that becomes the Setpoint of the Slave, is displayed, in engineering units, as a Setpoint value. The only setpoint the user can change, is the one of the Master, because the one of the Slave is just displayed.



**1) Tag**

This tag is the identifier of the panel and consists of up to 10 alphanumeric characters. It is assigned automatically when the module is created and can be modified through AC\_Edit/AC-Prograph.

**2) Engineering Units**

Engineering units mnemonic, consisting of a string of 3 characters maximum. It is entered and modified through AC\_Edit/AC-Prograph.

**3) Main Variable Value**

Numerical visualization of the Master controlled variable, consisting of 6 characters, including the sign and the decimal point.

**4) Scrolled Variable Tag**

This 3 characters label, specified by the Customer, identifies the scrolled variable displayed.

The following ones are some examples of tags, as already defined in the resident configurations. In the custom strategies, these tags are almost defined by the user, but the ones related to general variables, like the Working Setpoint etc.:

TSP :Target Set Point; value of the Setpoint.

WSP :Working Set Point; value of the Set to the PID module.

RSP :Remote Set Point; value of the Setpoint input signal.

CSP :Computer Set Point; value set by the Computer.

PV1 :Process Variable 1; value of the main variable n°1.

PV2 :Process Variable 2; value of the main variable n.2.

WSR :Working Set Ratio; value of the ratio setpoint.

**5) Scrolled Variable Value**

Numerical display of the selected scrolled variable. The list of the variables includes the Local Setpoint and other analog input signals of the module. It consists of 6 characters, including the sign and the decimal point.

**6) Scale high/low Limits**

They define the values of upper and lower limits of the scale. Each value consists of 6 characters, including the sign and the decimal point.

**7) Variable 1 Bargraph**

Bargraph indication of the process variable n° 1, controlled by the Master loop. The bargraph shows the process variable value in 200 steps, providing a resolution of 0,5 %.

**8) Variable 2 Bargraph**

Bargraph indication of the process variable n° 2, controlled by the Slave loop.

**9) Set point Slider 1**

Graphic representation, through a moving slider, of the real time value of the Setpoint n°1, corresponding to the Master loop. The slider is moved in steps of 0,5 %.

**10) Set point Slider 2**

Graphic representation, through a moving slider, of the real time value of the Setpoint n°2, corresponding to the Slave loop. The slider is moved in steps of 0,5 %.

**11) Loc/Rem/Com**

Display of the Setpoint operating mode, that the user has requested from the controller keyboard. The Setpoint refers to loop 1 (Master). The mode is indicated by the mnemonics Loc, Rem and Com.

**12) Auto/Man**

Display of the Out station operating mode. The possible modes are AUT or MAN.

**13) Output bargraph**

Horizontal bargraph, showing the loop 2 (Slave) control output value in steps of 1 %.

**14) Output Value**

Numerical display of the loop 2 (Slave) control output, in percentage.

**15) Alarms and Digital**

Display, by mean of user defined, 3 characters, mnemonics, of the status of the 3 digital inputs of the module. These inputs are used for representing alarms or simple logic status.

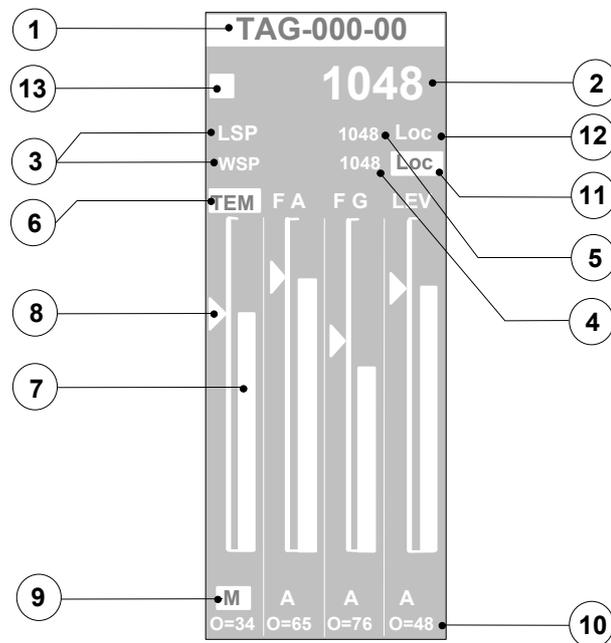
**16) Setpoint Operating Mode**

This short mnemonic reports the current Setpoint operating mode of the loop.1 (Master) The various modes are: Loc, Rem, Com.

**3.3.3 4 Bar Panel**

This display type is less rich of informations than the previous ones; because it lacks the output bargraph and the main variable engineering units, but, surely, it is the most versatile; as soon as you connect the signals of a loop, it adds the bargraph and the slider, related to it. This way to operate improves dramatically the readability, because the panel is not always filled with 4 bargraphs, when you need just two.

Furthermore, for each bargraph, you can choose if you want the slider or not, so that, if you want to display just a measure, you do not have a meaningless slider around. And, you can mix, as you like, bargraphs with the slider, for control loops, and without, for measures and A/M stations.

**1) Tag**

This tag is the identifier of the panel and consists of up to 10 alphanumeric characters. It is assigned automatically when the module is created and can be modified through AC\_Edit/AC-Prograph.

**2) Main Variable Value**

Numerical visualization of the controlled variable of the selected loop, consisting of 6 characters, including the sign and the decimal point. Each loop is selected cyclically, and the one selected has its tag displayed in reverse.

**3) Setpoint Label**

LSP (Local Set Point) Mnemonic label of the setpoint value (n°5).

WSP (Working Set Point) Mnemonic label of the setpoint value (n°4).

**4) Working Setpoint Value**

Numerical display of the value of the Working Setpoint of the selected loop

**5) Local Setpoint Value**

Numerical display of the value of the Local Setpoint of the selected loop. The Local setpoint is entered by the user through the front keyboard.

**6) Loops tag**

This 3 characters label, specified by the Customer, identifies the tag of the loop. The loop selected has its tag displayed in reverse.

**7) Bargraphs**

Bargraph indication of the process variables 1, 2, 3, 4, of the loops.

**8) Set point sliders**

Graphic representation, through a moving slider, of the real time value of the Setpoints of the loops 1, 2, 3 and 4.

**9) Auto/Man**

Display of the Out station operating mode. The possible modes are A (Auto) or M (Manual).

**10) Output Value**

Numerical display of the loop control output, in percentage.

**11) Setpoint Operating Mode**

This short mnemonic reports the current Setpoint operating mode of the loop 1 (Master). The various modes are: Loc, Rem, Com.

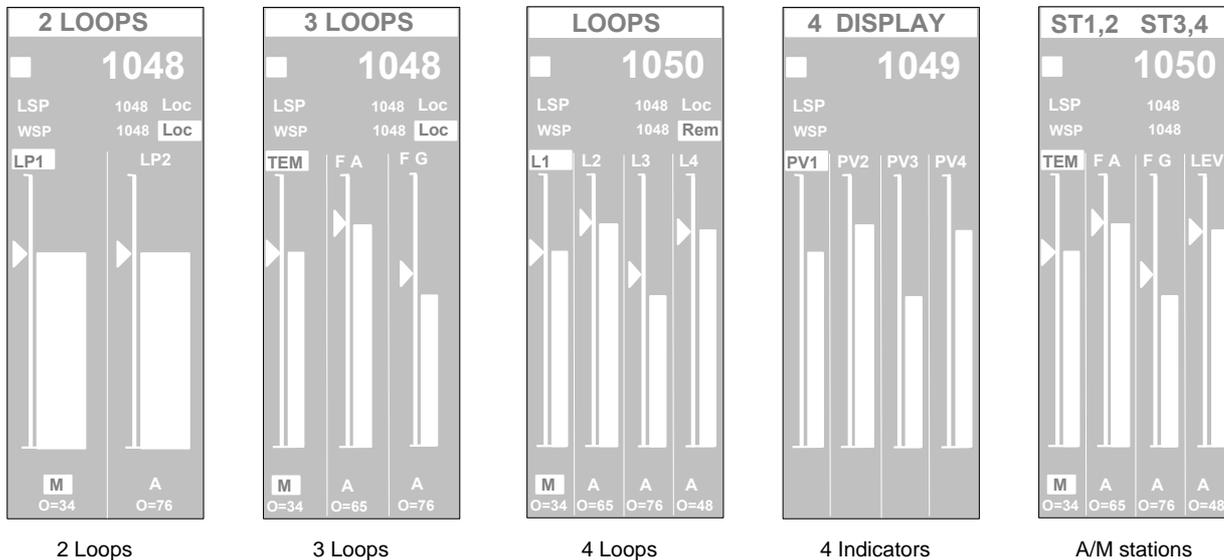
**12) Loc/Rem/Com**

Display of the Setpoint operating mode, that the user has requested from the controller keyboard. The Setpoint refers to loop 1 (Master). The mode is indicated by the mnemonics Loc, Rem and Com.

**13) Alarms**

Blinking box, usually flagging anomalous conditions, requiring the operator attention. It is activated by a digital input signal.

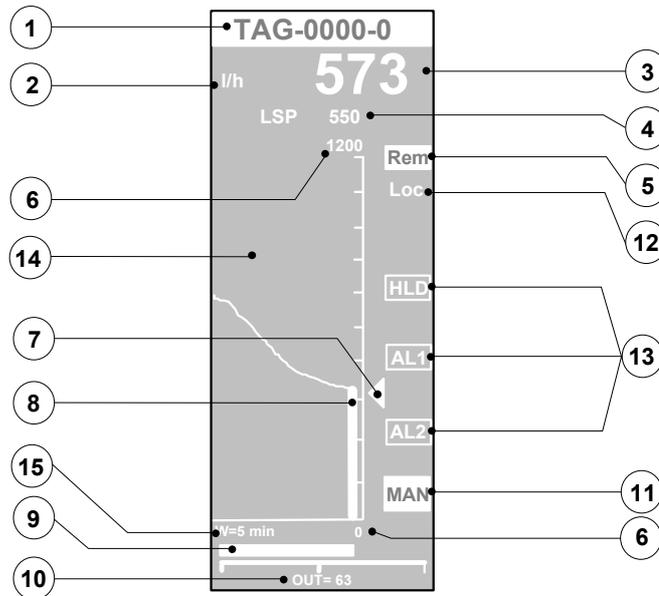
The following are few examples of the types of display you can achieve with this panel. The type of visualization is automatically selected, according to the connections performed on the module inputs, through AC\_Edit/AC-Prograph.



**3.3.4 Trend Panel**

This display has almost the same functionality of the 1 Bar Panel module, with the addition of a trend chart of an analog variable. Its main purpose is to provide the front panel of a simple control loop. The trend indication gives the operator a better understanding of the situation of the process, than just the real time display of process data.

This display is provided in all the resident strategies of the AC controller.



### 1) Tag

This tag is the identifier of the panel and consists of up to 10 alphanumeric characters. It is assigned automatically when the module is created and can be modified through AC\_Edit/AC-Prograph.

### 2) Engineering Units

Engineering units mnemonic, consisting of a string of 3 characters maximum. It is entered and modified through AC\_Edit/AC-Prograph.

### 3) Main Variable Value

Numerical visualization of the main variable, consisting of 6 characters, including the sign and the decimal point.

### 4) Scrolled Variable Value

Numerical display of the selected scrolled variable. The list of the variables includes the Local Setpoint and other analog input signals of the module. It consists of 6 characters, including the sign and the decimal point.

### 5) Setpoint Operating Mode

This short mnemonic reports the current Setpoint operating mode of the loop. The various modes are: Loc, Rem, Com.

### 6) Scale high/low Limits

They define the values of upper and lower limits of the scale. Each value consists of 6 characters, including the sign and the decimal point.

### 7) Set point Slider

Graphic representation, through a moving slider, of the real time value of the Setpoint. The slider is moved in steps of 0,5 %.

### 8) Bargraph

Bargraph indication of the process variable. The bargraph shows the process variable value in 200 steps, providing a resolution of 0,5 %.

### 9) Output bargraph

Horizontal bargraph, showing the loop control output value in steps of 1 %.

### 10) Output Value

Numerical display of the loop control output, in percentage.

### 11) Auto/Man

Display of the Out station operating mode. The possible modes are AUT or MAN.

**12) Loc/Rem/Com**

Display of the Setpoint operating mode that the user has requested from the controller keyboard. The mode is indicated by the mnemonics Loc, Rem and Com.

**13) Alarms and Digital**

Display, by mean of, user defined, 3 characters mnemonics, of the status of the 3 digital inputs of the module. These inputs are used for representing alarms or simple logic status.

**14) Trend Chart**

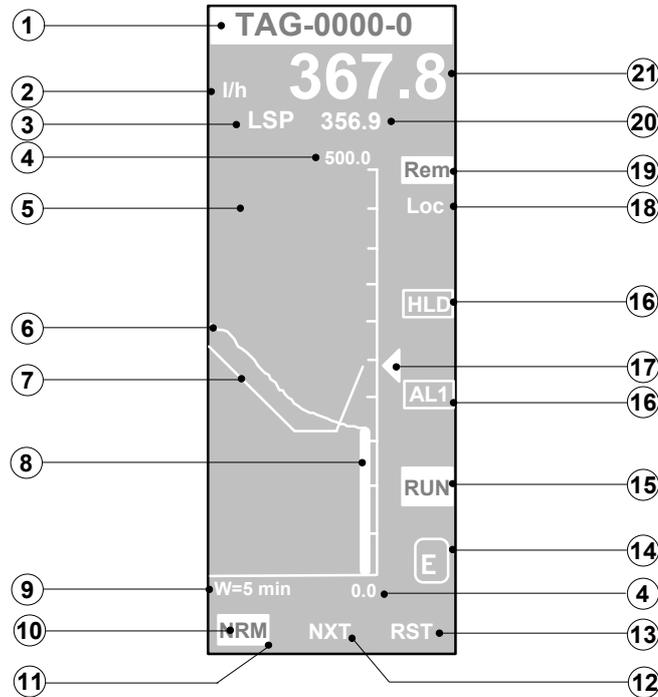
Area dedicated to the graphic display of the recent trend curve of a variable. The time width of the chart corresponds to 75 samples.

**15) Time Scale**

Numerical display of the time span of the trend chart. The user defines this value by choosing between the following set: 1, 2, 5, 10, 30 min. - 1, 2, 5 hours.

**3.3.5 2 Trend Panel**

This display provides a suitable interface to the Setpoint programmer module, available on the AC30 controller, only. It provides both the trend of 2 variables and the status displays and the user commands to the Setpoint programmer. Furthermore, it represents the status of 2 general purpose logic signals. The time span of the trend chart is defined by the user, by choosing between the following set: 1, 2, 5, 10, 30 min. - 1, 2, 5 hours.



**1) Tag**

This tag is the identifier of the panel and consists of up to 10 alphanumeric characters. It is assigned automatically when the module is created and can be modified through AC\_Edit/AC-Program.

**2) Engineering Units**

Engineering units mnemonic, consisting of a string of 3 characters maximum. It is entered and modified through AC\_Edit/AC-Program.

**3) Scrolled Variable Tag**

This 3 characters label, specified by the Customer, identifies the scrolled variable displayed.

Pressing the  button, the tag, together with the corresponding value, of each variable of a list, is displayed, one at a time and sequentially. The list includes the LSP and the 5 analog input signals of the module.

**4) Trend chart high/low scale Limits**

They define the values of upper and lower limits of the scale. Each value consists of 6 characters, including the sign and the decimal point.

**5) Trend Chart**

Area dedicated to the graphic display of the recent trend curve of one or more variables.

**6) Trend of BI1**

Recent trend curve display of the analog input signal BI1.

**7) Trend of CI1**

Recent trend curve display of the analog input signal CI1.

**8) Bargraph**

Bargraph indication of the analog input signal BI1.

**9) Time scale**

Numerical display of the time span of the trend chart.

**10) Normal/Fast Function**

Display of the running mode of the Programmer. The running mode can be changed, by mean of the two button  and , selecting, respectively, the Fast and the Normal mode. After pressing the button, push the Enter key to confirm.

**11) Selection Cursor**

Highlighting of the selected command. From this panel you can enter some commands to the Programmer. These are the ones listed at the lower line of the display (Normal/Fast, Next, Reset). To do it, you must first select the command, by moving the cursor with the  button. The selected command is the one displayed in reverse. Once you have selected the command, follow the instruction related to it, to proceed.

**12) Next Function**

Next command mnemonic. To send a Next command, that forces the Programmer to skip to the next segment, you must select this field and confirm with Enter.

**13) Reset Function**

Reset command mnemonic. To send a Reset command you must select this field and confirm with Enter.

**14) Enter (OK function)**

Icon of the Enter button, corresponding to the physical button . This button must be pressed to confirm the command that has been selected, as described at Point 1. It causes the starting of its execution.

**15) Operating mode**

Display of the operating mode of the Programmer (Run or Hld). The user can change the operating mode, forcing the program to run or holding it, by mean of the button .

**16) Digital**

Display, by mean of user defined, 3 character mnemonics of the status of 2 digital input signals. The user can define a mnemonic for each state of the digital signal.

**17) Setpoint slider**

Graphic representation, through a moving slider, of the real time value of the Setpoint., corresponding to the analog input signal CI1.

**18) Loc/Rem/Com**

Display of the Setpoint operating mode that the user has requested from the controller keyboard, by mean of the  key. The choices are:

- LOC Local Setpoint
- REM Remote Setpoint
- COM Computer Setpoint

**19) Setpoint Operating Mode**

This short mnemonic reports the current Setpoint operating mode of the loop.

**20) Scrolled Variable Value**

Numerical display of the selected scrolled variable, selected by mean of the  key. The list of the variables includes the Local Setpoint and other analog input signals of the module. It consists of 6 characters, including the sign and the decimal point.

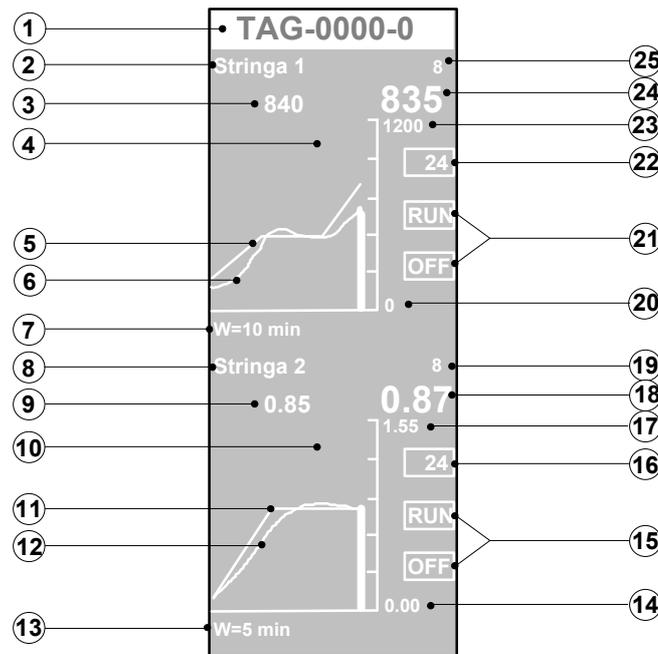
**21) PV Variable Value**

Numerical visualization of the PV variable, consisting of 6 characters, including the sign and the decimal point. Usually, this variable corresponds to the one at input BI1.

**3.3.6 4 Trend Panel**

This panel is intended for displaying on a single panel, up to 4 trended analog variables. Furthermore, it display the numeric value of these 4 analog input signals and the logic status of 4 digital input signals.

Available only on the AC30 controller, Its main purpose is to provide a complete user interface for the Setpoint Programmer. The time span of each trend chart is defined by the user, independently from the other, by choosing between the following set: 1, 2, 5, 10, 30 min. - 1, 2, 5 hours.



**1) Tag**

This tag is the identifier of the panel and consists of up to 10 alphanumeric characters. It is assigned automatically when the module is created and can be modified through AC\_Edit/AC-Program.

**2/8) Chart title**

String of up to 10 alphanumeric characters, with the name of the trend chart below. The string can be entered or modified through AC\_Edit/AC-Program.

**3/9) SP values**

Numeric display of the values of the analog input signals SP1 and SP2. These signals are trended in the chart, too.

**4/10) Trend Chart**

Area dedicated to the graphic display of the recent trend curve of the variables.

**5/11) Trend of SP**

Recent trend display of the SP1 and SP2 analog input signals.

**6/12) Trend of PV**

Recent Trend display of the PV1 and PV2 analog input signals.

**7/13) Time Scale**

Numerical display of the time span of the trend chart.

**14/20) Trend Chart Low Limit**

They define the values of the low limits of the scale. Each value consists of 6 characters, including the sign and the decimal point.

**15/21) Digital**

Display, by mean of user defined, 3 characters mnemonics of the status of 4 digital input signals. The user can define a mnemonic for each state of the digital signal.

**16/19/22/25) 4 Variables Values**

Numerical display of the value of the 4 trended variables. The ones with big size numbers, correspond to PV, while the others correspond to SP. It consists of 3 characters, including the sign and it doesn't allow the decimal point.

**17/23) Trend Chart High Limits**

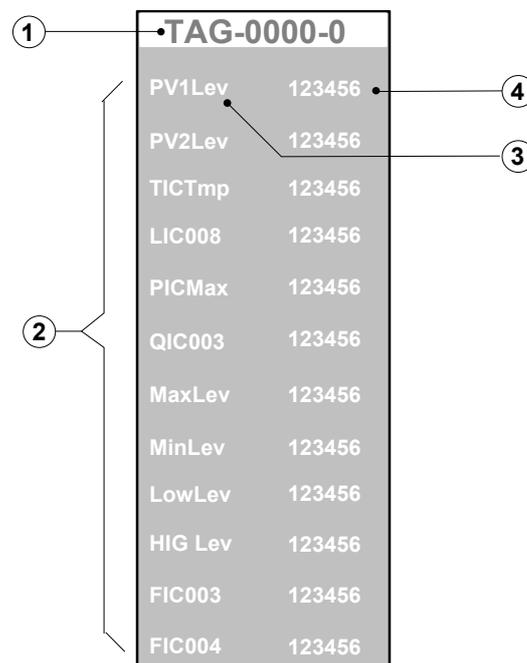
They define the values of the high limits of the scale. Each value consists of 6 characters, including the sign and the decimal point.

**18/24) PV Values**

Numerical values of the analog input signals PV1 and PV2.  
These signals are trended in the chart, too.

**3.3.7 12 Analog Display Panel**

This display provides the functionalities of a set of analog indicators. It displays both the value and the 6 characters tag, of up to 12 analog variables, connected to it, as analog inputs.

**1) Tag**

This tag is the identifier of the panel and consists of up to 10 alphanumeric characters. It is assigned automatically when the module is created and can be modified through AC\_Edit/AC-Program.

**2) Indicators Area**

Area for the display of the analog input variables. Each line of the display offers both the tag and the value of one of the 12 analog input signals.

**3) Variable Tags**

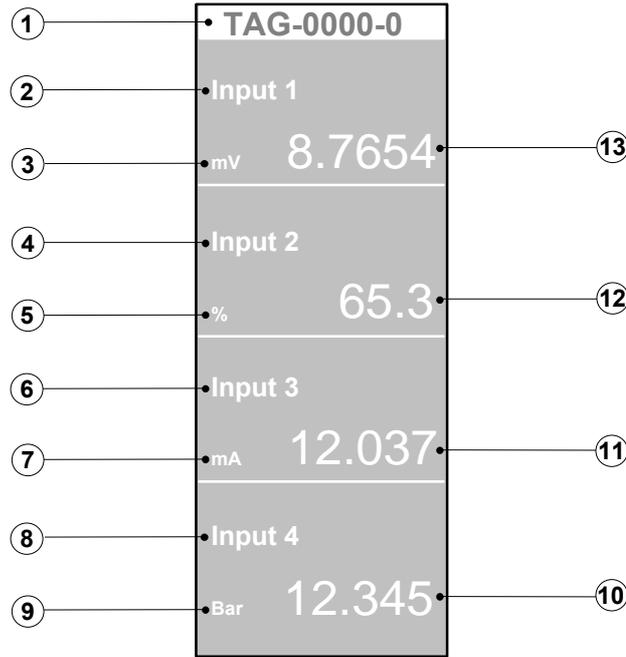
This 6 characters label, specified by the Customer, identifies the displayed variable.

**4) Variable Values**

Numerical display of the analog input signal. It consists of 6 characters, including the sign and the decimal point.

**3.3.8 4 Analog Display Panel**

This display provides the functionalities of a set of analog indicators. It displays the value, the 10 characters tag and the 3 characters engineering units of up to 4 analog variables, connected to it, as analog inputs. The value is shown either as a 6 digits number, without decimal point, or as a 5 digits number, with decimal point.



**1) Tag**

This tag is the identifier of the panel and consists of up to 10 alphanumeric characters. It is assigned automatically when the module is created and can be modified through AC\_Edit/AC-Program.

**2/4/6/8) Variable Tags**

This 10 alphanumeric characters label, specified by the Customer, identifies the displayed variable.

**3/5/7/9) Engineering Units**

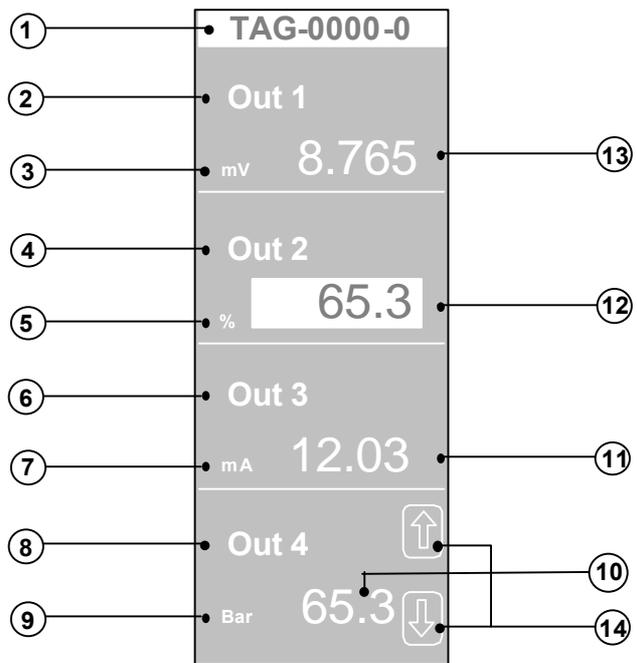
Engineering units mnemonic, consisting of a string of 3 alphanumeric characters maximum.

**10/11/12/13) Variables Values**

Numerical display of the analog input signal. It consists of 6 characters, including the sign and the decimal point.

**3.3.9 4 Writable Analog Display Panel**

This panel allows the contemporaneous display or generation of up to 4 analog-type variables. Each variable is characterized by a tag (max 10 characters) and an engineering unit (max. 3 characters)

**1) Tag**

This tag is the identifier of the panel and consists of up to 10 alphanumeric characters. It is assigned automatically when the module is created and can be modified through AC\_Edit/AC-Program.

**2/4/6/8) Variable Tags**

This 10 alphanumeric character label, specified by the Customer, identifies the displayed variable.

**3/5/7/9) Engineering Units**

Engineering units mnemonic, consisting of a string of 3 alphanumeric characters maximum.

**10/11/12/13) Variables Values**

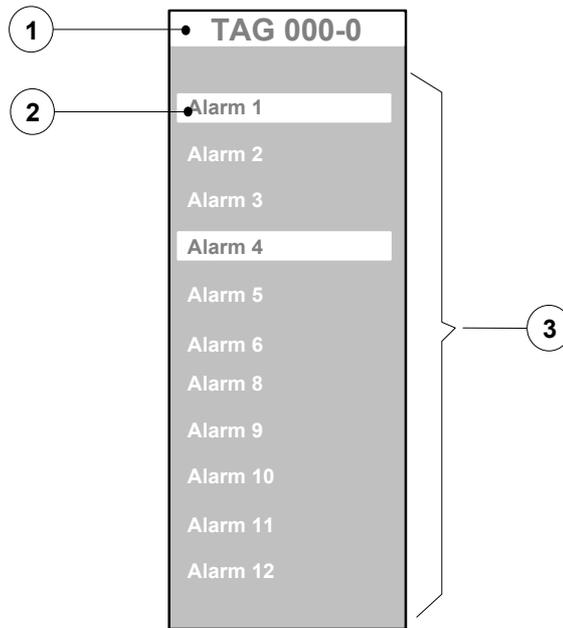
Numerical display of the analog input signal. It consists of 6 characters, including the sign and the decimal point.

**14) Cursor positioning**

Through these keys, the user scrolls the cursors on all the variables, to point to the variable to modify.

**3.3.10 Alarm Panel**

This module provides the functionalities of an alarm annunciator with 12 alarm messages. Each message is connected with a digital input, that defines the visualization of the message. All the 12 messages are listed at a predefined position on the display, with different visualization modes, according to the status of the associated digital input; in reverse, if the input is active, or in normal, if it is inactive. This display can be used not only for alarms, but for listing digital status, too.



**1) Tag**

This tag is the identifier of the alarm panel and consists of up to 10 alphanumeric characters. It is assigned automatically when the module is created and can be modified through AC-Prograph / AC-Edit.

**2) Alarm Messages**

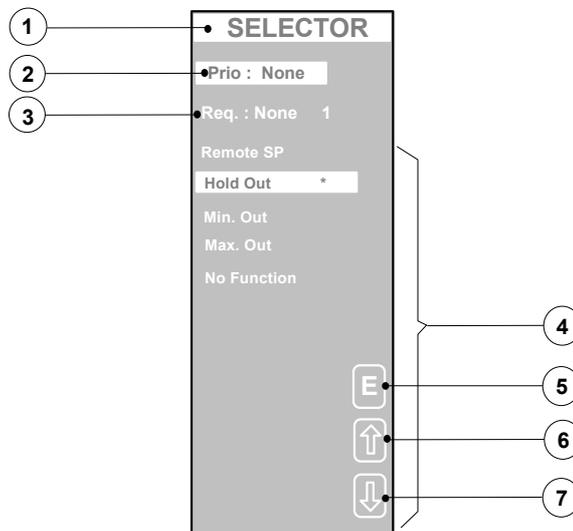
The alarm message is a 12 alphanumeric character string (including space and symbols) associated to a digital input signal. If this signal is in the active state, the message is displayed in reverse, otherwise in normal.

**3) Message Area**

This display is reserved for 12 alarm messages, each on a line of the display.

**3.3.11 Selector Panel**

This display provides the functionality of a control panel for digital commands. It has 4 outputs, that are driven all together, by the pattern selected through one of the 3 supported selection modes: Keyboard, Supervisory Computer and the 4 Digital Inputs. Through these modes, a number from 0 to 15 is specified, that forces the 4 digital outputs to assume a well defined pattern, corresponding to the binary coding of the number and identified by an alphanumeric label, for immediate understanding.



**1) Tag**

This tag is the identifier of the panel and consists of up to 10 alphanumeric characters. It is assigned automatically when the module is created and can be modified through AC-Prograph / AC-Edit e.

**2) Selection Priority**

Display of the selection mode that currently has the highest priority and that, as a consequence, is selecting the output pattern. The priority is defined by the user, by mean of the AC\_Prograph, to the 3 potential selection modes: Keyboard, Digital Inputs and Computer.

**3) Selection Request**

Display of the selection mode, that has been requested by the user and, should be granted. By mean of the **L/R** button, the user can modify the priority scheme, defined through the AC\_Prograph, giving the highest priority to the keyboard. This mechanism allows that the control of the Selector is, usually, performed by the strategy and/or the Supervisory computer, leaving the possibility of operators interventions, through the keyboard, when required. The number at the right of this field, indicates the item number of the last selected pattern.

**4) Item Area**

This area consists of 16 lines, each associated to a defined output pattern (named item) and identified by an alphanumeric, custom defined tag. In AC\_Prograph the user configures the Item ( from 1 to 16). The star symbol on the right of the item name specifies the last item selected, whose pattern has set the digital outputs.

**5) Enter Key**

Enter key, required to confirm the choice operated with the button 6 and 7, in order to proceed with the execution.

**6 - 7) Item Selection Key**

Through this key, the user scrolls the cursors on all the items, to point to the item to select. This selection operation is possible only if the highest priority has been assigned to the keyboard.

## 3.4 Management of the active panels

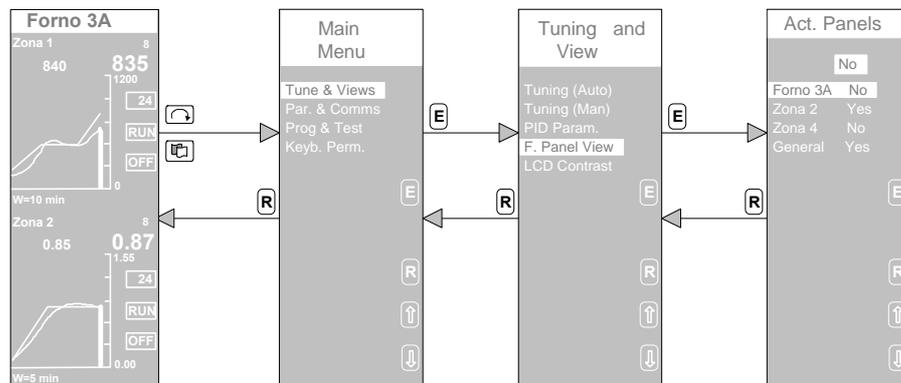
*Each active panel can be set in the following way:*

R/W: Panel and keyboard enabled

Read: Panel enabled and keyboard locked

NO: Panel not displayed

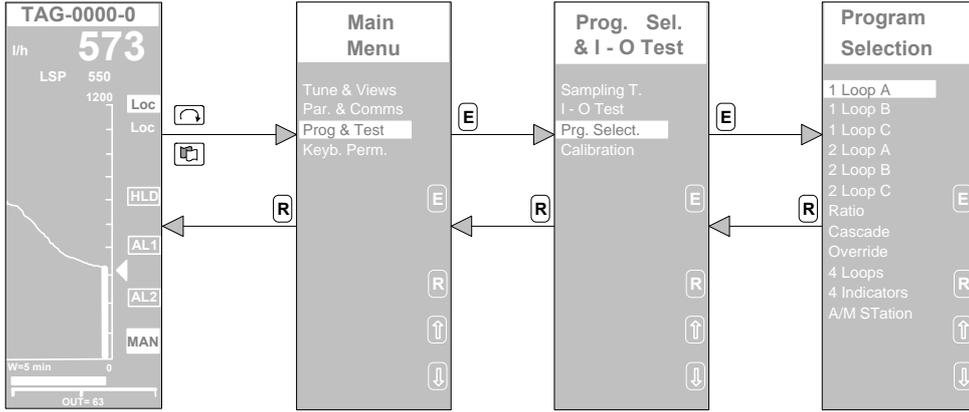
*To set the panel's active modalities, do the following:*



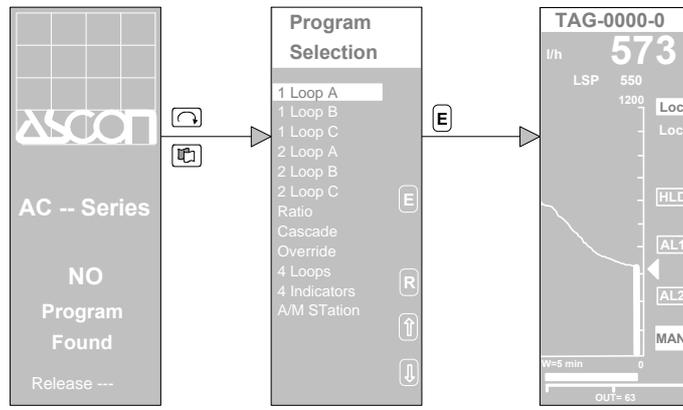
## 3.5 Selection of a resident configuration

At power up, the controller can either show, on the display, the first panel of the selected configuration or display the "NO Program Found" message, when no configuration has been already selected. In both cases, you can select a new configuration, as shown below.

**A) The controller has already a configuration**



**B) The controller doesn't have a configuration.**



In this case, the page with the standard resident configuration, stored in ROM, is displayed.

## 4. PID, Tune and Communication

### 4.1 Tuning

The Tuning method, used in the AC series controller, is an highly sophisticated, new generation algorithm, that represents the state of the art in this technology area. The basic principle, this method is based, is illustrated below.

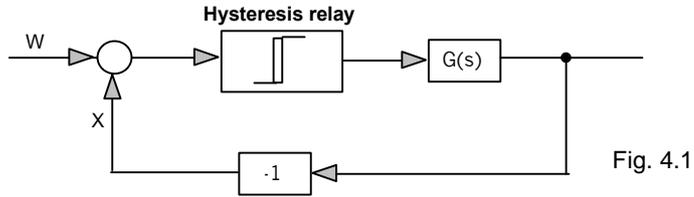


Fig. 4.1

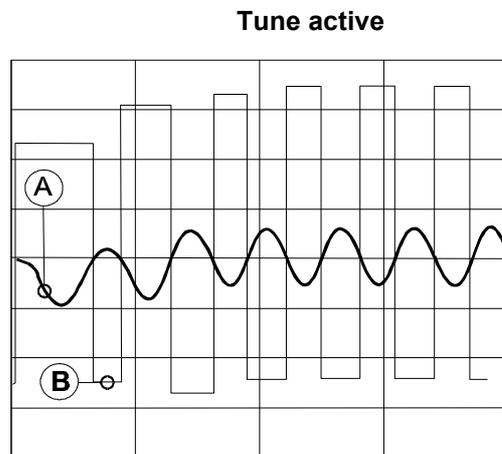


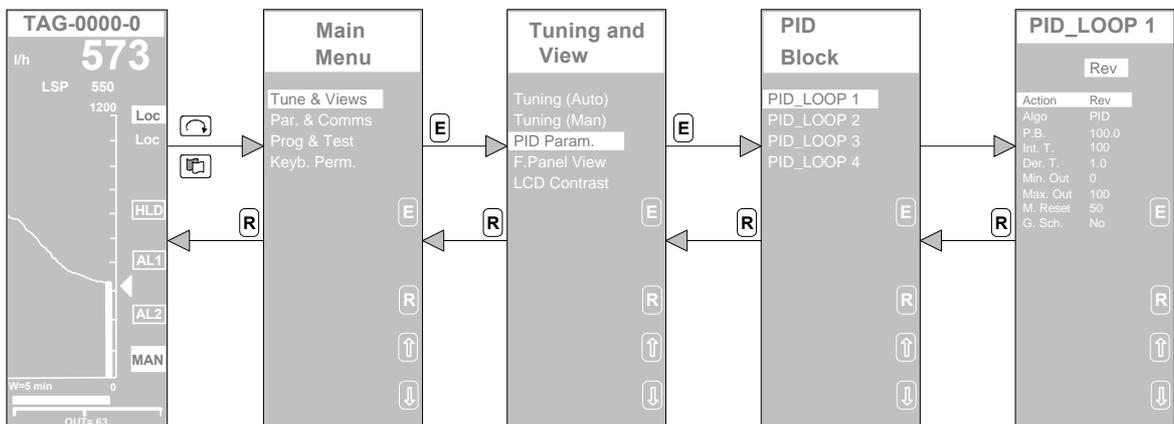
Fig. 4.2

Start of Tune      A= Variable PV      B= MV control output

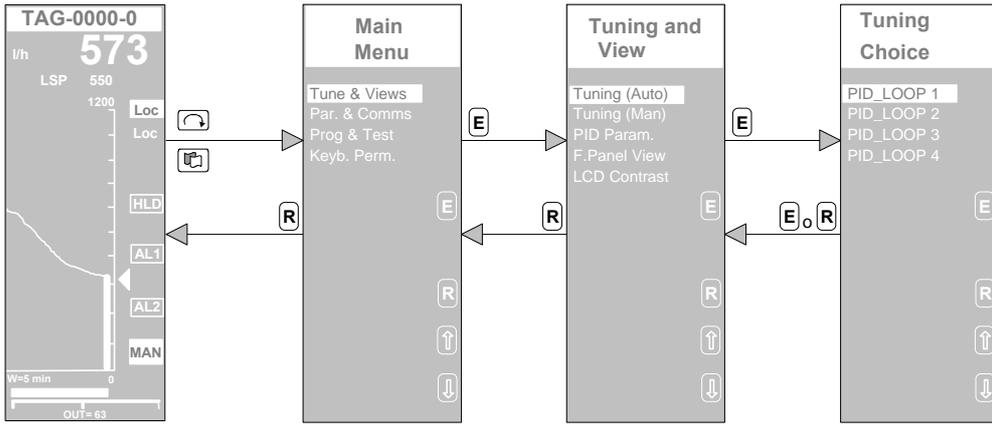
In the closed loop configuration, illustrated above, the hysteresis relay, causes a continuous endless oscillation of the measured variable. These oscillations are carefully examined, in term of amplitude and period, by the Tune algorithm, that, on the basis of this analysis, determines the optimal PID terms values.

The use of the Tune is very simple, because it works with every process, either in steady conditions or during transients. Furthermore, the Tune algorithm is automatically fitted to the type of PID (P, PI, PID) selected.

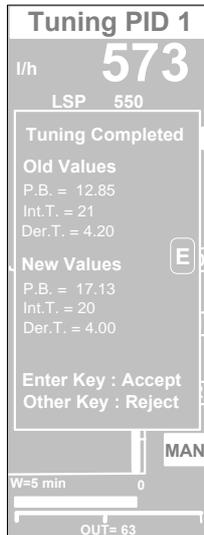
The first step of the Tune procedure is to check and, if necessary, to change the type of PID, by carrying on the following steps:



Once terminated this configuration step, the Tune procedure is launched, by carrying on the following steps, that allow you to specify the loop to be tuned.



During the Tuning process, the message “Tune PID LOOP...” appears in the tag field, at the top of the display panel of the loop under tuning. It is possible to abort the Tuning procedure, anytime before the completion, forcing the loop to Manual or returning back to the Main Menu display. The controllers recognizes the abort of the Tuning, by displaying the message “Tuning Aborted”. This message disappears after the user has acknowledge it, by stroking any key. You can select between two operating modes of the Tune algorithm, according to the way the computed PID terms values are used: an AUTO mode, that, at the end of the processing, writes the computed PID terms values in the loop parameters directly, and a MAN (Manual) one, that presents the values on the display, asking the user to confirm or cancel, before writing them in the loop.



Display panel at the end of the Tuning procedure (Man)

## 4.2 Gain Scheduling

Gain scheduling is based on the technique of changing the value of the 3 terms parameters of the PID algorithm, according to the value of a variable, like the setpoint, the manipulated variable, the controlled variable and other process signals. The main purpose of this functionality is to adjust automatically the 3 terms parameters when dynamic changes occur in the process to control, as, for instance, a load change. The gain scheduling is a very effective control technique with superb results, but its diffusion has been limited by the high skills and the considerable development efforts required to implement it.

The word Gain scheduling is the historical name, and it doesn't mean absolutely that only the Proportional band value can be changed, because this technique is now extended to all the 3 terms, including the integral time and the derivative time.

The PID module of the AC series controllers has 3 analog inputs, named KP, KI, KD, whose values multiply the configured 3 terms parameters (Gain, Integral Time and Derivative Time), to determine the coefficients values to use in the PID formula, as explained below:

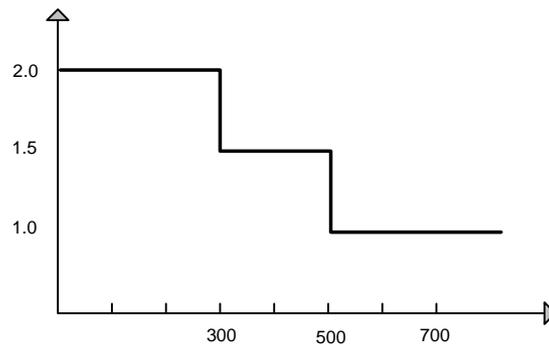
$$PB_u = \frac{PB_p}{KP} \quad TI_u = TI_p * KI \quad TD_u = TD_p * KD$$

where PBU, TIu and TDu are the coefficients of the 3 terms, used in the PID formula, while the PBp, TIp and TDp are the values set by the user.

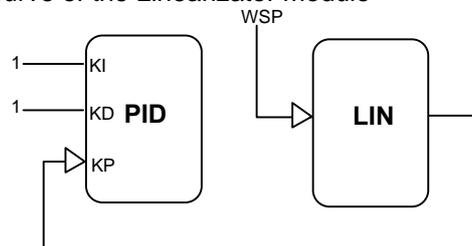
For instance, let us guess to have calculated three sets of the 3 terms parameters, each one related to well defined setpoint range. You can imagine that each set has been computed automatically by the controller Tuning facility, as described in the Chapter 4.1.

Setpoint Range	Optimal PB
0-300	10
300-500	13,3
500-700	20

The best result is achieved if the Gain parameter is set according to the value of the setpoint. This can be implemented automatically, exploiting the scheduling facility, as illustrated below. A linearizator module, whose input variable is the PID Working Setpoint, selects the appropriate coefficient, that, through the KP input, multiplies the predefined value of PB (that is 20), achieving the Gain value in the table above.



Characterization curve of the Linearizator module



Block diagram of the strategy for implementing a variable gain PID.

### 4.3 PID with two degree of freedom

In order to provide very effective control capabilities, the AC controllers are supplied with a PID algorithm with two degree of freedom.

This second degree corresponds to the *Beta* parameter, that provides a sort of weighting of the setpoint that goes in the PID formula. The benefit of using this parameter, is a consistent lowering of the overshoot and the undershoot, during the setpoint changes.

This *Beta* parameter, also named *Set Point Weighting*, has the same characteristics of the *Set Point Filtering*, that is used by other Vendors, because it doesn't change the response at steady conditions. It modifies the position of some zeroes in the closed loop transfer function, and this causes a more beneficial response to the overshoot. The following picture illustrates the concept and the better response achieved with an optimal value of *Beta*.

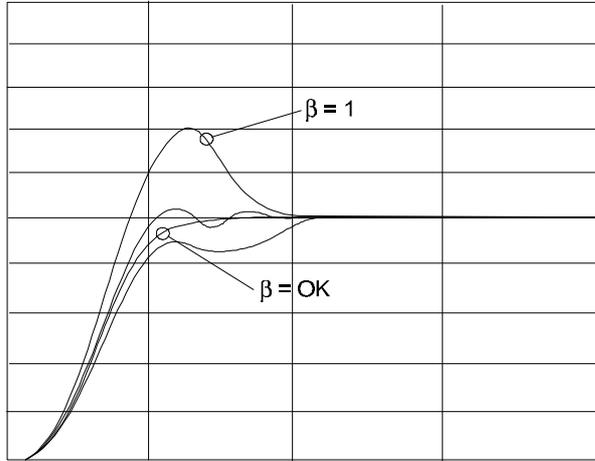


Fig. 4.3

Various simulation studies have demonstrated that the *Set Point Weighting* is more effective than the *Set Point Filtering*, because, in identical conditions of dumping amplitude, it reaches the target setpoint in a shorter time.

## 4.4 Communications

The AC series controllers are supplied with 3 serial ports:

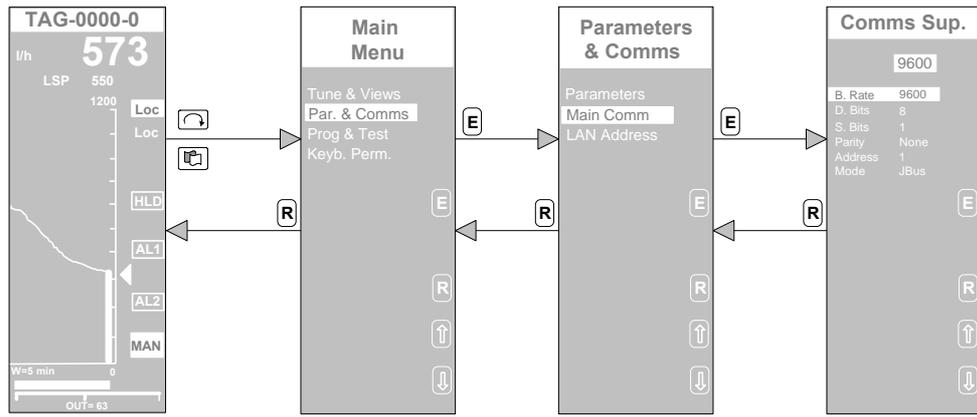
- RS232 serial port for instrument programming.
- RS485 serial port to the Supervisory Computer.
- RS485 serial port to auxiliary units (Expansion Units).
- LAN network (ARCNET type) for "peer to peer" communication and to the Supervisory Computer.

### 4.4.1 Handling the Programming port

The programming port (named service port, too) is mainly used to download and upload strategies in the AC controller, by mean of the AC\_Prograph or to modify the parameters of a strategy, by mean of the AC\_Edit. This RS232 serial port is configured with the fixed settings 9600, E, 7, 2 (9600 baud, even parity, 7 data bits, 2 stop bits) that cannot be changed by the user, because its use is reserved to AC-Prograph / AC-Edit.

### 4.4.2 Handling the Main Comm Supervisory Computer

The AC controller communicates, through this port, with a Supervisory Computer, with the MODBUS and JBUS protocols. The physical media is a twisted pair and up to 31 devices can be connected on a cable. The setting of this port is as follows:



**Main Comm port Setting**

<b>B. Rate</b>	Baud rate setting. Allowed values: 110, 300, 600, 1200, 2400, 4800, 9600, 19200
<b>D. Bits</b>	Fixed value set to 8.
<b>S. Bits</b>	Stop bits, the choice is between 1 or 2.
<b>Parity</b>	The choice is None, Odd, Even.
<b>Address</b>	MODBUS/JBUS address of the controller. It is a number from 1 to 247.
<b>Mode</b>	ModBus or Jbus protocol.

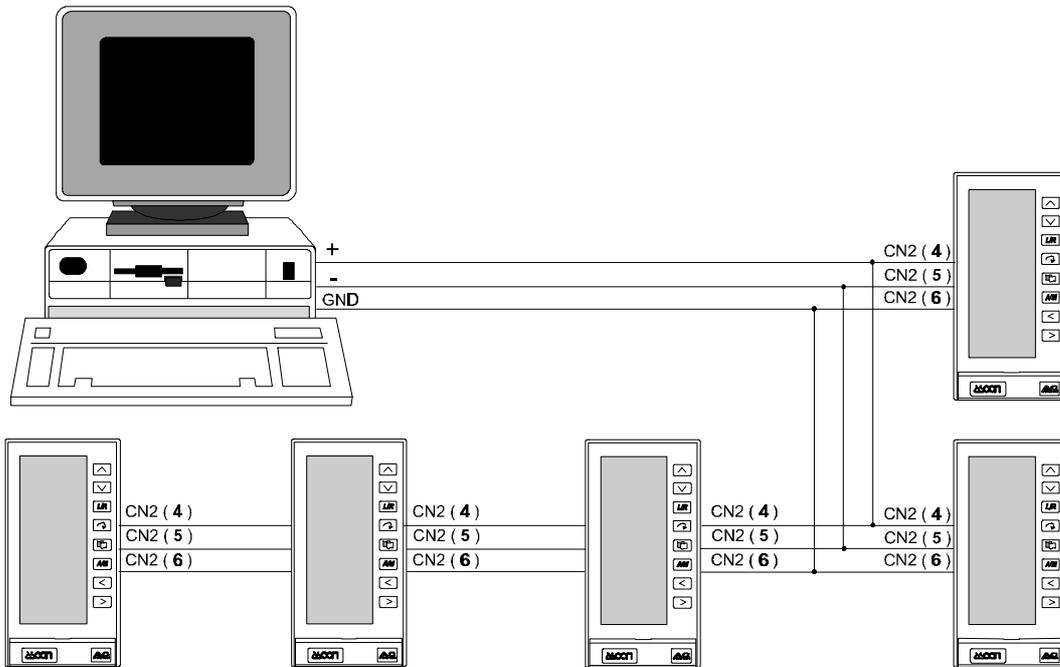


Fig. 4.4

**Supervisory port specification.**

Interface: RS485 differential (2 wires)  
 Baud Rate: 110 .. 19200 Bit per Seconds  
 Type of connection: Multidrop  
 Max n° of controllers on a cable: 31 plus the Supervisory computer

**Note:**

It is strongly suggested to insert the termination resistors of 120Ω at both ends of the cable, where the Supervisory computer and the last instrument of the multidrop chain are located. Furthermore, to improve the noise rejection figures, it is possible to bias the two wires of the differential line with the insertion of a pull up resistors on a wire and a pull down resistors on the other. This is achieved by moving the on board switch **S3** to position **A** and **S4** to position **B**. Obviously, the bias must be enabled on one instrument only. If there are more than one controller, is preferable to apply the bias, by setting the switches as described above, on the last one.

- *Example 1:* There is a Supervisory computer connected with a controller, only. The termination resistors must be applied both on computer and the controller.
- *Example 2:* There are “n” controllers on the line. The termination resistors must be applied both on the Supervisory computer and the last controller on the line. On the controller, the insertion of the termination resistors is achieved by moving the on board switch **S1** to position **B**.

The on board switches for the bias and the termination of the line, are located inside the instrument, close to the gold dual edge connector of the CPU card (Refer to Fig. 4.5 below).

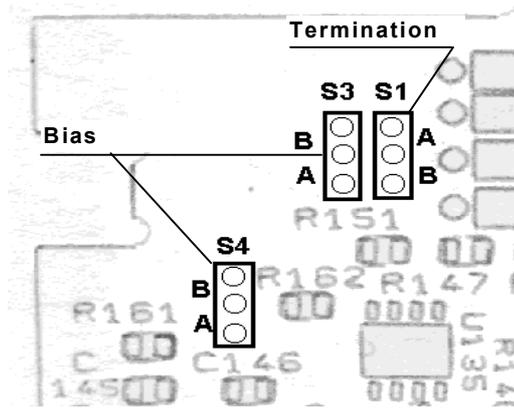


Fig. 4.5 Detail of the CPU card with the switches for the termination and the bias of the line.

For more information on the MODBUS and JBUS protocol, consult the Communication manual Cod. J30 - 304 - 1ACSAC

#### 4.4.3 Handling the Aux Comm

This serial port is provided on the AC20 and AC30 controllers only, and uses the RS485 standard. Its purpose is the transfer of real time data between the Controller and Expansion units mod AAC-EU/88/4 or AAC-EU/88 or the safety station, currently under development.

To get this connection operating, the user has just to make the appropriate cabling, because all the hardware and the firmware required is already on board and doesn't require any configuration. Refer to Chapter 2.4.9 for the diagram of the connections.

Once the Expansion unit is connected, its I/O can be easily used in the strategy, you are designing with the AC\_Prograph, as any other signal from the controller. For more detail, refer to the AC\_Prograph User Manual cod. J30-304-AACPROGRAPH.

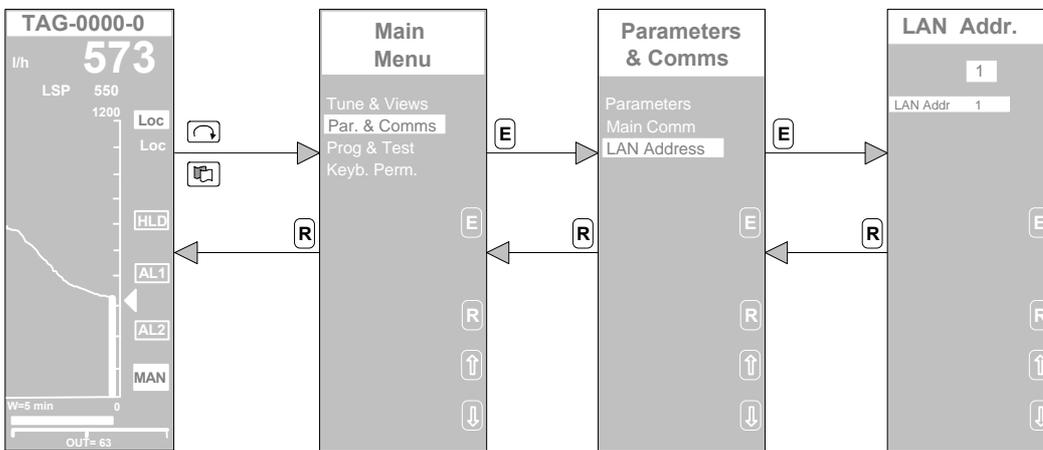
### 4.4.4 Handling the LAN (ARCNET )

The interface card to this network is supplied, as an option, on the AC20 and AC30 controllers only. The purpose of this network is to handle the peer to peer communication between all the devices on the LAN (Local Area Network).

This LAN offers two big advantages:

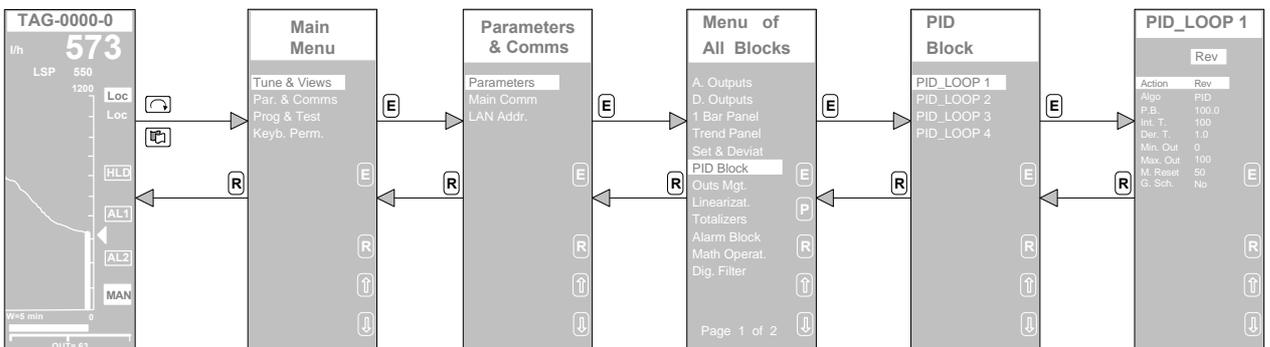
- 1) It allows the softwiring between up to 8 controllers, located on 120 mt. of cable (maximum distance between the first and the last controller), without any additional hardware or software. This easy to use functionality, with the plug and play feature, provides the transmission of real time signals among the controllers, required for developing global control strategies, involving a cluster of AC controllers.
- 2) It provides a communication media (2.5 Mbit/s) to a Supervisory computer faster than the RS485 serial line. This feature, that requires an appropriate hardware and software interface on the computer side, is particularly useful in high performing application.

For more details, refer to the Communication manual Cod. J30 - 304 - 1ACSAC. The setting of this port is carried on as follows:



### 4.5 Parameter change

You can modify the parameter values, assigned by AC\_Prograph to the modules of the strategy, by carrying on the following procedure:



## 4.6 AC-Prograph / AC\_Edit Software

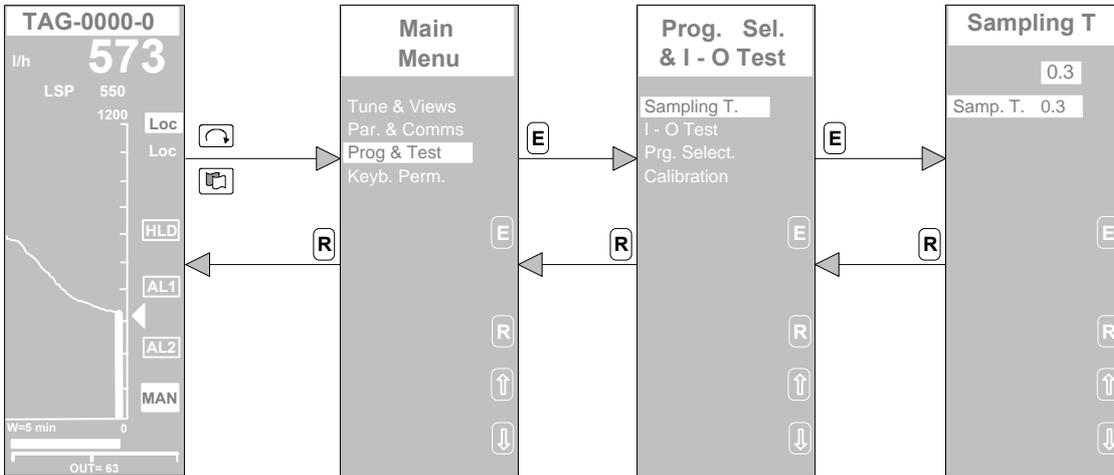
AC-Edit/AC-Prograph run on a PC or a compatible PC, with Windows operating system, version 3.x or later, for basic editing of the AC controller strategies. It allows to analyze the strategy in a controller and to change the parameters values of the various modules and other strings, like tags. Furthermore. it allows to save the parameters on a disk file, display them again and download them into the controller. For more information, refer to the AC-Edit/AC-Prograph User Manual.

## 4.7 Sampling time

The resident configurations have a predefined sampling time of 300 msec., that is perfectly suitable for most of the processes. Anyway, you can change this time, by mean of the SYS module, and set it to a new value, with range 0,1 to 10,0 seconds at steps of 0,1 seconds.

The sampling time must be carefully set, because a too large value slows the response time of the control strategy, risking the incapability of the control of the process, while, if the sampling time is too short, the response of the control strategy tends to overreact to process variations.

The following picture illustrate the procedure to use in order to modify the sampling time.



## 5. Modules

This chapter describes all the functional modules available in the AC controllers, in order to provide you all the detailed informations, you need to built up your control strategy.

### 5.1 Rules used throughout this chapter

The following rules have been used in this chapter to describe the modules:

The values in “engineering units” of parameters, input and output signals, have, by default and unless differently specified, the allowed range: -9999 to 999999.

The values in “percentage” of parameters, input and output signals, have, by default and unless differently specified, an allowed range: 0.0 to +100.0.

The two status of a digital output are indicated by:

“H” or “Active” for the status = 1

“L” or “Inactive” for the status = 0

In the drawing of the module symbol, the input signals are always on the left, while the output signals are on the right.

## 5.2 I/O Modules

### 5.2.1 Analog Input (AI)

*Description*

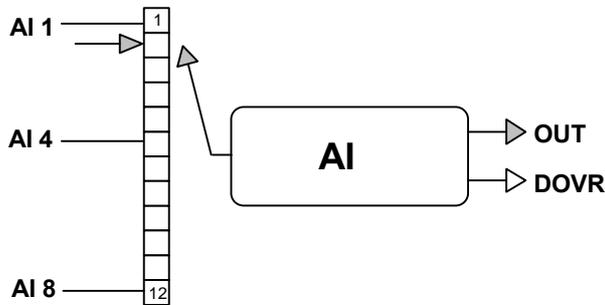
This module converts one of the four/eight analog input signals, connected to the termination unit of the controller, into a number, in engineering units. The hardware range of the signal is 0-5V or 1-5V.

Beyond the conversion process, this module provides conditioning, filtering, percentage ranging, linearization and out of range detection, on the input signal. The available linearization curves include the square root and the most diffused thermocouple and resistance thermometer.

If the range of the signal is less than the standard hardware one (0-5V or 1-5V), you configure directly this not standard range, in order to transform the measure in engineering units, avoiding any further interpolation calculation.

For, instance, if your signal is the output of a transmitter with an actual range of 2 to 4 V, while the standard is 0 to 5 V, you select the 0 - 5V standard and you enter, in the Input Scaling Parameter, the actual range of your signal (40% and 80% of the standard scale), that corresponds to the specified engineering units range.

It is strongly recommended that the hardware range of the signal is greater than 1.5 Volt.



*I/O Connections*

<b>OUT</b>	Value, in engineering unit, of the input signal.
<b>DOVR</b>	Out of range detector. Active ( 1 logic ) if the signal is out of the configured range, like in the case of some failure on the transmitter device <b>(1)</b>

**Note:**

1. The detection is operating only if the selected range is 1-5 V (4-20 mA). In this case the out of range is detected when the signal is lower than 0.875 Volt ( or 3.5 mA)

*Parameters*

**PV LOOP 1**

No

Scaling	No	
% Low	0.00	
% High	100.00	
Inp.Type	0-5V	E
Linear.	Ident	
SqrCtOff	0.0	
Filter	0.0	
Range Lo	0.0	R
Range Hi	100.0	
Format	XXXX.X	↑
		↓

**Displayed Parameters**

<b>Scaling</b>	Enables/disables the selection of the actual hardware range of the signal, when different from the standard hardware range. The choice is Yes or No
<b>% Low</b>	Defines the low limit of the actual hardware range of the signal. It is entered as a percentage (0 to 100%) of the standard hardware range specified.
<b>%High</b>	Defines the high limit of the actual hardware range of the signal. It is entered as a percentage (0 to 100%) of the standard hardware range specified.
<b>Inp. Type</b>	Specifies the standard hardware range of the signal. The choices are: 0-5V / 1-5V
<b>Linear.</b>	Defines the linearization curve to apply to the input signal <b>(2)</b>
<b>SqrCtOff</b>	Specifies the Cutoff value used with flow measurement <b>(3)</b>
<b>Filter</b>	Filter time constant ( if the value is 0, the filter is disabled )
<b>Range Lo</b>	Low range, in engineering units of the signal <b>(4)</b>
<b>Range Hi</b>	High range, in engineering units, of the signal <b>(4)</b>
<b>Format</b>	Defines the number of digits (format) of the output value

**Note (2)**

IDENT.	<b>No linearization is performed</b>
Sqr	<b>Square Root</b>
TCT	<b>Thermocouple T Range -200..400 °C</b>
TCJ	<b>Thermocouple J Range -40.. 760 °C</b>
TCK	<b>Thermocouple K Range -40..1200 °C</b>
TCS	<b>Thermocouple S Range -50..1650 °C</b>
TCR	<b>Thermocouple R Range -50..1650 °C</b>
TCB	<b>Thermocouple B Range 400..1800 °C</b>
TCN	<b>Thermocouple N Range 0..1300 °C</b>
TCP	<b>Thermocouple P (Platinel) Range -50..1250 °C</b>
TCL	<b>Thermocouple L Range -40..760 °C</b>
PT100	<b>Resistance thermometer PT100 Range -200..850 °C</b>
NI100	<b>Resistance thermometer NI100 Range -60..180 °C</b>

**Note:**

- (3)** The Cutoff value that is continuously compared with the input signal. If the input signal falls below this value, it is considered 0. This is particularly useful with flow measurement, where the measure becomes meaningless when too low.
- (4)** Any change of these two values automatically affects the values of the Scale range of the display panel modules ( Bar panel e Trend ) and the “SDV “ module ( Setpoint and Deviation calculation ), related to the analog input.

## 5.2.2 Frequency Input (FI)

### Description

This module converts a frequency signal input, with range 0 to 20.000 Hz, to a number, in engineering unit. The signal is applied to the termination unit of the digital input n°1 (D1) of the AC controller.

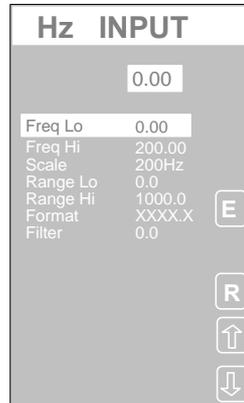
The range of the output signal doesn't necessarily start from 0, while the module provide a filtering of the output value, to properly process the signal.



### I/O Connections

<b>Out</b>	Value, in engineering unit, of the frequency input signal.
<b>Dovr</b>	Out of range detector. Active ( 1 logic ) if the signal is out of the configured range, like in the case of some failure on the transmitter device.

### Parameters



### Displayed Parameters

<b>Freq Lo</b>	Low limit of the frequency range of the signal. Adjustable from 0 to 20.000 Hz (1)
<b>Freq Hi</b>	High limit of the frequency range of the signal. Adjustable from 0 to 20.000 Hz (1)
<b>Scale</b>	Selects the hardware range of the signal (2)
<b>Range Lo</b>	Low range, in engineering units, of the signal (3)
<b>Range Hi</b>	High range, in engineering units of the signal (3)
<b>Format</b>	Defines the number of digits (format) of the output value
<b>Filter</b>	Filter time constant ( if the value is 0, the filter is disabled )

**Note 1)** If the entered value exceeds the high range of the signal, as specified in the parameter "Scale", after pressing the "E" enter button, the value is automatically clamped to the range limit.

**Note 2)** The choice is between the following ranges:

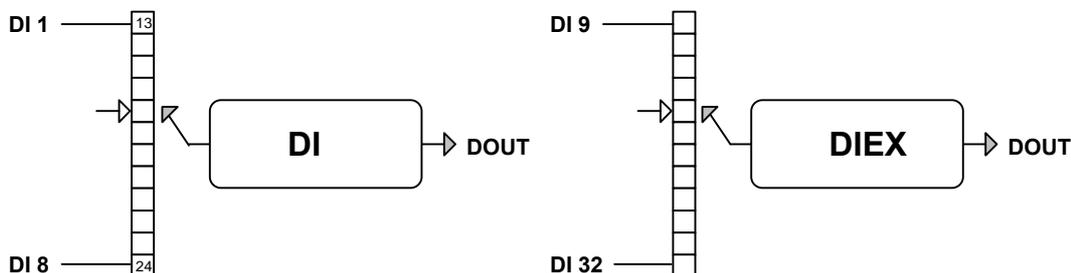
Display	Range	Sampling
200 Hz	0.01 ... 200 Hz	10 msec / 100 sec
2.000 Hz	0.1 ... 2.000 Hz	1 msec / 10 sec
20 kHz	1 ... 20 kHz	1 sec

**Note 3)** Any change of these two values automatically affects the values of the Scale range of the display panel modules( Bar panel e Trend ) and the "SDV " module ( Setpoint and Deviation calculation ), related to the analog input.

### 5.2.3 Digital Input (DI)

*Description*

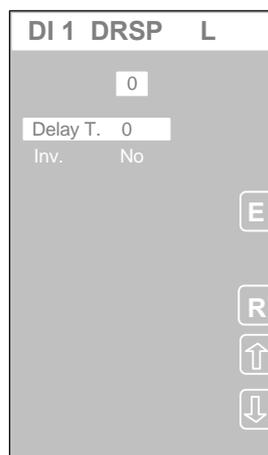
This module acquires one digital input and output it to the control strategy. Beyond the basic acquisition task, this module performs some processing on the digital signal, like inversion and delay.



*I/O Connections*

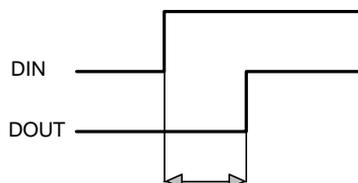
<b>DOUT</b>	Output
-------------	--------

*Parameters*



*Displayed Parameters*

<b>Delay T.</b>	Defines the time the input signal must be delayed, before being retransmitted to the output. It is entered as a multiple of the sampling time of the controller. If it is set to 0, then the signal is not delayed. Range from 0 to 30.
<b>Inv.</b>	When selected, the module performs an inversion of the status of the digital input. The output signal corresponds to the Boolean NOT of the input signal.

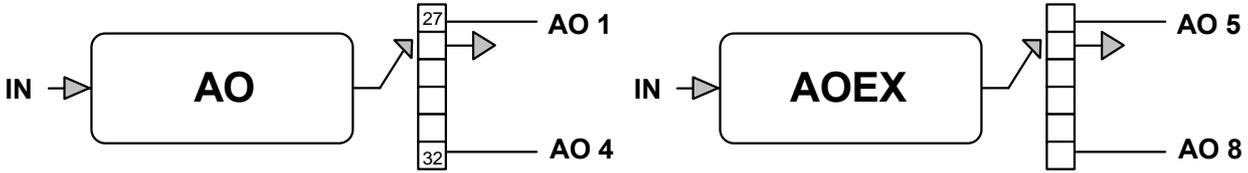


Delay (sec) = Delay T. \* Sampling T.

### 5.2.4 Analog Output (AO)

*Description*

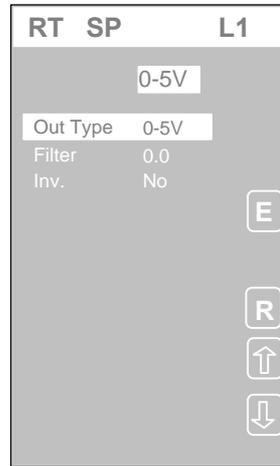
This module converts a percentage value (range 0 - 100%) of the IN input, in a signal, generated on the termination unit of the instrument. Beyond the conversion, this module provides the inversion of the signal (complement to 100), the filtering and the selection of the hardware characteristics of the signal, between various choices.



*I/O Connections*

<b>IN</b>	Input signal with the percentage value of the output.
-----------	-------------------------------------------------------

*Parameters*



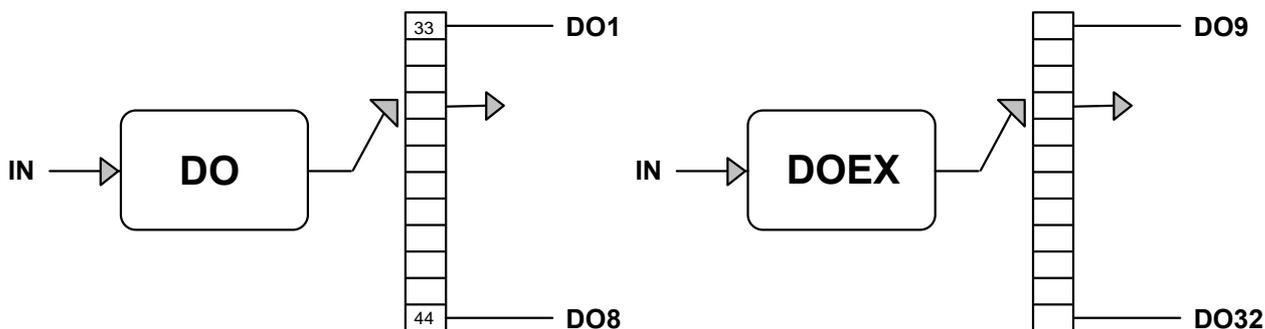
*Displayed Parameters*

<b>Out Type</b>	Hardware range of the output signal. The choices are: 0-5 V, 1-5 V, 0-20 mA, 4-20 mA.
<b>Filter</b>	Time constant value of the filter applied to the IN value. The range is between 0 and 30 seconds.
<b>Inv.</b>	When selected, it "inverts" the value of the IN input. The math expression for this "inversion" operation is: 100 - IN. The choices are: No or Yes.

### 5.2.5 Digital Output (DO)

*Description*

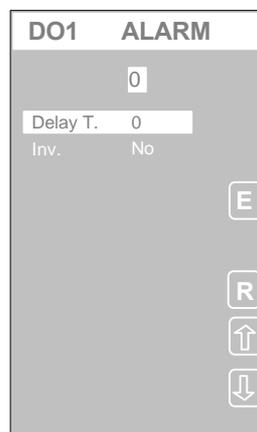
This module transfers the status of a digital variable, IN, generated by the strategy to a physical output of the controller. Beyond this basic output task, this module performs the inversion and the delay of the output signal.



*I/O connections*

<b>In</b>	Digital Input
-----------	---------------

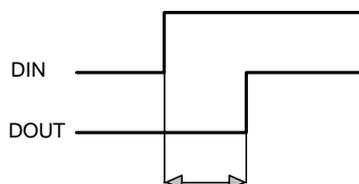
*Parameters*



*Displayed Parameters*

<b>Delay T.</b>	Defines the time the IN signal must be delayed before being retransmitted to the physical output. It is entered as a multiple of the sampling time of the controller. If it is set to 0 then the signal is not delayed. Range from 0 to 30 (1)
<b>Inv.</b>	When selected, the modules performs an inversion of the status of the DIN digital input. The physical output corresponds to the Boolean NOT of the IN input signal.

( 1 )



Delay (sec) = Delay T. \* Sampling T.

## 5.3 Display panel

The maximum number of active panels is 12 (including the REAL TIME CLOCK for AC30).

The display sequence of the front display panels can be set in the Tools – Edit Modules menu of AC Prograph / AC Edit.

For the above refer to Section 7.6.2. of the manual.

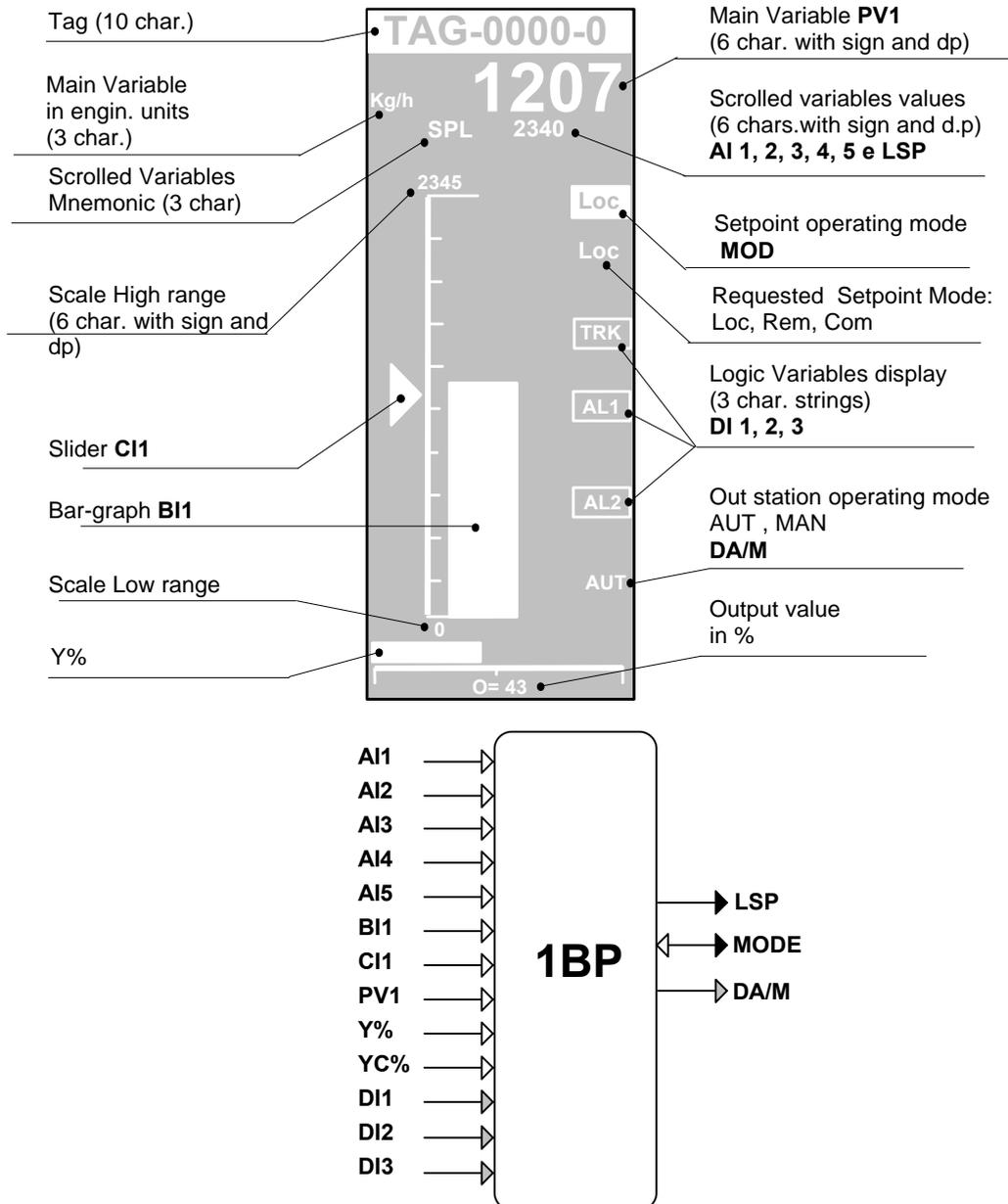
### 5.3.1 Single bargraph panel (1BP)

#### Description

This module provides the display, both by bargraph and numerically, of an analog variables, logic variables by symbolic names of the states and alarms by messages.

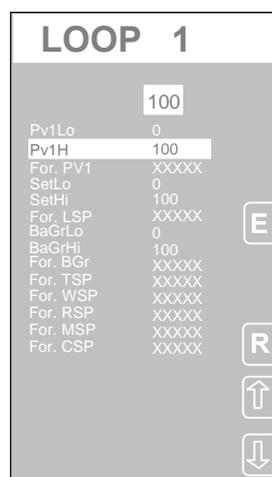
Furthermore, this module is not just a display device: It's a front panel, providing all the functionalities to carry out all the basic operations required to interact with the loop. In fact, it allows:

- the setting of the Local Setpoint
- the change of the Setpoint operating mode, between Local, Remote and Computer
- the change of the Output operating mode between Auto and Local



**I/O Connections**

<b>DI1, DI2, DI3</b>	Digital inputs, whose status is displayed through a 3 characters label. The most common use is to flag alarms or other digital events.
<b>AI1 ÷ AI5</b>	Analog variables, displayed numerically in the scrolled list, with a short 3 characters mnemonic. The number of displayed inputs can be set through the parameter "items" in the module "1-Bargraph-Edit" of AC Prograph / AC Edit. <i>For the above refer to Section 9.10.1 of the manual.</i>
<b>BI 1</b>	Analog Input displayed, graphically, on a bargraph, with a decimal scale.
<b>CI 1</b>	Analog input, displayed, graphically, by mean of a slider, moving along the decimal scale.
<b>PV 1</b>	Main Variable, displayed numerically, with big digits, at the top of the display.
<b>Y%</b>	Analog Input, displayed, in percentage, numerically and by an horizontal bargraph at the bottom of the display. It is intended for the control output of a loop.
<b>Yc%</b>	Analog Input, displayed, together with Y%, at the lower part of the display, both numerically and by an horizontal bargraph. While Y% is intended for a normal loop or for the Heat output, this variable is intended for displaying the Cool output of an Heat/Cool loop.
<b>DA/M</b>	Operating mode of the Out station: Manual (active), Auto (inactive)
<b>LSP</b>	Local setpoint value, entered through the keyboard.
<b>MOD</b>	Special I/O signal handling the Setpoint operating mode change.

**Parameters****Displayed parameters**

<b>Pv1Lo</b>	Main variable low range
<b>Pv1Hi</b>	Main variable high range
<b>For. PV1</b>	Format: defines the number of digits of the PV variable.
<b>SetLo</b>	Minimum value of the Local Setpoint
<b>SetHi</b>	Maximum value of the Local Setpoint
<b>For. LSP</b>	Format: defines the number of digits of the Local Setpoint
<b>BaGrLo</b>	Low range of the bargraph variable
<b>BaGrHi</b>	High range of the bargraph variable
<b>For. BGr</b>	Format: defines the number of digits of the Bargraph variable.
<b>For. TSP</b>	Format: defines the number of digits of the AI1 variable (note 1)
<b>For. WSP</b>	Format: defines the number of digits of the AI2 variable (note 1)
<b>For. RSP</b>	Format: defines the number of digits of the AI3 variable (note 1)
<b>For. MSP</b>	Format: defines the number of digits of the AI4 variable (note 1)
<b>For. CSP</b>	Format: defines the number of digits of the AI5 variable (note 1)

**Note (1)**

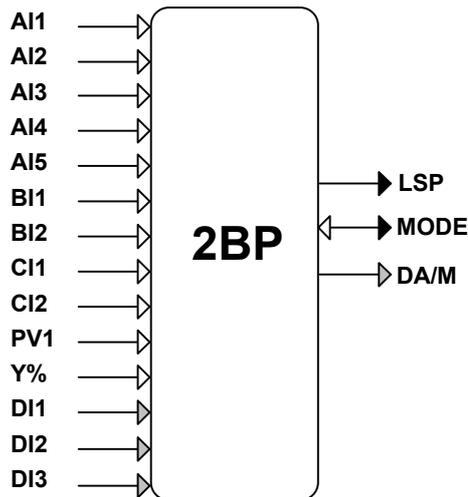
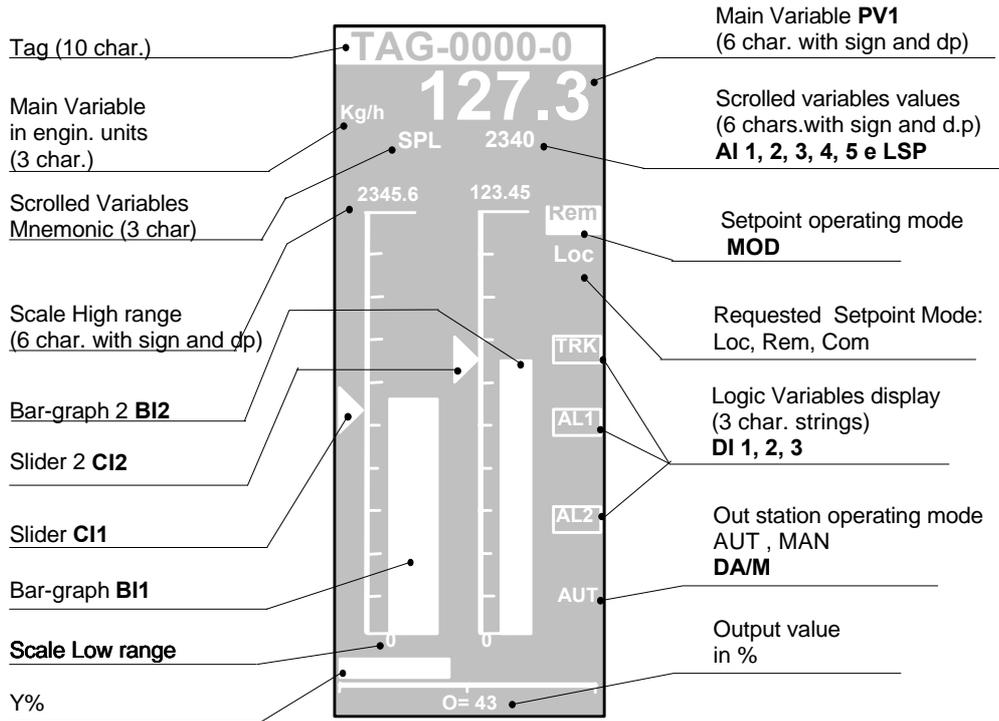
The 3 characters mnemonic of these 5 analog inputs is defined completely in the configuration by the user.

### 5.3.2 Double bargraph panel (2BP)

*Description*

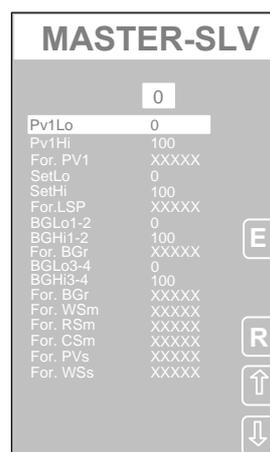
This module has the same functionalities of the previous one, the 1BP. The only difference is that it accommodates a second bargraph with its slider, and, therefore, it has additional inputs.

Its main purpose is to provide the front panel of a cascade loop. In this case, the setpoint and the measured variable of the Master loop (the one generating the setpoint for the Slave loop) are displayed on the left bargraph, while the ones of the Slave are on the right. The control output of the Slave is displayed in the lower part of the panel. Both the setpoints are displayed, but only the one of the Master can be changed from the keyboard.



**I/O connections**

<b>DI1, DI2, DI3</b>	Digital inputs, whose status is displayed through a 3 characters label. The most common use is to flag alarms or other digital events.
<b>AI1 ÷ AI5</b>	Analog variables, displayed numerically in the scrolled list, with a short 3 characters mnemonic. The number of displayed inputs can be set though the parameter "items" in the module "2-Bargraph-Edit" of AC Prograph / AC Edit. <i>For the above refer to Section 9.10.2 of the manual.</i>
<b>BI 1</b>	Analog Input displayed, graphically, on a bargraph 1, with a decimal scale.
<b>CI 1</b>	Analog input, displayed, graphically, by mean of a slider 1, moving along the decimal scale.
<b>BI 2</b>	Analog Input displayed, graphically, on a bargraph 2, with a decimal scale.
<b>CI 2</b>	Analog input, displayed, graphically, by mean of a slider 2, moving along the decimal scale.
<b>PV 1</b>	Main Variable, displayed numerically, with big digits, at the top of the display.
<b>Y%</b>	Analog Input, displayed, in percentage, numerically and by an horizontal bargraph at the bottom of the display. It is intended for the control output of a loop.
<b>Yc%</b>	Analog Input, displayed, together with Y%, at the lower part of the display, both numerically and by an horizontal bargraph. While Y% is intended as the output of either a normal or a Heat loop, this variable is intended for displaying the Cool output of an Heat/Cool loop.
<b>DA/M</b>	Operating mode of the Out station: Manual (active), Auto (inactive)
<b>LSP</b>	Local setpoint value, entered through the keyboard.
<b>MOD</b>	Special I/O signal handling the Setpoint operating mode change.

**Parameters****Displayed Parameters**

<b>Pv1Lo</b>	Main variable low range
<b>Pv1Hi</b>	Main variable high range
<b>For. PV1</b>	Format: defines the number of digits of the PV variable.
<b>SetLo</b>	Minimum value of the Local Setpoint
<b>SetHi</b>	Maximum value of the Local Setpoint
<b>For. LSP</b>	Format: defines the number of digits of the Local Setpoint
<b>BGLo1-2</b>	Low range of the bargraph 1 variable
<b>BGHi1-2</b>	High range of the bargraph 1 variable
<b>For. BGr</b>	Format: defines the number of digits of the Bargraph 1 variable.
<b>BGLo3-4</b>	Low range of the bargraph 2 variable
<b>BGHi3-4</b>	High range of the bargraph 2 variable
<b>For. BGr</b>	Format: defines the number of digits of the Bargraph 2 variable.
<b>For. WSm</b>	Format: defines the number of digits of the AI1 variable (note 1)
<b>For. RSm</b>	Format: defines the number of digits of the AI2 variable (note 1)
<b>For. CSm</b>	Format: defines the number of digits of the AI3 variable (note 1)
<b>For. PVs</b>	Format: defines the number of digits of the AI4 variable (note 1)
<b>For. WSs</b>	Format: defines the number of digits of the AI5 variable (note 1)

**Note (1)**

The 3 characters mnemonic of these 5 analog inputs is defined in the configuration by the user.

### 5.3.3 Quadruple bargraph panel (4BP)

*Description*

These module has the same basic functionalities of the 1BP panel module and it is intended for displaying, on an unique panel, more than one loop, together with some analog measures or outputs.

Obviously, it is less rich of information than 1BP; it lacks the output bargraph and the main variable engineering units. But, surely, it is the most versatile; as soon as you connect the signals of a loop, it adds the bargraph and the slider, related to it.

Furthermore, for each bargraph you can choose if you want the slider or not, so that, if you want to display just a measure, you do not have a meaningless slider around. And, you can mix, as you like, bargraphs with the slider, for "control loops", and without, for "measures" and "A/M station".

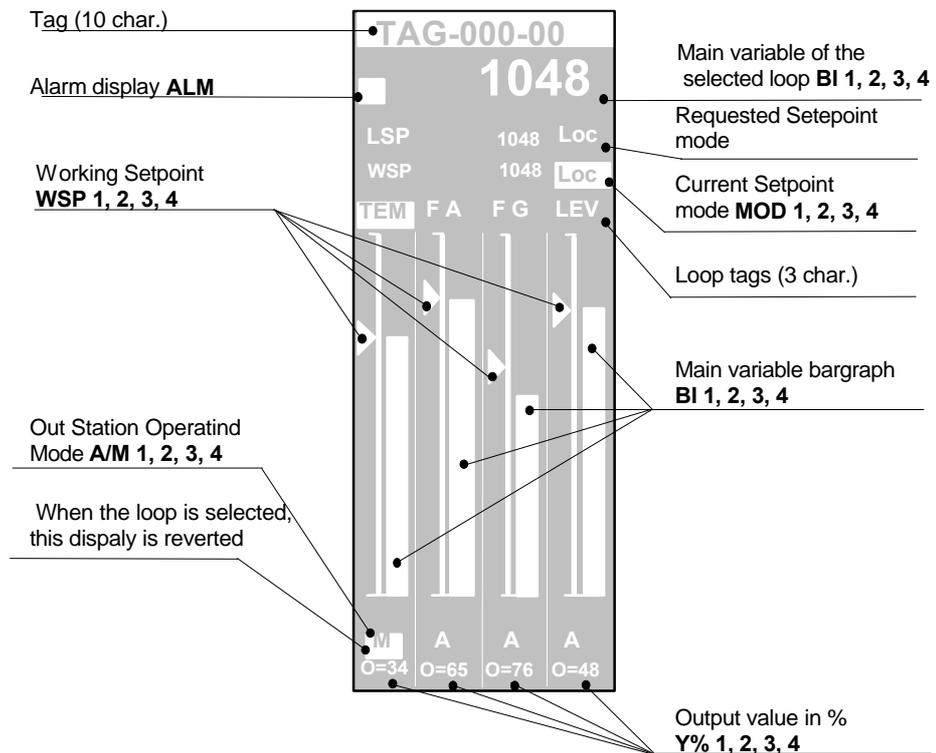
At last, an alarm display is available. This is connected to a digital inputs in order to flag anomalous conditions, requiring the operator attention. When the alarm occurs, a rectangle blinks at the top of the display panel.

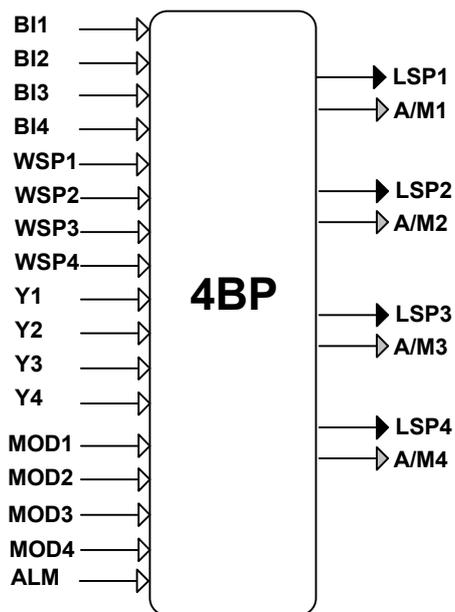
The modules settles automatically the display, detecting which are the signals connected to it. It checks, for each bargraph, that the signals B (bargraph value), Y% (manipulated variable) and A/M (operating mode) are connected and, according to the result, sets the display, as follows:

For each B signal connected, a bargraph is displayed.

If the Y% signal is connected, then the slider is displayed, too, because it is assumed the presence of a "control loop"; otherwise the slider is not displayed at all, because it is assumed the presence of a "measure".

If the A/M signal is connected, then the operating mode is displayed. The lack of this connection doesn't affect the bargraph and the slider display; for instance, the lack of A/M, with the presence of Y%, is recognized as the presence of a loop without the Out station, with fixed Auto operating mode.

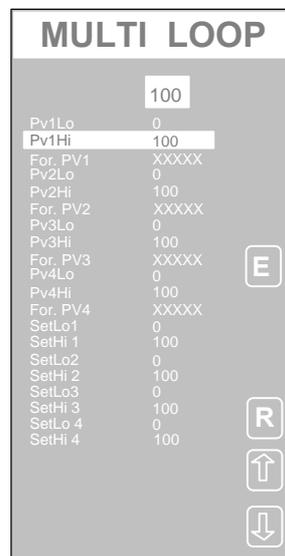




*I/O connections*

<b>B11 ÷ B14</b>	Analog Inputs displayed, graphically, on a bargraphs, with a decimal scale.
<b>WSP1 ÷ WSP4</b>	Analog inputs, displayed, graphically, by mean of a sliders, moving along the decimal scale.
<b>Y1 ÷ Y4</b>	Analog Input, displayed, numerically, in percentage, at the bottom of the display. It is intended for the control output of a loop.
<b>MOD1 ÷ MOD4</b>	Special I/O signals handling the Setpoint operating mode change.
<b>ALM</b>	Alarm input, activating the corresponding flag on the display
<b>A/M1 ÷ A/M4</b>	Operating mode of the Out stations: Manual (active), Auto (inactive)
<b>LSP1 ÷ LSP4</b>	Local setpoint values, entered through the keyboard.

*Parameters*



*Displayed Parameters*

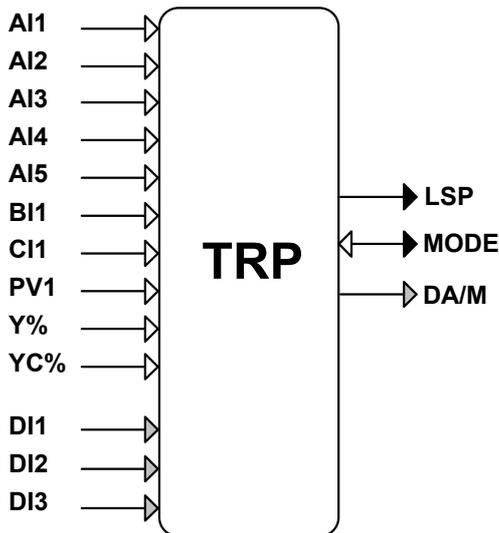
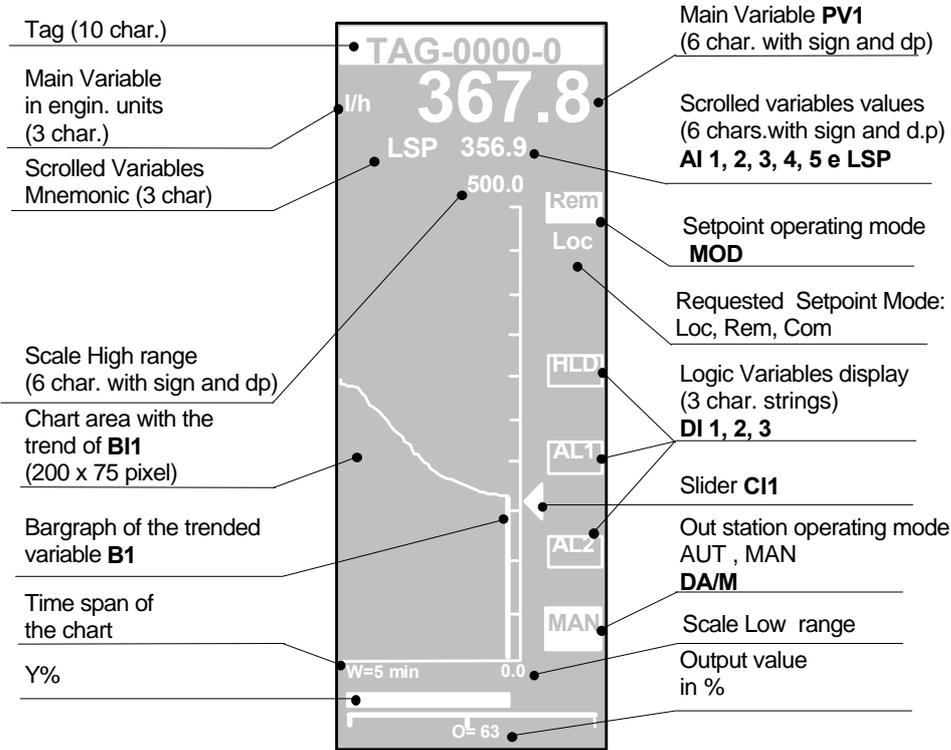
<b>PV1Lo ÷ PV4Lo</b>	Low range of the analog inputs PV1-PV4
<b>PV1Hi ÷ PV4Hi</b>	High range of the analog inputs PV1-PV4
<b>For. PV1Lo ÷ PV4Lo</b>	Format: defines the number of digits of the Local Setpoint
<b>SetLo1 ÷ SetLo4</b>	Minimum value of the Local Setpoint 1-4
<b>SetHi1 ÷ SetHi4</b>	Maximum value of the Local Setpoint 1-4

### 5.3.4 Trend Panel (TRP)

*Description*

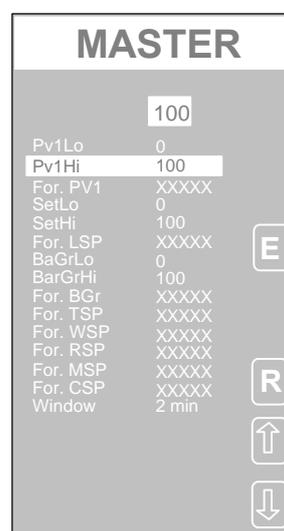
This module has almost the same functionality of the 1BP panel module, with the addition of a trend chart of an analog variable. Its main purpose is to provide the front panel of a simple control loop.

The trend is referred to the most recent values of the variable, during the last minutes. It is continuously scrolled on the left, as soon as new more recent samples are acquired. On the right side, a bargraph, at the beginning of the trend curve, shows the real time value of the trended variable.



**I/O Connections**

<b>DI1, DI2, DI3</b>	Digital inputs, whose status is displayed through a 3 characters label. The most common use is to flag alarms or other digital events.
<b>AI1 ÷ AI5</b>	Analog variables, displayed numerically in the scrolled list, with a short 3 characters mnemonic. The number of displayed inputs can be set though the parameter "items" in the module "2-Trend Panel" of AC Prograph / AC Edit. <i>For the above refer to Section 9.10.4 of the manual.</i>
<b>BI 1</b>	Analog Input displayed, graphically, on a bargraph, with a decimal scale
<b>CI 1</b>	Analog input, displayed, graphically, by mean of a slider, moving along the decimal scale.
<b>PV 1</b>	Main Variable, displayed numerically, with big digits, at the top of the display.
<b>Y%</b>	Analog Input, displayed, in percentage, numerically and by an horizontal bargraph at the bottom of the display. It is intended for the control output of a loop.
<b>Yc%</b>	Analog Input, displayed, together with Y%, at the lower part of the display, both numerically and by an horizontal bargraph. While Y% is intended for a normal loop or for the Heat output, this variable is intended for displaying the Cool output of an Heat/Cool loop.
<b>DA/M</b>	Operating mode of the Out station: Manual (active), Auto (inactive)
<b>LSP</b>	Local setpoint value, entered through the keyboard.
<b>MOD</b>	Special I/O signal handling the Setpoint operating mode change.

**Parameters****Displayed Parameters**

<b>Pv1Lo</b>	Main variable low range
<b>Pv1Hi</b>	Main variable high range
<b>For. PV1</b>	Format: defines the number of digits of the PV variable.
<b>SetLo</b>	Minimum value of the Local Setpoint
<b>SetHi</b>	Maximum value of the Local Setpoint
<b>For. LSP</b>	Format: defines the number of digits of the Local Setpoint
<b>BaGrLo</b>	Low range of the bargraph variable
<b>BaGrHi</b>	High range of the bargraph variable
<b>For. BGr</b>	Format: defines the number of digits of the Bargraph variable.
<b>For. TSP</b>	Format: defines the number of digits of the AI1 variable (note 1)
<b>For. WSP</b>	Format: defines the number of digits of the AI2 variable (note 1)
<b>For. RSP</b>	Format: defines the number of digits of the AI3 variable (note 1)
<b>For. MSP</b>	Format: defines the number of digits of the AI4 variable (note 1)
<b>For. CSP</b>	Format: defines the number of digits of the AI5 variable (note 1)
<b>Window</b>	Time span of the trend chart. Possible choices: 1, 2, 5, 10, 30 minutes or 1, 2, 5 hours

**Note (1)**

The 3 characters mnemonic of these 5 analog inputs is defined in the configuration by the user.

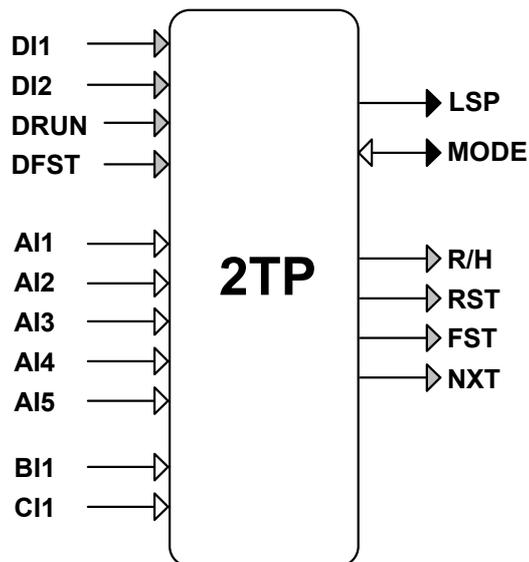
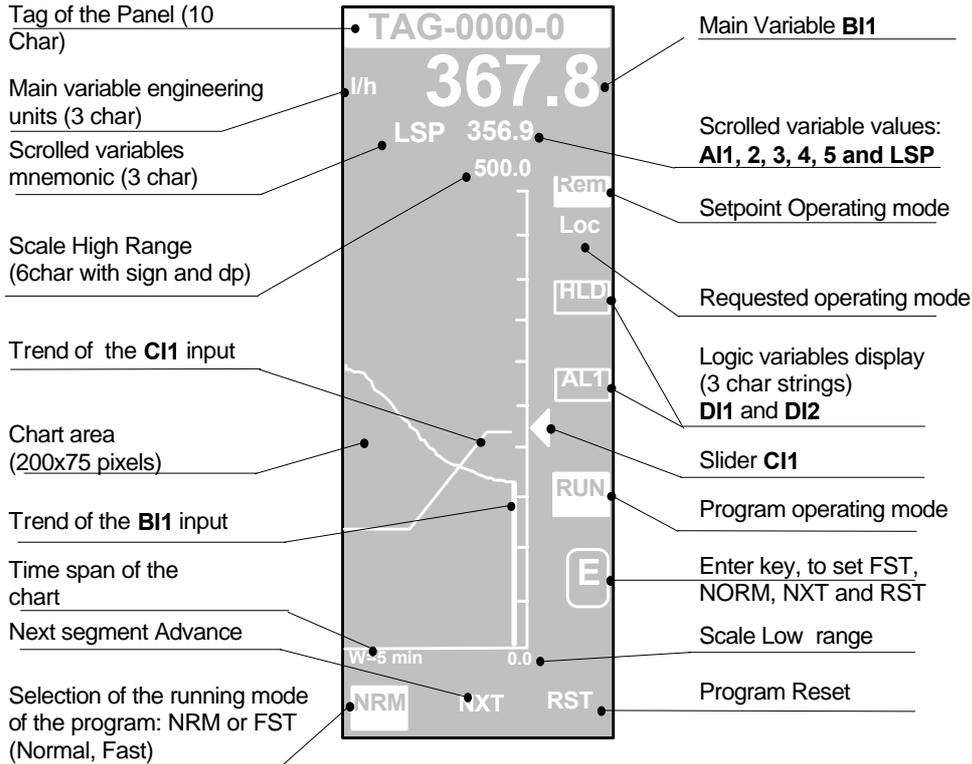
### 5.3.5 Dual Trend Panel (2TP)

*Description*

This panel module is almost identical to the TRP module, but it provides both the trend on a second variable, C11, and a suitable interface to the Setpoint Programmer module PRG, available in the AC30 controller.

The second trend, on the variable C11 (in the TRP module, C11 was dedicated to move, just, the slider) is intended for the setpoint output of the Setpoint Programmer. In this way, you have on the same trend chart both the setpoint and the process variable, situation particularly useful when you deal with Setpoint profile.

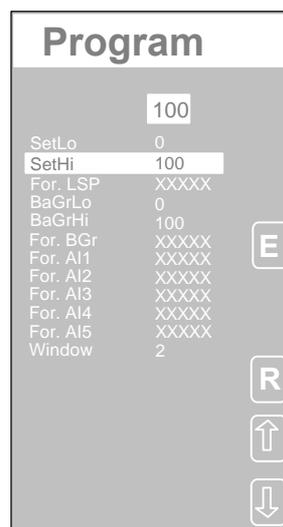
*This panel module is available only on the AC30 controller. When you add this module in your strategy, you must be sure that the target is an AC30 controller.*



## I/O Connections

<b>DI1, DI2</b>	Digital inputs, whose status is displayed through a 3 characters label. The most common use is to flag alarms or other digital events.
<b>DRUN</b>	Run digital input. When this input goes active, the digital output R/H goes active, with the effect of running the program.
<b>DFST</b>	Fast digital input. When this input goes active, the digital output FST goes active, forcing the programmer to run in Fast mode.
<b>AI1 ÷ AI5</b>	Analog variables, displayed numerically in the scrolled list, with a short 3 characters mnemonic. The number of displayed inputs can be set though the parameter "items" in the module "Dual Trend Panel" of AC Prograph / AC Edit. <i>For the above refer to Section 9.11.2 of the manual.</i>
<b>BI1</b>	Analog Input displayed, graphically on a bargraph and trended in the chart as the Process Variable
<b>C11</b>	Analog Input displayed, graphically on a bargraph and trended in the chart as the Setpoint value.
<b>LSP</b>	Local setpoint value, entered through the keyboard.
<b>MODE</b>	Special I/O signal handling the Setpoint operating mode change.
<b>R/H</b>	Run/Hold digital output. It must be connected to the R/H input of the PRG module
<b>RST</b>	Reset digital output. It must be connected to the RST input of the PRG module.
<b>FST</b>	Fast digital output. It must be connected to the FST input of the PRG module.
<b>NXT</b>	Next digital output. It must be connected to the NXT input of the PRG module.

## Parameters



## Displayed Parameters

<b>SetLo</b>	Low range of the slider variable C11
<b>Seth</b>	High range of the slider variable C11
<b>For. LSP</b>	Format: defines the number of digits of the Local Setpoint
<b>bagel</b>	Low range of the bargraph variable BI1
<b>burgh</b>	High range of the bargraph variable BI1
<b>For. Bar</b>	Format: defines the number of digits of the Bargraph variable.
<b>For. AI1</b>	Format: defines the number of digits of the AI1 variable (note 1)
<b>For. AI2</b>	Format: defines the number of digits of the AI2 variable (note 1)
<b>For. AI3</b>	Format: defines the number of digits of the AI3 variable (note 1)
<b>For. AI4</b>	Format: defines the number of digits of the AI4 variable (note 1)
<b>For. AI5</b>	Format: defines the number of digits of the AI5 variable (note 1)
<b>Window</b>	Time span of the trend chart. Possible choices: 1, 2, 5, 10, 30 minutes or 1, 2, 5 hours

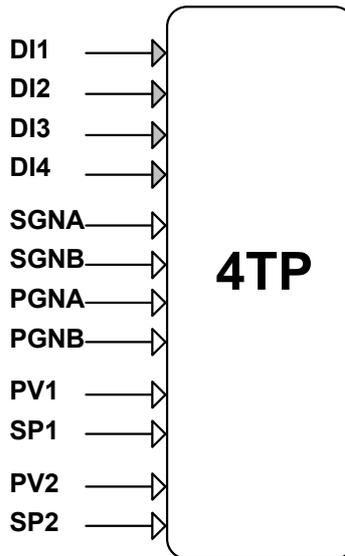
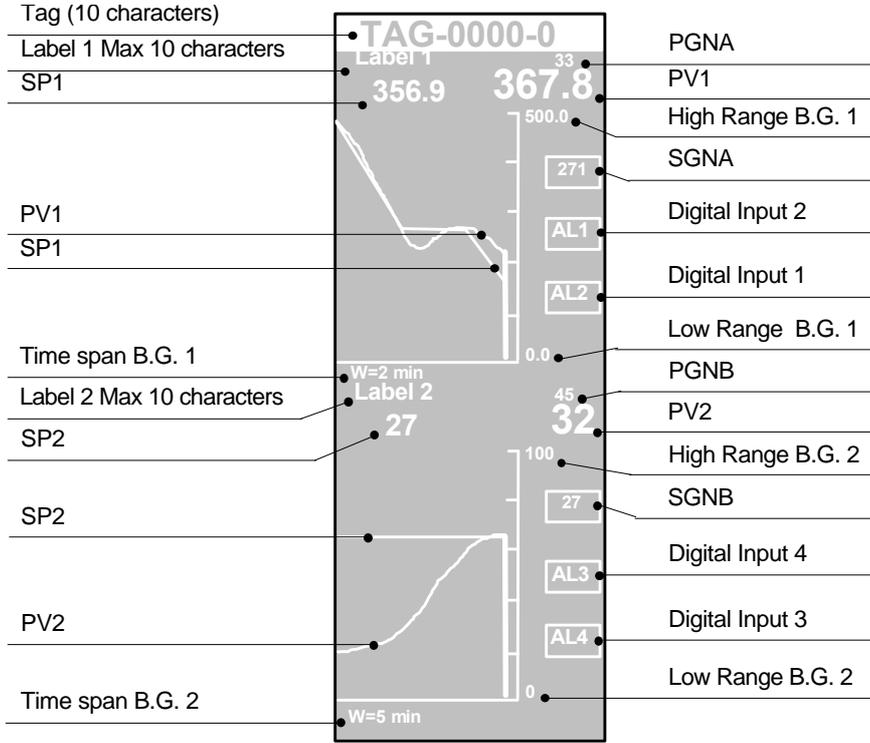
**Note (1)**

The 3 characters mnemonic of these 5 analog inputs is defined in the configuration by the user.

### 5.3.6 Four Trend Panel (4TP)

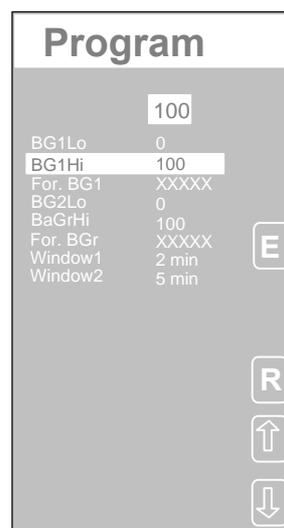
*Description*

This module has the same basic functionalities of the TRP module and is intended for displaying on a single panel, up to 4 trended analog variables. Its main purpose is to provide a complete user interface for the Setpoint Programmer, providing graphically the trend of the Profile Setpoint and the process variable, the display of the program and segment number in execution, the visualisation of the status of digital outputs, controlled by the program, and a 10 characters title of each chart.



*I/O connections*

<b>DI1 ÷ DI4</b>	Digital inputs, whose status is displayed through a 3 characters labels. They, usually, flag alarms, events and status.
<b>SGNA</b>	Analog input providing the number of the segment, currently running on the PRG module. It's displayed in the upper chart.
<b>SGNB</b>	Analog input providing the number of the segment, currently running on the PRG module. It is displayed in the lower chart.
<b>PGNA</b>	Analog input providing the number of the program, currently running on the PRG module. It's displayed in the upper chart.
<b>PGNB</b>	Analog input providing the number of the program, currently running on the PRG module. It is displayed in the lower chart.
<b>PV1</b>	Analog input providing one of the two trended variables in the upper chart.
<b>PV2</b>	Analog input providing one of the two trended variables in the lower chart.
<b>SP1</b>	Analog input providing one of the two trended variables in the upper chart.
<b>SP2</b>	Analog input providing one of the two trended variables in the lower chart.

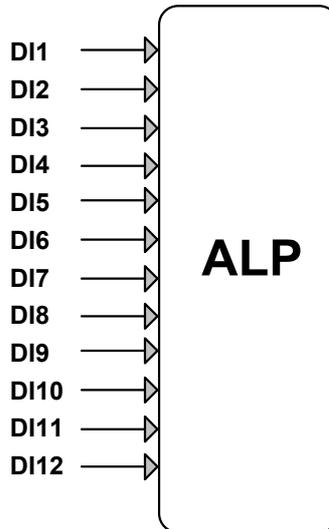
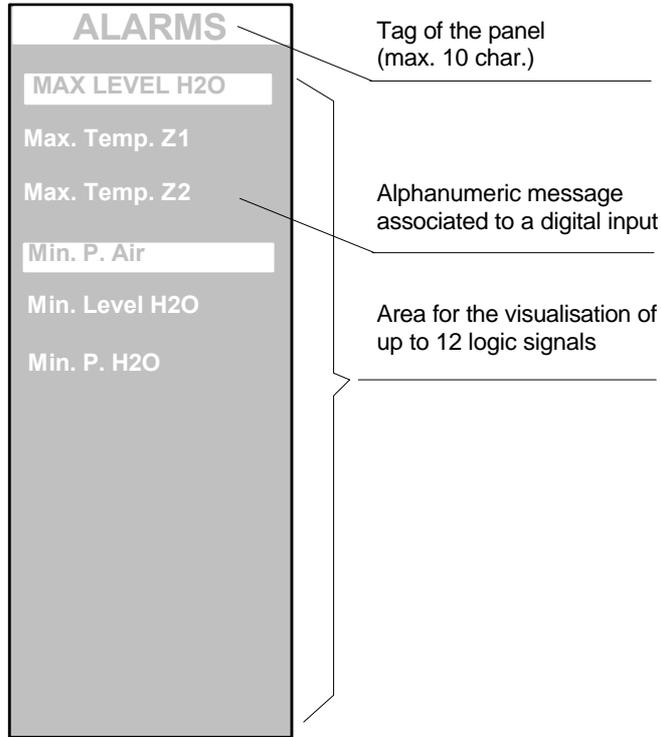
*Parameters**Displayed parameters*

<b>BG1Lo</b>	Low limit of the scale of the upper chart
<b>BG1Hi</b>	High limit of the scale of the upper chart
<b>For. BG1</b>	Format: defines the number of digits of the upper chart variables.
<b>BG2Lo</b>	Low limit of the scale of the lower chart
<b>BG2Hi</b>	High limit of the scale of the lower chart
<b>For. BG2</b>	Format: defines the number of digits of the lower chart variables.
<b>Window 1</b>	Time span of the upper trend chart. Possible choices: 1, 2, 5, 10, 30 minutes or 1, 2, 5 hours.
<b>Window 2</b>	Time span of the lower trend chart. Possible choices: 1, 2, 5, 10, 30 minutes or 1, 2, 5 hours.

### 5.3.7 Alarm TagList (ALP)

*Description*

This module provides the functionalities of an alarm annunciator with 12 alarm messages. Each message is connected with a digital input, that defines the visualization of the message. All the 12 messages are listed on the display at a predefined position on the display, in a different mode, according to the status of the associated digital input; in reverse, if the input is active, or in normal, if it is inactive. The messages are 14 characters strings, configured by the user.



*I/O connections*

<b>DI1 ÷ DI12</b>	Digital input controlling the display of the associated message string. The string is displayed in reverse, if the input is active, or in normal, if it is inactive. The string is configured by the user through the AC-Program or AC-Edit program, only.
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### 5.3.8 Multiswitch panel (16SW)

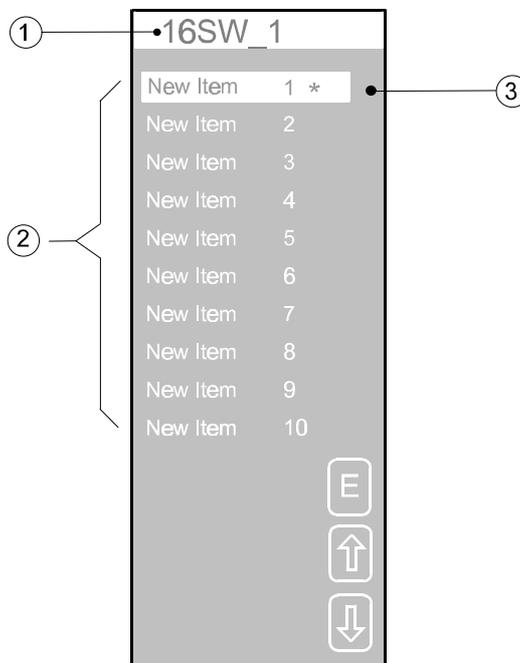
*Description*

With this active panel it is possible to activate up to 16 digital keyboard commands.

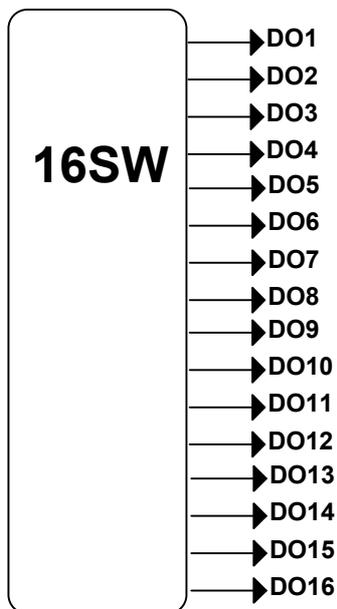
Use the arrows to select the command and ENTER to confirm.

Upon activation, the corresponding output is put to ON and an asterisk appears to the right of the message.

To lock the command, press ENTER again.



- 1 Page name (max. 10 characters)
- 2 Command area (max. 16 commands)
- 3 Activated command



*Description of connections*

DO1 ÷ DO16	Digital outputs on which to generate the command
------------	--------------------------------------------------

*Parameters*



*Multiswitch panel*

<b>Item No</b>	Command number to display on the panel. Select a number using the arrows on the keyboard.
----------------	----------------------------------------------------------------------------------------------

## 5.4 Selector Panel (SELP)

### Description

This module provides the functionality of a control panel for digital commands. It has 4 outputs, that are driven all together, by the pattern selected through one of the 3 supported selection modes: Keyboard, Supervisory Computer and the 4 Digital Inputs. Through these modes, a number from 0 to 15 is specified, that forces the 4 digital outputs to assume a well defined pattern (also named item), corresponding to the binary coding of the number.

Each of these three different selection modes is enabled to select and has a custom specified priority, as specified through the SELP module parameters; the mode that has the highest priority, makes the selection first. In the case the selection mode with the highest priority has the “no choice” status, the selection is done by the one with the immediately lower priority, and so on.

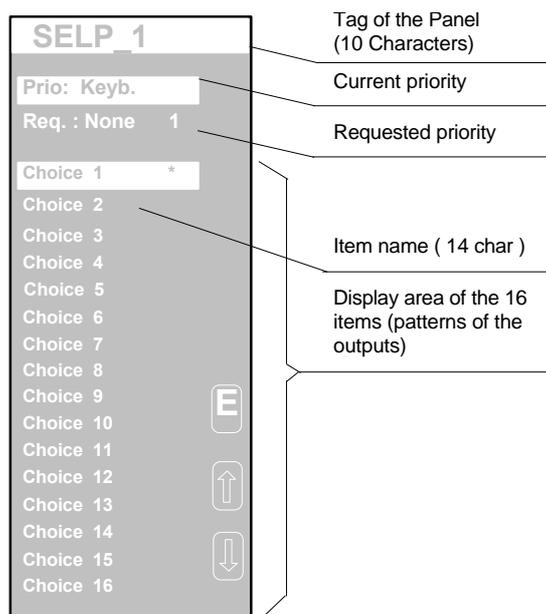
The priority order can be changed further, directly from the controller front panel, as described at Chapter 3.- Start up, assigning the highest priority to the keyboard. This mechanism of overriding the priority scheme, defined in the strategy configuration, allows the user to operate, when the process condition requires his intervention, leaving the control in the hands of the strategy, at the end of the user operations.

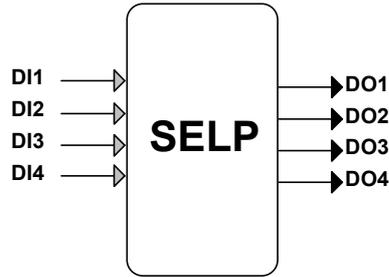
Each of the 16 states of the digital outputs is indicated, on the display, through an alphanumeric string, called item name, intended to provide an immediate perception of what that pattern does on the process. For instance, one item name can be “Valve XX open”, flagging that, when selected, the digital outputs will assume the status required by the strategy to open the valve XX.

### Selection Modes

The three selection modes supported are:

- Supervisory Computer. Through the serial communication line, a computer selects the item (that is the pattern of the outputs) , by writing into a particular register. Please, refers to the Communication manual, for the details about the location and the format of the register to write.
- Through a four bit code, specified by the **DI1-DI4** digital inputs of the SELP module, providing the item number.
- Through the front panel keyboard of the AC controller by mean of the **Scroll** keys. By pressing this key, you choose the item to select and, after, you confirm the choice, by pressing **Enter**.





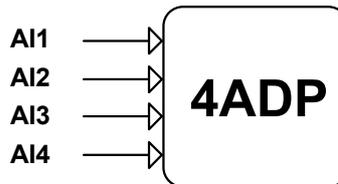
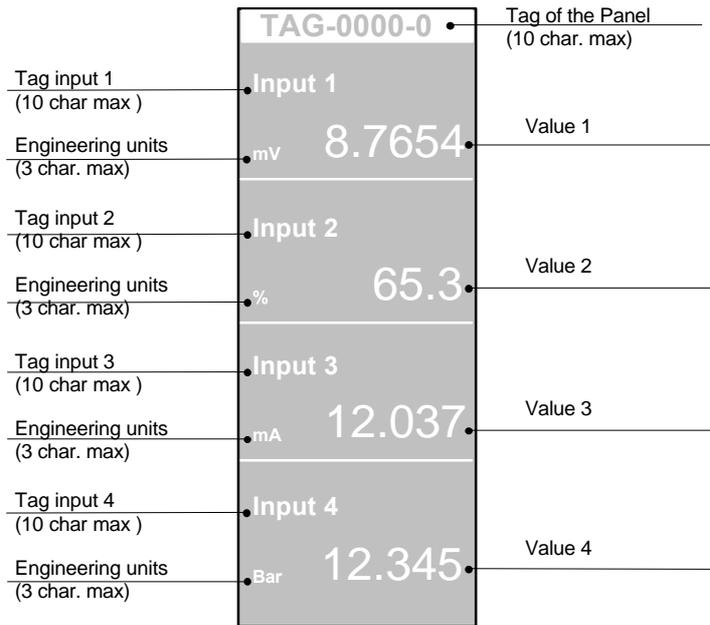
*I/O Connections*

<b>DI1 - DI4</b>	Digital Inputs specifying a 4 bit number from 0 to 15 corresponding to the output pattern. If the Digital Input mode is the selection mode with the highest priority, the digital outputs DO1 - DO4 will assume the value of the inputs. The item name, displayed on the panel, is configured through the AC-Prograph or AC-Edit program, only.
<b>DO1 - DO4</b>	Digital Outputs, set according to the item selected and the priority arbitration result.

### 5.4.1 Four Analog Display Panel (4ADP)

*Description*

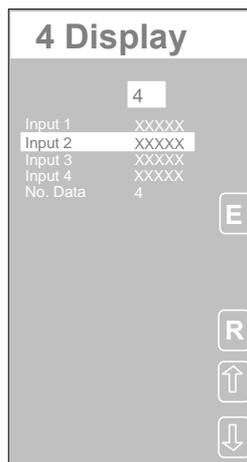
This module provides the functionalities of a set of analog indicators. It displays the value, the 10 characters tag and the 3 characters engineering units of up to 4 analog variables, connected to it, as analog inputs. The value is shown as a 6 digits number, without decimal point, or as a 5 digits number, with decimal point.



*I/O Connections*

<b>AI1 ÷ AI4</b>	Analog Inputs. Each of these inputs is associated with a position on the panel, where its value and its tag is displayed.
------------------	---------------------------------------------------------------------------------------------------------------------------

Parameters



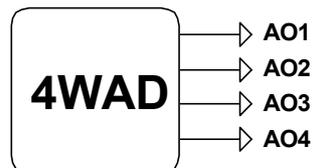
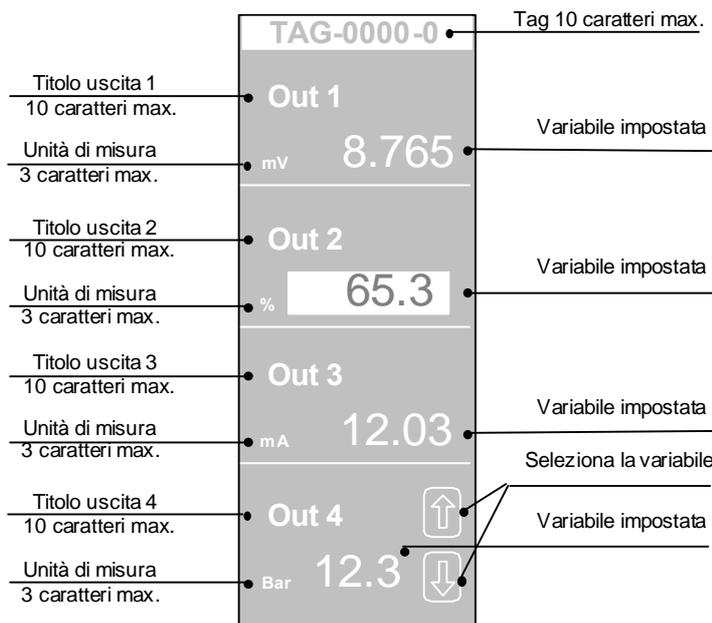
Displayed Parameters

<b>Input 1 ÷ Input 4</b>	Format: defines the number of digits of the 4 measured variables. Both the tag and the engineering units of each measure, are configured through the AC-Prograph and AC-Edit, only.
<b>No. Data</b>	Number of the variables displayed on the panel.

5.4.2 4 Writable Analog values (4ADP)

Description

This display panel allows to display or generate 4 analog-type variables contemporaneously. Each variable is characterized by a tag (max 10 characters) and an engineering unit (max. 3 characters)



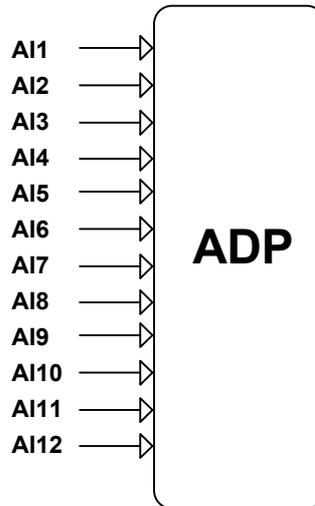
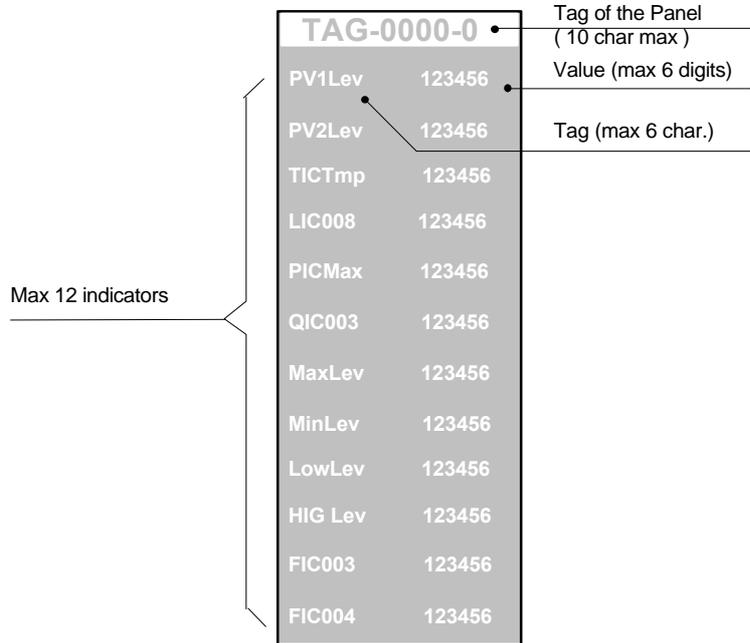
I/O Connections

<b>AO1 ÷ AO4</b>	Analog values outputs.
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### 5.4.3 Analog Display Panel (ADP)

*Description*

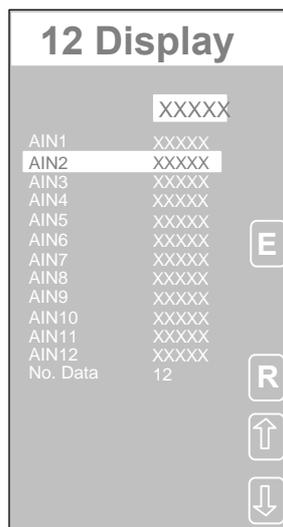
This module provides the functionalities of a set of analog indicators. It displays both the value and the 6 characters tag, of up to 12 analog variables, connected to it as analog inputs. The value is shown either as a 6 digits number, without decimal point, or as a 5 digits number, with decimal point.



*I/O Connections*

AI1 ÷ AI12	Analog Inputs. Each of these inputs is associated with a position on the panel, where its value and its tag is displayed.
------------	---------------------------------------------------------------------------------------------------------------------------

Parameters



Displayed Parameters

<b>AIN1 ÷ AIN12</b>	Format: defines the number of digits of the 4 measured variables. Both the tag and the engineering units of each measure, are configured through the AC-Prograph and AC-Edit, only.
<b>No. Data</b>	Number of the variables displayed on the panel.

5.4.4 System CLK ( Date and time display panel )

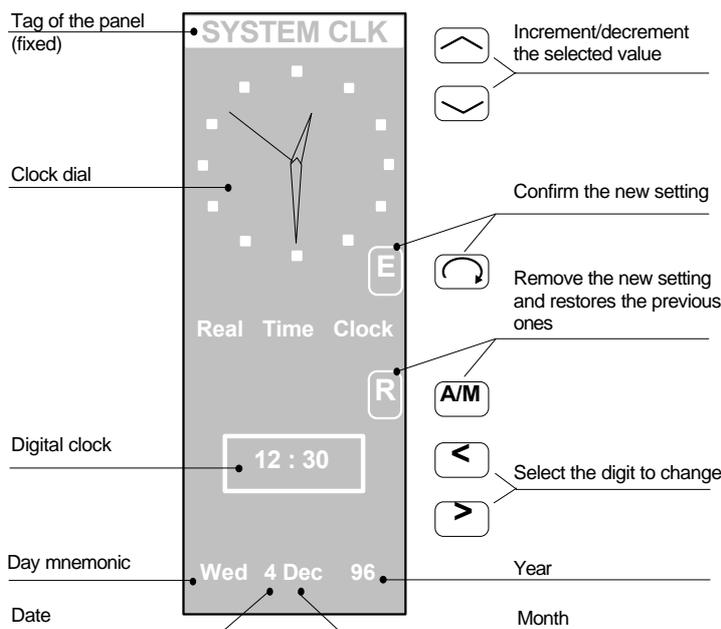
Description

This display is automatically shown on the AC30 front panel and is not associated with any module of the strategy. It's a standard basic function of the instrument, that is provided independently of the strategy.

The display of the panel can be disabled through the *F.Panel View* item of the *Tune & View* menu.

When this display is shown, the only operations the user can do is to change the date and time. These operations can be done either from the keyboard or through the serial communication (Main Comm).

*The clock is battery backed up; therefore, it works even if the instrument supply is disconnected.*



## 5.5 Processing and Control Functions

### 5.5.1 Setpoint and Deviation Calculation ( SDV )

*Description*

This module generates some preliminary processing of the signals required in a PID algorithm, consisting of the calculation of the internal Working Setpoint of the loop, according to the operating mode, and the calculation of the deviation variables.

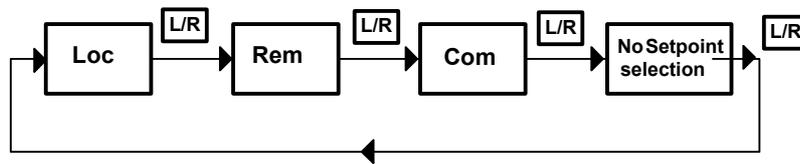
The module receives 3 possible initial Setpoints: by the Operator (Local), by the Computer (Computer) or by a Remote signal (Remote).

The selection of the Working Setpoint from the three setpoints above is done by a selection strategy, consisting of three different modes to operate, with a custom specified priority assigned to each of them. These modes are: Keyboard, Supervisory Computer and Digital Inputs. The mode that has the highest priority, makes the selection first. In the case the selection mode with the highest priority has the “no choice” status, the selection is done by the one at the immediately lower priority, and so on.

The priority, for each of the selection modes, is defined by the user, between the choices: “low”, “medium” or “high”. But the user can also disable completely a mode, if he/she doesn't want to use it. To avoid conflicts, it is strongly recommended that each selection mode has a different level of priority.

The Selection mechanism provides a fourth choice, beyond the Local, Computer and Remote Setpoint. This choice consists in not selecting any setpoint and passing the responsibility of the selection to the immediately lower priority mode.

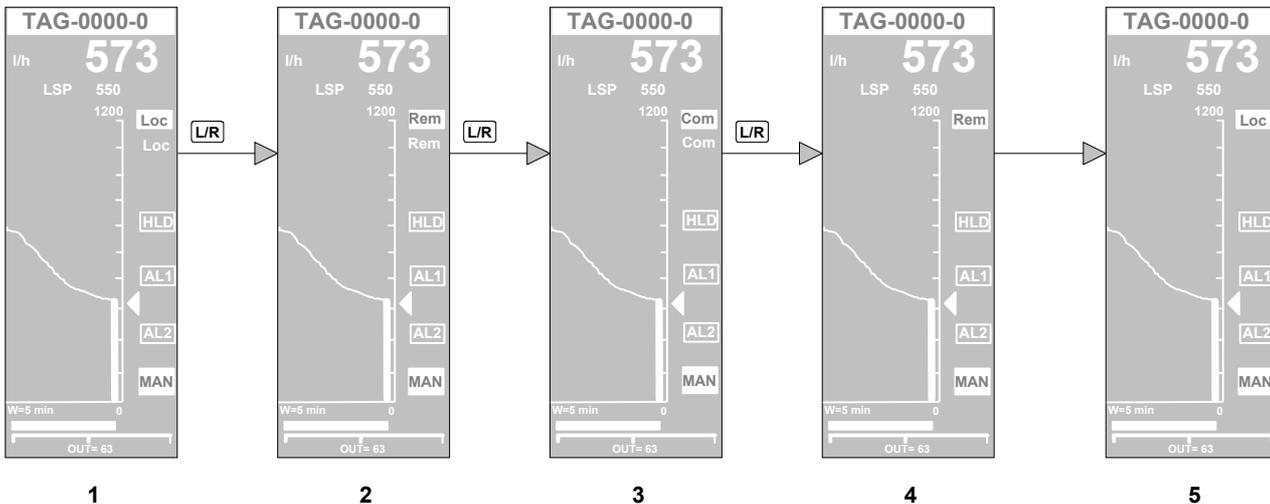
*SetPoint selection mechanism*



**Example**

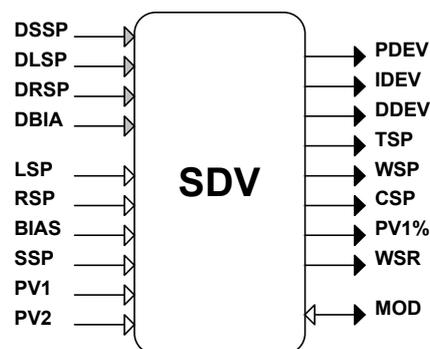
In the example below, the properties are assigned as follows:

Type	Keyboard	Digital Inputs	Supervisory
Priority	high	medium	low



**Note:**

- 1) The Local setpoint is selected, pressing the L/R key.
- 2) The Remote setpoint is selected, pressing the L/R key.
- 3) The Computer Setpoint is selected, pressing the L/R key.
- 4) Pressing again the L/R key, the “no selection” option is chosen for the keyboard. Therefore, the highest priority mode after the keyboard, is the one driving the output. This mode is the one based on the digital inputs, whose status is selecting the Remote Setpoint.
- 5) Later on, the digital inputs are set to the “no selection” status. Therefore, it is the Supervisory Computer that selects the Setpoint, choosing the Local Setpoint.

**I/O Connections**

<b>DSSP</b>	Digital Input forcing the Safety Setpoint as the loop setpoint.
<b>DLSP</b>	Together with the DRSP digital input specifies a two bit code, that selects the Setpoint, according to the table above. (2)
<b>DRSP</b>	Together with the DLSP digital input specifies a two bit code, that selects the Setpoint, according to the table above. (2)
<b>DBIA</b>	Enables the sum of the BIAS input to the Local or Remote Setpoint, in order to calculate the Working Setpoint
<b>RSP</b>	Remote Setpoint analog input
<b>BIAS</b>	Analog input with the value of the bias to add to the Local or Remote Setpoint.
<b>SSP</b>	Analog input with the value of the Safety Setpoint.
<b>PV1</b>	Controlled variable analog input.
<b>PV2</b>	Secondary variable analog input. Valid only for ratio loop.
<b>PV1%</b>	Retransmission of PV1 as a percentage of the span.
<b>PDEV</b>	Error value for the computation of the proportional term.
<b>IDEV</b>	Error value for the computation of the integral term.
<b>DDEV</b>	Error value for the computation of the derivative term.
<b>MOD</b>	Special bidirectional signal controlling the operating mode of the Setpoint.
<b>TSP</b>	Target Setpoint value.
<b>WSP</b>	Working Setpoint value, in case of a standard loop. It corresponds to the Target Setpoint after the rate limiting operation.
<b>CSP</b>	Computer Setpoint.
<b>LSP</b>	Local Setpoint.
<b>WSR</b>	Working Setpoint value, in case of a ratio loop. (1)

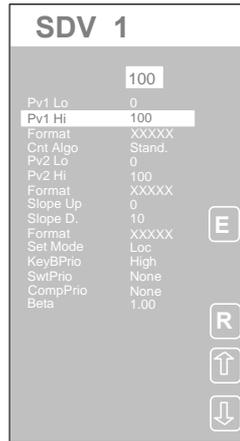
**Note:**

- 1)  $WSR$  is  $PV2 * WSP$  in case of a direct ratio loop;  $PV2 / WSP$  in case of a inverse ratio loop.

## 2)

<b>DLSP</b>	<b>DRSP</b>	<b>Action</b>
0	0	No Setpoint selection
1	0	Local Setpoint request
0	1	Remote Setpoint request
1	1	Computer Setpoint request

Parameters



Displayed Parameters

<b>PV1 Lo</b>	Low limit of the controlled variable.
<b>PV1 Hi</b>	High limit of the controlled variable.
<b>Format</b>	Format: defines the number of digits of the controlled variable.
<b>CNT Ago</b>	Selection of the type of PID loop: Stand.=standard PID, Rt.x=direct ratio, Rt.1/x=inverse ratio.
<b>PV2 Lo</b>	Low limit of the secondary variable (reference) of a ratio loop.
<b>PV2 Hi</b>	High limit of the secondary variable (reference) of a ratio loop.
<b>Format</b>	Format: defines the number of digits of the ratio loop secondary variable.
<b>Slope up</b>	Rising rate limit on the Setpoint e.u / sec.
<b>Slope D.</b>	Falling rate limit on the Setpoint in e.u / sec.
<b>Format</b>	Format: defines the number of digits of the rate limits.
<b>Set Mode</b>	Defines which of the three Setpoints must be considered in the Setpoint selection process (1).
<b>KeyBPrio</b>	Priority assigned to the selection mode Keyboard (2).
<b>SwtPrio</b>	Priority assigned to the selection mode Digital Inputs (2).
<b>CompPrio</b>	Priority assigned to the selection mode Computer (2).
<b>Beta</b>	Set Point Weighting: from 0.01 to 1.00 .

1) The possible choices are:

- Loc = Local
- Rem = Remote
- LocRem = Local and Remote
- LocSup = Local and Supervisory Computer
- LoReSu = Local, Remote and Supervisory Computer

2) The choices for the priority level are:

- None
- Low
- Medium
- High.

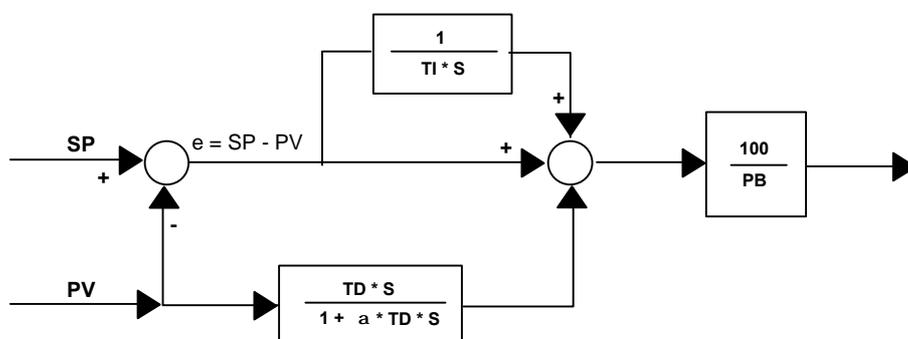
It is strongly recommended to avoid that two selection modes have the same level of priority.

## 5.5.2 PID Algorithm(PID)

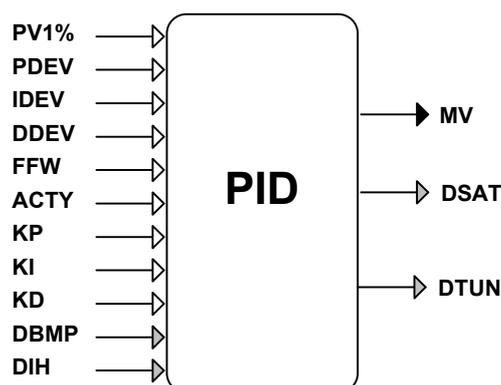
### Description

This module implements the PID algorithm and generates the control output, starting from the deviation value between the Setpoint and the controlled variable. The control output drives the external actuator, in order to keep the controlled variable at the target Setpoint level.

The PID algorithm (with the derivative term on the process variable) is illustrated in the following picture.



The derivative term includes a filter, in order to reject as much as possible noise ( $\alpha = 1/10$ ). In lack of this filter, being this term computed as the derivative of the process variable, the noise would be the major source of the derivative term, with unsuccessful results in the process control capability.



### I/O connections

<b>PV1%</b>	Retransmission of PV1 as a percentage of the span.
<b>PDEV</b>	Error value for the computation of the proportional term.
<b>IDEV</b>	Error value for the computation of the integral term.
<b>DDEV</b>	Error value for the computation of the derivative term.
<b>FFW</b>	Feed - Forward input signal.
<b>ACTY</b>	Actual Output value. This signal is generated by the Out station module of the controller and it is fed to the actuator of the loop.
<b>DBMP</b>	Digital Input, indicating, through its negative transition, when the adjustment of the PID terms, for the BUMPLESS transition functionality, must be performed.
<b>KP</b>	Proportional Gain coefficient (1)
<b>KI</b>	Integral Gain coefficient (1)
<b>KD</b>	Derivative Gain coefficient (1)
<b>DIH</b>	Integral term disable.
<b>MV</b>	Control output, in percentage, also named manipulated variable.
<b>DSAT</b>	Desaturation Output. When active, this signal flags that the PID is in saturation.
<b>DTUN</b>	Digital Output flagging that the Tune algorithm is active.

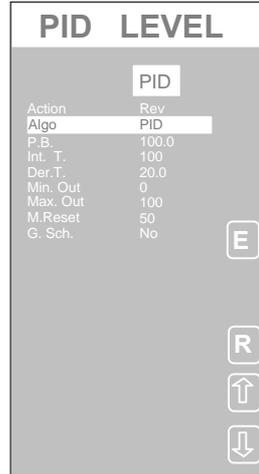
**Note:**

- 1) If the gain scheduling is enabled, the three terms of the PID algorithm are computed according to the following formulas:

$$PB_u = \frac{PB_p}{KP} \quad TI_u = TI_p * KI \quad TD_u = TD_p * KD$$

where PB<sub>u</sub>, TI<sub>u</sub> and TD<sub>u</sub> are the coefficients of the 3 terms, used in the PID formula, while the PB<sub>p</sub>, TI<sub>p</sub> and TD<sub>p</sub> are the values set by the user.

*Parameters*



*Displayed Parameters*

<b>Action</b>	Selection of the control output direction: direct or inverse.
<b>Algo</b>	Selection of the type of PID algorithm: P, PI, PID .
<b>P.B.</b>	Value of the Proportional Band, in percentage, with range from 0,5 to 9999.
<b>Int. T.</b>	Value of the Integral time, in seconds, with range from 0 to 9999.
<b>Der. T.</b>	Value of the derivative time, with range from 0 to 9999.
<b>Min. Out</b>	Low limit of the control output, in percentage, with range from 0 to 100 %.
<b>Max. Out</b>	High limit of the control output, in percentage, with range from 0 to 100 %.
<b>M. Reset</b>	Manual Reset value, with range from 0 to 100 %.
<b>G. Sch.</b>	Enable/disable of the "gain scheduling" functionality.

More information about the PID and the Tuning process are provided in Chapter 4.

**5.5.3 Output Station (MV)**

*Description*

This module is an Auto-Man station, to be connected downstream a PID module, providing the functionalities the operator needs, to interact with the loop. The module provides auto/manual/track/hold/force operating mode, output limits and the keys for incrementally set the output. The operating modes are defined by a set of digital inputs, as listed above, ordered according to their priority level:

- 1) Auto\_Manual                      DA/M
- 2) Hold                                    DHLD
- 3) Force Ymax                        DYMx
- 4) Force Ymin                        DYMN
- 5) Tracking                             DTRK

Depending on these digital inputs, the functionality of the module changes as follows:

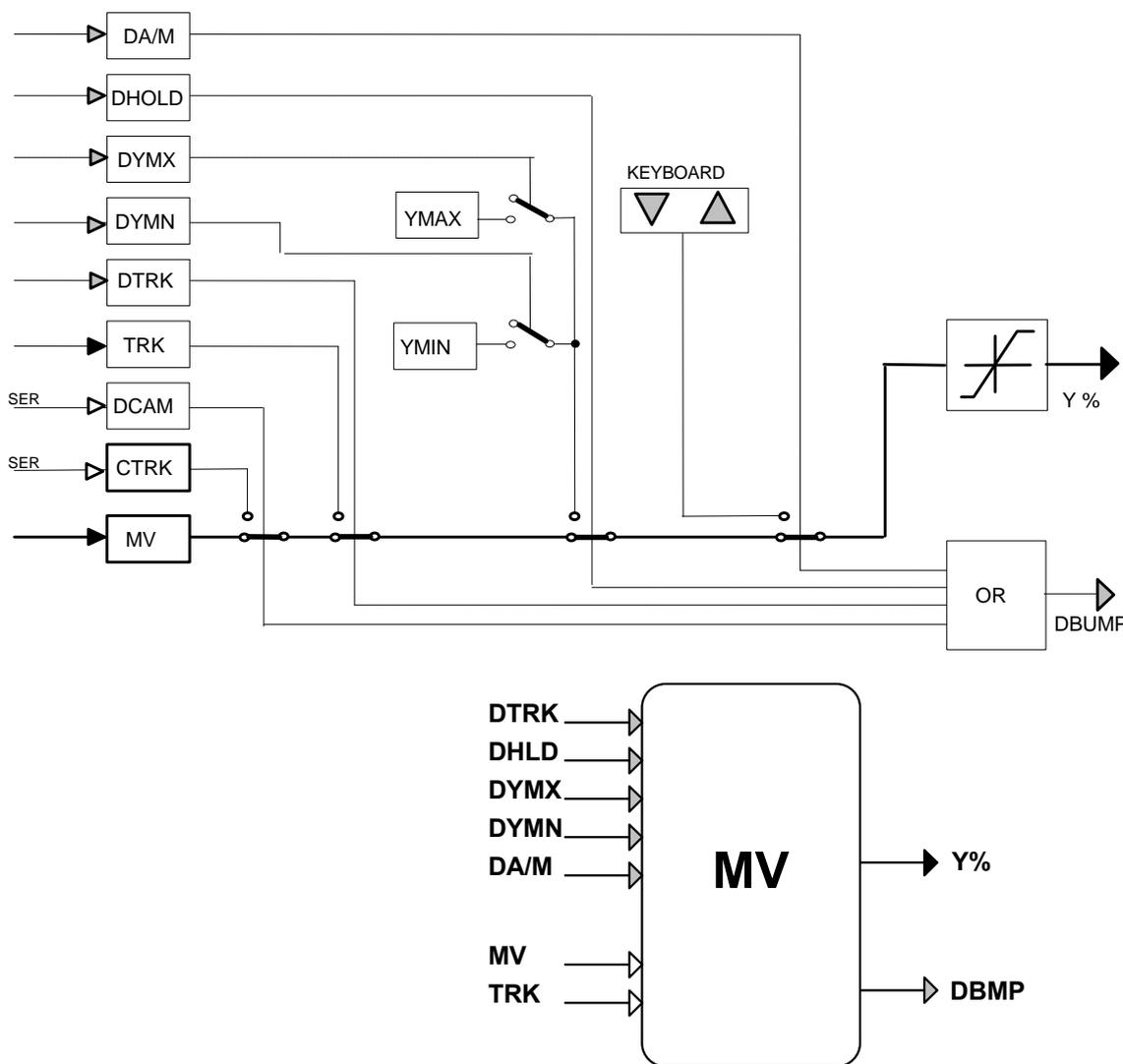
If none of these digital signals are active, the module doesn't alter the control output signal, that is led unchanged directly from the input MV (from the PID module) to the output Y%.

If DTRK (Tracking) is active, the output Y% assumes the value of the analog input TRK.

If DHLD (Hold) is active, the output is frozen.  
 If both DHLD(Hold)and DYMN (Force Min) are active, the output Y% is set to the minimum forcing value.  
 If both DHLD (Hold) and DYMx (Force Max) are active, the output Y% is set to the maximum forcing value.  
 If the DA/M input is active (Manual mode request), the current output Y% is not changed any longer according to the MV input, but it is changed only from the keyboard.

All these digital inputs are connected to an OR logic gate, whose output is the signal DBMP. This signal, active when the module status is either manual, or track, or hold, or forced, is connected with the PID block, to stop the PID execution and to perform BUMPLESS transition, on the change from the active to the inactive state.

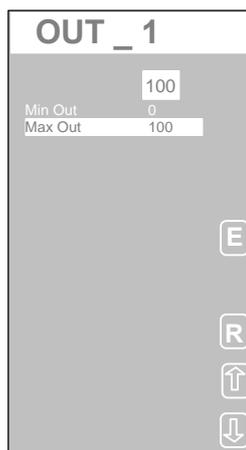
Note: the modules MV N° 1 and 2 are alternative to the modules HCMV N° 1, while the modules MV N° 3 and 4 are alternative to the module HCMV N° 2



### I/O Connections

<b>MV</b>	Controlled variable (also named manipulated variable). It is generated by the PID module as a percentage value of the span.
<b>DTRK</b>	Track input. It enables the Track functionality
<b>TRK</b>	Track value. Analog signal with the value to set the output Y% when the Track is enabled
<b>DHLD</b>	Hold input. When active, the output Y% is frozen.
<b>DYMX</b>	Digital input enabling the forcing of the Y% to the Max Forcing value.
<b>DA/M</b>	Digital input selecting the Auto and Manual mode.
<b>DYMN</b>	Digital input enabling the forcing of the Y% to the Min Forcing value.
<b>DBMP</b>	Digital input, indicating through its negative transition, when the adjustment of the PID terms for the BUMPLESS transition must be performed.
<b>Y %</b>	Control output, in percentage

### Parameters



### Displayed Parameters

<b>Min Out</b>	Minimum Forcing value of the control output, with range from 0 to 50.
<b>Max Out</b>	Maximum forcing value of the control output, with range from 0 to 100.

### 5.5.4 Heat/Cool Output Station (HCMV)

#### *Description*

This module is an Output station for an Heat/Cool loop, providing the functionalities the operator needs to interact with the loop. The loop is controlled by two PIDs, connected downstream to this module; each one is dedicated to one channel. The module provides auto/manual/track/hold/force operating mode, output limits and the keys for incrementally set the output.

The operating modes, that are unique for both the Cool and the Heat output, are defined by a set of digital inputs, as listed above, ordered according to their priority level.

Auto_Manual	DA/M
Hold	DHDL
Force Ymin	DMIN
Force Ymax	DMAX
Tracking	DTRK

Depending on these digital inputs, the functionality of the module changes as follows:

If none of these digital signals are active, the module doesn't alter the control output signals, that are led, unchanged, directly from the input MVC and MVH to the output Y% and Yc%. The Deadband parameter defines how the Cool and the Heat channel interact each other in the phase splitter. The phase splitter is used when a single output value, like in Manual mode or Track mode, needs to drive both the Heat and Cool output. When it is positive, this parameter defines the deadband width, centered around a value 0 of the output. It means that for each output value included in the deadband both the Yc% and the Y% output are 0. When it is negative, the opposite occurs; for each value included in the deadband (now named cross band), both the Yc% and the Y% are different from 0.

If DTRK (Track) is active, the outputs are set according to the value of the analog input TRK. This signal, that has a range from -100 to +100, drives, through a phase splitter, both Y% and Yc%.

When its value is in the range -100 to 0, it means that a Cool action must be taken; therefore, Y% is set to 0, while Yc% is set to the value of TRK, with the sign inverted.

Inversely, when it is in the range 0 to 100, Yc% is set to 0, while Y% is set to TRK.

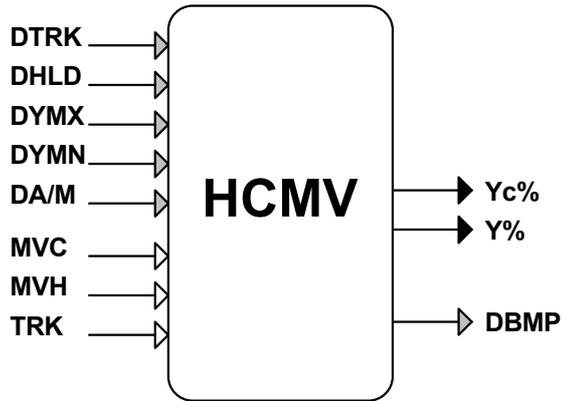
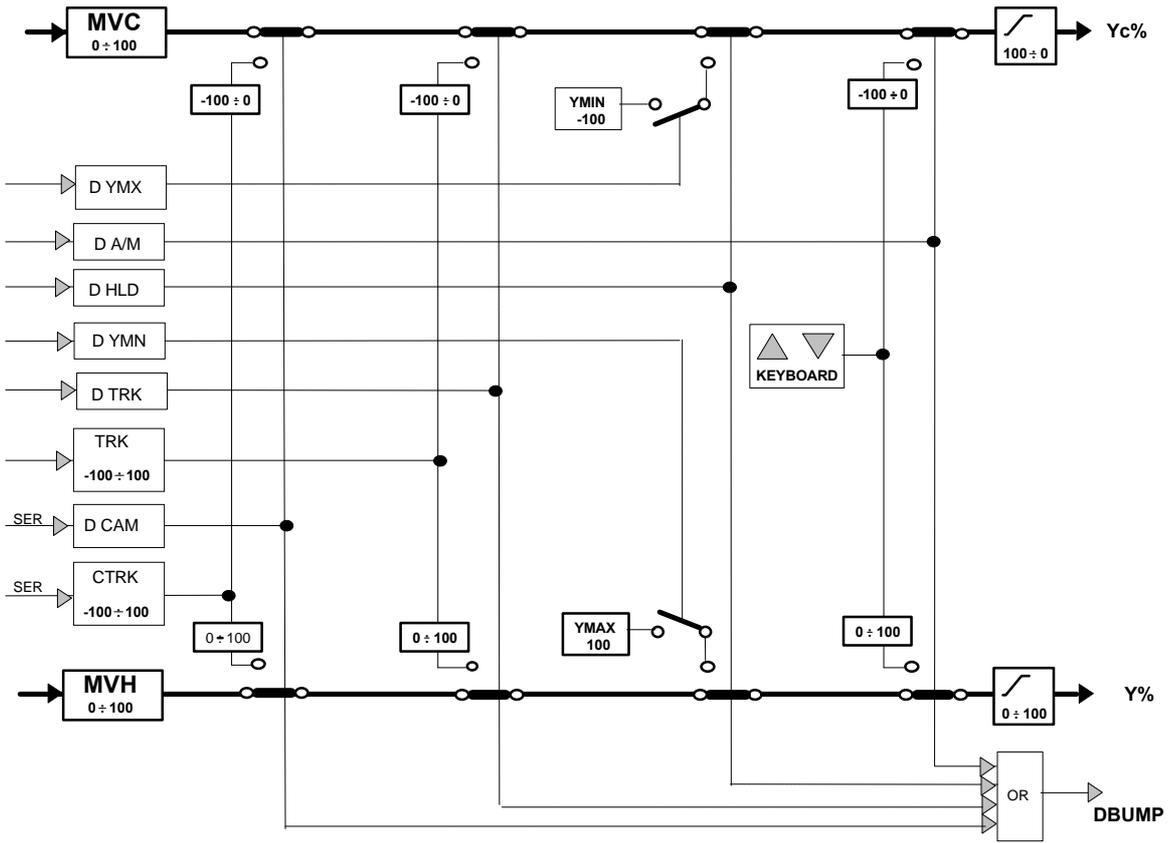
These values are valid if the deadband of the phase splitter is set to 0, otherwise they slightly change.

If DHLD (Hold) is active, both outputs are frozen.

If both DHLD(Hold)and DYMN (Force Min) are active, the output Yc% is set to the maximum Cool Forcing value.

If both DHLD (Hold) and DYMN (Force Max) are active, the output Y% is set to the maximum Heat Forcing value.

If the DA/M input is active (Manual mode request), the current outputs are not driven any longer according to the MV inputs, but they are changed only from the keyboard.



*I/O Connections*

<b>MVH</b>	Analog input, corresponding to the control output (also named manipulated output) of the Heat PID module. Value in percentage.
<b>MVC</b>	Analog input, corresponding to the control output (also named manipulated output) of the Cool PID module. Value in percentage.
<b>DTRK</b>	Track input. It enables the Track functionality.
<b>TRK</b>	Track value. Analog signal with the value to set the outputs Y% and Yc% when the Track is enabled.
<b>DHLD</b>	Hold input. When active, the output Y% and Yc% are frozen.
<b>DYMX</b>	Digital input enabling the forcing of the Y% to the Max Forcing value.
<b>DA/M</b>	Digital input selecting the Auto and Manual mode.
<b>DYMN</b>	Digital input enabling the forcing of the Yc% to the Min Forcing value.
<b>DBMP</b>	Digital input, indicating through its negative transition, when the adjustment of the PID terms for the BUMPLESS transition must be performed.
<b>Y %</b>	Control output, in percentage, of the Heat channel
<b>Yc %</b>	Control output, in percentage, of the Cool channel

*Parameters**Displayed Parameters*

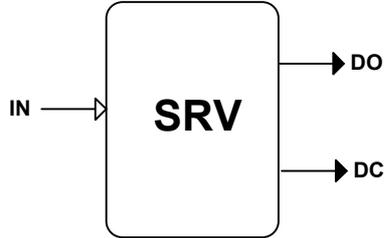
<b>Max Heat</b>	Maximum forcing value of the heat channel, with range from 0 to 100 %
<b>Max Cool</b>	Maximum forcing value of the cool channel, with range from 0 to 100 %
<b>Dead Band</b>	Deadband, with range from -10.0 to +10.0 %

### 5.5.5 Servomotor Output (SRV)

*Description*

This module is a servo-positioner, like a valve positioner, that controls, by mean of a raise and lower digital output, the movement of the actuator up to the target position, specified by the IN analog input.

The IN analog input provides the position, in percentage units with range from 0 to 100%, the actuator has to assume.



*I/O Connections*

<b>IN</b>	Analog input, specifying the actuator position.
<b>DO</b>	Digital Output, enabling the movement in the Open direction.
<b>DC</b>	Digital Output, enabling the movement in the Close direction.

*Parameters*



*Displayed Parameters*

<b>Travel T.</b>	Travel time, with range from 15 to 600 seconds, required by the servomotor to go from the zero position to the full travel end.
<b>Dead Band</b>	Dead band of the actuator, with range from 0,1 to 5,0 <b>(1)</b>

**(1)** To assure a correct operation of this module, you must check that the dead band value, you configure, satisfies the following relationship:

$$\text{Dead Band} \geq \frac{100 * T_s}{\text{Travel T.}}$$

Where Ts = Sampling Time in seconds

### 5.5.6 Time Proportioning Output (TPO)

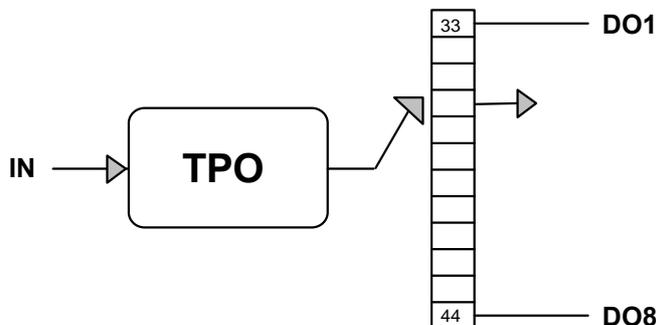
*Descriptions*

This module converts an analog signal, IN, generated by the strategy, in a rectangular wave digital signal, with variable mark/space ratio, proportional to the input. The digital signal is generated on a physical digital output of the AC controller only, with the exclusion of the outputs of the Auxiliary Units.

The cycle time of the rectangular wave is configured by the user, while the duty cycle is controlled by IN.

The IN signal is in percentage, with range 0 to 100%.

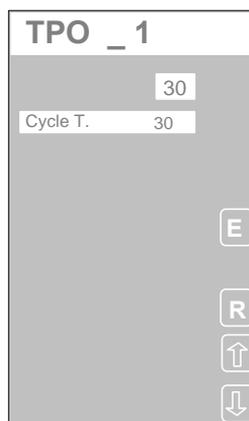
The maximum number of blocks of this type in a strategy is limited to 8.



*I/O Connections*

<b>IN</b>	Analog input, in percentage.
<b>DO1 .. DO8</b>	Time proportioning digital output.

*Parameters*



*Displayed Parameters*

<b>Cycle T.</b>	Cycle time, in seconds, of the period of the rectangular wave with variable mark/space ratio. The range is between 1 to 100 seconds. The mark part of the rectangular wave is proportional to IN.
-----------------	---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

### 5.5.7 Scale Changer (SCH)

*Descriptions*

This module re-ranges an analog signal, according to the new range limits, set by the user. The applications of this module are quite extensive; among the many, the most important conversions are:

- From an engineering unit to another.
- From an engineering unit to a percentage unit.
- From a percentage unit to an engineering unit.



*I/O Connections*

<b>IN</b>	Input signal, in engineering units (1)
<b>OUT</b>	Analog output, in engineering units (1)

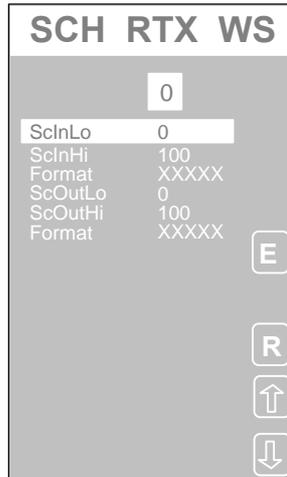
1) The relationship between IN and OUT, implementing the range conversion, is as follows:

$$OUT = \frac{FSu - ISu}{FSi - ISi} * (IN - ISi) + ISu$$

where:

- FS = High range
- IS = Low range
- i = Input
- u = Output

*Parameters*



*Displayed Parameters*

<b>ScInLo</b>	Low range of the input signal
<b>ScInHi</b>	High range of the input signal
<b>Format</b>	Format: it defines the number of digits of the input signal
<b>ScOutLo</b>	Low range of the output signal
<b>ScOutHi</b>	High range of the output signal
<b>Format</b>	Format: it defines the number of digits of the output signal

### 5.5.8 Filter (FILT)

#### Descriptions

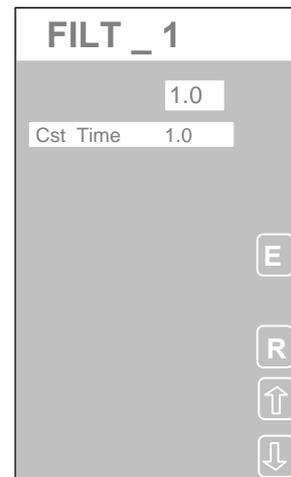
This module implements a first order RC filter, with the filter time constant defined by the user.



#### I/O Connections

<b>IN</b>	Input signal in engineering units
<b>OUT</b>	Output signal in engineering units

#### Parameters



#### Displayed Parameters

<b>Cst Time</b>	Time constant of the filter, in seconds, with range from 0 to 30 seconds. If set to 0, the filter is disabled.
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### 5.5.9 Analog Delay (ADLY)

*Descriptions*

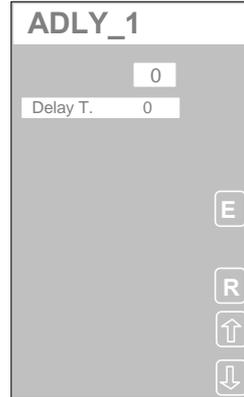
This module is a delay line, reproducing, on the output OUT, the signal on the input IN, delayed by a predefined time, named Delay Time.



*I/O Connections*

<b>IN</b>	Input signal in engineering units
<b>OUT</b>	Output signal in engineering units

*Parameters*



*Displayed Parameters*

<b>Delay T.</b>	Delay time, to apply to the input signal, with range from 0 to 3.600 sec.
-----------------	---------------------------------------------------------------------------

### 5.5.10 Digital Delay (DDLJ)

*Descriptions*

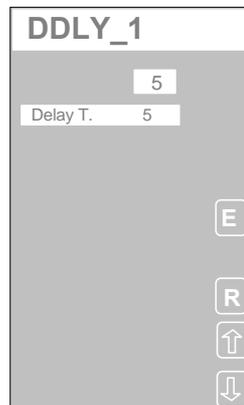
This module reproduces, on the output DOUT, the digital signal on the input DIN delayed by a predefined time, named Delay Time.



*I/O Connections*

<b>DIN</b>	Digital input signal
<b>DOUT</b>	Digital output signal

*Parameters*



*Displayed Parameters*

<b>Delay T.</b>	Delay time, to apply to the input signal, with range from 0 to 3.600 sec.
-----------------	---------------------------------------------------------------------------

### 5.5.11 Rate Limiter (MSL)

#### Descriptions

This module provides a rate limiting functionality. It retransmits the input IN to the output OUT, by limiting it, to a predefined value the rate of change. The effect is that OUT ramps continuously towards the signal IN, but limited to a specified rate of change.

The formula below explains the module functionality. The module, continuously, computes the derivative of the IN signal, by calculating the difference of the value at one sample and at the next sample, and comparing it with the slope limit:

$$dIN/Ts = IN(T + Ts) - IN(T) / Ts \leq \text{Slope}$$

where Ts is the sampling time of the controller at runtime.

According to the result of the comparison, the module takes two different actions:

If the increment of input signal IN, during the TS time, exceeds (Slope \* Ts), then OUT is set to (Slope \* Ts).

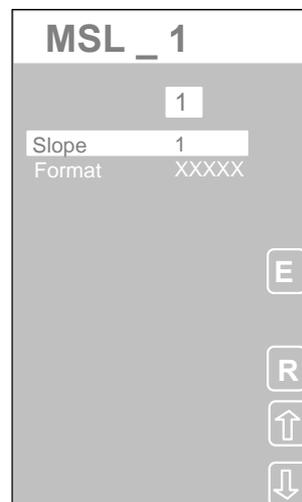
If the increment of input signal IN, during the TS time, doesn't exceed (Slope \* Ts), then OUT is set to the value of IN.



#### I/O Connections

<b>IN</b>	Analog Input in engineering units
<b>OUT</b>	Analog output in engineering units

#### Parameters



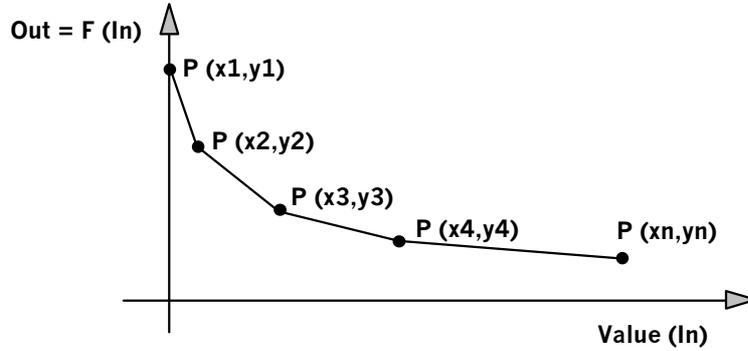
#### Displayed Parameters

<b>Slope</b>	Slope Limit, corresponding to the maximum allowed rate of change of the IN signal in the time Ts. Range from 0 to 9999
<b>Format</b>	Format: it defines the number of digits of the Slope value

### 5.5.12 Linearizator (CHAR)

*Description*

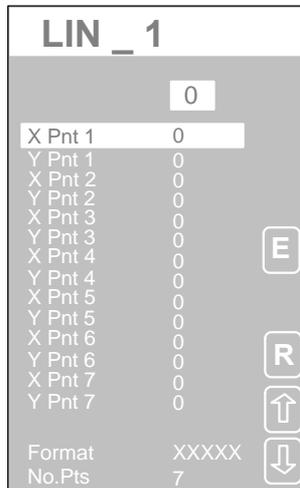
This module, provides the same functionality of an analog characterizer, with up to 12 breakpoints. Each breakpoint is defined by a coordinate pair (X,Y), specifying the value of the IN input variable (X), and the corresponding value of the OUT output variable (Y). The function  $OUT=F(IN)$ , for all the values of IN, is derived by the characterizer breakpoints list, by mean of simple linear interpolation calculation. The minimum number of breakpoint is 2. The output is set continuously to the value  $OUT = F(IN)$ .



*I/O Connections*

<b>IN</b>	Analog input in engineering units
<b>OUT</b>	Analog output in engineering units

*Parameters*



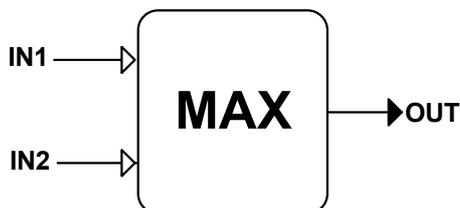
*Displayed Parameters*

<b>X Pnt 1....12</b>	Value, in engineering units, of the coordinate IN for a breakpoint
<b>Y Pnt 1....12</b>	Value, in engineering units, of the coordinate OUT for a breakpoint
<b>Format</b>	Format: it defines the number of digits of the breakpoint coordinates
<b>No. Pts</b>	Number of breakpoints (X,Y), with range form 2 to 12

### 5.5.13 Minimum and Maximum Selector (MAX)

*Description*

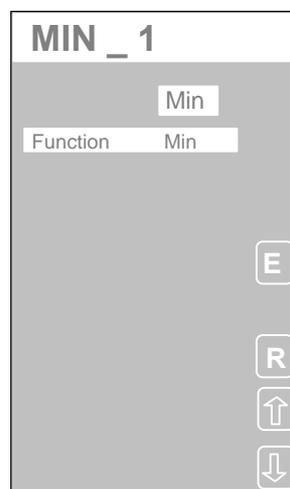
This module has two inputs and can be configured to select the minimum or the maximum of these two inputs. The input selected is retransmitted out through the OUT output.



*I/O Connections*

<b>IN 1</b>	Analog input signal n.1
<b>IN 2</b>	Analog input signal n. 2
<b>OUT</b>	Output

*Parameters*



*Displayed Parameters*

<b>Function</b>	Selection of the operation to perform on the two analog input signals: "Min" for the minimum and "Max" for the maximum.
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### 5.5.14 Software Analog Multiplexer (AMUX)

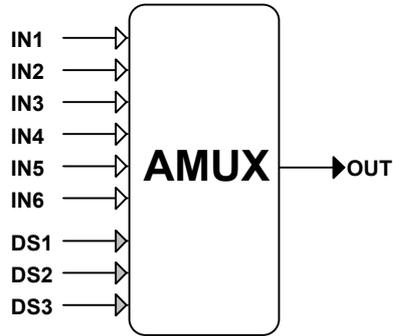
*Description*

This module is a 6 to 1 multiplexer of analog signals. One of the 6 inputs is retransmitted on the OUT output.

The Input to retransmit is selected by one of the two following modes:

- a) Static mode, by mean of a parameter set during the configuration of the strategy.
- b) Dynamic mode, through a 3 bit code from the DS1÷DS3 inputs, specifying the input number, according to the following table:

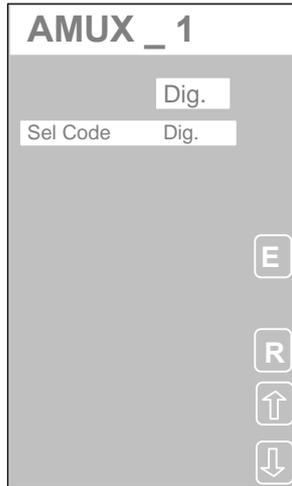
DS 3	DS 2	DS 1	Input transmitted to OUT
0	0	0	IN 1
0	0	1	IN 2
0	1	0	IN 3
0	1	1	IN 4
1	0	0	IN 5
1	0	1	IN 6



*I/O Connections*

<b>IN 1....6</b>	Analog inputs to multiplex
<b>DS 1..3</b>	Selection inputs
<b>OUT</b>	Output

*Parameters*



*Displayed parameters*

<b>Sel Code</b>	Specification of the selection mode to use (dynamic or static)
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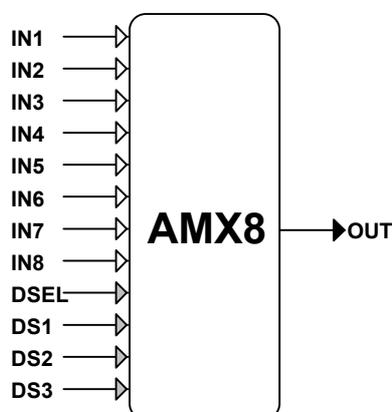
### 5.5.15 Hardware Analog Multiplexer (AMX8)

#### Description

This module is an 8 to 1 multiplexer. One of the 8 inputs IN1÷IN8, selected by mean of the 3 bit code on the DS1÷DS3 inputs, is retransmitted on the OUT output. Furthermore, the module can be selected or deselected through an external input DSEL. Once the module is deselected, its OUT output will hold the value it had before the deselection, until further selected.

The input to multiplex, is selected, with the DSEL signal in the active state, by mean of the inputs DS1÷DS3, as in the following table:

DS1	DS2	DS3	Input transmitted to OUT
0	0	0	IN 1
1	0	0	IN 2
0	1	0	IN 3
1	1	0	IN 4
0	0	1	IN 5
1	0	1	IN 6
0	1	1	IN 7
1	1	1	IN 8



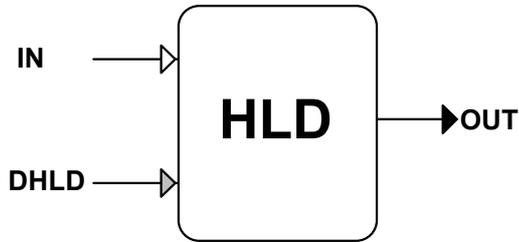
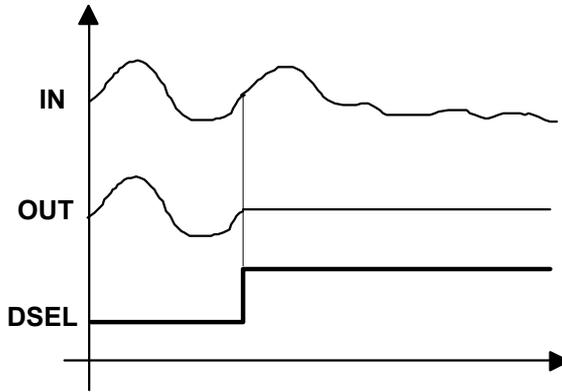
#### I/O Connections

<b>IN 1....8</b>	Inputs to multiplex
<b>DS 1..3</b>	Selection Inputs
<b>DSEL</b>	Selection enable input
<b>OUT</b>	Output

### 5.5.16 Analog Hold (HLD)

*Description*

This module has the functionality of a Sample and Hold circuit. It latches the value of the analog input IN on the output OUT, in correspondence of the rising edge of the latch digital input DHLD. When DHLD is inactive, the value of the output OUT is identical with the signal at the input IN, that is  $OUT = IN$ . When DHLD goes active, the OUT output is latched and this value is hold until the DHLD signal goes inactive again.



*I/O Connections*

<b>IN</b>	Input
<b>DHLD</b>	Hold command input
<b>OUT</b>	Output

*Parameters*

This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

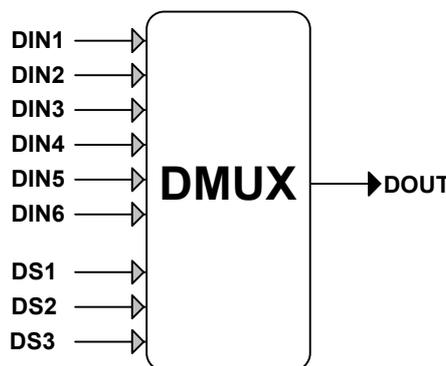
### 5.5.17 Software Digital Multiplexer (DMUX)

*Description*

This module is a 6 to 1 multiplexer of digital signals. One of the 6 inputs is retransmitted on the digital DOUT output. The Input to retransmit is selected by one of the two following modes:

- a) Static mode, by mean of a parameter set during the configuration of the strategy, specifying which of the inputs DIN1 to DIN6 must be selected.
- b) Dynamic mode, through a 3 bit code from the DS1÷DS3 inputs, specifying the input number, according to the following table:

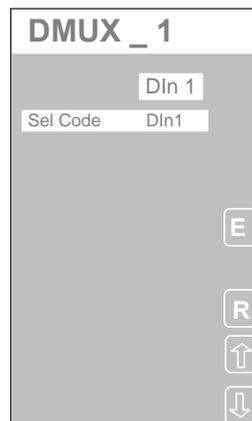
DS 3	DS 2	DS 1	Input transmitted to OUT
0	0	0	DIN 1
0	0	1	DIN 2
0	1	0	DIN 3
0	1	1	DIN 4
1	0	0	DIN 5
1	0	1	DIN 6



*I/O Connections*

<b>DIN 1.....6</b>	Digital Inputs to the multiplexer
<b>DS 1..3</b>	Selection inputs
<b>OUT</b>	Output

*Parameters*



*Displayed Parameters*

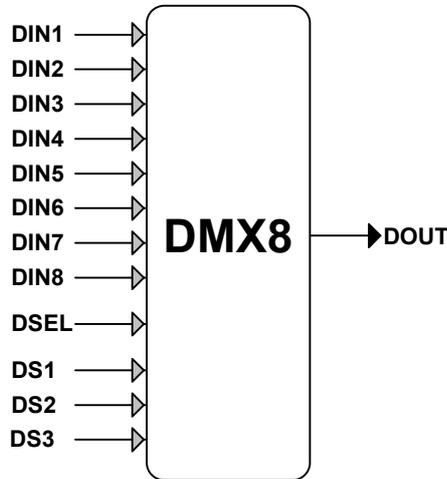
<b>Sel Code</b>	Specification of the selection mode to use (dynamic or static)
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### 5.5.18 Hardware Digital Multiplexer (DMX8)

*Description*

This module is an 8 to 1 multiplexer. One of the 8 inputs DIN1÷DIN8, selected by mean of the 3 bit code on the DS1÷DS3 inputs, is retransmitted on the OUT output. Furthermore, the module can be selected or deselected through an external input DSEL. Once the module is deselected, its OUT output will hold the value it had before the deselection, until further selected. The input to multiplex, is selected, with the DSEL signal in the active state, by mean of the inputs DS1÷DS3, as in the following table:

DS1	DS2	DS3	Input transmitted to OUT
0	0	0	DIN 1
1	0	0	DIN 2
0	1	0	DIN 3
1	1	0	DIN 4
0	0	1	DIN 5
1	0	1	DIN 6
0	1	1	DIN 7
1	1	1	DIN 8



*I/O Connections*

<b>DIN 1....8</b>	Inputs to multiplex
<b>DS 1..3</b>	Selection Inputs
<b>DSEL</b>	Selection enable input
<b>OUT</b>	Output

*Parameters*

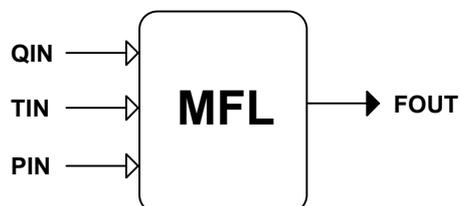
This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

### 5.5.19 Mass Flow (MFL)

#### Description

This module converts a raw flow or a differential pressure measurement, into a pressure and temperature-compensated flow measure, in order to compute the exact mass flow of the fluid.

The compensated flow is retransmitted as an analog value (FOUT), to other modules, like PID or totalizers.



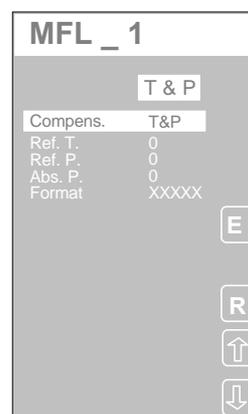
#### I/O Connections

<b>QIN</b>	Raw flow or differential pressure, in engineering units
<b>TIN</b>	Fluid temperature in Celsius degree
<b>PIN</b>	Relative pressure measure, in engineering units
<b>OUT</b>	Compensated flow output

The compensation formula is illustrated below; you can select if you want to have temperature compensation or pressure compensation or both.

$$OUT = QIN * \sqrt{\left(\frac{TR + 273.14}{TIN + 273.14}\right)} * \sqrt{\left(\frac{PIN + PABS}{PR + PABS}\right)}$$

#### Parameters



#### Displayed parameters

<b>Compens.</b>	Selection of the type of compensation (temperature, pressure or both)
<b>Ref. T.</b>	Reference Temperature in °C, considered in the design of the primary measuring device.
<b>Ref. P</b>	Reference Pressure, considered in the design of the primary measuring device.
<b>Abs. P.</b>	Absolute atmospheric Pressure, relative to vacuum.
<b>Format</b>	Format: it defines the number of digits of the values above.

### 5.5.20 Analog Totalizer ( TOT )

*Description*

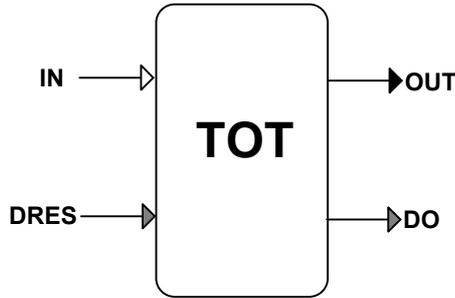
This module performs the totalization of the analog input IN, retransmitting the totalizer results on the output OUT. This module includes other functionalities, related to the flow totalization, like the generation of a pulse output, for driving external counters, a cutoff threshold on the Input (Dropout), that stops the totalization when the Input signal is below it, the alarming when the counter reaches a predefined level (Pulse V. and Rollover) and the scaling of the Input signal before the totalization, in order to set the engineering units of the totalizer.

The totalization is carried on, every time sample, according to the following formula:

$$Out_{new} = Out_{old} + In * SF * \left(\frac{Ts}{3600}\right)$$

where:

- Out = Output with the current value of the totalizer (new = current one, old = previous calculation)
- In = Input with the value to totalize
- Ts = Sampling time in seconds
- SF = Scale Factor, for ranging the value to the totalization engineering units



*I/O Connections*

<b>IN</b>	Analog Input
<b>DRES</b>	Reset input of the totalizer
<b>OUT</b>	Analog output with the totalization value
<b>DO</b>	Pulse output for external totalization <sup>(1)</sup>

**Note:**

The module generates a pulse, with time width equal to the controller sampling time, every time the OUT totalization value reaches the threshold or its multiple, specified by the value of the Pulse V. parameter. The DO pulse output allows external counting device, like mechanical counters, to further totalize, with a greater number of digits, the IN signal.

**Example**

Let us totalize the quantity, in liters, of a fluid during an entire year, guessing that the average instantaneous flow rate is 30 l/h.

Considering that the maximum value the totalizer can reach before a rollover is 99999, the Scale Factor (SF) should be set to the value computed in the following formula, in order to prevent a rollover, before the end of the year:

$$SF = \frac{99999}{30 * 365 * 24} = 0.3805$$

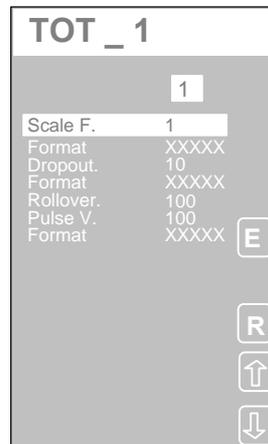
Setting SF to the value above, the totalizer will be set to the value of 0.3805 after 1 hour, assuming for the flow a constant value of 1 l/h.

In order to have the totalizer engineering unit immediately understandable, it is better to set SF to a lower value than above, and, precisely, to 0.1.

In this way we achieve that the totalizer doesn't roll over in one year and that its engineering unit are immediately related to the flow engineering unit. Setting SF to 0.1, the totalization unit is tens liters and after one hour of totalization, the value is, assuming a constant flow of 1 l/h:

$$SF = \frac{0.1}{1 * 1} = 0.1$$

*Parameters*



*Displayed Parameters*

<b>Scale F.</b>	Scale factor, in engineering units, with range from 0 to 99999
<b>Format</b>	Format: it defines the number of digits of the Scale Factor value
<b>Dropout</b>	Minimum value of the input signal, for enabling the totalization. If IN is below this value, the totalization is unchanged. Range from 0 to 99999.
<b>Format</b>	Format: it defines the number of digits of the Dropout value.
<b>Rollover</b>	Rollover value. When the totalization reaches this value, the totalizer restart from 0. Range from 0 to 99999.
<b>Pulse V.</b>	Value of totalization corresponding to one pulse. Every time the totalization value reaches this threshold or its multiple, a pulse is sent out on the Output DO.
<b>Format</b>	Format: it defines the number of digits of the Rollover and Pulse V. value

### 5.5.21 Analog Limiter (LMT)

*Description*

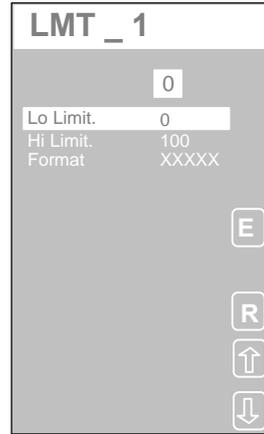
This module retransmits the input signal to the output, limiting it to a predefined range, set by the user. You define the minimum and the maximum allowed value. When the signal exceeds one of the two limits it is clamped to them.



*I/O Connections*

<b>IN</b>	Input
<b>OUT</b>	Output

*Parameters*



*Displayed Parameters*

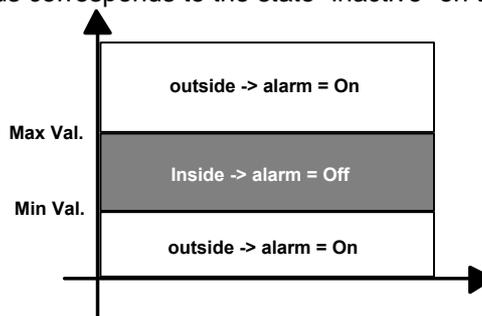
<b>Lo Limit</b>	Value of the minimum limit to apply to the output
<b>Hi Limit</b>	value of the maximum limit to apply to the output
<b>Format</b>	Format: it defines the number of digits of the values above

### 5.5.22 Alarms ( ALM )

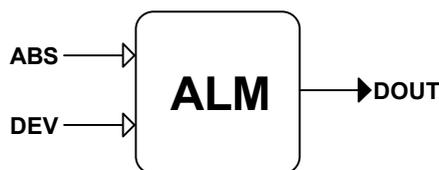
*Description*

This module is an alarm comparator, that can be configured to flag either absolute or deviation alarms, with an hysteresis band, defined by the user. Being structured internally as a comparator; its use is not limited to alarms; in fact, it can be used, also, as a control element of the strategy, performing real time comparisons on process variables. The status of the digital output is fully programmable, in order to support all the various combinations of high, low, deviation alarm.

The diagram below illustrates the operating principle of the ALM module, valid for all the alarm configurations. When the module is configured as a deviation alarm, with the band defined by the two thresholds, MIN VAL and MAX VAL, if the signal DEV is inside the band, the alarm is off, otherwise is on. The “off” status corresponds to the state “inactive” on the output DOUT.



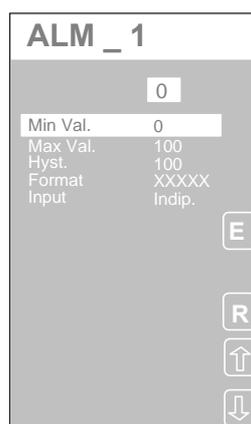
In the next page, a few examples of alarm configurations are shown.



*I/O Connections*

<b>ABS</b>	Absolute alarm analog input
<b>DEV</b>	Deviation alarm analog input
<b>OUT</b>	Digital output with the result of the alarm comparison

*Parameters*

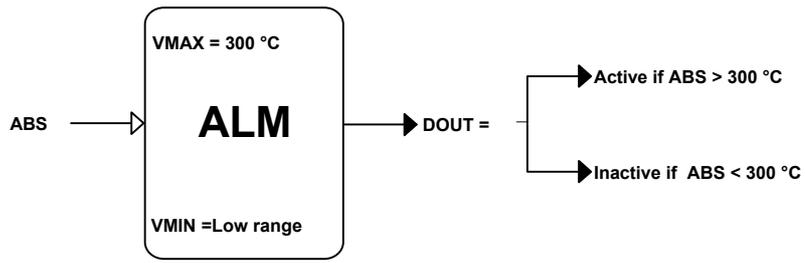


*Displayed Parameters*

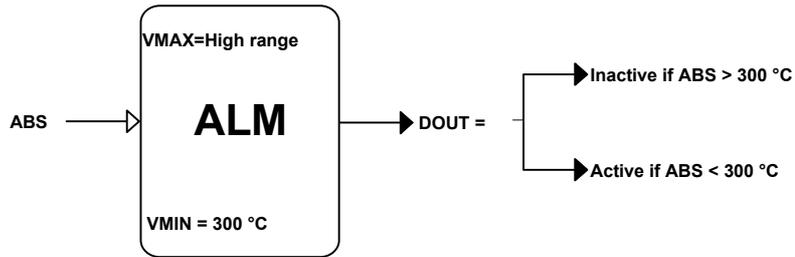
<b>Min Val.</b>	Low alarm threshold
<b>Max Val.</b>	High alarm threshold
<b>Hyst.</b>	Alarm Hysteresis
<b>Format</b>	Format: it defines the number of digits of the values above
<b>Input</b>	Selection of the type of alarm: absolute (independent) or deviation

Examples

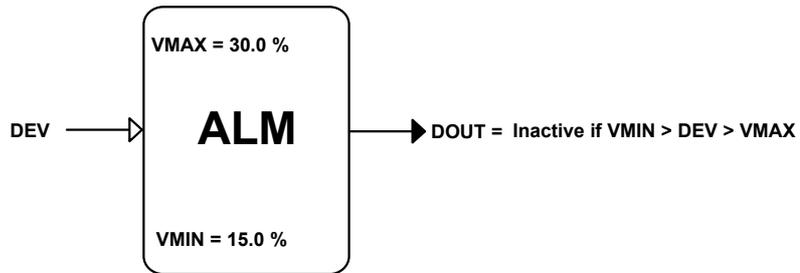
1) Absolute (independent) high alarm



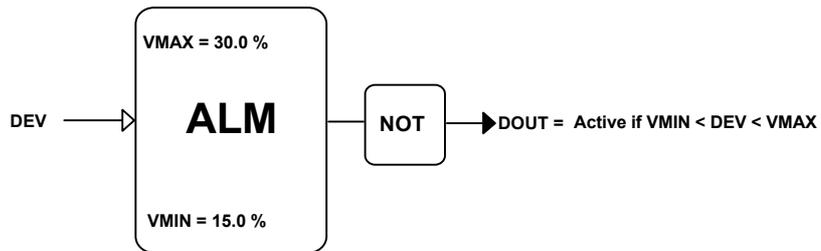
2) Absolute (independent) low alarm



3) Deviation alarm (active when out of the deviation band)



4) Deviation alarm (active when in the deviation band).  
This configuration requires an external module to perform a Boolean NOT operation.



### 5.5.23 Rate Alarm ( SALM )

*Description*

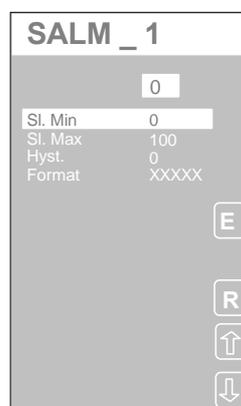
This module is an alarm comparator that flags rate alarms, with an hysteresis band defined by the user. This module computes the derivative of the signal at the input IN and compares it with a low and high thresholds, defined by the user. If the derivative of the signal is between the two threshold, the alarm is off, otherwise is on. When the alarm is on the OUT digital output goes in the active state.



*I/O Connections*

<b>IN</b>	Input
<b>OUT</b>	Output

*Parameters*



*Displayed parameters*

<b>Sl. Min</b>	High rate alarm threshold
<b>Sl. Max</b>	Low rate alarm threshold
<b>Hyst.</b>	Alarm Hysteresis
<b>Format</b>	Format: it defines the number of digits of the values above

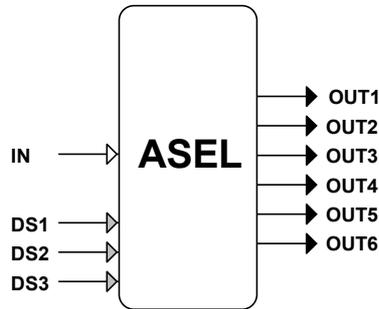
### 5.5.24 Analog Software Demultiplexer ( ASEL )

*Description*

This module is a 1 to 6 demultiplexer of analog signals. It retransmits its IN analog input to one, of the 6 OUT1÷OUT6 analog outputs, that has been selected. The other not selected outputs are set to 0. The output is selected by one of the two following modes:

- a) Static mode, by mean of a parameter set during the configuration of the strategy, specifying the number of the output OUT1÷OUT6 to select.
- b) Dynamic mode, through a 3 bit code from the DS1÷DS3 inputs, specifying the output number, according to the following table:

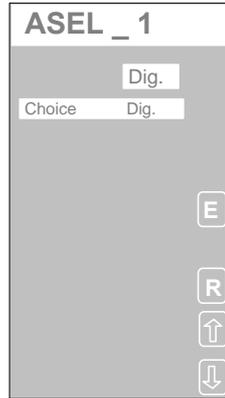
DS 3	DS 2	DS 1	Selected Output (OUT)
0	0	0	OUT 1
0	0	1	OUT 2
0	1	0	OUT 3
0	1	1	OUT 4
1	0	0	OUT 5
1	0	1	OUT 6



*I/O Connections*

<b>IN</b>	Input to demultiplex
<b>DS 1..3</b>	Selection inputs
<b>OUT 1.....6</b>	Outputs

*Parameters*



*Displayed parameters*

<b>Sel Code</b>	Specification of the selection mode to use (dynamic or static)
-----------------	----------------------------------------------------------------

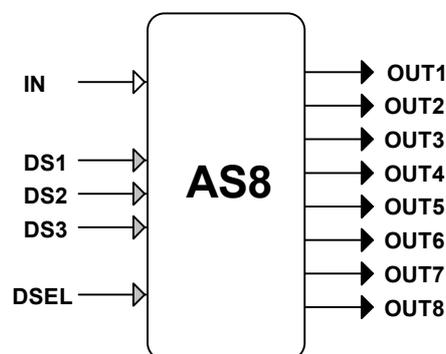
### 5.5.25 Analog Hardware Demultiplexer ( AS8 )

#### Description

This module is a 1 to 8 demultiplexer of analog signals. It retransmits its IN analog input to one of the 8 OUT1÷OUT8 analog outputs. The output is selected through the 3 bit code on the DS1÷DS3 inputs, as listed in the following table. The other not selected outputs are set to 0.

Furthermore, the module can be selected or deselected through an external input DSEL. Once the module is deselected, its OUT output will hold the value it had before the deselection, until further selected.

DS1	DS2	DS3	Selected Output (OUT)
0	0	0	OUT 1
1	0	0	OUT 2
0	1	0	OUT 3
1	1	0	OUT 4
0	0	1	OUT 5
1	0	1	OUT 6
0	1	1	OUT 7
1	1	1	OUT 8



#### I/O Connections

<b>IN</b>	Input to demultiplex
<b>DS 1..3</b>	Selection inputs
<b>DSEL</b>	Selection enable input
<b>OUT 1.....8</b>	Outputs

#### Parameters

This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

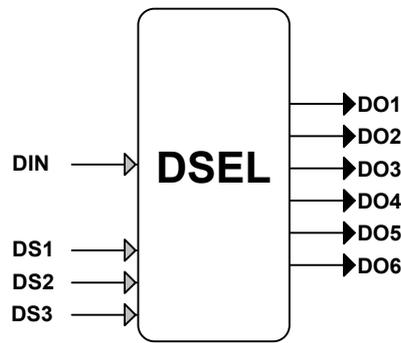
### 5.5.26 Digital Software Demultiplexer ( DSEL )

*Description*

This module is a 1 to 6 demultiplexer of digital signals. It retransmits its DIN digital input to one of the 6 DO1÷DO6 digital outputs, that has been selected. The other not selected outputs are set to 0. The output is selected by one of the two following modes:

- a) Static mode, by mean of a parameter set during the configuration of the strategy, specifying the number of the output DO1÷DO6 to select.
- b) Dynamic mode, through a 3 bit code from the DS1÷DS3 inputs, specifying the output number, according to the following table:

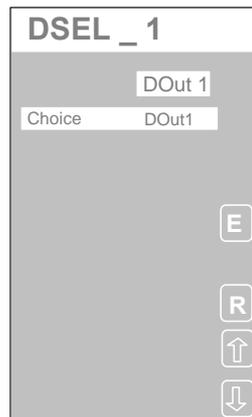
DS 3	DS 2	DS 1	Selected Output (DO)
0	0	0	DO 1
0	0	1	DO 2
0	1	0	DO 3
0	1	1	DO 4
1	0	0	DO 5
1	0	1	DO 6



*I/O Connections*

<b>DIN</b>	Input to demultiplex
<b>DS 1..3</b>	Selection enable inputs
<b>DO 1.....6</b>	Outputs

*Parameters*



*Displayed Parameters*

<b>Sel Code</b>	Specification of the selection mode to use (dynamic or static)
-----------------	----------------------------------------------------------------

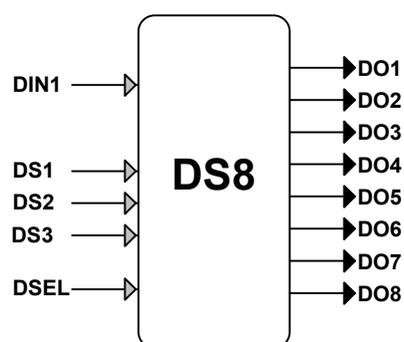
### 5.5.27 Hardware Digital Demultiplexer ( DS8 )

#### Description

This module is a 1 to 8 demultiplexer of digital signals. It retransmits its DIN digital input to one of the 8 DO1÷DO8 digital outputs. The output is selected through the 3 bit code on the DS1÷DS3 input, as listed in the following table. The other not selected outputs are set to 0.

Furthermore, the module can be selected or deselected through an external input DSEL. Once the module is deselected, its DOn output will hold the value it had before the deselection, until further selected.

DS1	DS2	DS3	Selected Output (DO)
0	0	0	DO 1
1	0	0	DO 2
0	1	0	DO 3
1	1	0	DO 4
0	0	1	DO 5
1	0	1	DO 6
0	1	1	DO 7
1	1	1	DO 8



#### I/O Connections

<b>DIN</b>	Input to demultiplex
<b>DS 1..3</b>	Selection inputs
<b>DSEL</b>	Selection enable input
<b>DO 1.....8</b>	Outputs

#### Parameters

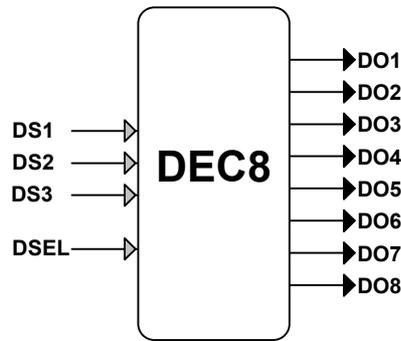
This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

### 5.5.28 Decoder ( DEC8 )

*Description*

This module is a 1 to 8 decoder. It selects, one of the 8 DO1÷DO8 digital outputs, according to the 3 bit binary code specified on the DS1÷DS3 inputs, as listed in the table below. The selected output is set to 1, while the others are set to 0. The DSEL digital input, enables the module, when set to 1, and disables it, when 0. Once the module is disabled, the output selected doesn't change, even if the 3 bit binary code value varies. Enabling again the module, the output is selected according to the 3 bit binary code.

DS1	DS2	DS3	Selected Output(DO)
0	0	0	DO 1
1	0	0	DO 2
0	1	0	DO 3
1	1	0	DO 4
0	0	1	DO 5
1	0	1	DO 6
0	1	1	DO 7
1	1	1	DO 8



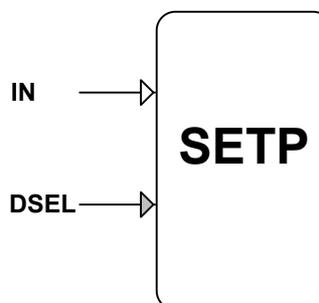
*I/O Connections*

<b>DS 1..3</b>	Select inputs
<b>DSEL</b>	Selection enable input
<b>DO 1.....8</b>	Decoder Outputs

### 5.5.29 Set page block (SETP)

#### Description

This module allows to set an active panel when DSEL (digital input) switches from "0" to "1".



#### Description of connections

<b>IN</b>	Analogue input for panel selection
<b>DSEL</b>	Digital input for panel activation*

\* The multiswitch panel cannot be used to generate the DSEL digital command.

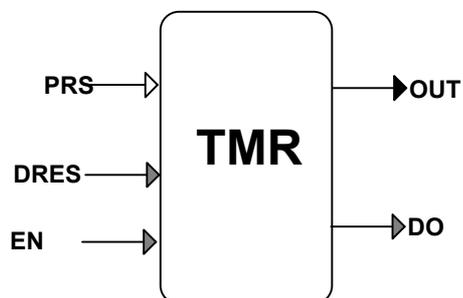
#### Parameters

This block has no parameters, and is not present in the Controller's menus.

### 5.5.30 Timer Block (TMR)

*Description*

This module performs a Timer function, with the possibility of setting a pre-set value.



*Description of connections*

<b>PRS</b>	Analogue input for second preselection.
<b>EN</b>	Digital input for Timer activation.
<b>DRES</b>	Digital input for Timer reset.
<b>OUT</b>	Analogue output for the Timer instantaneous value in seconds This output is reset with the DRES command.
<b>DO</b>	Digital output. This output is activated when the Timer reaches the pre-set value.

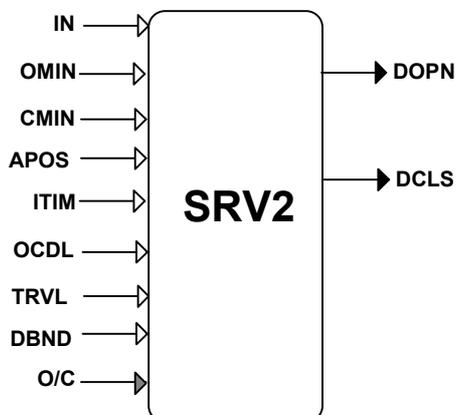
*Parameters*

This block has no parameters, and is not present in the Controller's configuration menu.

### 5.5.31 Servomotor in Open/Close loop Block (SRV2)

#### Description

This module generates the valve open and close commands in relation to the position required by the IN signal and to the present valve position as detected by the APOS signal.



#### Description of connections

<b>IN</b>	Required position (0÷100)
<b>OMIN</b>	Minimum duration of open command in seconds
<b>CMIN</b>	Minimum duration of close command in seconds
<b>APOS</b>	Valve position
<b>ITIM</b>	Integral time
<b>OCDL</b>	Minimum time between an open and a close command (and vice versa)
<b>TRVL</b>	Servomotor travel time in seconds
<b>DBND</b>	Dead band (in %)
<b>O/C</b>	Open/Close Loop selection

#### Parameters

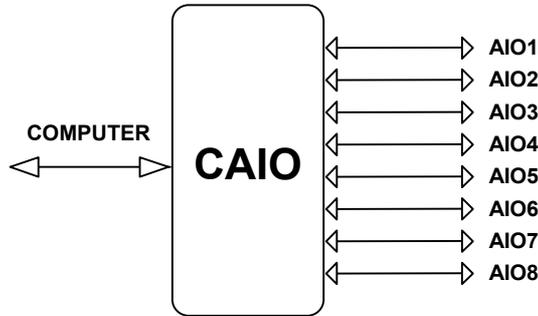
This block has no parameters, and is not present in the Controller's configuration menu.

## 5.6 Supervisory I/O Modules

### 5.6.1 Analog I/O to Computer (CAIO)

*Description*

This module consists of 8 analog values, corresponding to input or output values of the strategy, that can be easily accessed, through the RS485 JBUS serial port ( Main Comm ), by a Supervisory computer. The computer accesses the variables, by writing in the input ones and reading the output ones. A maximum of 4 modules of this type can be included in the strategy.



*I/O Connections*

<b>AIO 1..8</b>	Analog I/O
<b>Computer</b>	JBUS Addresses of the register with the I/O values

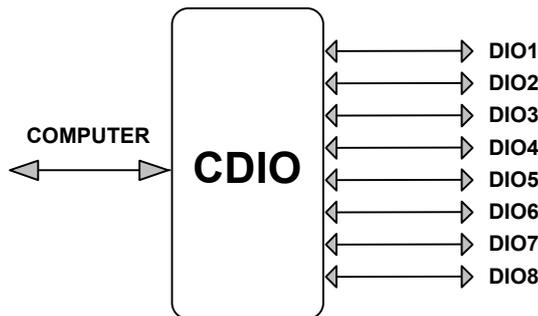
*Parameters*

This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

### 5.6.2 Digital I/O to Computer (CDIO)

*Description*

This module consists of 8 digital values, corresponding to input or output states of the strategy, that can be easily accessed, through the RS485 JBUS serial port ( Main Comm ), by a Supervisory computer. The computer accesses the variables, by writing in the input ones and reading the output ones. A maximum of 4 modules of this type can be included in the strategy.



*I/O Connections*

<b>DIO 1..8</b>	Digital I/O
<b>Computer</b>	JBUS Addresses of the register with the I/O values

*Parameters*

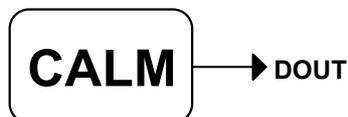
This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

## 5.7 System Modules

### 5.7.1 Computer Timeout ( CALM )

*Descriptions*

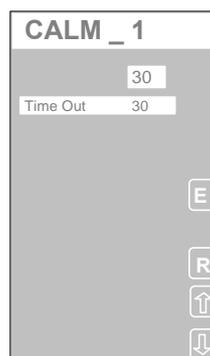
This module monitors the communication activity with the Supervisory Computer, activating the DOUT alarm output if the computer stops to interrogate the instrument for a time greater than the specified timeout.



*I/O Connections*

<b>DOUT</b>	Alarm output, flagging the lack of communication
-------------	--------------------------------------------------

*Parameters*



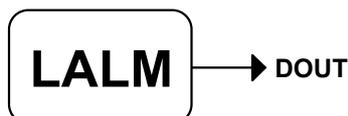
*Displayed Parameters*

<b>Time out.</b>	Minimum lack of communication time : 0 to 600 seconds
------------------	-------------------------------------------------------

### 5.7.2 LAN Timeout ( LALM )

*Description*

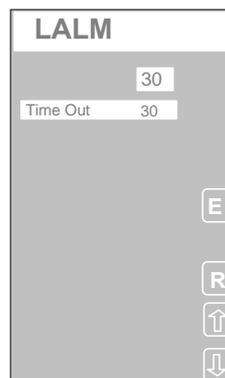
This module generates an alarm, activating the DOUT output if the controller doesn't receive, on the LAN, the values of "consumer" type variables, for a time greater than the specified timeout.



*I/O Connections*

<b>DOUT</b>	Alarm output flagging the lack of LAN communication
-------------	-----------------------------------------------------

*Parameters*



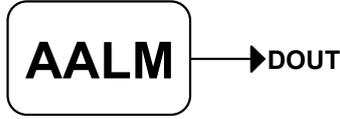
*Displayed Parameters*

<b>Time out.</b>	Minimum lack of LAN communication time : 0 to 600 seconds
------------------	-----------------------------------------------------------

### 5.7.3 Expansion Unit Timeout ( AALM )

*Description*

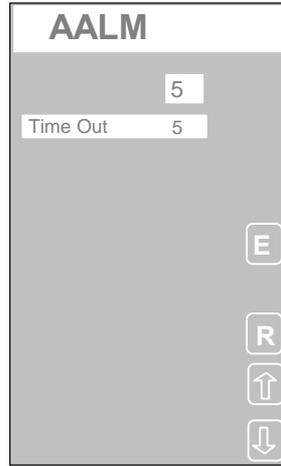
This modules activates a digital alarm output when there is not communication between the AC controller and its Expansion units for a time greater than the specified timeout.



*I/O Connections*

<b>DOUT</b>	Alarm output, flogging the lack of communication with the Expansion Units
-------------	---------------------------------------------------------------------------

*Parameters*



*Displayed Parameters*

<b>Time out.</b>	Minimum lack of communication time : 0 to 600 seconds
------------------	-------------------------------------------------------

### 5.7.4 System Configuration ( SYS )

*Description*

This module, configurable through the AC-Prograph only, defines the optional characteristics and the configurable behaviors of the AC30 controller. It specifies:

- the characteristics of the communication protocol of Main Comm.
- the characteristics and the addressing of the LAN.
- the sampling time.
- the levels of access of some operations and the password.



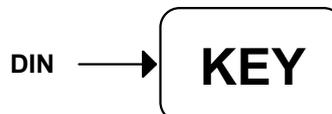
*Parameters*

This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

### 5.7.5 Key Selector ( KEY )

#### Description

This module provides the functionality of the key pressing simulation, allowing the strategy to “press” the keys on the AC30 controller. When its DIN digital input goes active, the result will be the same than pressing the corresponding key of the AC 30 8 buttons keyboard. The configuration of this module is carried out through the AC-PROGRAPH only.



#### I/O Connections

DIN	Digital Input forcing the pressing of the key
-----	-----------------------------------------------

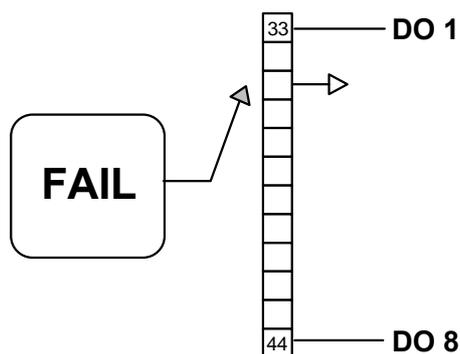
#### Parameters

This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

### 5.7.6 Failure Module ( FAIL )

#### Description

This module, once the diagnostic of the AC controller has detected a failure, activates a digital output, in order to trigger the safety logic external to the instrument. The user chooses which of the 8 digital outputs of the controller must be activated.



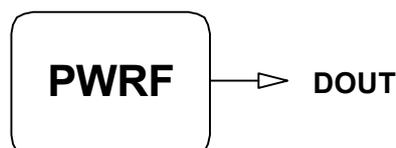
#### Parameters

This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

### 5.7.7 Power Failure AC Restart flag ( PWRF )

#### Description

This module generates a pulse, on its output, every time a power up or a strategy download occurs on the controller. The pulse duration corresponds to 3 times the parameter T Sample (sampling time of the controller, specified in the SYS module).



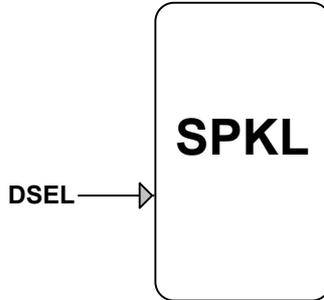
#### Parameters

This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

### 5.7.8 Setpoint control key lock Block (SPKL)

*Description*

By switching DSEL from “OFF” to “ON”, the keys that control the Setpoints (Increase/Decrease and L/R) on all active panels of the active strategy, are locked.



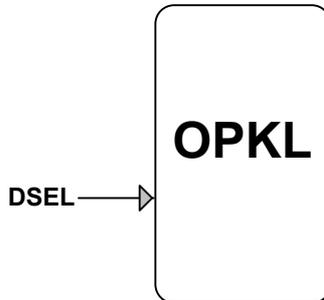
*Parameters*

This block has no parameters, and is not present in the Controller's configuration menu.

### 5.7.9 Output Change Key Lock Block (OPKL)

*Description*

By switching DSEL from “OFF” to “ON”, the keys that control the output change (Increase/Decrease and A/M) on all active panels of the active strategy, are locked.



*Parameters*

This block has no parameters, and is not present in the Controller's configuration menu.

## 5.8 Math and Logic Function

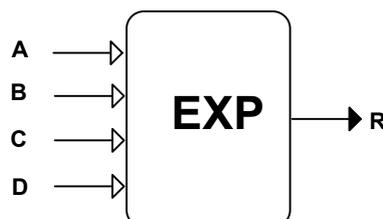
### 5.8.1 Expression ( EXP )

#### Description

This module allows the entry of an alphanumeric string, specifying a mathematical expression, manipulating up to 4 input variables (Inputs A, B, C, D) and involving arithmetic operators, math functions and parenthesis. The result, is returned in the output R.

The arithmetic operators are: addition, subtraction, multiply, division and Exponentiate.

The math functions are: Absolute value, Square root, Square, Sine, Cosine, Arc Tangent (Radians), Natural Logarithm (base e), Logarithm (base 10), Exponentiation e (2.71828).



#### I/O Connections

<b>A</b>	Input, corresponding to the variable A of the expression
<b>B</b>	Input, corresponding to the variable B of the expression
<b>C</b>	Input, corresponding to the variable C of the expression
<b>D</b>	Input, corresponding to the variable D of the expression
<b>R</b>	Result

#### Parameters

This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

### 5.8.2 Arithmetic ( OPR )

#### Description

This module executes a basic arithmetic operation on a couple of scaled analog inputs, A and B, returning the result on the output R.



#### I/O Connections

<b>A</b>	Input, corresponding to the variable A of the expression
<b>B</b>	Input, corresponding to the variable B of the expression
<b>R</b>	Result

Parameters



Displayed Parameters

<b>Function</b>	Specification of the Arithmetic operation. The choices are: Add, Sub, Mul, Divide, Power
-----------------	------------------------------------------------------------------------------------------

where:

- Add = addition ( $A+B = Y$ )
- Sub = subtraction ( $A-B = Y$ )
- Mul = multiply ( $A \times B = Y$ )
- Divide = division ( $A/B = Y$ ) Note: Input B cannot be zero
- Power = Exponentiate ( $A^B = Y$ )

5.8.3 Function ( FN )

Description

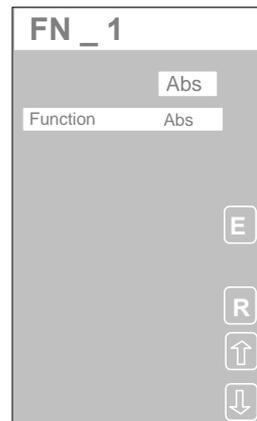
This module executes the selected math operation (trigonometric, logarithmic or exponential) on an analog input.



I/O Connections

<b>IN1</b>	Input
<b>RFN</b>	Output with the result of the execution of the selected function

Parameters



**Displayed Parameters**

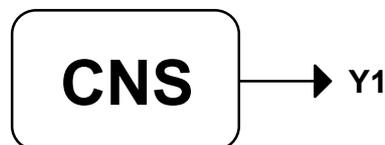
<b>Function</b>	Selection of the function to execute. The choices are: Abs, Sqrt, Sqr, Sin, Cos, Atan, Loge, Log10, Exp, Deriv.
-----------------	--------------------------------------------------------------------------------------------------------------------

where:

Abs = Absolute value of the input signal  
 Sqrt = Square root  
 Sqr = Square  
 Sin = Sine (Radians)  
 Cos = Cosine (Radians)  
 Atan = Arc tangent (Radians)  
 Loge = Natural logarithm (base e)  
 Log10 = Logarithm (base 10)  
 Exp = Exponentiation of e(2.71828)

**5.8.4 Analog Single Constant ( CNS )***Description*

This module generates a fixed analog signal on the output Y1, whose value is specified by the user through AC-Prograph / AC-Edit..

*I/O Connections*

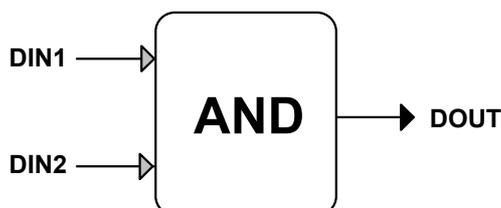
<b>Y 1</b>	Output with the constant value
------------	--------------------------------

*Parameters*

This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

**5.8.5 AND***Description*

This module performs the Boolean AND operation between two digital inputs

*I/O Connections*

<b>DIN 1</b>	Digital Input 1
<b>DIN 2</b>	Digital Input 2
<b>DOUT</b>	Output

*Truth Table (AND)*

DIN 1	DIN 2	DOUT
0	0	0
0	1	0
1	0	0
1	1	1

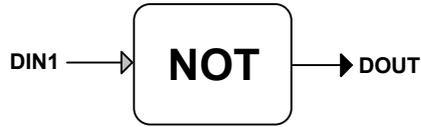
*Parameters*

This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

### 5.8.6 NOT

*Description*

This module perform the Boolean NOT of a digital input.



*I/O Connections*

<b>DIN 1</b>	Digital input
<b>DOUT</b>	Output

*Truth*

*Table(NOT)*

DIN 1	DOUT
0	1
1	0

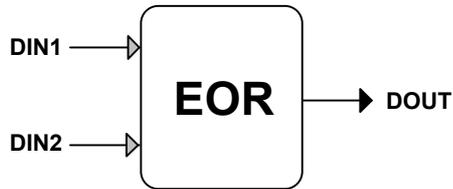
*Parameters*

This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

### 5.8.7 EOR (XOR)

*Description*

This module performs the Boolean XOR (Exclusive OR) between two digital inputs.



*I/O Connections*

<b>DIN 1</b>	Digital Input 1
<b>DIN 2</b>	Digital Input 2
<b>DOUT</b>	Output

*Truth Table(EOR)*

DIN 1	DIN 2	DOUT
0	0	0
0	1	1
1	0	1
1	1	0

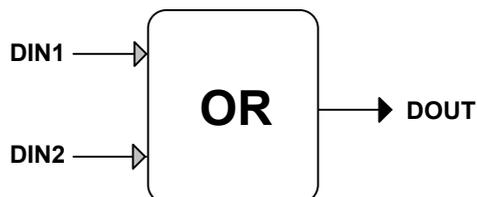
*Parameters*

This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

### 5.8.8 OR

#### Description

This module performs the Boolean OR between two digital inputs



#### I/O Connections

<b>DIN 1</b>	Digital Input 1
<b>DIN 2</b>	Digital Input 2
<b>DOUT</b>	Output

#### Truth

##### Table (OR)

DIN 1	DIN 2	DOUT
0	0	0
0	1	1
1	0	1
1	1	1

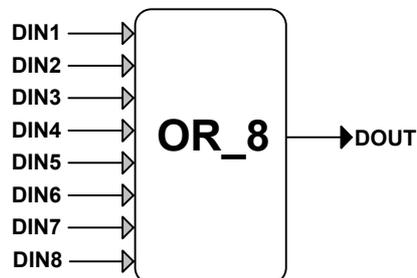
#### Parameters

This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

### 5.8.9 8 Inputs OR (OR8)

#### Description

This modules performs the Boolean OR between 8 digital inputs.



#### I/O Connections

<b>DIN 1.....8</b>	Digital Inputs
<b>OUT</b>	Output with the result of the OR operation

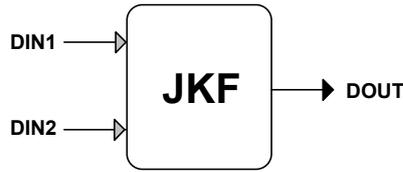
#### Parameters

This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

### 5.8.10 Flip-Flop J-K LATCH (JKF)

*Description*

This module performs a J-K Latch Flip - Flop with two digital inputs.



*I/O Connections*

<b>DIN 1</b>	Digital Input 1
<b>DIN 2</b>	Digital Input 2
<b>DOUT</b>	Output

*State Table (JKF)*

DIN 1	DIN 2	DOUT
0	0	No Toggle
1	1	Toggle
1	0	1
0	1	0

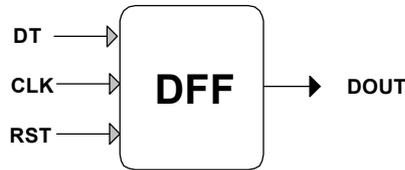
*Parameters*

This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

### 5.8.11 D LATCH Flip-Flop

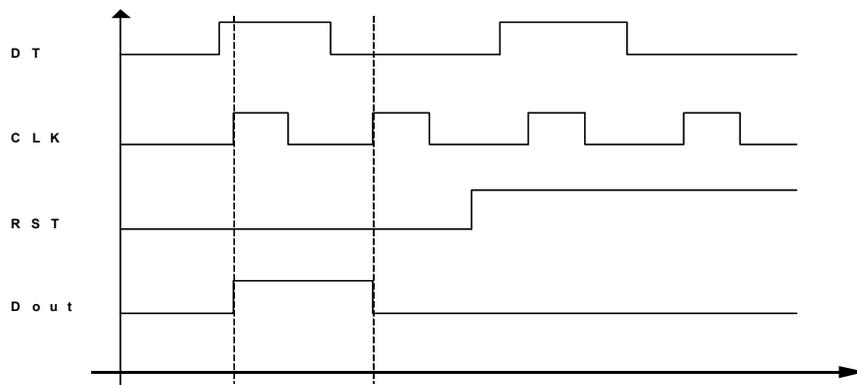
*Description*

This module operates as the classical Flip-Flop D Latch, with 3 digital inputs, setting the output, according to the timing chart below.



*I/O Connections*

<b>DT</b>	Data digital input
<b>CLK</b>	Clock
<b>RST</b>	Reset
<b>DOUT</b>	The output is calculated on the basis of the DT, Clk and RST digital inputs as illustrated below.



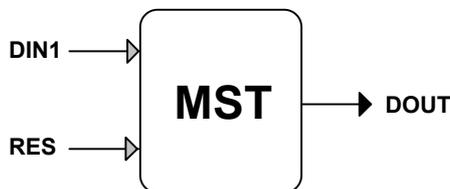
*Parameters*

This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

### 5.8.12 Monostable ( MST )

*Description*

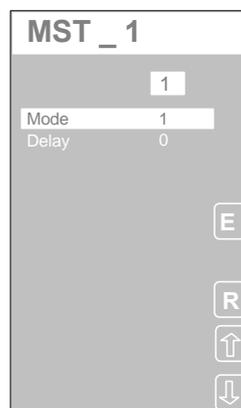
This module implements a monostable circuit, triggered by the digital inputs and capable to generate pulses of variable delays. Through the Parameters of this module, you choose between different operating mode (Mode) and you enter the time values (Delay) for the generated pulses



*I/O Connections*

<b>DIN 1</b>	Monostable trigger digital input
<b>RES</b>	Monostable reset (set the output to 0)
<b>DOUT</b>	Digital Output of the monostable

*Parameters*



*Displayed Parameters*

<b>Mode</b>	Selection of the operating mode. The choices are: 0, 1, 2, 3 <b>(1)</b>
<b>Delay</b>	Time delay value, entered as a number of sampling time. Range from 0 to 300.

(1) The monostable is supporting 4 different operating modes, selected by the codes 0, 1, 2, 3. Their behavior is listed in the following picture:

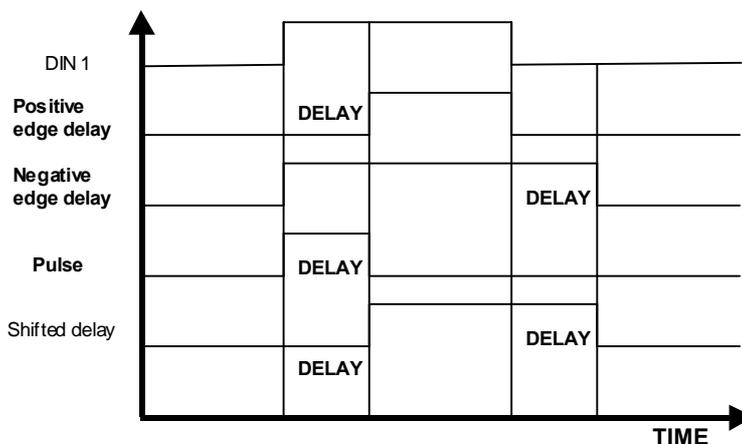
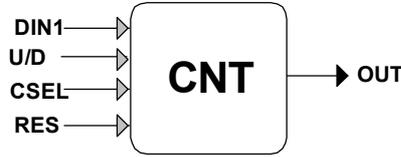


Chart illustrating the different monostable operating modes

### 5.8.13 Counter ( CNT )

*Description*

This module counts the input pulses, defined by the positive edge of the digital input DIN1. The counter total is returned on the analog output OUT. It can be configured as either an up or a down counter and it is controlled by a pair of digital inputs, defining the operating mode.



*I/O Connections*

<b>DIN 1</b>	Counter input. Each positive edge increases the counter of one unit.
<b>CSEL</b>	Counting enabling digital input.
<b>RES</b>	Counter Reset digital Input.
<b>U/D</b>	Counting direction select input (Up or Down).
<b>OUT</b>	Output with the current value of the counter.

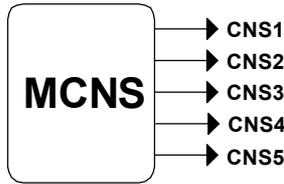
*Parameters*

This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

### 5.8.14 Multiple Analog Constants ( MCNS )

*Description*

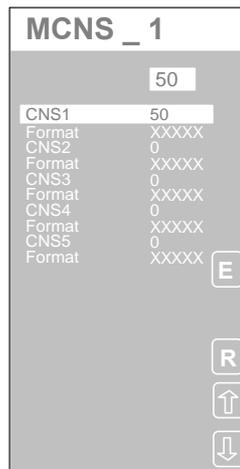
This module generates a fixed analog signal on the 5 outputs CNS 1 - 5, whose values are specified by the module parameters.



*I/O Connections*

<b>CN 1...5</b>	Analog Outputs
-----------------	----------------

*Parameters*



*Displayed Parameters*

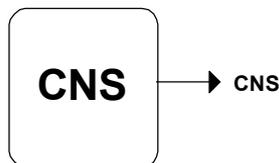
<b>CNS 1...5 (1)</b>	Values to set the analog outputs
<b>Format</b>	Format: it defines the number of digits of the values above

(1) The tag of the 5 analog constants, as displayed on the controller panel, is directly configured by the AC-Prograph.

### 5.8.15 Analog Single Constant ( CNS )

*Description*

This module generates a fixed analog signal on the output CNS, whose value is specified by the Value parameter.



*I/O Connections*

<b>CNS</b>	Analog output set to the predefined value
------------	-------------------------------------------

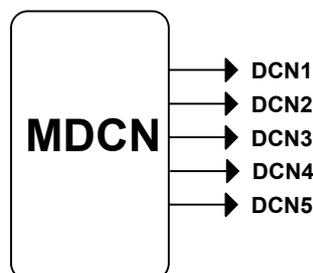
*Parameters*

This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

### 5.8.16 Multiple Digital Constant ( MDCN )

*Description*

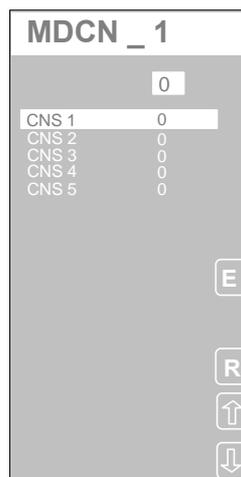
This modules generates a fixed digital signal on the 5 outputs DCN 1 - 5, whose values are specified by the module parameters.



*I/O Connections*

<b>DCN 1...5</b>	Digital Outputs
------------------	-----------------

*Parameters*



*Displayed Parameters*

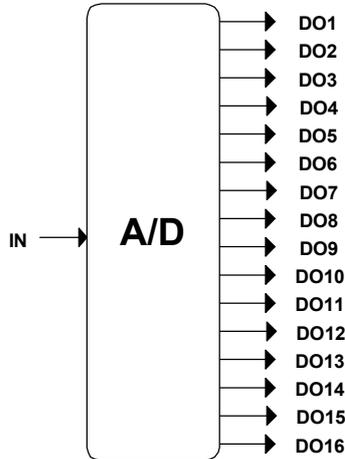
<b>CNS 1...5 (1)</b>	Status to set the digital outputs
----------------------	-----------------------------------

(1) The tag of the 5 digital constants, as displayed on the controller panel, is directly configured by the AC-Prograph.

### 5.8.17 Analog To Digital converter ( A/D )

*Description*

This module performs the conversion of a number, provided as an input signal to the module, to a 16 bit binary number, specified through 16 digital outputs. The range of the input number is 0 ÷ 65535. If the input number exceeds this range, it is still converted in binary number, but the 16 digital outputs corresponds to the status of the least significant bits. The Carry output is not available, to flag the overrange: therefore, the strategy must provide the actions to avoid or take care of this situation.



*I/O Connections*

<b>IN</b>	Analog Input
<b>DO1 - DO16</b>	Digital Output

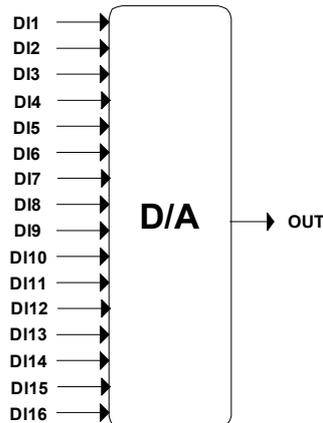
*Parameters*

This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

### 5.8.18 Digital To Analog Converter ( D/A )

*Description*

This module converts a 16 bit binary number, provided through 16 digital inputs, into a number. The number is transferred out through the analog output of the module, with range 0 to 65535. The Carry output is not available.



*I/O Connections*

<b>OUT</b>	Analog Output
<b>DI1 - DI16</b>	Digital Input

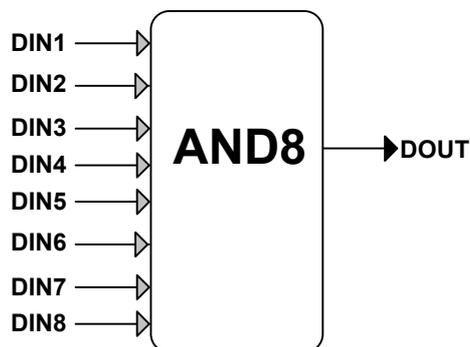
*Parameters*

This module doesn't have any parameter and, therefore, it is not displayed on the instrument panel.

### 5.8.19 AND\_8 Block (AND8)

#### Description

The block performs the AND logic function of the DIN1 ÷ DIN8 inputs. The non-configured inputs are put to "ON"



#### Description of connections

<b>DIN 1</b>	Digital input 1
<b>DIN 2</b>	Digital input 2
<b>DIN 3</b>	Digital input 3
<b>DIN 4</b>	Digital input 4
<b>DIN 5</b>	Digital input 5
<b>DIN 6</b>	Digital input 6
<b>DIN 7</b>	Digital input 7
<b>DIN 8</b>	Digital input 8
<b>DOUT</b>	Output

#### Parameters

This block has no parameters, and is not displayed on the Controller.

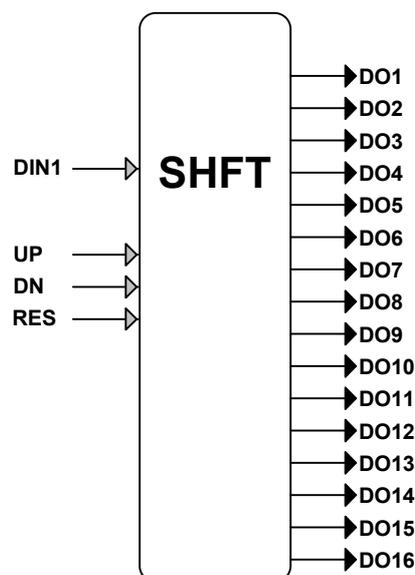
### 5.8.20 Shift Block (SHFT)

#### Description

The block performs the logic SHIFT function on 16 outputs.

By switching the UP input from "OFF" to "ON", the output bits DO1÷DO16 are moved one position forward and the DO1 output is put to the value present on DIN1 (SHIFT UP).

By switching the DN input from "OFF" to "ON", the output bits DO16÷DO1 are moved one position backward and the DO16 output is put to the value present on DIN1 (SHIFT DOWN).



*Description of connections*

<b>DIN 1</b>	Shift register input
<b>UP</b>	SHIFT UP Input
<b>DN</b>	SHIFT DN Input
<b>RES</b>	Input for DO1÷D016 output reset
<b>DO1 ÷ DO16</b>	Outputs as a result of the SHIFT operation

*Parameters*

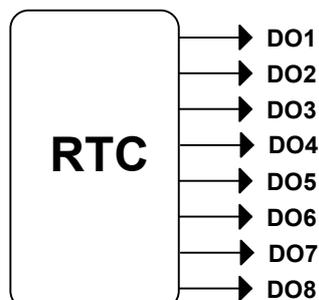
This block has no parameters, and is not displayed on the Controller.

## 5.9 Programmer Functions

### 5.9.1 Real Time Clock with 8 outputs ( R.T.C. )

#### Description

This module, available on the AC30 controller only, provides the functionalities of a weekly timer. It has 8 digital outputs that can be pulsed, independently each other, once a day and for all the day of the week, at predefined times. The generated pulse has a fixed time duration of 1 minute. You configure the timer, specifying, for each output, the day of the week it must be activated and if it must be enabled or disabled.



#### I/O Connections

<b>DO1 ÷ DO8</b>	Digital Outputs
------------------	-----------------

#### Parameters



#### Displayed Parameters

<b>DO0 ÷ DO7</b>	Digital output activated at predefined time and date
<b>Active</b>	Enable/Disable of the activation

### 5.9.2 Setpoint Programmer (PRG)

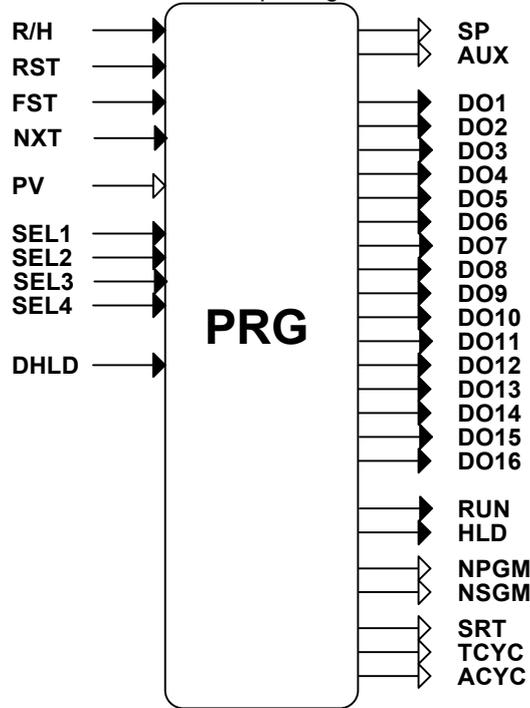
#### Description

This module, available on the AC30 controller only, provides the functionalities of a Setpoint Programmer generating the profile of an analogue setpoint SP, organized as a series of segments, and setting the status of 16, segments related, digital outputs DO1 - DO 16 and the level of an auxiliary analog output AUX.

The module can store up to 100 segments and a maximum of 16 programs. Each program has a variable number of segments but the overall number of segments of all the programs cannot exceed the limit above. A strategy can house up to 4 PRG modules. Therefore, the maximum capability of an AC30 controller is to house up to 64 programs, with an total number of segments of up to 400 and driving up to 64 digital outputs.

Despite the sophisticated performance of this programmer, it is easily programmed, both through the AC-Prograph or the controller keyboard, in a friendly, simple and guided environment. The use of AC-Prograph is very effective and strongly recommended.

A wide selection of strategies is offered by the PRG to recover the program from anomalous situations of the process. For instance, you choose, among several possibilities the actions to take after a power failure. Briefly, you can chose if your Programmer must be Reset, Hold or Resumed on the basis of the time the power has stayed off, on the basis of the deviation of the process variable PV from the last Setpoint generated, or, simply, always.



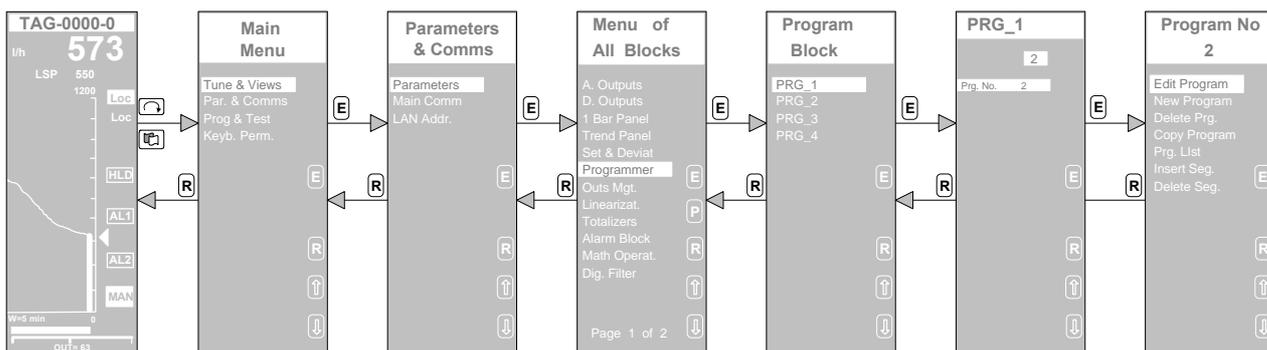
**I/O Connections**

<b>R/H</b>	Run/Hold I/O. Bidirectional signals, specifying the operating status of the Programmer. When in Hold mode, the Programmer doesn't progress and all the outputs are frozen. When in Run mode, the Programmer executes the predefined program, stepping between the segments, up to the end.
<b>RST</b>	Reset. Digital input specifying that the Programmer must be reset, forcing it to restart from the initial segment 0.
<b>FST</b>	Fast Input. When inactive the program is executed on the basis of the configured times values. Otherwise (Fast mode) all the times are scaled by a predefined factor and the program segments are executed very rapidly.
<b>NXT</b>	Next. Digital input forcing, on the rising edge (inactive to active) the Programmer to go to the next segment .
<b>PV</b>	Main Variable. This analog input is intended for acquiring the process variable, that is, continuously, compared with the Setpoint output of the Programmer, in order to detect an excessive deviation.
<b>SEL1 ÷ SEL4</b>	Select digital inputs. These 4 digital inputs specify a 4 bit code, corresponding to the program to be selected.
<b>DHLD</b>	Hold Input. This digital input, on the rising edge, (inactive to active) forces the Programmer to the Hold mode, stopping the execution of the current segment.
<b>SP</b>	Analog output, with the Setpoint value generated by the module.
<b>AUX</b>	Auxiliary Setpoint output. This analog output is set, automatically, at the beginning of each segment and it is kept constant for the entire segment.
<b>DO1 ÷ DO16</b>	Digital outputs, set, at the beginning of the segment, to the pattern, configured. These values are hold for the entire segment.
<b>RUN</b>	Run mode. This digital output is active when the program is running and becomes inactive, when the Programmer enters in Hold mode.

<b>HLD</b>	Hold mode. This digital output is active when the Programmer is in Hold mode, due either to an excessive deviation between SP and PV or other causes.
<b>NPGM</b>	Program Number. Analog output, returning the number of the program currently executed.
<b>NSGM</b>	Segment Number. Analog output, returning the number of the segment currently executed.
<b>SRT</b>	Remaining time. This analog output returns the remaining time to complete the segment, currently under execution.
<b>TCYC</b>	Total Cycles. This number returns the configured number of cycles of the program currently running.
<b>ACYC</b>	Actual Cycles. This number returns the number of cycles, already executed, since the beginning of the program, currently running.

**Operativity**

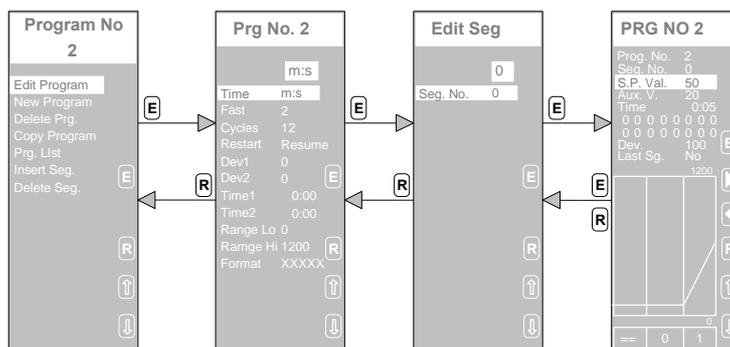
The following picture explains the procedure to follow in order to edit the parameters of a program in a PRG module. First, you reach the panel with the list of all the modules (*Menu of All Block*); here, you select the Programmer module. Second, in the (*Program Block*) panel, you choose which of the 4 PRG modules of the strategy, houses the program you want to edit. Next, you continue by selecting the program to edit ( in the example the program n°2 of the PRG module n°1 has been chosen). At this point you reach the (*Program No “n”*) display panel, consisting in a menu of all the operations you can do on the selected program.



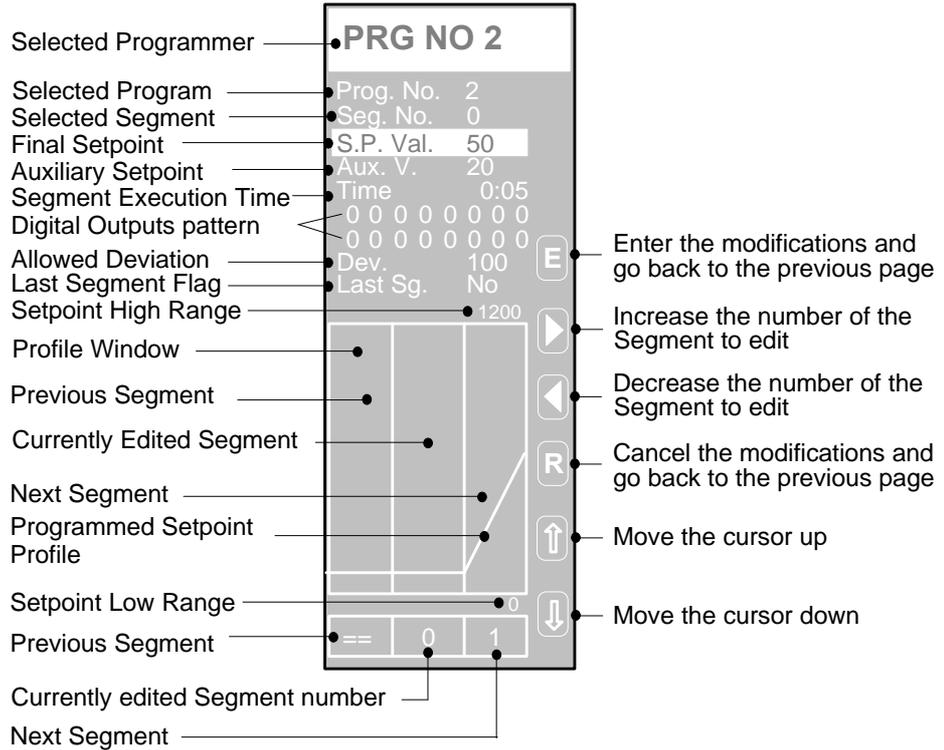
In the following pages, all the various commands of the menu (*Program No “n”*), allowing to operate with the PRG programs, are described in detail.

**Program No “n” Edit Program**

This command allows you to edit all the data of an existing program. The first display (*Prg No. “n”*) presents the basic data of a program, while the second one presents, one at a time, the data regarding one segment. The panel (*Edit Seg.*) allows you to choose the segment to edit. Once the segment to edit has been selected, its data are presented on the (*PRG NO “n”*) panel, where they can be easily modified.



Detailed view of the PRG NO "n" display panel

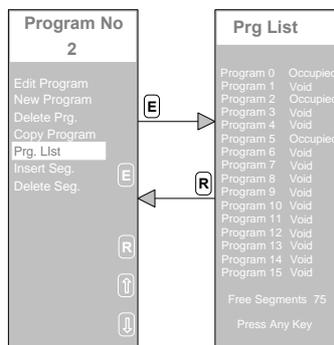


Description of the Parameters

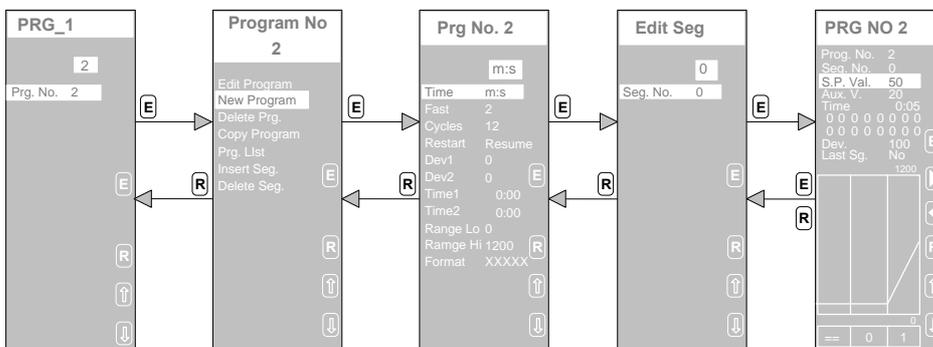
<b>S.P. Val.</b>	Value, in engineering units, specifying the target value of the SP Setpoint output at the end of the segment.
<b>Aux. V.</b>	Value, in engineering units, specifying the level the AUX analog output (Auxiliary Setpoint value) will assume at the beginning of the segment and will hold for the entire segment.
<b>Time</b>	This is the time assigned for the execution of the entire segments. The format of the time is hh:mm or mm:ss, according to the setting operated in the display panel Prg No. "n".
<b>Digital Outputs</b>	Pattern of the 16 digital outputs. 0= Off, 1=On. At the beginning of the segment execution, the digital output will assume the specified pattern and will hold it, for the entire segment. The upper row is for Outputs 1 to 8, while the lower one is for the Outputs 9 to 16.
<b>Dev.</b>	This parameter specifies the maximum allowed deviation between the SP Setpoint output and the PV Main variable input. This deviation is continuously monitored during the execution of the segment. If the deviation value exceeds the configured threshold, the program goes automatically in Hold. It returns back to the Run mode when PV reenters in the allowed range.
<b>Last Sg.</b>	Setting Yes, you flag this segment as the last one of the Program, while, setting No, you specify that another segment will follow the current one.

**Program No “n” New Program**

This command allows you to enter a new program from scratch. The first thing to do is to select, from the menu *Program List* the number of the Program. This menu will list all the 16 programs of a PRG module, reporting the status of each of them, the total number of segments used and the quantity of available segments.

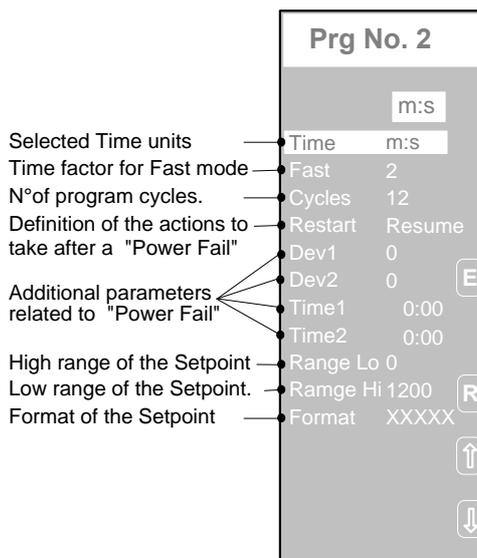


After having set the program number, you proceed with the definition of the new program by entering, first, the basic informations, and, after, the data of all the segments of the Program, as illustrated in the picture below.



**Detail of the PRG No. “n”**

Through this panel all the basic parameters of your program, are provided.



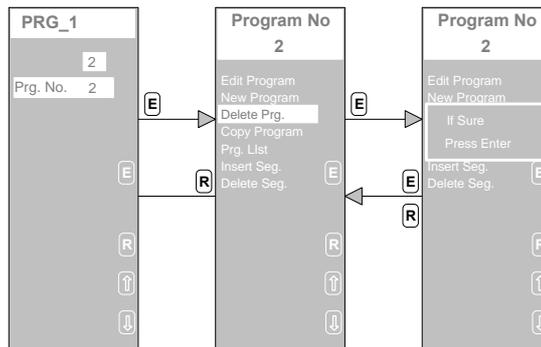
**Description of the Parameters**

<b>Time</b>	It specifies the time units for all the time values of the program . The choices are <i>h:m</i> (hours:minutes) and <i>m:s</i> (minutes:seconds).
<b>Fast</b>	Acceleration factor. All the time values of the program are scaled by the value specified by this parameter. The effect is that the program will be executed in a shorter time.
<b>Cycle</b>	Cycles number. This number specifies how many times a program must be cycled, before terminating it.
<b>Restart</b>	These parameters allow to define the recover strategy after a power failure, choosing between a wide range of possibilities. The 4 possible choices are: 1) <b>Resume</b> - Automatic restart of the program, at power on, from the same status, the Programmer was, at power off. 2) <b>SP = PV</b> - Automatic restart of the program, at power on, after setting the SP output at the measured value of PV. If the segment in execution at the power off time was a dwell, the program restarts from the previous ramp segment. 3) <b>Hold</b> - The Programmer is forced in the Hold mode, at power on. The Programmer stays in the Hold status until an operating or a running mode change occurs. 4) <b>Reset</b> - The Programmer is automatically reset, forcing it to segment 0, and in hold, until an operating or a running mode change occurs.
<b>Dev1</b>	Parameter of a recovery strategy, based on the deviation value between SP and PV at the power on time. If the deviation exceeds the value set in this parameter, the SP output is set equal to PV input and the program restarts from the point at power off.
<b>Dev2</b>	Parameter of a recovery strategy, based on the deviation value between SP and PV at the power on time. If the deviation exceeds the value set in this parameter, the programmer is reset to segment 0 and put in hold, waiting for an operator intervention.
<b>Time1</b>	Parameter of a recovery strategy, based on the time the power has been off. If this interruption time has been greater than the value set in this parameter, the SP output is set equal to PV input and the program restarts from the point at power off.
<b>Time2</b>	Parameter of a recovery strategy, based on the time the power has been off. If this interruption time has been greater than the value set in this parameter, the programmer is reset to segment 0 and put in hold, waiting for an operator intervention.
<b>Range Lo</b>	Low range of the Setpoint output.
<b>Range Hi</b>	High range of the Setpoint output.
<b>Format</b>	Format: it defines the number of digits of the Setpoint output

**Program No “n” Delete Program**

This command allows you to delete an existing program. First, you must select the program to delete, from the panel *PRG*, specifying its number. Next, you select the *Delete Prg.* item form the *Program No “n”* menu. At this point, the alert message “If Sure Press Enter” is displayed. You must

confirm the delete command, by pressing the **E** button, in order to proceed with the delete operation. Otherwise, you can abort the delete operation and return back to the *Program No “n”* menu, by pressing the **R** button.



### Program No “n” Copy Program

This command allows you to duplicate a program, by copying an existing program in an empty one.

First, you must select the program to copy, as illustrated above, and select the *Copy Program* command from the *Program No “n”* menu. At this point, a dialog box will be displayed, asking to specify the number of the destination program. After entering these data, you must confirm the operation, by

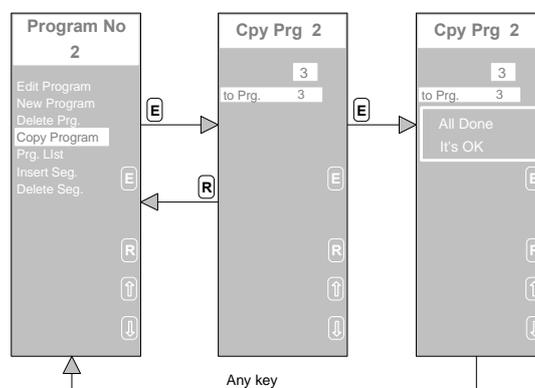
pressing the **E** button, in order to progress. Two potential situations can occur:

- *The destination program is empty.*

The message “All done it’s OK” is displayed, in order to confirm the successful conclusion of the operation.

- *The destination program is not empty.*

The alert message “First delete program” is displayed, to flag that the operation cannot be carried on. At this point, you must press a key to return back to the *Program No* menu.



### Program No “n” Insert Segment

This command allows you to add to an existing program a new empty segment, at a predefined program position. Once added, the segment is parameterized by mean of the *Edit Program* command. After issuing the command, you define the segment, which the new one should be inserted

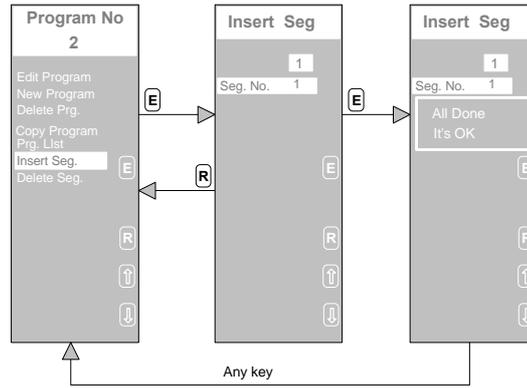
afterward. You confirm the entry by pressing the **E** button. Two potential situations can occur:

- *The segment specified is one of the segment of the program.*

The alert message “All Done” is displayed, in order to confirm the successful operation. Next, you must press any key for the message to disappear and return back to the *Program No* menu.

- *The segment specified doesn't exist, because its number is greater than the total number of segments, the program consist of.*

The message “Segment not Available” will be displayed, to flag that the operation cannot be carried on. At this point, you must press a key to return back to the *Program No* menu.

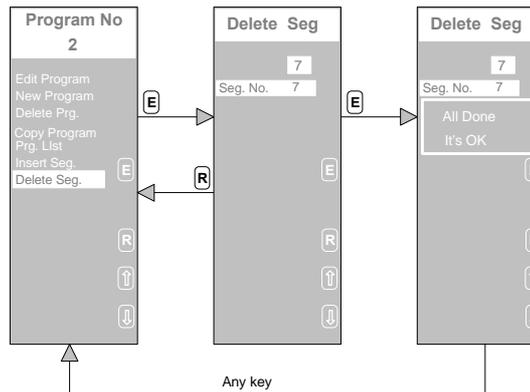


After the insertion of the segment, all the other segments of the program following the new one, have its numbers incremented by one. To enter the data in the new segment, you must select the command *Edit Program* from the *Program No "n"* selection menu and follow the instructions given above for that command.

**Program No "n" Delete Segment**

This command allows you to delete an existing segment of a program. After issuing the command, you define the segment which should be deleted, from the *Delete Seg.* panel. You confirm the entry by pressing the **E** button. Two potential situations can occur:

- *The segment to delete is existing*  
The alert message "All Done" is displayed, in order to confirm the successful operation. Next, you must press any key for the message to disappear and return back to the *Program No* menu.
- *The segment to delete doesn't exist, because its number is greater than the total number of segments, the program consists of.*  
The message "Segment not Available" will be displayed, to flag that the operation cannot be carried on. At this point, you must press a key to return back to the *Program No* menu.



After the deletion of the segment all the other segments of the program following the new one, have its numbers decremented by one.

## 6. Password and Access Control

### Description

This chapter refers to an innovative feature of the AC Controller, consisting in customizing the access mode for each display panel, in order to prevent unauthorized intervention of the user. You can easily configure, for each display panel, if the user can recall it on the screen and if he/she can change the values and the parameters.

In order to facilitate the configuration of the access modes, most of the operations, performed by the AC Controller, are classified in just 3 groups: A, B, C.

Furthermore, two more operations, consisting in the typical operator front panel setting and not included in these groups, are considered as two separate groups; they are the Setpoint Management and the Auto/Manual station, involving the Setpoint handling and the Out station.

For all these 5 groups, the picture below lists all the possible modes the user can assign, separately, to each of them.

Description	Display	Group	Possible Modes
Tuning procedure	Tune & Views	A	N.Visa, Visabl. Vi&Mo
Parameters, Modules and Communication	Par & Comms	B	N.Visa, Visabl. Vi&Mo Prog.
Configuration and Diagnostics	Prog & Test	C	Visabl., N.Visa
Setpoint modification from keyboard	Set. Pnt		Lock - Unlock
Auto/Manual Station	Manual		Lock - Unlock

A brief explanation of the modes is as follows:

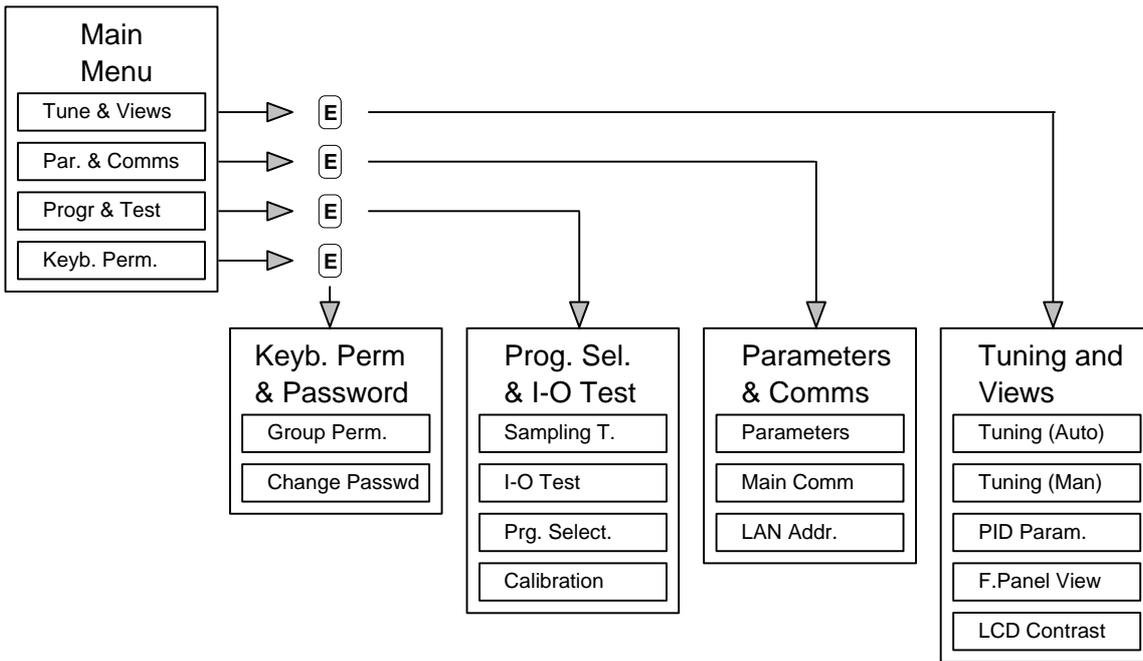
Not visible	means that the display panel is hidden to the user.
Visible	means that the display panel is presented on the screen, but the user cannot enter any data or command.
Visible and modifiable	means that the display panel is presented on the screen and the user can fully operate with it.
Blocked	means that the panel is displayed but the user cannot enter any value or setting.
Unblocked	means that the panel is displayed and the user can fully operate with it.
Prog.	allows to display/change the programmers' (PRG) parameters and to lock all the other parameters.

### 6.1 Setting Access Modes

The following drawing shows the basic menu structure on the AC Controller. Starting from the Main Menu, 4 submenu are accessible:

Keyb Perm & Password	allowing password definitions and access mode setting.
Program Select & I-O	allowing diagnostic and calibrations.
Parameters & Comms	allowing the setting of Comms parameters and the access to modules data and parameters.
Tuning & Views	allowing the self tuning procedure and other display setting.

The last 3 submenu correspond to the operations of groups A, B and C.



To set the access mode, you must select the *Keyb Perm* item from the *Main menu* and reach the *Permission* display panel, where all the 5 groups are listed, with their mode on the left side.

The modes can be easily changed with the scroll buttons, followed by a confirmation, by mean of the **E** button, in order to permanently store the modifications.

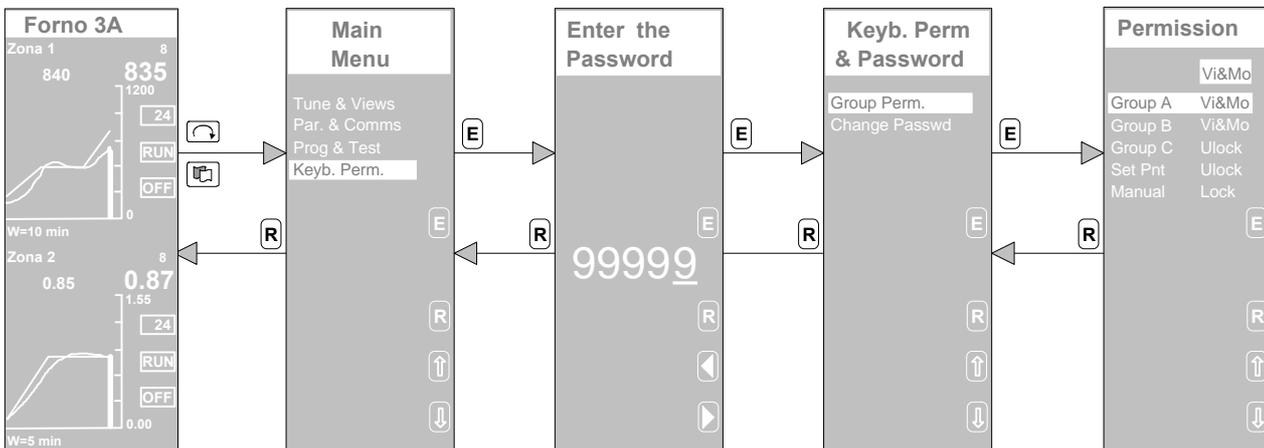
The setting choices, for each of the 5 groups, are listed in the column Possible Modes of the table above.

For a better security of important features, like the access modes customization, it is possible to insert an optional password, in order to allow the modification of the setting to authorized people, only.

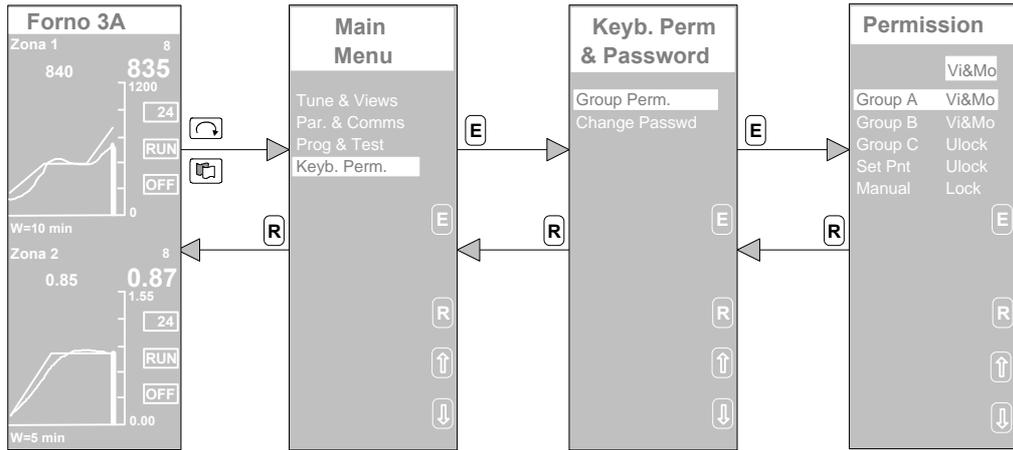
In this case, to reach the *Keyb Perm* menu, the user must enter the proper password; if the password is not the correct one, the access to the menu is denied.

The following pictures show the procedure for the access modes setting in either in presence of password or without it.

*With Password*



Without Password



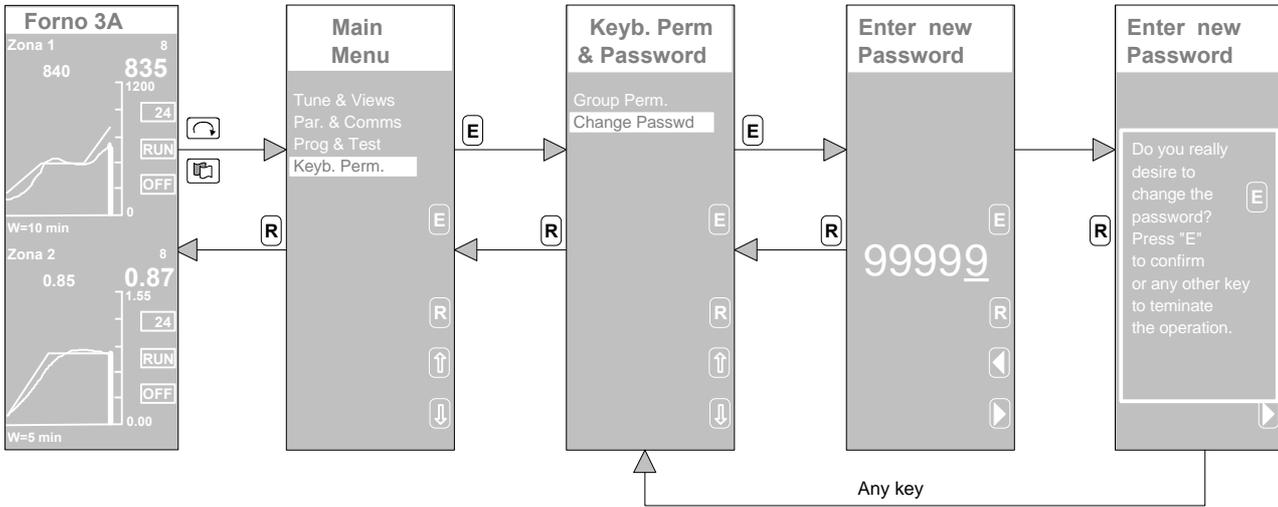
By default the AC controller doesn't have the password protection. You can easily add it by following the procedure below for Password Change.

**Note**

- The password consists of 5 alphanumeric characters
- The AC controller doesn't have the password protection when shipped
- Once a password has been defined, it operates, unchanged, up to the next modification or deletion.

## 6.2 Password Change

The following picture shows the steps required to insert the password for the first time. You access the *Key. Perm* menu, select the *Change Passwd* command, enter the password and confirm with the **E** button.



In the case of an already existing password, the procedure slightly changes. To reach the *Key. Perm* menu, in order to modify the password, the user must enter the old password, otherwise the procedure is aborted. Anyway, in both cases, once the new password has been entered, a confirmation is required to the user, in order to avoid to accept wrongly typed passwords.

## 6.3 Password Delete

To delete the password, the user must change the existing password to the new value of "00000", as illustrated above. Once this new value has been entered, the password won't be asked any further.

### 6.3.1 Don't panic!

If you have forgotten the password, don't panic, because you have not lost your data. In fact, through the Supervisory Computer Comm line, you can read at predefined addresses, the password value. Refer to the Communication Manual, in order to get the proper informations. Once the password is read, you must enter it from the AC controller panel and operate as you like. Furthermore, the value of the password can be read from the Programming port, by mean of the AC\_Edit, too.

## 7. Maintenance and Diagnostic

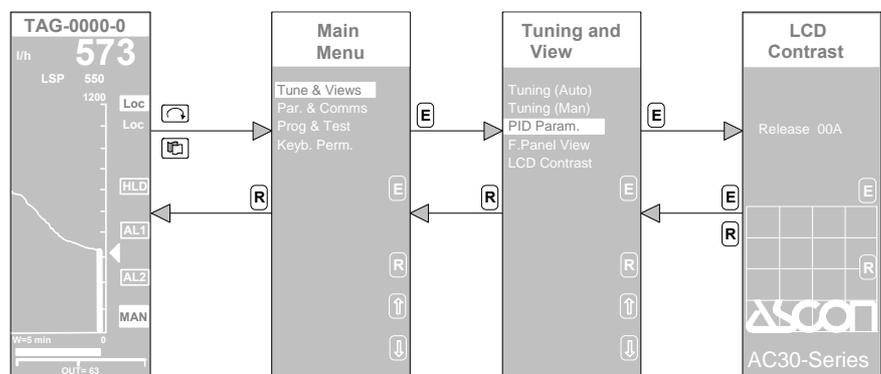
### 7.1 Adjustment of the display contrast

The contrast of the front panel LCD display can be adjusted in order to perfectly match it with the light at the installation site. This operation is carried out from the controller keyboard, carrying on the following steps.

Once reached the *LCD Contrast* panel, the contrast of the display is changed pressing the  and the  button. The LCD display reflects automatically

the new setting. When the preferred contrast has been achieved, the  button must be pressed in order to store permanently the new setting.

After the setting, the contrast is automatically varied according to the temperature changes, in order to compensate the drift caused by the temperature and achieve an optimal readability over the entire temperature range of 0 ÷ 50 °C.



### 7.2 Error messages

The AC controller is provided with a diagnostic system, capable to detect a wide range of faults and automatically alert the operator. Most of this faults are caused by wrong assignment of parameters or other mistakes in the instrument configuration. When one of these anomalous situations arises, the display is completely blanked and an error message appears, in order to alert the user.

The operator must acknowledge the message, by pressing, at the same time, the  and  keys. As a consequence, the message disappears and the display returns to its previous conditions.

The following are the various error message that the AC controller handles:

- **Net Ovrfl**
- **Due to NET**  
This message flags anomalous situations on the network, usually due to memory overflow, when receiving large amount of data, or a duplication of the addresses of the LAN cards.
- **Net Error**  
This message is, usually, caused by errors in the configuration data.
- **Overflow**
- **Invalid Instruct.**
- **Divide By Zero**
- **Address Error**  
This error messages do not appear when the instrument hardware isn't properly working. Therefore, if they appears on the display, please refer to the Technical Service.

### 7.3 Master Reset

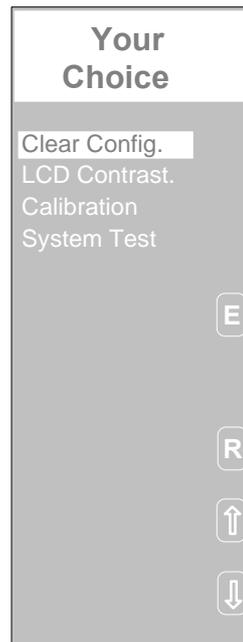
This functionality is required when, due to a temporary failure of the hardware, normally triggered by some anomalous external conditions, the AC controller appears completely locked and doesn't allow to operate from the keyboard or the serial ports. In most of these cases, you can recover the situation by "resetting" the AC controller.

When a failure of the type described above, occurs, the first thing to do is to switch off and on the AC Controller; operation that in a lot of cases, forces the instrument to start to properly work.

If the AC controller doesn't restart, you must proceed with the Reset operation, by switching off the instrument and on, again, with the two keys

 and  pressed.

After the power up, the following display panel is shown.



The 4 commands of this menu perform the following functions:

- *Clear Config.* Deletion of the existing configuration
- *LCD Contrast.* Adjustment of the display contrast
- *Calibration* Operations for the calibration of the controller
- *System Test* Operations of system test

To Reset the instrument, you must select the command *Clear Config.* and

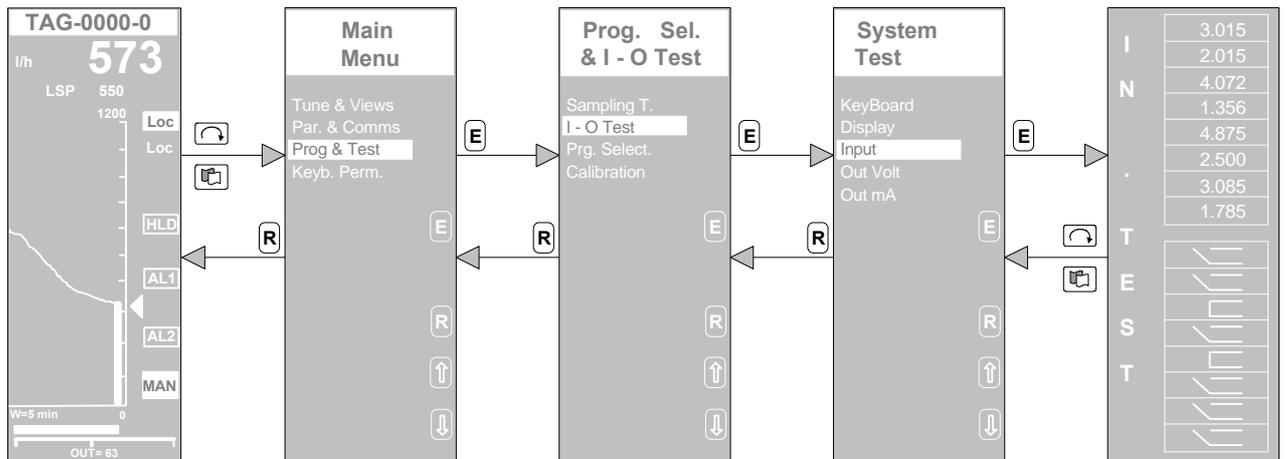
confirm by pressing the  key. The existing configuration will be completely deleted; at the end the message "No program Found" will appear on the display. Now, the instrument is fully operating and ready to accept a new configuration, that will be downloaded as usual.

### 7.4 Diagnostic Test and Calibration

This Chapter describes how to perform the autodiagnostic and the calibration procedures. It is recommended the use of a digital multimeter, for taking precise measures of the signals generated by the AC controller during the test phase, as well as a calibrator for testing the analog outputs, like the ASCOCAL 10 series model or one with similar performances.

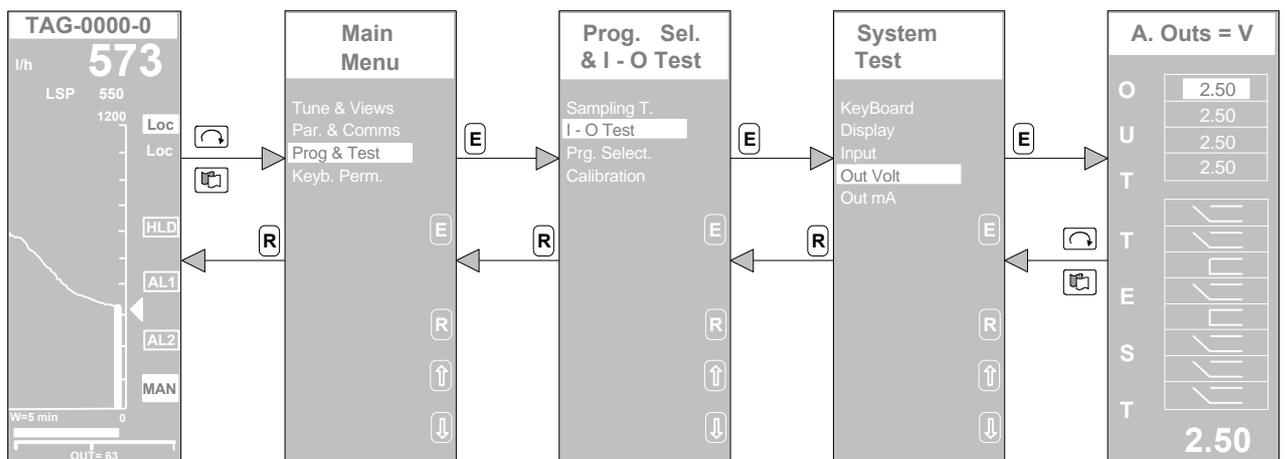
### 7.4.1 Diagnostic Tests

To execute the self test procedure, you have to access to the *System Test* panel, carrying out the following steps:



From the *System Test* you can select 5 test functions, capable to exercise most of the hardware of the instruments. These functions are:

- Keyboard test (Keyboard). It tests the keyboard by lighting a rectangle on the display when the corresponding key is pressed.
- Display test (Display). It tests the display, by switching on and off, alternatively, contiguous pixels of the LCD panel.
- Input test (Input) It displays a panel with 8 (4 for the AC10) analog inputs, in Volt, and 8 digital inputs. By exercising externally this inputs, by mean of the calibrator, and checking the results on the display, the faulty inputs are detected.
- Voltage output (Out V/Out mA): You access the test page of the analogue and digital outputs. At the beginning of the test all the digital and analogue outputs are locked on the last value calculated by the strategy. The analogue outputs may be changed as V or mA depending on their configuration. The non-configured outputs may be changed both as V and as mA.



When the *A Outs = V* panel has been displayed, the analog output to exercise is selected through the and buttons, followed by the button, for confirming the operation. The voltage value, the output is set, is shown in the lower right corner of the display.

Now you can drive the output at various level, by changing this value, in order to take different measures with the external multimeter. This is done through the  and  buttons, followed by the  confirmation button. The procedure is quite the same for the digital outputs. Once the output has been selected, pressing the  key causes its status to complement.

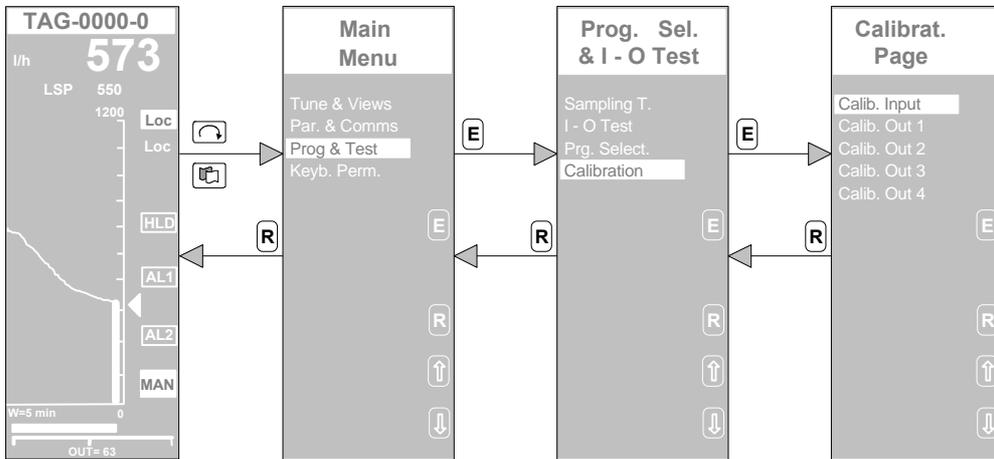
- Current Output test. (Out mA) It's like the previous one, but related to the current outputs only.

**Note**

To abort one of these test functions, press, at the same time, both the  and the  key.

**7.4.2 Calibrations**

The AC controller allow the on site calibration of the analog inputs and outputs. As shown in the picture below, the first step consists in reaching the *Calibr. Page* menu, with all the various calibration functions.



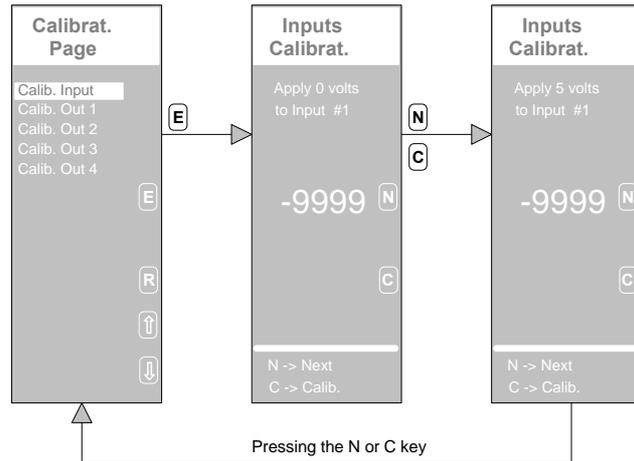
**Inputs calibration (Calib. Input).**

This calibration procedure involves the analog input 1 and calibrates all the analog inputs at the same time. To perform the procedure, you must connect a calibrator to input 1 (terminals 1 and 2) and apply the voltages asked on the display. You will be asked to apply 0 Volt. Once you have done it, press the "N" (Next) key. You will be asked to apply 5 Volt. Once you have done it, press "C" to compute the calibration coefficients and store them permanently.

N -> Next: go to the next calibration value.

C -> Calib: store the calibration coefficients.

The following picture illustrate this procedure.



**Outputs N° 1, 2, 3, 4 (Calib. Out).**

This procedure must be followed, for each of the 4 analog outputs separately and works as follows.

The AC controller generates, on the selected output, a voltages that the user must measure with the multimeter, entering the read value in the controller. Four signal are generated by the AC controller to complete a calibration: two voltages, one at 5% and the other at 95% of the span and two corresponding currents.

The picture below illustrates the procedure. In the *Calibrat. Out No.* menu, the list of the 4 calibration signals appears.

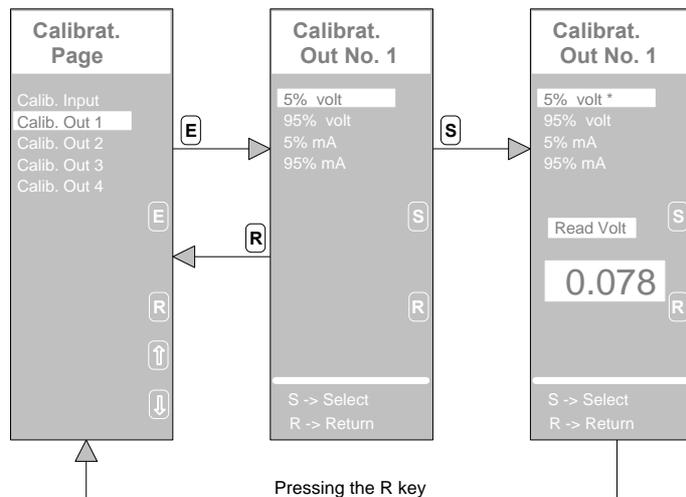
Pressing S (Select) the first signal is generated on the output.

At this point the user must measure the signal at the controller terminal and enter the measured value in the controller, that is displayed with big size digits in the lower part of the display.

Press again S (Select) to proceed to the next signal and carry out the operations, as listed above for the first signal, up to completion. Do it for all the four calibration signals. The calibration signal currently in use is marked with an "\*" in the *Calibrat. Out No.* menu.

S -> Select: The first time is pressed, it selects the first calibration signal; next, it confirms the measured value, just entered.

R -> Return: Terminate the calibration procedure.



*Display for the calibration of the analog outputs*

## 7.5 Replacement of Faulty Components

Some components require continuous maintenance and they are, therefore, designed to be easily replaced by the user. These components are: the cool cathode backlight lamp and the supply fuse.

The lamp requires to be changed every 20.000 hours, because of the aging. To replace the lamp, follow this simple and safe procedure:

- Switch the power of the AC controller off.
- Unscrew the blocking screw in the lower part of the instrument and pull it out.
- Remove the front panel cover, sliding it in the direction of the arrow.
- Unplug the lamp connector and remove the lamp from the socket.
- Insert the new lamp and insert the connector.
- Adjust, if required, the LCD display contrast, following the procedure listed at Chapter 7.1

The fuse, must be checked either every time the AC controller doesn't light up, when switched on, or in the case it simply switch off, when operating regularly, with the power connected. The fuse is located into the controller on the power supply card.

To replace the fuse, follow this simple and safe procedure:

- Disconnect the power supply from the instrument
- Unscrew the blocking screw in the lower part of the instrument and pull it out.
- Remove the protective cover of the fuse.
- Plug the fuse out and check that is not an open circuit, by mean of a simple tester or a digital multimeter. If it is broken, replace it with a glass fuse of 5x20, 1A 250V delayed.

## 7.6 Spare Parts

Pos.	Description	Note	Part number
1	9 poles female connector Kit (LAN)		H10-301-D09FD
2	Connection kit for inst. programming		H10-395-1A1D9
3	CCFL lamp		A61-259-7A0

## 7.7 Manuals

Pos.	Description	Note	Part number
1	User manual of the AC10 - AC20 - AC30 controllers		J30 - 304 - 1AMIAC
2	AC_PROGRAPH / AC-EDIT software User Manual		J30 - 304 - ACPROGRAPH
3	Communication protocols of the AC controllers		J30 - 304 - 1ACSAC
4	Introduction to the control of an industrial process		NT.1 / 95.05

## 8. Expansion Unit

### 8.1 General Informations

The Expansion units AAC-EU/88/4 and AAC-EU/88 series, provide the AC controller with an additional number of analog and digital I/O, up to a maximum expansion of 8 analog outputs, 32 digital inputs and 32 digital outputs. The analog inputs are not supported by the available Expansion Units. The digital inputs can be, directly, connected to a free voltage contact or can be driven by an open collector NPN transistor.

The digital outputs are provided with a normally open contact from a relay. The relay can support resistive load of up to 220Vac/5A. The 4 analog outputs, on the AAC-EU/88/4 Expansion Units, are of 4..20 mA type.

### 8.2 Technical Characteristics

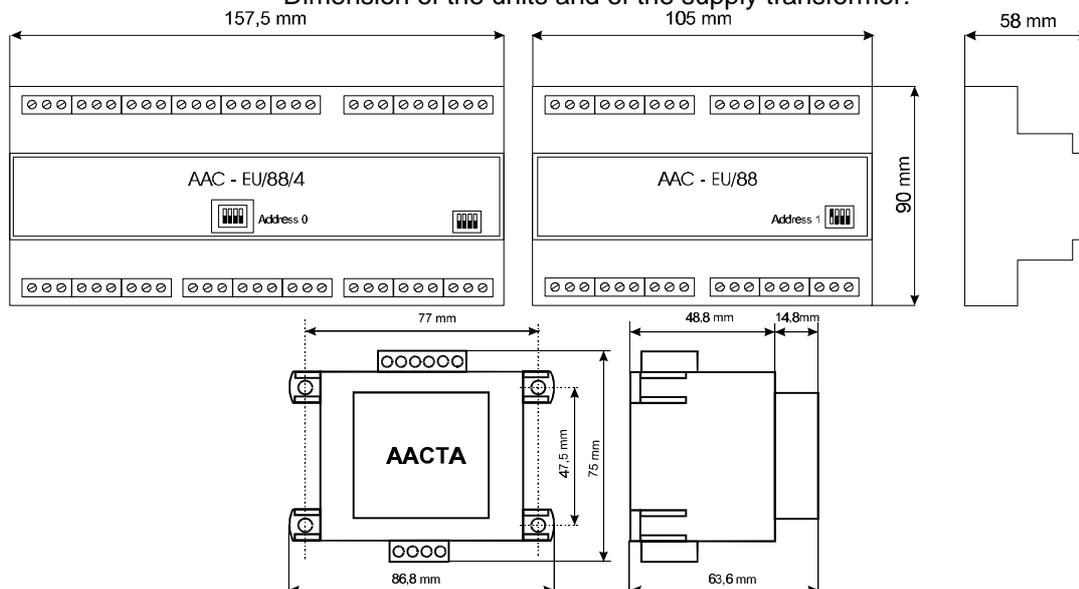
The AAC-EU/88/4 and AAC-EU/88 Expansion Units have been designed for properly working in harsh environment, typical of the industrial plants. These units complies completely to the IEC 801-4 level 4 standard.

<i>Max n° of units:</i>	One AAC-EU/88/4 unit and two AAC-EU/88 units or 3 AAC-EU/88 units
<i>Digital Inputs:</i>	8 Optoisolated
<i>Digital Outputs:</i>	8 relays type with N.A. contact 220 Vac 5A
<i>Analog Outputs 4 .. 20 mA:</i>	4 on the AAC-EU/88/4 only
<i>Power supply:</i>	2 supplies for each unit, 11Vac 600mA for the I/O section and 11Vac 200mA for the CPU card.
<i>Led:</i>	8 led for the inputs, 8 led for the outputs, 1 led for Run and 1 led for Alarm (Failure)
<i>Serial Line:</i>	RS-485 standard with ModBus protocol
<i>Noise Immunity:</i>	Level IV° of the IEC 801-4 standard
<i>Case unit AAC-EU/88:</i>	DIN 6 modules (105 mm)
<i>Case unit AAC-EU/88/4:</i>	DIN 9 modules (157.5 mm)

### 8.3 Installation

The Expansion units are suitable to be installed into a cubicle, mounted on a rail of type omega or Top Hat.

Dimension of the units and of the supply transformer:



## 8.4 Electrical Connections

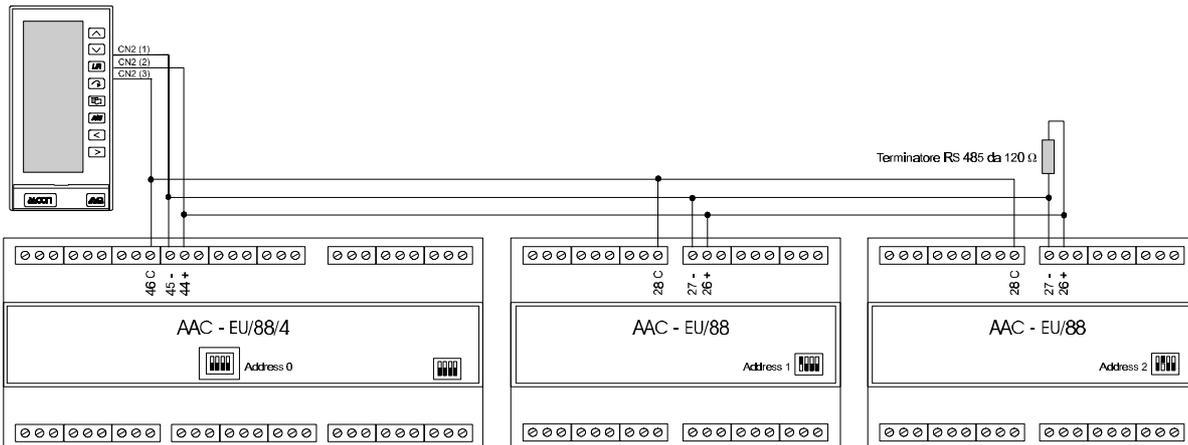
### 8.4.1 RS-485

The Expansion Units are connected to the AC controller through a RS-485 serial communication bus. This communication has a Plug and Play capability, because the setting of the baud rate and the other communication parameters is embedded in the firmware of the controller and doesn't require any customization by the user. The user has, just, to set the address on the expansion units, make the cabling and use the additional I/O in the strategy, he/she is developing with the AC-Program.

It is important to remind that:

- the digital I/O from 1 to 8 and the 4 analog outputs from 1 to 4 are on the AC controller,
- the digital I/O from 9 to 16 and, possibly, the analog outputs from 5 to 8, are on the Expansion Unit with address **0**
- the digital I/O from 17 to 24 are on the Expansion Unit with address **1**
- the digital I/O from 25 to 32 are on the Expansion Unit with address **2**.

The maximum distance between the AC Controller and the farthest expansion unit is limited, by the RS-485 standard, to about 1.000 mt. When the line is at the maximum limits of length the layout of the communication cable and the choice of the cable type must be carried out carefully.

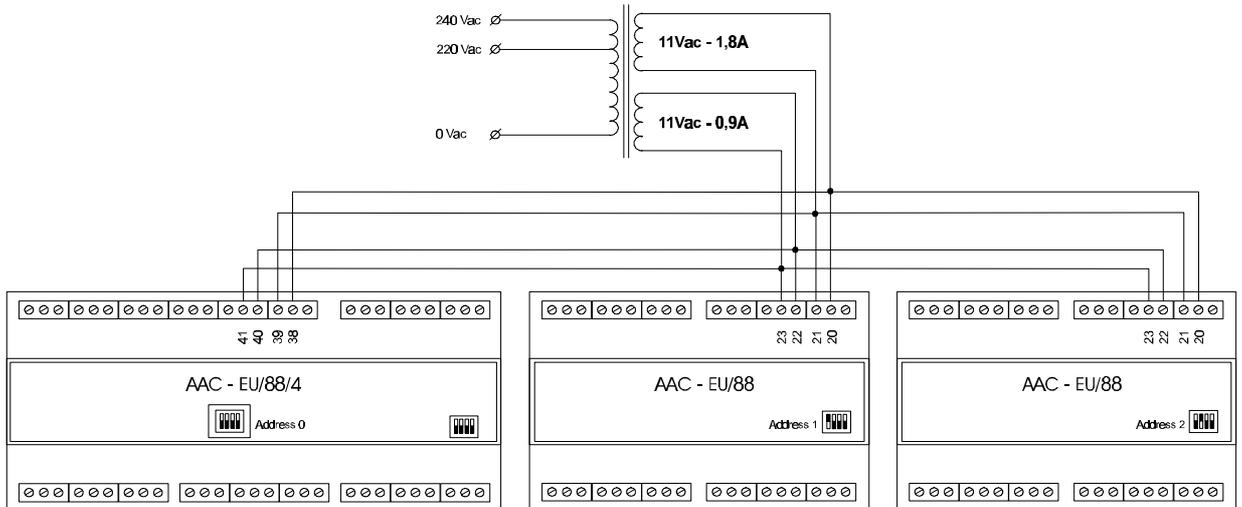


**Note:**

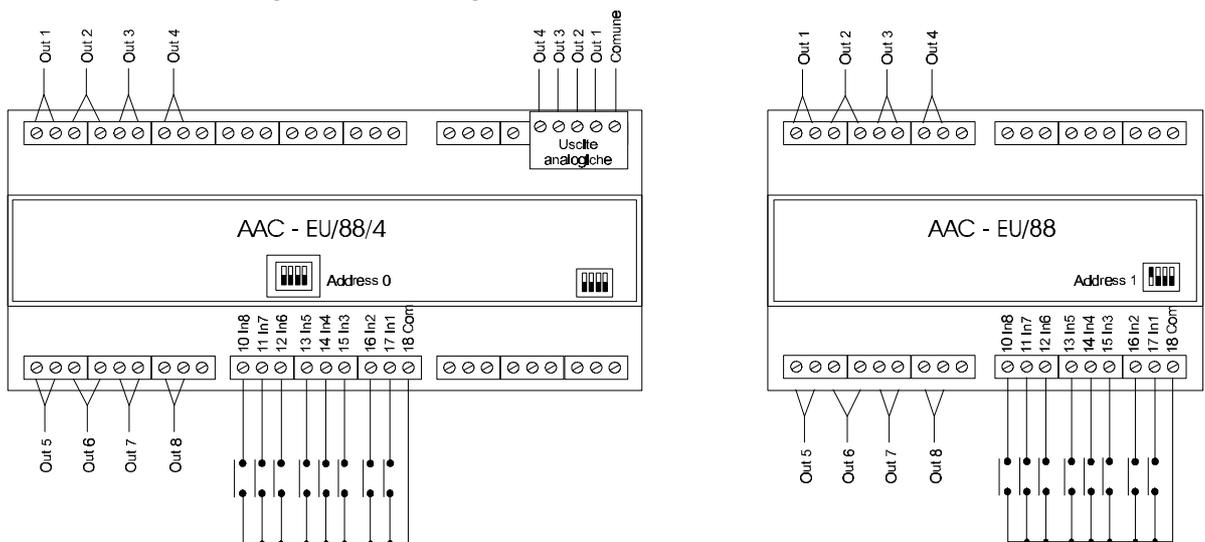
This drawing reports the configuration with the maximum number of expansion units, an AC controller can support. If, among the Expansion units, there is the AAC-EU/88/4 model, this latter one unit must be compulsory set to the address "0", setting the address of the others to "1" and "2". If only one Expansion Unit is connected, its address must be set to "0". Furthermore, don't forget to add a termination resistor of 120Ω 1/4W to the unit at the other end of the line, opposite to the AC controller.

### 8.4.2 Power Supply

The power supply of the Auxiliary Units must be provided through the transformer with double secondary windings, mod. AAC-TA. The picture below illustrates the connections.



### 8.4.3 Inputs and Outputs



### 8.5 Auxiliary Units Addressing

Each Auxiliary Unit has an address, with range from 0 to 2, set by the user, generally at the installation time, by mean of 4 switches, located on the unit. The address must be unique among the various Units connected to the line. In setting the address the following simple rules must be complied:

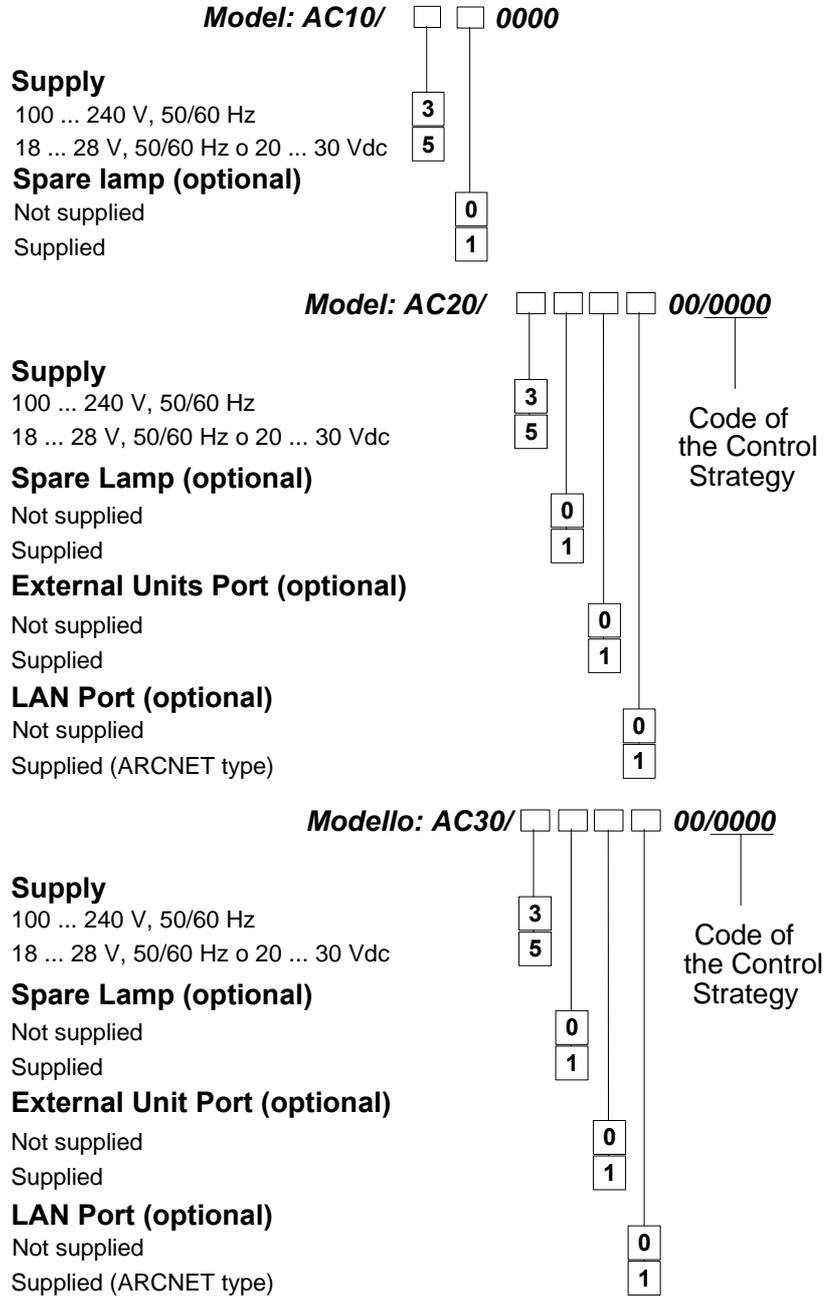
- The first unit must always be set to address 0.
- If there is an AAC-EU/88/4 Unit, these one must be set to address 0.
- The only valid addresses are: 0, 1, 2 and are set according to the following drawing:



## 9. Ordering Data

Multifunction, multi I/O Unit, ASCON AC10 - AC20 - AC30 series

### 9.1 Ordering Code



### 9.2 Auxiliary Units

Expansion Unit with 8 digital I/O

**AAC-EU/88**

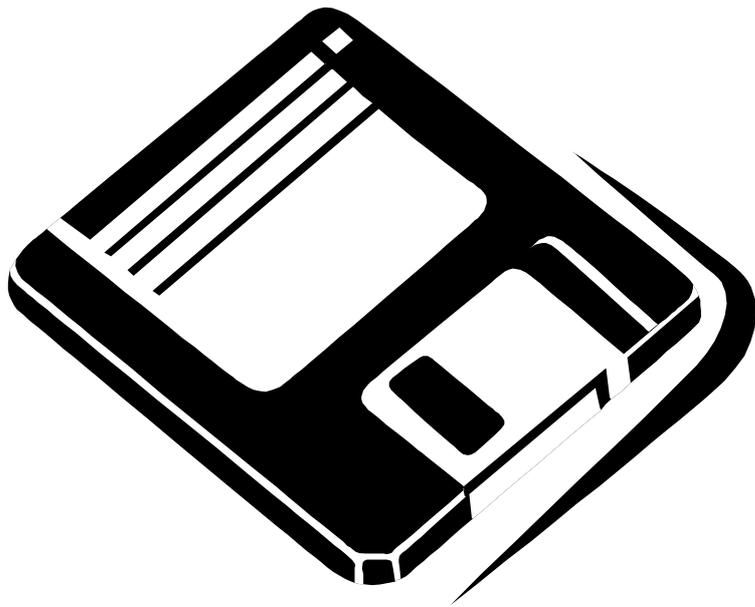
Expansion Units with 8 digital I/O and 4 4..20 mA outputs

**AAC-EU/88/4**

Power supply for 1..3 Auxiliary Units mod. AAC-EU/88 and AAC-EU/88/4.  
 Supply: 220/240 Vac 50Hz.

**AAC-TA**

## 10. Annex “A” Resident Configurations



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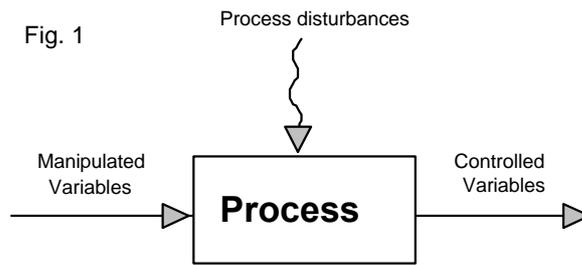
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## 11. How to implement a PID controller



The purpose of a PID loop is to control a variable of an industrial process. The purpose of an industrial process is to produce materials, products or energy, using the minimum quantity of energy and providing the maximum level of safety. To achieve this target with a high level of quality standard, each single element of the process must work precisely. That means that each variable of the process must be, finely, tuned and kept as much as possible close to the predefined setpoint. The operation of keeping the variables close to the setpoint is called regulation, and the PID is one of the tool that does it.

To understand how the regulation process works, we have to consider that the process is a system, whose behaviour is determined by the 3 class of magnitudes, as shown in fig. 1:

controlled variable, manipulated variable and disturbances.

The controlled variables are the chemical, physical and electrical magnitudes, that must be controlled and kept at the setpoint, in order to produce efficiently and with an high degree of quality. For instance, pressures, levels, flows, temperature etc. are controlled variables. They are, usually, named with the mnemonic **PV** (process value), while its setpoint is named **SP**.

The manipulated variables are the ones the regulation system moves continuously, in order to carry out the control action and keep stable and close the controlled variable to the setpoint. For instance, air, water, oil, gas, energies, fuels etc. are manipulated variable.

The disturbances are transient situations, related to physical magnitudes, that interfere, randomly and abruptly, with the process and have the effect of moving "**PV**" far away from "**SP**". For instance, the simple change of the Setpoint can be considered a disturbance.

Therefore, the purpose of controller is to carry out all the actions required to satisfy the equation:  $PV - SP = 0$ , generating a control output, that, driving dedicated actuators, acts on the manipulated variables. This control output is named M.V. (manipulated value) and, not having a well defined engineering unit, is indicated in percentage.

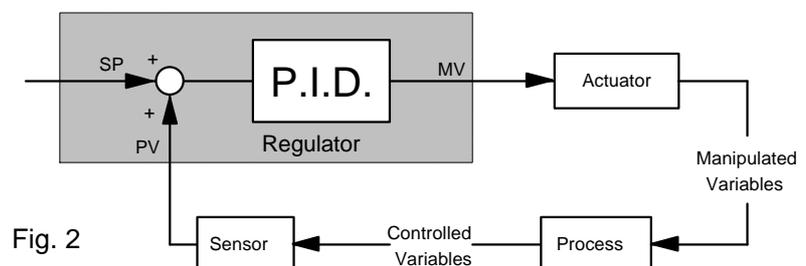


Fig.2 shows the process, with the various magnitudes types and an elementary PID regulator. Following the considerations above, a block diagram of this PID loop can be easily determined. First of all, the PID must have an analog input circuit capable to acquire, from the field, the PV signal, connected to the termination unit of the loop. Second, the PV value is compared with the SP Setpoint in the node at the PID input. The result of this comparison is named error, or deviation and is fed into the PID algorithm.

The output of the PID algorithm is the signal MV, that, usually, is not connected directly with the termination blocks of the controller, because the output signal needs, in some cases, when operator interventions are required, to be generated manually.

Therefore, a special module, named Auto/Manual Station is inserted between the MV output and the instrument terminations blocks. The MV output of the PID module is connected to the input of the Auto/Manual Station. The output of the Auto/Manual Station is connected to the termination blocks, providing an electrical signal capable to drive the external actuator.

Fig 3 shows the block diagrams of the complete loop.

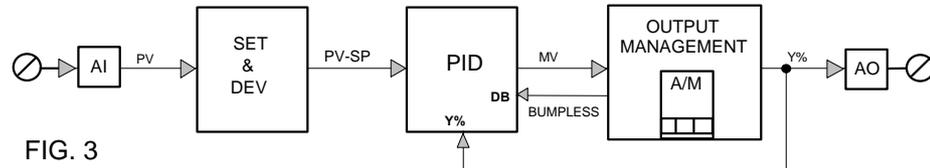


FIG. 3

This is a simple PID with an Auto/Manual station and consists of the following modules.

The PV signal is applied to the AI module, that converts the signal in a number.

The module SET DEV computes the error between the SP and PV.

The PID module computes the control output on the basis of the error input.

The OUT MANAGEMENT module handles the manipulated variable, together with others control signals (Aut/Man, Hold, Tracking, Bumpless etc.), supporting various operating modes.

The AO modules converts the calculated value in an electric signal, available at the termination blocks.



DI1	DI2	SP
Off	Off	LSP
Off	On	LSP
On	Off	RSP
On	On	MSP

## 12.5 Forcing Operations

These operations are related to the loop output and consist of the Hold and Tracking mode. The Hold mode freezes the loop output, until the DI5 digital input is active, while the Tracking mode sets the output to the value of the constant n° 2 of the module MCNS, until DI6 is active.

## 12.6 Alarms

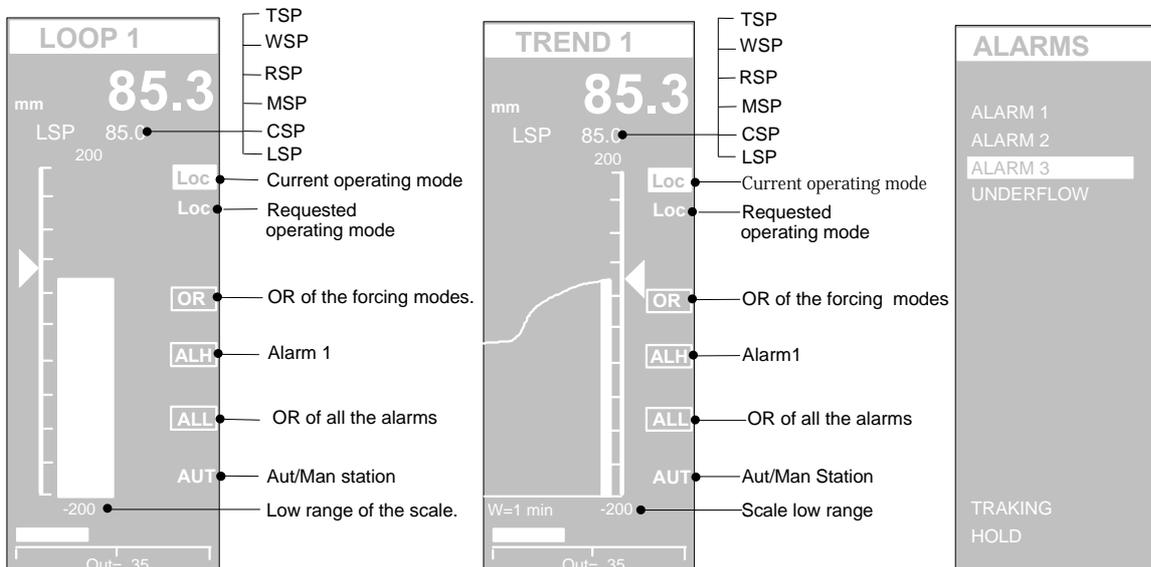
There are three alarms either on the controlled variable PV1 or the deviation, according to the parameters selected in each of the ALM modules. The module WSP-PV computes the deviation, in the same engineering units of the controlled variable PV1. The status of each alarm is retransmitted out through the DO1, DO2 and DO3 modules. A fourth alarm, the digital output DO4 flags the out of range of the variable PV1.

## 12.7 Variables Retransmission

The controlled variable PV1 is retransmitted out to the termination unit, through the SCH and AO2 modules.

The module SCH allows the modification of the ranges of the retransmitted output, that are not, necessarily, the same of the PV1 input. This is achieved by setting the input range parameters of the SCH module to different values than the output range parameters. In this way, the retransmitted PV1 can be limited to a portion of the input signal scale, with the advantage of an improved resolution.

## 12.8 Graphic Displays



The pictures above show the different types of display panels, providing the most effective interface for this strategy configuration.

The most used panels are the single bargraph display and the single pen trend, that provides the same functionalities of the previous panel, with the addition of a programmable time width chart, displaying the trend profile of the controlled variables.

The main controlled variable is displayed both in the large size digits display and through the bargraph, the Working Setpoint, WSP, is displayed by the slider and the output by the horizontal bargraph and numerically.

The following variables, consisting of the entire set of Setpoints, are displayed, one at a time, in the scrollable display area:

LSP	Local setpoint
TSP	Target setpoint
WSP	Working setpoint
RSP	Remote setpoint
MSP	Memorised setpoint
CSP	Computer setpoint

The squared digital indications, on the right side of the panel, are flagging the status of the alarms and the forcing mode of the loop. More precisely, they highlight the following general situations:

- 1 When an alarm is active, the label ALL is visible
- 2 When the Alarm 1 is active, the label AL1 is visible.
- 3 When a forcing mode is active the label FOR is displayed.

These are global flags: the detailed cause of the event, is shown in the ALARMS panel, where the digital status of each alarm and forcing input is clearly shown.

These are:

ALL 1	Alarm 1
ALL 2	Alarm 2
ALL 3	Alarm 3
UNDERFL	Input AI1 out of range (for 1-5V or 4-20 mA signals, only)
TRACKING	Force the control output to a predefined value
HOLD	Freeze the control output

## 12.9 Applications

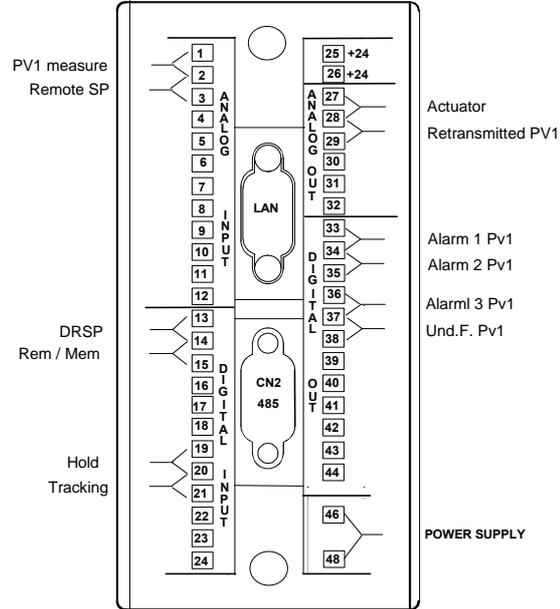
This easy to use configuration is for simple applications, where the control requirements need some additional functionalities than the basic classic PID loop, like the availability of multiple setpoints, remote or predefined, selectable through an external digital signal. Furthermore, this configuration offers the possibility to acts on the control output, both by forcing it to a predefined value and by freezing it, upon an external command.

The multiple alarm modules offer an effective tool for monitoring continuously the controlled variable and for detecting anomalous changes.

The retransmission of the controlled variable, over a different range, improves the resolution of the signal, because it is limited to the meaningful portion of the original range (zoom effect)

## 12.10 Electrical Connections

The following picture provides a clear view of all the termination blocks, with the associated functionality, and it is specific of this configuration. No signals must be connected to the termination blocks not used by the strategy. The termination blocks 25 and 26 are providing a 24V DC output, particularly suitable to supply of the 2 wires transmitters.



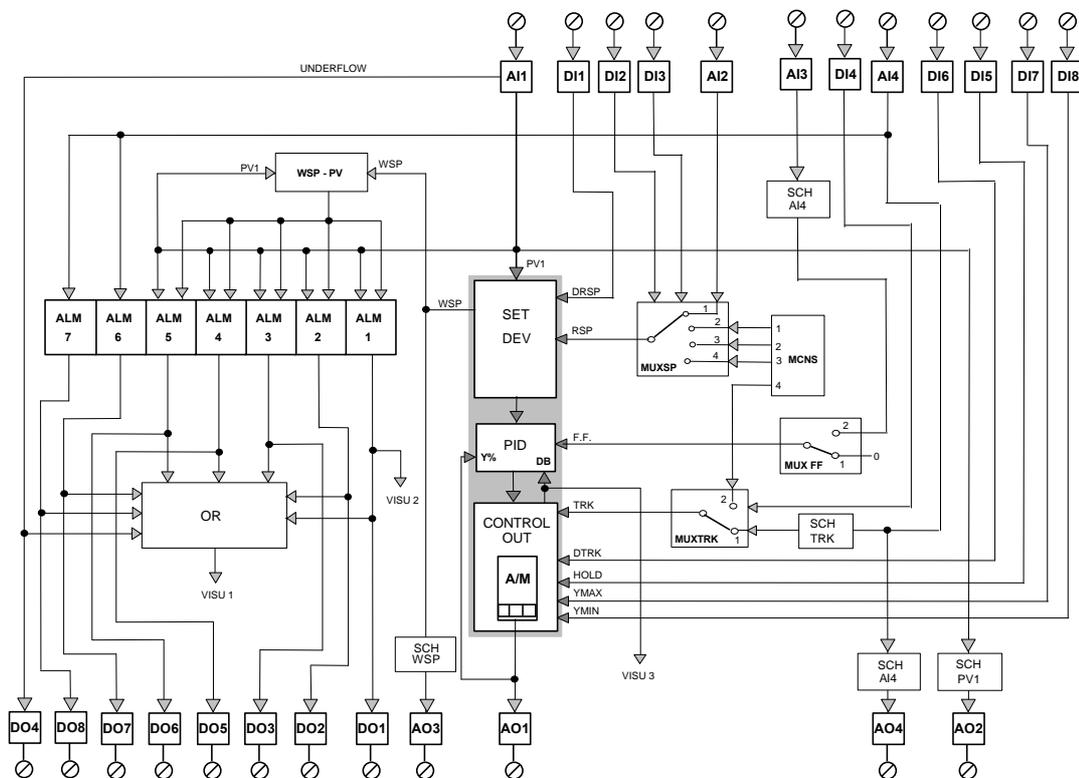
## 13. 1Loop B

### 13.1 Description

The drawings below are providing the following informations:  
 Block Diagram.  
 User interface, consisting in a set of display panels.  
 Termination unit for the connection to the field.

### 13.2 Block Diagram

In the following block diagram the interconnections between the various modules and the display panels are not indicated, in order to improve the understanding of the functionality performed. This configuration is a single loop with enriched functionalities than the previous one, suitable for more demanding process control applications.



### 13.3 Control

The AI module performs the A/D, the scaling and the conversion in engineering unit of the controlled variable and detects the out of range of the signal, presumably caused by a sensor failure. The output value of the AI module, PV1 is fed into the three modules which implement the core of the PID loop. The output of the PID is connected to the terminal blocks of the instrument through the output module AO1.

The control loop provides important additional functions than the basic controlling ones, like, for instance, the remote setpoint, the forcing modes, the feed forward, up to 7 alarm modules and the retransmission of the controlled variable.

### 13.4 Remote Setpoint

This configuration supports the Remote Setpoint, providing sophisticated features, selectable through the external digital inputs DI1-DI3, as illustrated in the table below. The features offered are:

- a) The Remote Setpoint value is selected, among four different possibilities, through the MUX SP module, by mean of the DI2 and DI3 inputs.
- b) The Remote Setpoint is enabled, by activating the digital input DI1; in fact, the setpoint mode selection, as illustrated in the SDV module description, is more complicated, because it is based on the arbitration of the requests coming from various sources.
- c) When the DI2 and DI3 inputs are both inactive, the Remote Setpoint corresponds to the signal at the analog input AI2.
- d) The other three combinations of DI2 and DI3 selects three different predefined values, stored in the MCNS analog constant module.

DI1	DI2	DI3	SP
Off	x	x	Loc
On	Off	Off	Remote from AI2
On	On	Off	Mem 1
On	Off	On	Mem 2
On	On	On	Mem 3

x= Don't care

### 13.5 Feed Forward

This feature provides a lead action to the control algorithm, consisting in anticipating the response of the loop to a change of the controlled variable. It is enabled by a parameter of the multiplexer MUX FF module and it consists in connecting the analog input AI3 to the Feed-Forward input of the PID module.

### 13.6 Forcing Operations

These operations are related to the loop output, that can be driven by other sources than the straight PID algorithm. This configuration allows the following 4 modes:

- Tracking
- Hold
- Hold + Y Max
- Hold + Y Min

- a) Tracking: it is enabled by the DI6 digital input and it consists in setting the control output either to a predefined value or to the value of the analog input AI4. The selection between these two choices is operated by the MUX TRK multiplexer module, by mean of the DI4 digital input.  
When DI4 is active, the control output value is provided by the analog constant of the MCNS module, while, when the DI4 is inactive, it is provided by AI4 signal, after being properly ranged to percentage units by the SCH TRK module.
- b) Hold: when DI5 is active, the control output is frozen at the value it had at the time of the rising transition.
- c) Hold+Ymax: When both DI5 (Hold) and DI7 are active, the control output is forced to its maximum value, defined by the parameters of the CONTROL OUT module.
- d) Hold+Ymin: When both DI5 (Hold) and DI8 are active, the control output is forced to its minimum value, defined by the parameters of the CONTROL OUT module.

An important point to bear in mind is that, all these forcing modes are handled by the module, according to the following priority: A/M; Ymin, Ymax, Hold and Track.

## 13.7 Alarms

There are 5 alarms either on the controlled variable PV1 or the deviation, according to the parameters selected in each of the ALM modules. The module WSP-PV computes the deviation, in the same engineering units of the controlled variable PV.

The other 2 alarms are related to the analog input AI4, that has multiple functionalities.

The status of all these alarms is retransmitted out through the DO1 to DO8 digital output.

The DO4 digital output flags the out of range of the variable PV1.

## 13.8 Variables Retransmissions

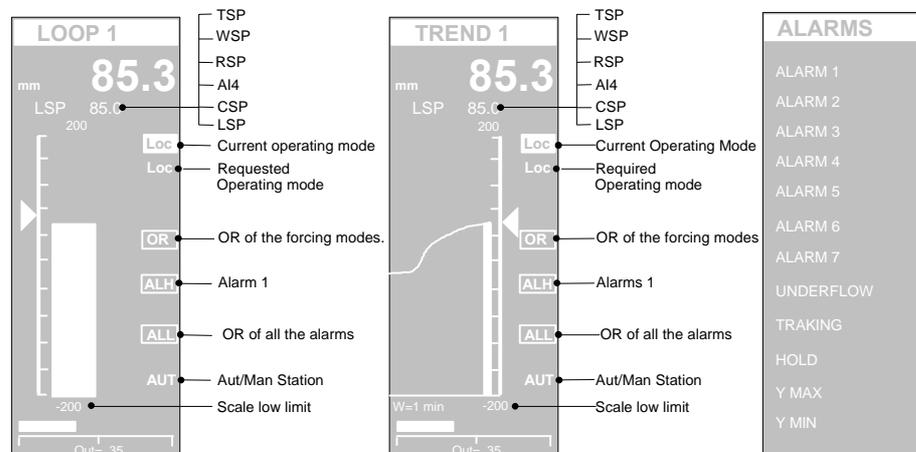
The controlled variable PV1 is retransmitted out to the termination unit, through the SCH and AO2 modules.

The module SCH allows the modification of the ranges of the retransmitted output, that are not, necessarily, the same of the PV1 input. This is achieved by setting the input range parameters of the SCH module to different values than the output range parameters. In this way, the range of the variable can be changed, in order to consider only a part of the original signal scale, with sensible advantages on the resolution of the output.

The WSP, working set-point, is retransmitted out, though the analog output AO3, properly reranged by the SCH WSP module, with the previously described advantages in term of resolution.

The AI4 analog input, suitable for multiple functionalities (tracking/retransm./all), can be retransmitted out to output AO4, after the rerange, operated by the SCH AI4 module.

## 13.9 Graphic Displays



The pictures above show the different types of display panels, providing the most effective interface for this strategy configuration.

The most used panels are the single bargraph display and the single pen trend, that provides the same functionalities of the previous panel, with the addition of a programmable time width chart, with the trend profile of the controlled variables.

The main controlled variable is displayed, both in the large size digits display and through the bargraph, the Working Setpoint, WSP, is displayed by the slider and the output, by the horizontal bargraph and numerically.

The following variables, consisting of the entire set of Setpoints, are displayed, one at a time, in the scrollable display area:

LSP	Local setpoint
TSP	Target setpoint
WSP	Working setpoint
RSP	Remote setpoint
CSP	Computer setpoint
AI4	Multifunction Analog input 4

The squared digital indications, on the right side of the panel, are flagging the status of the alarm and the forcing mode of the loop. More precisely, they highlight the following general situations:

- 1 When an alarm is active, the label ALL is visible
- 2 When the Alarm 1 is active, the label AL1 is visible.
- 3 When a forcing mode is active the label FOR is displayed.

These are global flags: the detailed cause of the event, is shown in the ALARMS panel, where the digital status of each alarm and forcing input is clearly shown.

These are:

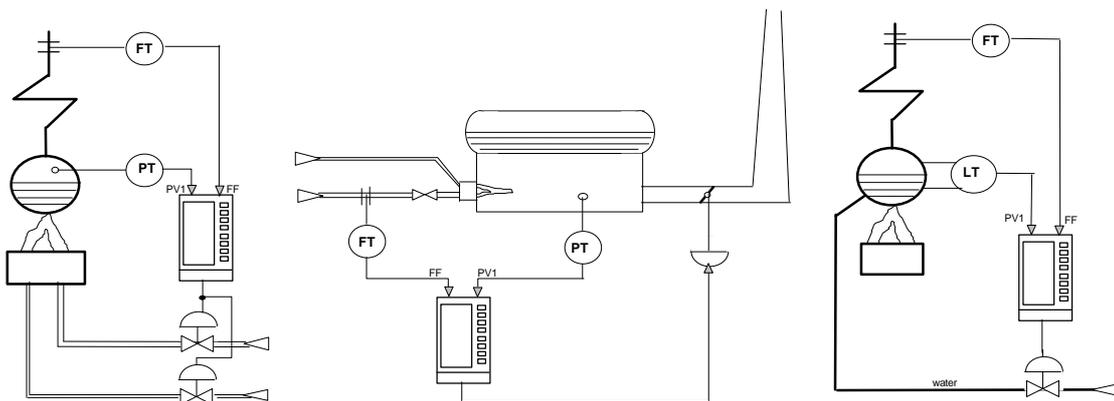
ALL 1 PV	Alarm 1
ALL 2 PV	Alarm 2
ALL 3 PV	Alarm 3
ALL 4 PV	Alarm 4
ALL 5 PV	Alarm 5
ALL 6 RTX	Alarm 6 on the variable AI4
ALL 7 RTX	Alarm 7 on the variable AI4
UNDERFL	Input AI1 out of range (for 1-5V or 4-20 mA signals, only)
TRACKING	Force the control output to a predefined value
HOLD	Freeze the control output
Y MAX	Force the control output to the maximum value.
Y MIN	Force the control output to the minimum value.

## 13.10 Applications

This easy to use, single loop configuration, provides a wide set of additional functionalities than the basic classic PID loop, like the availability of multiple setpoints, chosen between 3 predefined values and a remote one, generated by an analog input. This feature is strongly used in the discontinuous processes, like the management of both solid and liquid materials.

The feed forward functionality is an useful feature, when the process provides a variable that can anticipate the future changes of the controlled variable. The following processes are suitable to benefit from this feature:

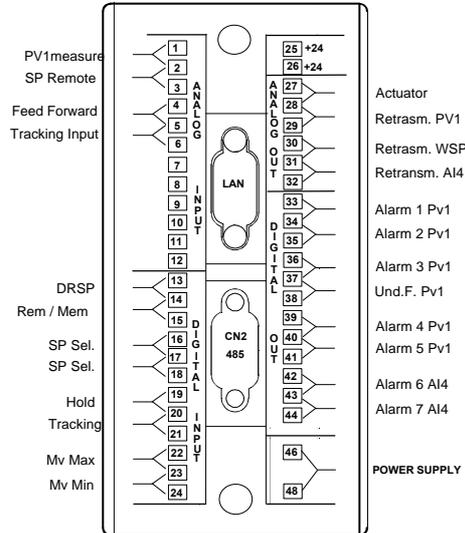
- a) Control of the pressure of the steam in a boiler (master ), using the steam flow as the feed-forward variable.
- b) Control of the pressure of the combustion chamber, using the fuel flow as the feed-forward variable.
- c) Control of the level of the two elements boiler barrel of a steam generator, using the steam flow as the feed-forward variable, considering that it generates the major demand of water.



These control applications can strongly benefit from the availability of the Remote Setpoint and the forcing modes features, provided by the controller and triggered by external signals. These features allow effective implementations of automatic operation like the cleaning of the combustion chamber and the automatic forcing to the minimum level during the idle times.

### 13.11 Electrical Connections

The following picture provides a clear view of all the termination blocks, with the associated functionality, and it is specific of this configuration. No signals must be connected to the termination blocks not used by the strategy. The termination blocks 25 and 26 are providing a 24V DC output, particularly suitable to supply of the 2 wires transmitters.



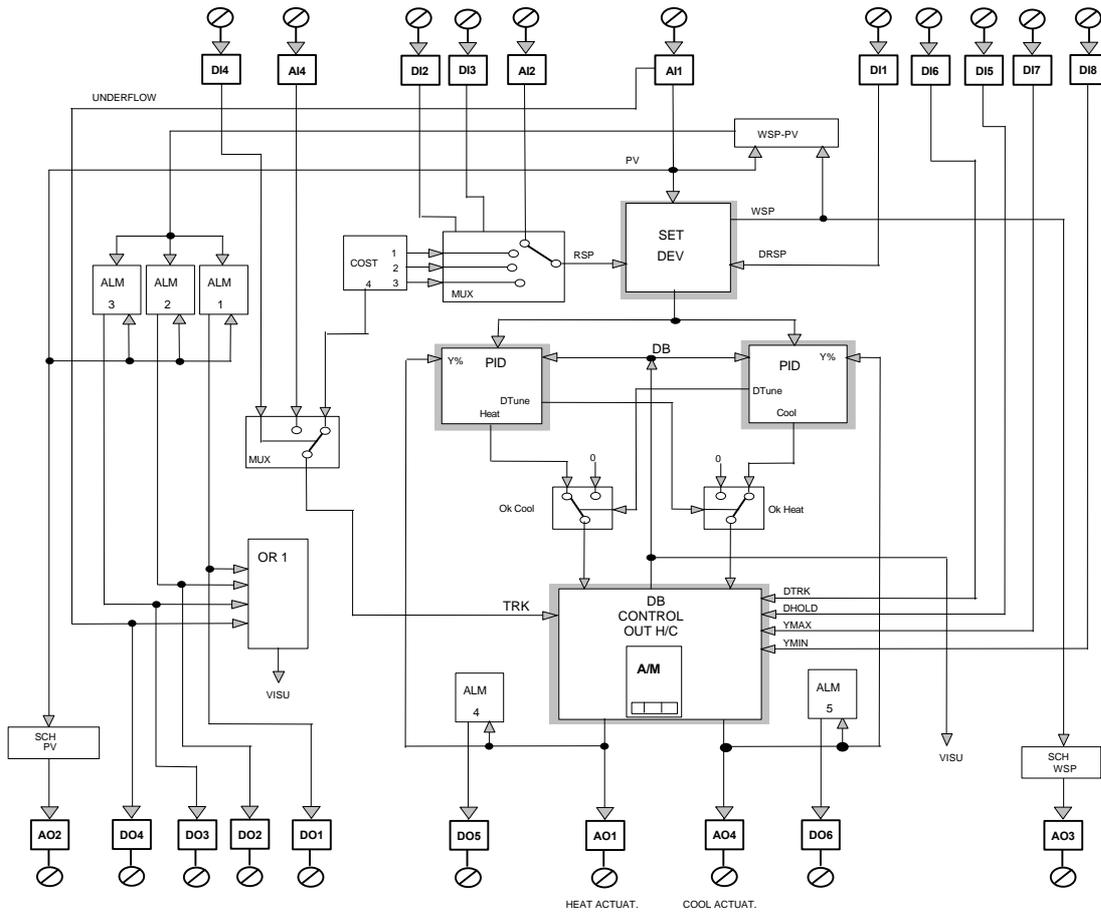
# 14. 1Loop C

## 14.1 Description

The drawings below are providing the following informations:  
 Block Diagram.  
 User interface, consisting in a set of display panels.  
 Termination unit for the connection to the field.

## 14.2 Block Diagram

In the following block diagram the interconnections between the various modules and the display panels are not indicated, in order to improve the understanding of the functionality performed.



This configuration is suitable for those processes which require two actuators in order to control the process variable. For instance, a temperature control, that needs both a heating function and a cooling function. The configuration consists of a single "Set-Dev" module, generating an unique setpoint both for the cool and the heat channel, two PID and an Heat/Cool output module. It has the advantage of allowing a separate set of the three terms parameters for the cool and the heat channel. This characteristic improves abruptly the control capabilities, because of the compensation of the mismatch of the two channel.

## 14.3 Control

The process variable PV is acquired by the AI1 module, providing the ranging, the conversion in engineering units and the out of range detection. It is transmitted to the SET DEV module that computes the deviation for the two PID modules, controlling both the Heat channel, with inverse action, and the Cool channel, with direct action.

The outputs of the two PID are connected to the single H/C output station, through two MUX multiplexer modules, required for properly selftuning the loops.

These two multiplexers interfere with the control output only when the Tune operation has been started on one of the PID modules, as flagged out by the Dtune signal.

The H/C Out station offers a wide range of forcing strategies and, first of all, a phase slitter, providing a deadband or a crossover between the two outputs.

## 14.4 Remote Setpoint

This configuration supports Remote Setpoints, both from an analog input AI2 and a set of 3 predefined values. The Remote Setpoint functionality is enabled by the DI1 digital input, while the DI2 and DI3 inputs select the source of the Setpoint, as illustrated in the following table.

DI1	DI2	DI3	Selected Value
Off	x	x	Set Loc
On	Off	Off	Input AI2
On	On	Off	Mem 1
On	Off	On	Mem 2
On	On	On	Mem 3

## 14.5 Forcing Operations

These operations are related to the loop output, that can be driven by other sources than the straight PID algorithm. This configuration allows the following 4 modes, selected through the DI5-6-7-8 digital inputs:

Tracking  
Hold  
Hold + Y Max  
Hold + Y Min

- a) Tracking: it is enabled by the DI6 digital input and it consists in setting the control output either to a predefined value, from the CONST analog constant module, or to the value of the analog input AI4. The selection between these two choices is operated by the MUX multiplexer module, by mean of the DI4 digital input. The range of the track value is -100 to 100, with -100 corresponding to the maximum cool value.
- b) Hold: when DI5 is active, the control output is frozen at the value it had at the time of the rising transition.
- c) Hold+Ymax: When both DI5 (Hold) and DI7 are active, the control output is forced to its maximum value, defined by the parameters of the CONTROL OUT H/C module.
- d) Hold+Ymin: When both DI5 (Hold) and DI8 are active, the control output is forced to its minimum value, defined by the parameters of the CONTROL OUT H/C module.

An important point to bear in mind is that, all these forcing modes are handled by the module, according to the following priority: A/M; Ymin, Ymax, Hold and Track.

## 14.6 Alarms

There are 3 alarms either on the controlled variable PV or the deviation, according to the parameters selected in each of the ALM modules. The module WSP-PV computes the deviation, in the same engineering units of the controlled variable PV. The status of all these alarms is retransmitted out, through the DO1 to DO3 digital output.

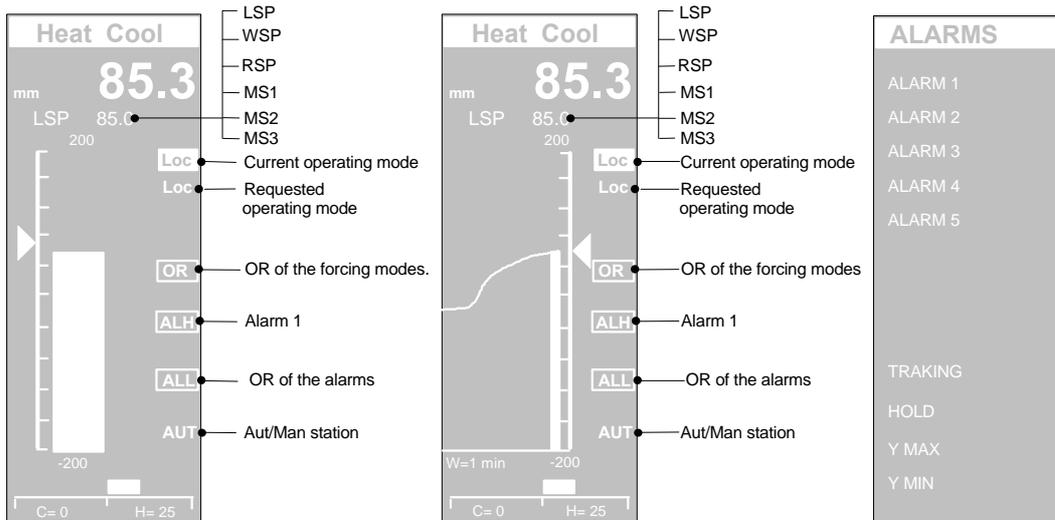
The DO4 digital output flags the out of range of the variable PV (underflow).

Two alarms are related to the control outputs of the two actuators. Their status is transmitted out to the DO5-6 digital outputs and are used to flag which of the two channel is operating.

## 14.7 Variables Retransmissions

The controlled variable PV is transmitted out, after the reranging operated by the SCH PV module, to the output AO2. The WSP, working set-point, is retransmitted out, though the analog output AO3, properly reranged by the SCH WSP module; the range of the variable can be changed, in order to consider only a part of the original signal scale, with sensible advantages on the resolution of the output.

## 14.8 Graphic Displays



The pictures above show the different types of display panels, providing the most effective interface for this strategy configuration.

The most used panels are the single bargraph display and the single pen trend, that provides the same functionalities of the previous panel, with the addition of a programmable time width chart, with the trend profile of the controlled variables.

The main controlled variable is displayed both in the large size digits display and through the bargraph, while the Working Setpoint, WSP, is displayed by the slider.

The outputs are displayed both numerically and by the horizontal bargraph, with the value of 0 in the central position, the output of the cool actuator on the left and the output of the heat actuator on the right.

The following variables, consisting of the entire set of Setpoints (Local plus other 5 setpoints), are displayed, one at a time, in the scrollable display area:

- LSP Local setpoint
- WSP Working setpoint
- RSP Remote setpoint
- MS1 Memorised set 1
- MS2 Memorised set 2
- MS3 Memorised set 3

The squared digital indications, on the right side of the panel, are flagging the status of the alarm and the forcing mode of the loop. More precisely, they highlight the following general situations:

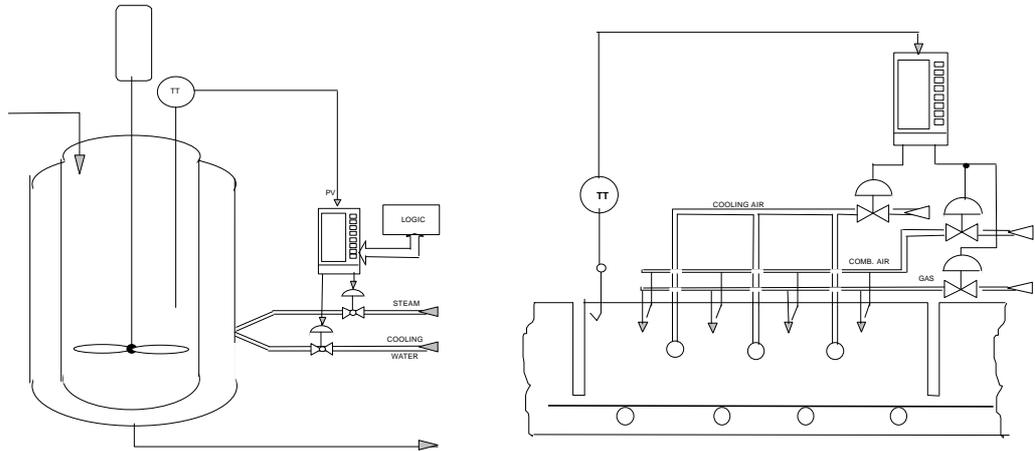
- 1 When an alarm is active, the label ALL is visible
- 2 When the Alarm 1 is active, the label AL1 is visible.
- 3 When a forcing mode is active the label FOR is displayed.

These are global flags: the detailed cause of the event, is shown in the ALARMS panel, where the digital status of each alarm and forcing input is clearly shown.

## 14.9 Applications

The typical application of this configuration is in the temperature control area, where both the heat and the cool actions are required, for keeping the temperature at the setpoint, when there are material changes, line speed variation and peculiar chemical reactions.

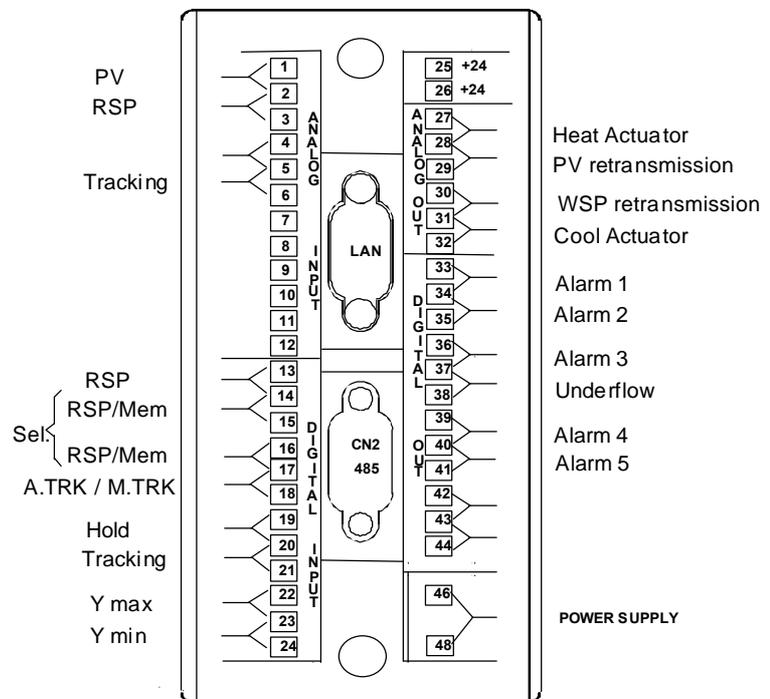
A few examples of the process using this configurations are the continuous heat treatment furnaces and most of the chemical reactors.



## 14.10 Electrical connections

The following picture provides a clear view of all the termination blocks, with the associated functionality, and it is specific of this configuration. No signals must be connected to the termination blocks not used by the strategy.

The termination blocks 25 and 26 are providing a 24V DC output, particularly suitable to supply of the 2 wires transmitters.



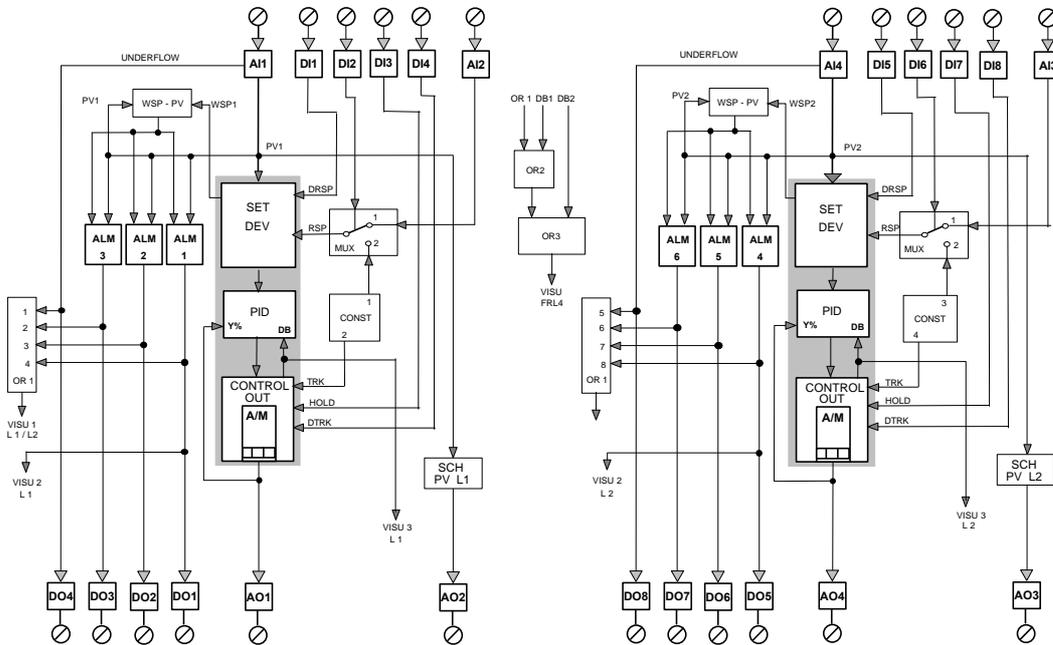
# 15. 2 Loops A

## 15.1 Description

This configuration consists of 2 separate basic PID loop, not interconnected each other. Each loop provides the following functionality: Remote Setpoint, Output Forcing modes, 3 alarms and the PV out of range (underflow) detection. The description of the control functionalities is reported, in the following pages, related to the loop1, only. The functionality of the loop 2 is perfectly identical but with the index numbers of the modules different. To the get the proper index numbers for loop 2, refer to the Block Diagram.

## 15.2 Block Diagram

In the following block diagram the interconnections between the various modules and the display panels are not indicated, in order to improve the understanding of the functionality performed.



## 15.3 Control

The AI1 module performs the A/D, the scaling and the conversion in engineering unit of the controlled variable and detects the out of range of the signal, presumably caused by a sensor failure. The output value of the AI1 module, PV1 is fed into the three modules which implement the core of the PID loop 1 (SET DEV 1, PID 1 and CONTROL OUT 1). The output of the PID 1 is connected to the terminal blocks of the instrument, through the output module AO1, in order to drive the external actuator.

## 15.4 Remote Setpoint

This functionality is provided for both the loops. Referring to loop1, the following description applies. Activating DI1 (i. e., closing the contact as in the picture 2.4.4) the Remote Setpoint is the one selected for the loop; otherwise the Local Setpoint is selected. In fact, the setpoint mode selection, as illustrated in the SDV module description, is more complicated, because it is based on the arbitration of the requests coming from various sources. The Remote Setpoint can be the signal at the input AI2 (RSP), if the digital input DI2 is inactive, or the constant stored in

the MCNS module (MSP), if the digital input DI2 is active. The truth table below lists all the various combinations of setpoint.

DI1	DI2	Selected value
Off	x	Set Loc
On	Off	Input AI2
On	On	Set mem.

### 15.5 Forcing Operations

These operations are related to the loop output and consist of the Hold and Tracking mode.

- a) Tracking: The Tracking mode sets the output to the value of constant, named Ysafe, until DI4 is active.
- b) Hold: The Hold mode freezes the loop output, until the DI3 digital input is active.

### 15.6 Alarms

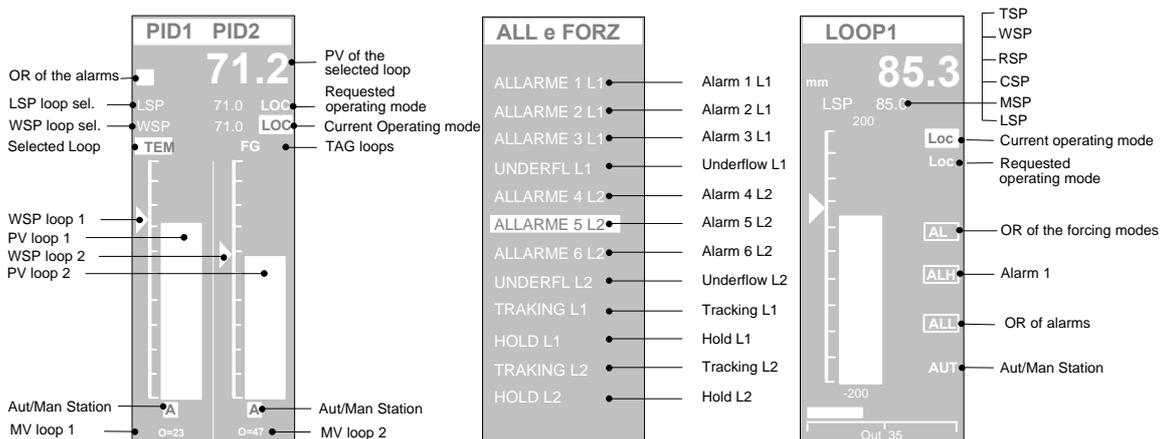
There are three alarms either on the controlled variable PV1 or the deviation, according to the parameters selected in each of the ALM modules. The module WSP-PV computes the deviation, in the same engineering units of the controlled variable PV. The status of each alarm is retransmitted out through the DO1, DO2 and DO3 modules. A fourth alarm, the digital output DO4 flags the out of range of the variable PV.

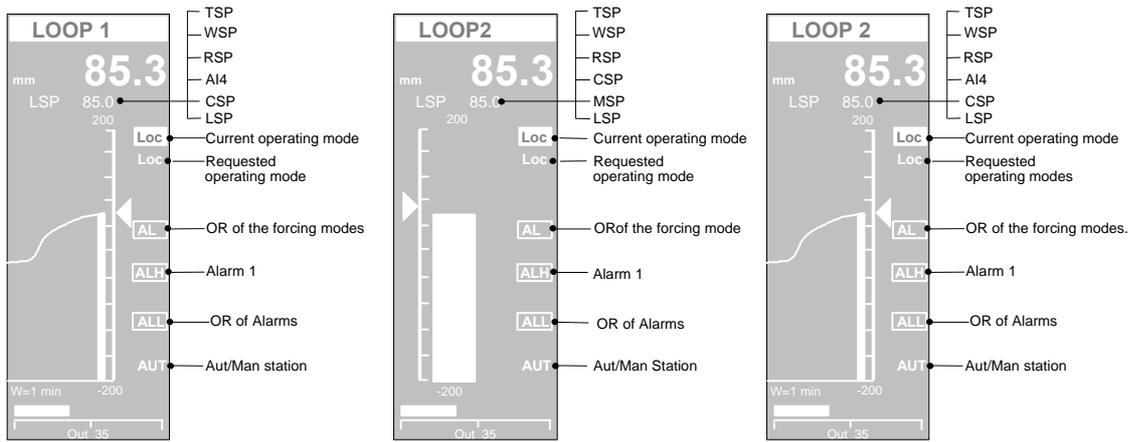
### 15.7 Variables Retransmission

The controlled variable PV1 is retransmitted out to the termination unit, through the SCH PV L1 and AO2 modules.

The module SCH PV L1 allows the modification of the ranges of the retransmitted output, that are not, necessarily, the same of the PV1 input. This is achieved by setting the input range parameters of the SCH PV L1 module to different values than the output range parameters. In this way, the range of the variable can be changed, in order to consider only a part of the original signal scale, with sensible advantages on the resolution of the output.

### 15.8 Graphic Display





The panel with the dual bargraph provides a complete view of both the loop, with a fine level of details on the most important parameters.

The left bargraph relates to loop 1 while the right relates to loop2. If you want to

operate on a loop, first you have to select it, by pressing the  button.

The loop selected is highlighted by the fact that both the tag and the output operating mode are displayed in reverse. Once the loop has been selected, it is possible to change either the Setpoint or the A/M station operating mode. Furthermore, the parameters shown in the upper part of the panel relates to the selected loop.

The status of the alarms is flagged by the small box on the upper left part of the panel. When an alarm or a forcing mode is activated, the box blinks continuously, to alert the operator. Next, the operator can get a more detailed view of the alarms, by looking at the ALL e FOR panel.

Furthermore, this configuration provides other 4 additional panels, 2 for each loop, with the well know bargraph and trend displays, with the following functionality.

The main controlled variable is displayed both in the large size digits display and through the bargraph, the Working Setpoint, WSP, is displayed by the slider and the output by the horizontal bargraph and numerically.

The following variables, consisting of the entire set of Setpoints, are displayed, one at a time, in the scrollable display area:

- LSP Local setpoint
- TSP Target setpoint
- WSP Working setpoint
- RSP Remote setpoint
- MSP Memorised setpoint
- CSP Computer setpoint

The squared digital indications, on the right side of the panel, are flagging the status of the alarm and the forcing mode of the loop. More precisely, they highlight the following general situations:

- 1 When an alarm is active, the label ALL is visible
- 2 When the Alarm 1 is active, the label AL1 is visible.
- 3 When a forcing mode is active the label FOR is displayed.

A more detailed view of the alarms and the forcing status is presented on the ALL e FOR display panel.

## 15.9 Applications

This easy to use configuration is for simple applications, where the control requirements needs some additional functionalities than the basic classic PID loop, like the availability of multiple setpoints, remote or predefined, selectable through an external digital signal. Furthermore, this configuration offers the possibility to acts on the control output, both by forcing it to a predefined value and by freezing it, upon an external command.

The multiple alarm modules offer an effective tool for monitoring continuously the controlled variable and detect anomalous changes.

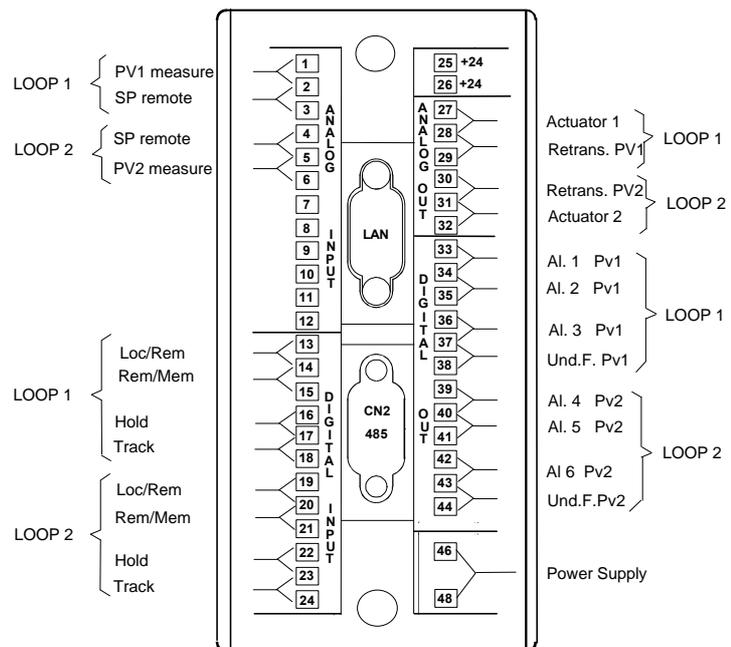
The retransmission of the controlled variable, over a different range, improves the resolution of the signal, because it is limited to the meaningful portion of the original range (zoom effect).

Furthermore, this configuration has the advantage of providing 2 loops in a single box, with perfectly identical characteristics, providing an attractive price/performance solution.

## 15.10 Electrical Connections

The following picture provides a clear view of all the termination blocks, with the associated functionality, and it is specific of this configuration. No signals must be connected to the termination blocks not used by the strategy.

The termination blocks 25 and 26 are providing a 24V DC output, particularly suitable to supply of the 2 wires transmitters.



# 16. 2 Loops B

## 16.1 Description

This configuration provides two loops:  
 1 with basic characteristics  
 1 with additional performing features

The loop 1 is the main one, it is the more powerful and it supports the following additional functionalities:

- Remote Setpoint from an analog input
- Remote Setpoint from stored constants
- Feed-Forward
- Forcing of the output
- 3 alarms on PV1
- Out of range detection (underflow) of PV1
- Retransmission of both PV1 and WSP

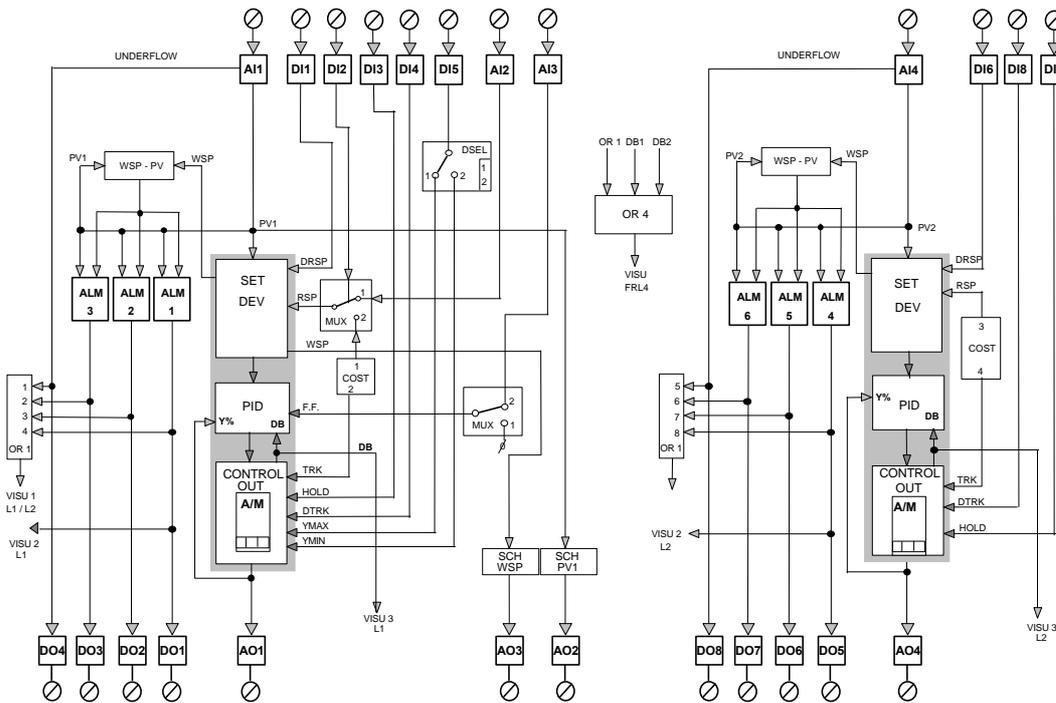
The loop 2 is the basic one and provides the following basic functionalities:

- Remote Setpoint from stored constants
- Forcing of the output
- 3 alarms on PV2
- Out of range detection (underflow) of PV2

The description of the control functionalities is reported, in the following pages, related to the loop1 only. The functionality of the second loop is perfectly identical but with the index numbers of the modules different. To the get the proper index numbers for the second loop, refer to the Block Diagram.

## 16.2 Block Diagram

In the following block diagram the interconnections between the various modules and the display panels are not indicated, in order to improve the understanding of the functionality performed.



## 16.3 Control

Referring to loop 1, the process variable PV1 is acquired by the AI1 module, providing the conversion in engineering units and the out of range detection. It is transmitted to the SET DEV module, that with the PID and CONTROL OUT modules, makes up the core PID block. The output is transmitted out on the terminal blocks, through the AO1 module, for driving the external actuator.

## 16.4 Remote Setpoint

This feature is supported on both the loops but with the following different performances.

*Loop 1*

- a) The remote setpoint is enabled by mean of the DI1 input
- b) The Remote Setpoint source (AI2 analog input or a stored constant) is selected through the MUX RSP multiplexer, by mean of the DI2 input.

DI1	DI2	Selected Value
Off	x	Set Loc
On	Off	Input AI2
On	On	Set mem.1

*Loop 2*

- a) The Remote Setpoint is enabled by mean of the DI6 input.
- b) The source of the Setpoint can be a stored constant with label Setmem 2

DI6	Selected Setpoint
Off	Set Loc
On	Set mem.2

## 16.5 Feed-Forward

This features is provided on loop 1 only and it provides a lead action to the control algorithm, consisting in anticipating the response of the loop to a future change of the controlled variable. It is enabled by a parameter of the multiplexer MUX module and it consists in connecting the analog input AI3 to the Feed-Forward input of the PID module.

## 16.6 Forcing Modes

These operations are related to the loop output, that can be driven by other sources than the straight PID algorithm. The functionality provided by the two loop are slight different, as described below.

*Loop1*

This configuration allows the following 4 modes:

- Tracking
- Hold
- Hold + Y Max
- Hold + Y Min

- a) Tracking: it is enabled by the DI4 digital input and it consists in setting the control output to a predefined constant value.
- b) Hold: when DI3 is active, the control output is frozen at the value it had at the time of the rising transition.
- c) Hold+Ymax: When both DI3 (Hold) is active, the selector module DSEL is on position 1 and DI5 is active, the control output is forced to its maximum value, defined by the parameters of the CONTROL OUT module.
- d) Hold+Ymin: When both DI3 (Hold) is active, the selector module DSEL is on position 2 and DI5 is active, the control output is forced to its minimum value, defined by the parameters of the CONTROL OUT module.

DI3	DI5	Dsel	Selected Value
Off	x	x	A/M or TRK
On	Off	x	Output frozen
On	On	1	Max Out
On	On	2	Min Out

**Loop 2**

This configuration allows only the following 2 modes: Tracking e Hold

- a) Tracking: the Tracking mode set the output to the value of the constant n° 2, named Trk L2, of the module MCNS, until DI8 is active
- b) Hold: The Hold mode freezes the loop output, until the DI3 digital input is active.
- c) These 2 forcing modes are handled by the module, according to the following priority: A/M; Hold and Track.

**16.7 Alarms**

**Loop 1**

There are three alarms either on the controlled variable PV1 or the deviation, according to the parameters selected in each of the ALM modules. The module WSP-PV computes the deviation, in the same engineering units of the controlled variable PV1. The status of each alarm is retransmitted out through the DO1, DO2 and DO3 modules. A fourth alarm, the digital output DO4, flags the out of range of the variable PV1 (underflow).

**Loop 2**

There are three alarms either on the controlled variable PV2 or the deviation, according to the parameters selected in each of the ALM modules. The module WSP-PV computes the deviation, in the same engineering units of the controlled variable PV2. The status of each alarm is retransmitted out through the DO5, DO6 and DO7 modules. A fourth alarm, the digital output DO8 flags the out of range of the variable PV2 (underflow).

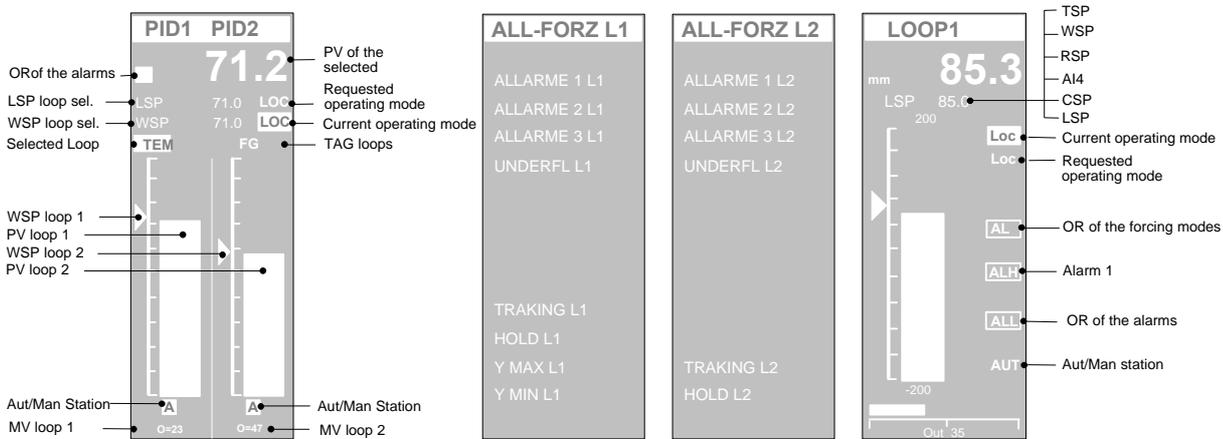
**16.8 Variables Retransmission**

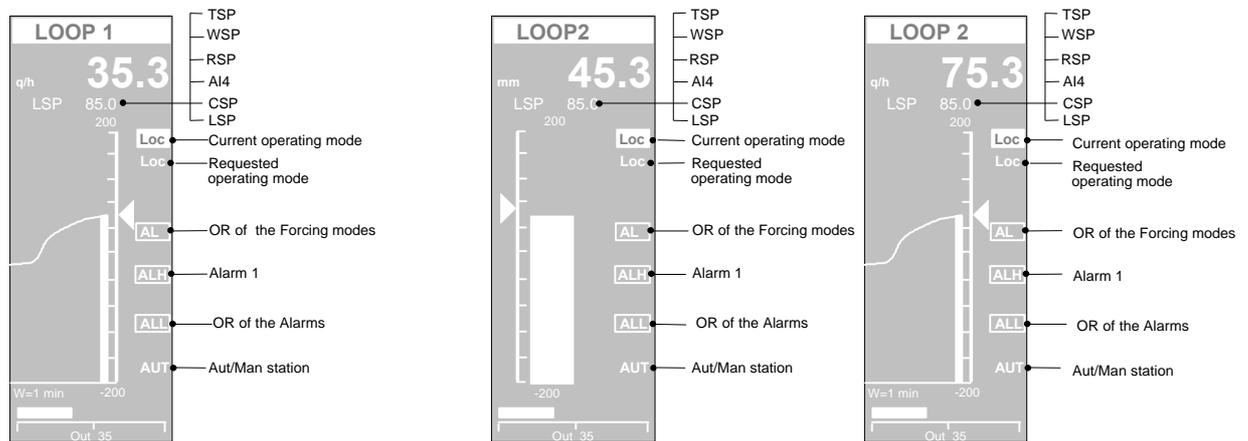
The controlled variable PV1 is retransmitted out to the termination unit, through the SCH PV1 and AO2 modules.

The module SCH allows the modification of the ranges of the retransmitted output, that are not, necessarily, the same of the PV1 input. This is achieved by setting the input range parameters of the SCH module to different values than the output range parameters. In this way, the range of the variable can be changed, in order to consider only a part of the original signal scale, with sensible advantages on the resolution of the output.

The WSP, working set-point, of loop 1 is retransmitted out, though the analog output AO3, properly reranged by the SCH WSP module, with the previously described advantages in term of resolution.

**16.9 Graphic Displays**





The panel with the dual bargraph provides a complete view of both the loop, with a fine level of details on the most important parameters.

The left bargraph relates to loop 1 while the right relates to loop2. If you want to

operate on a loop, first you have to select it, by pressing the  button.

The loop selected is highlighted by the fact that both the tag and the output operating mode are displayed in reverse. Once the loop has been selected, it is possible to change either the Setpoint or the A/M station operating mode. Furthermore, the parameters shown in the upper part of the panel relates to the selected loop.

The status of the alarms is flagged by the small box on the upper left part of the panel. When an alarm or a forcing mode is activated, the box blinks continuously, to alert the operator. Next, the operator can get a more detailed view of the alarms of each loop, by looking at the ALL-FORZ L"n" panels.

Furthermore, this configuration provides other 4 additional panels, 2 for each loop, with the well know bargraph and trend displays, with the following functionality.

The main controlled variable is displayed both in the large size digits display and through the bargraph, the Working Setpoint, WSP, is displayed by the slider and the output by the horizontal bargraph and numerically.

The following variables, consisting of the entire set of Setpoints, are displayed, one at a time, in the scrollable display area:

LSP	Local setpoint
TSP	Target setpoint
WSP	Working setpoint
RSP	Remote setpoint
MSP	Memorised setpoint
CSP	Computer setpoint

The squared digital indications, on the right side of the panel, are flagging the status of the alarm and the forcing mode of the loop. More precisely, they highlight the following general situations:

- 1 When an alarm is active, the label ALL is visible
- 2 When the Alarm 1 is active, the label AL1 is visible.
- 3 When a forcing mode is active the label FOR is displayed.

A more detailed view of the alarms and the forcing status is presented on the ALL -FORZ L"n" display panels, each one is associated to a loop.

## 16.10 Applications

This two loops configuration is particularly suitable for controlling processes with predictive variables, being the main loop equipped with the feed-forward.

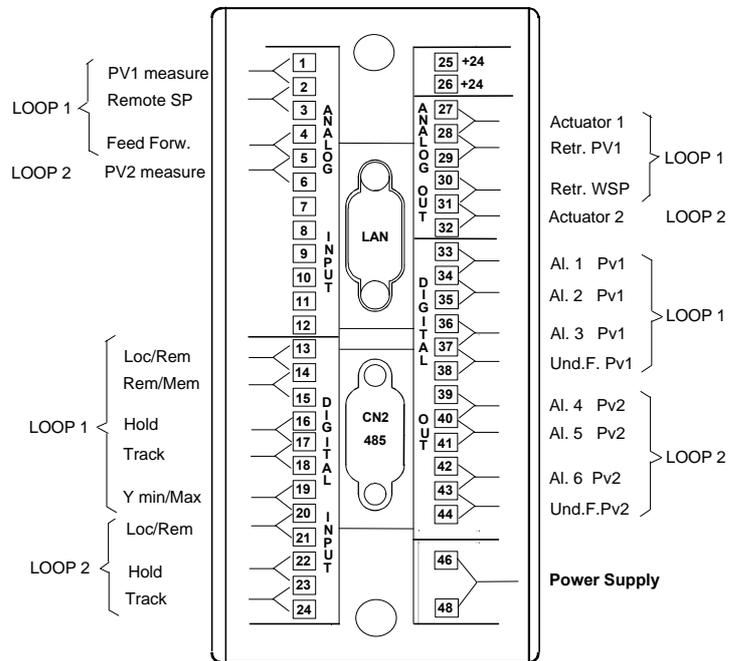
For instance, in a boiler control system, this configuration is dedicated both to the control of the 2 elements boiler barrel and to the more simple control of the air pressure or to another basic loop.

In a preheating furnace, for instance, this configuration is dedicated both to the control of the pressure of the furnace, using the global fuel flow as the predictive feed forward magnitude, and to the more basic control of the fuel air pressure.

## 16.11 Electrical Connections

The following picture provides a clear view of all the termination blocks, with the associated functionality, and it is specific of this configuration. No signals must be connected to the termination blocks not used by the strategy.

The termination blocks 25 and 26 are providing a 24V DC output, particularly suitable to supply of the 2 wires transmitters.



## 17. 2 Loops C

### 17.1 Description

The drawings below are providing the following informations:

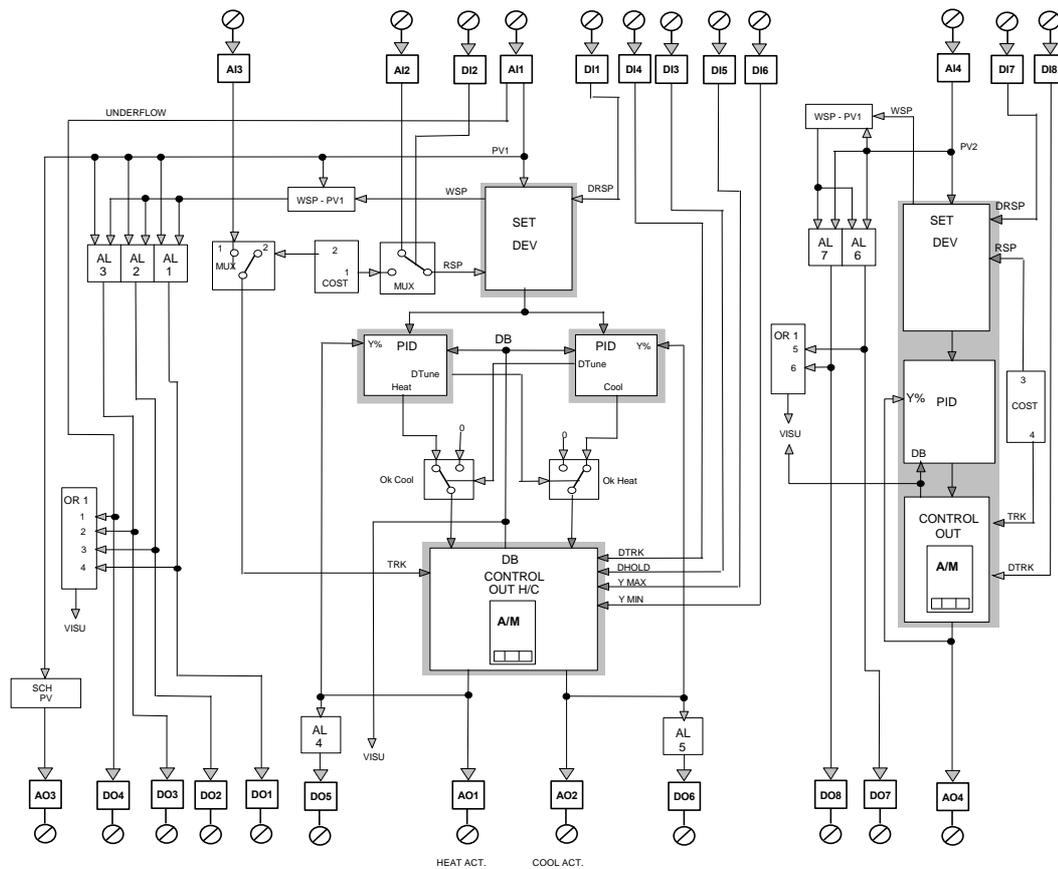
Block Diagram.

User interface, consisting in a set of display panels.

Termination unit for the connection to the field.

### 17.2 Block Diagram

In the following block diagram the interconnections between the various modules and the display panels are not indicated, in order to improve the understanding of the functionality performed.



This configuration is suitable for those processes requiring two actuators in order to control the process variable. For instance, a temperature control, that needs both a heating function and a cooling function.

The configuration consists of a single “Set-Dev” module, generating an unique setpoint both for the cool and the heat channel, two PID and an Heat/Cool output module. It has the advantage of allowing a separate set of the three terms parameters for the cool and the heat channel; this feature improves abruptly the control capabilities, because of the compensation of the mismatch of the two channel.

Furthermore, a basic standard loop is available in the controller.

## 17.3 Control

### Loop H/C

The process variable PV1 is acquired by the AI1 module, providing the ranging, the conversion in engineering units and the out of range detection. It is transmitted to the SET DEV module that computes the deviation for the two PID modules, controlling both the Heat channel, with inverse action, and the Cool channel, with direct action.

The outputs of the two PID are connected to the single H/C output station, through two MUX multiplexer modules, required for properly selftuning the loops.

These two multiplexers interfere with the control output, only when the Tune operation has been started on one of the PID modules, as flagged out by the Dtune signal.

The H/C Out station offers a wide range of forcing strategies and, first of all, a phase splitter providing a deadband or a crossover between the two outputs.

### Loop 2

The variable PV2 is acquired through the AI4 analog input module, providing the conversion in engineering units and the out of range detection. It is transmitted to the SET DEV module that, with the PID and CONTROL OUT modules, makes up the core PID block. The output is transmitted out on the terminal blocks, through the AO4 module, for driving the external actuator.

## 17.4 Remote Setpoint

This feature is supported on both the loop but with the following different performances.

### Loop H/C

- a) The remote setpoint is enabled by mean of the DI1 input.
- b) The Remote Setpoint source (AI2 analog input or a stored constant) is selected through the MUX RSP multiplexer, by mean of the DI2 input.

DI1	DI2	Selected Value
Off	x	Set Loc
On	Off	Input AI2
On	On	Constant SPM H/C

### Loop 2

- a) The Remote Setpoint is enabled by mean of the DI7 input.
- b) The source of the Setpoint can be a stored constant, named SPM L2

## 17.5 Forcing modes

These operations are related to the loop output, that can be driven by other sources than the straight PID algorithm. The functionality provided by the two loop are slight different, as described below.

### Loop H/C

This configuration allows the following 4 modes, selected through the DI3, DI4, DI5 and DI6:

- Tracking
- Hold
- Hold + Y Max
- Hold + Y Min

- a) Tracking: it is enabled by the DI4 digital input and it consists in setting the control output either to a predefined value, from the analog constant module, or to the value of the analog input AI3. The selection between these two choices is operated by the MUX multiplexer module, by mean of a parameter. The range of the track value is -100 to 100, with -100 corresponding to the maximum cool value.

DI4	Mux Trk	Selected Value
Off	x	A/M -- Hold
On	1	Input AI3
On	2	Constant YSIC H/

- b) Hold: when DI3 is active, the control output is frozen at the value it had at the time of the rising transition.
- c) Hold+Ymax: When both DI3 (Hold) and DI5 are active, the control output is forced to its maximum value, defined by the parameters of the CONTROL OUT H/C module.
- d) Hold+Ymin: When both DI3 (Hold) and DI6 are active, the control output is forced to its minimum value, defined by the parameters of the CONTROL OUT H/C module.

DI3	DI5	DI6	Selected Value
Off	x	x	A/M TRK
On	Off	Off	Hold
On	On	Off	(Ymax) Maximum Heat
On	Off	On	(Ymin) Maximum Cool

#### Loop 2

Only the Tracking mode is supported by this loop. The tracking is enabled by the digital input DI8 and set the output to the value specified by the constant, labelled TRK L2.

An important point to bear in mind is that, all these 4 forcing modes are handled by the module, according to the following priority: A/M; Ymin, Ymax, Hold and Track

## 17.6 Alarms

#### Loop H/C

There are three alarms either on the controlled variable PV1 or the deviation, according to the parameters selected in each of the ALM modules. The module WSP-PV computes the deviation, in the same engineering units of the controlled variable PV1.

The status of each alarm is retransmitted out through the DO1, DO2 and DO3 modules.

A fourth alarm, the digital output DO4 flags the out of range of the variable PV2 (underflow).

Two alarms are related to the control outputs of the two actuators. Their status is transmitted out to the DO5-6 digital outputs and are used to flag which of the two channel is operating.

#### Loop 2.

There are two alarms either on the controlled variable PV2 or the deviation, according to the parameters selected in each of the ALM modules. The module WSP-PV computes the deviation, in the same engineering units of the controlled variable PV2.

The status of each alarm is retransmitted out through the DO7 and DO8 modules.

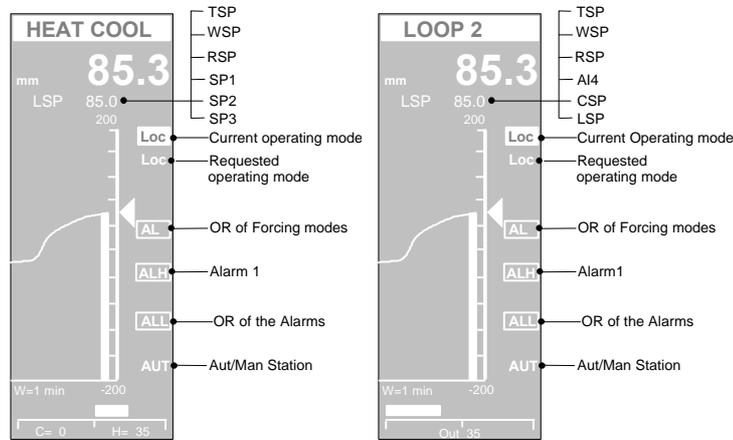
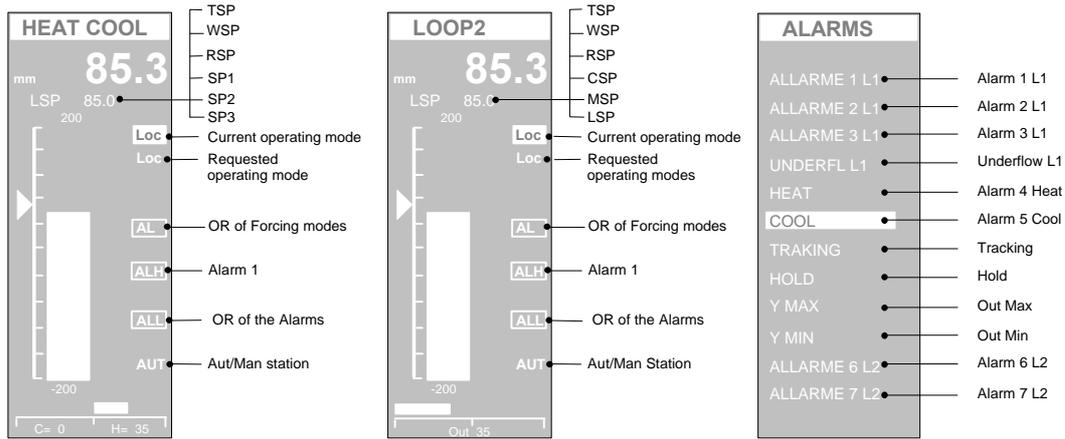
## 17.7 Variables Retransmission

#### Loop H/C

The controlled variable PV1 is retransmitted out to the termination unit, through the SCH PV and AO3 modules.

The module SCH allows the modification of the ranges of the retransmitted output, that are not, necessarily, the same of the PV1 input. This is achieved by setting the input range parameters of the SCH module to different values than the output range parameters. In this way, the range of the variable can be changed, in order to consider only a part of the original signal scale, with sensible advantages on the resolution of the output.

## 17.8 Graphic Displays



### Loop H/C

The pictures above show the different types of display panels, providing the most effective interface for this strategy configuration.

The most used panels are the single bargraph display and the single pen trend, that provides the same functionalities of the previous panel but the addition of a programmable time width chart, with the trend profile of the controlled variables.

The main controlled variable is displayed both in the large size digits display and through the bargraph, the Working Setpoint, WSP, is displayed by the slider.

The outputs are displayed both numerically and by the horizontal bargraph, with the value of 0 in the central position, the output of the cool actuator on the left and the output of the heat actuator on the right.

The following variables, consisting of the Local Setpoint plus other 5 analog variables, are displayed, one at a time, in the scrollable display area:

- LSP Local setpoint
- WSP Working setpoint
- RSP Remote setpoint
- MSP Memorised set
- TRK Tracking value
- PV2 Variable of loop 2

The squared digital indications, on the right side of the panel, are flagging the status of the alarm and the forcing mode of the loop. More precisely, they highlight the following general situations:

- 1 When an alarm is active, the label ALL is visible
- 2 When the Alarm 1 is active, the label AL1 is visible.
- 3 When a forcing mode is active the label FOR is displayed.

These are global flags: the detailed cause of the event, is shown in the ALARMS panel, where the digital status of each alarm and forcing input is clearly shown.

*Loop 2*

The most used panels are the single bargraph display and the single pen trend, that provides the same functionalities of the previous panel but the addition of a programmable time width chart, with the trend profile of the controlled variables. The main controlled variable is displayed both in the large size digits display and through the bargraph, the Working Setpoint, WSP, is displayed by the slider and the output by the horizontal bargraph and numerically.

The following variables, consisting of the Local Setpoints plus other 5 analog variables, are displayed, one at a time, in the scrollable display area:

LSP	Local setpoint
WSP	Working setpoint
MSP	Memorised set
YS2	Tracking value
PV1	Process variable of the Loop H/C
WS1	Working set of the Loop H/C

The squared digital indications, on the right side of the panel, are flagging the status of the alarm and the forcing mode of the loop. More precisely, they highlight the following general situations:

- 1 When an alarm is active, the label ALL is visible
- 2 When the Alarm 1 is active, the label AL1 is visible.
- 3 When a forcing mode is active the label FOR is displayed.

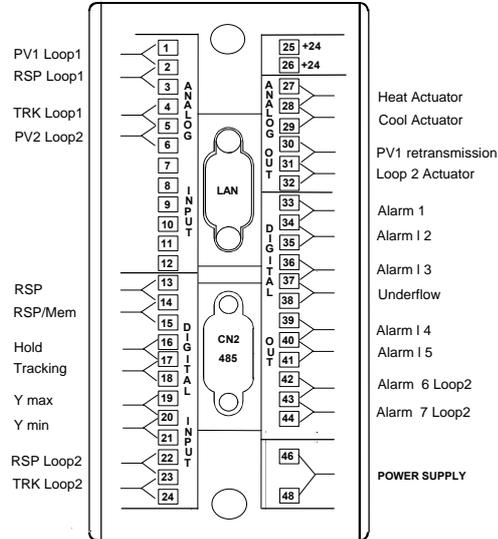
These are global flags: the detailed cause of the event, is shown in the ALARMS panel, where the digital status of each alarm and forcing input is clearly shown.

## 17.9 Applications

The typical application of this configuration is in the temperature control area, where both the heat and the cool actions are required for keeping the temperature at the setpoint. The availability, in the same box, of another basic PID loop is an advantage, because of the better the price/performance figures.

## 17.10 Electrical Connections

The following picture provides a clear view of all the termination blocks, with the associated functionality, and it is specific of this configuration. No signals must be connected to the termination blocks not used by the strategy.  
 The termination blocks 25 and 26 are providing a 24V DC output, particularly suitable to supply of the 2 wires transmitters.



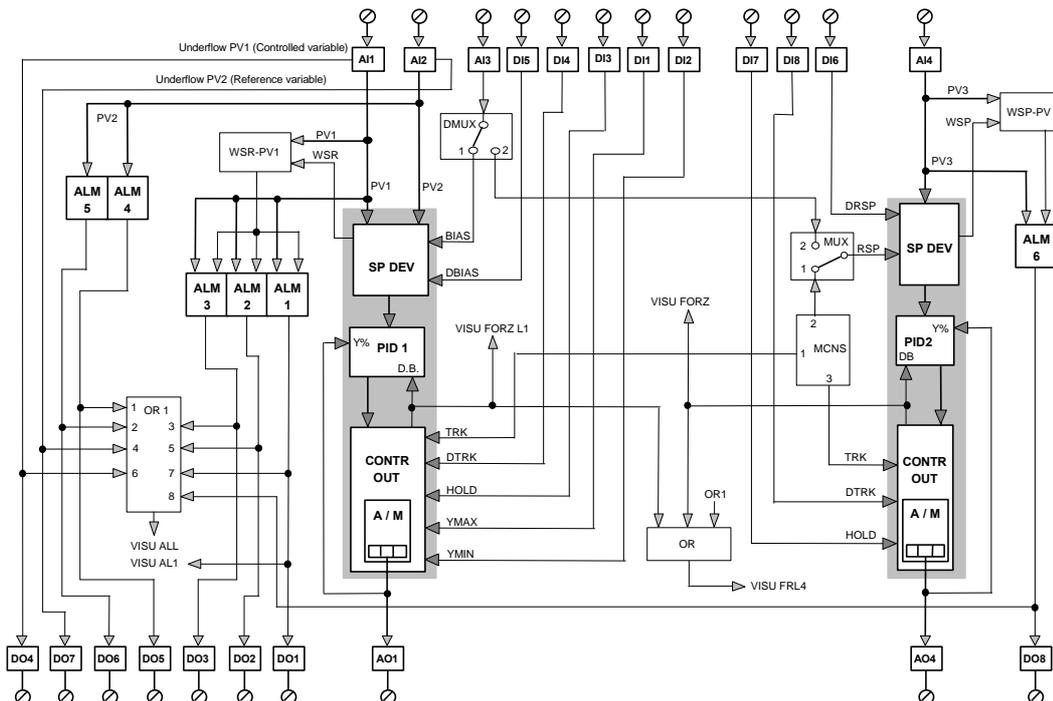
## 18. Ratio

### 18.1 Description

The drawings below are providing the following informations:  
 Block Diagram.  
 User interface, consisting in a set of display panels.  
 Termination unit for the connection to the field.

### 18.2 Block Diagram

In the following block diagram the interconnections between the various modules and the display panels are not indicated, in order to improve the understanding of the functionality performed.



This configuration consists of:

- 1 Ratio Loop
- 1 Standard loop

The first loop is the main loop of the instrument, it implements fully the ratio control algorithm, where the setpoint is derived, through a ratio operation, from the reference analog input signal (PV2), and it is equipped with the following list of important functionalities:

- Bias on the Local Setpoint
- Output forcing modes
- Alarms on PV1
- Alarms on PV2

The second loop is a basic PID loop, with the following functionalities :

- Memorised Setpoint
- Remote setpoint (through AI3 if this signal is not used for the bias)
- Output forcing modes
- Alarm on the controlled variable PV3

## 18.3 Control

### *Ratio Loop*

PV1, the controlled variable, is acquired through the AI1 module, providing the conversion in engineering units and the out of range detection.

PV2, the reference variable of the ratio loop, is acquired through the AI2 module, providing the conversion in engineering units and the out of range detection.

These two variables are transmitted to the SP DEV module, that computes the Working Setpoint for the loop, on the basis of the selected type of ratio (direct or reverse), as in the following formulas:

Direct ratio =  $PV2 \times \text{Ratio Setpoint} = \text{WSR}$

Inverse ratio =  $PV2 / \text{Ratio Setpoint} = \text{WSR}$

The Working Setpoint Ratio WSR is the target setpoint for the controlled variable PV1; it is the setpoint considered in the calculation of the PID deviations and in the visualisation of the display panel.

The output of the loop, suitable for driving the actuator, is transmitted out through the AO1 module.

### *Standard Loop*

The controlled variable PV3 is acquired through the AI4 module, providing the conversion in engineering units and the out of range detection. It is transmitted to the SET DEV module that, with the PID2 and CONTROL OUT modules, makes up the core PID block. The output is transmitted out on the terminal blocks, through the AO4 module, for driving the external actuator.

## 18.4 Bias

The bias feature consists in adding to the ratio setpoint, set in the SP DEV module a value, provided through the BIAS input (AI3). The result of the sum of these two values provides the resultant ratio setpoint, that, multiplied or divided by the reference variable (PV2), gives the Setpoint of the controlled variable. This feature is enabled when the digital input DI5 is in the active state.

## 18.5 Remote Setpoint

This feature is supported on the standard loop (Loop 2), only, and it is enabled by the active state of the DI6 digital input. The Remote Setpoint is selected, according to the parameter controlling the switch of the MUX module, between the constant value, stored in the MCNS module, and the analog input AI3. The latter choice is alternative to using AI3 as the Bias input of the Ratio loop.

## 18.6 Forcing modes

These operations are related to the loop output, that can be driven by other sources than the straight PID algorithm. The functionality provided by the two loops are slight different, as described below.

### *Ratio Loop*

This configuration allows the following 4 modes, selected through the DI1, DI2, DI3 and DI4:

- Tracking
- Hold
- Hold + Y Max
- Hold + Y Min

- a) Tracking: it is enabled by the active state of the DI4 digital input and it consists in setting the control output to the constant value stored in the MCNS module.
- b) Hold: when DI3 is active, the control output is frozen at the value it had at the time of the rising transition.

- c) Hold+Ymax: When both DI3 (Hold) and DI1 are active, the control output is forced to its maximum value, defined by the parameters of the CONTROL OUT module.
- d) Hold+Ymin: When both DI3 (Hold) and DI2 are active, the control output is forced to its minimum value, defined by the parameters of the CONTROL OUT module.

DI3	DI1	DI2	Selected Value
Off	x	x	A/M -- TRK
On	Off	Off	Hold
On	On	Off	Ymax
On	Off	On	Ymin

An important point to bear in mind is that all these 4 forcing modes are handled by the module, according to the following priority: A/M; Ymin, Ymax, Hold and Track.

#### *Standard Loop*

Only the Hold and the Tracking mode are supported by this module.

The Hold mode freezes the loop output, until the DI7 digital input is active

The Tracking mode set the output to the value of the constant stored in the MCNS module, until DI8 is active.

DI7	DI8	Selected Value
Off	Off	A/M
On	Off	Hold
Off	On	TRK Constant MV STBY
On	On	Hold (because of the higher priority than TRK)

## 18.7 Alarms

#### *Ratio Loop*

There are three alarms either on the controlled variable PV1 or the deviation, according to the parameters selected in each of the ALM modules. The module WSP-PV computes the deviation, in the same engineering units of the controlled variable PV1. The status of each alarm is retransmitted out through the DO1, DO2 and DO3 modules.

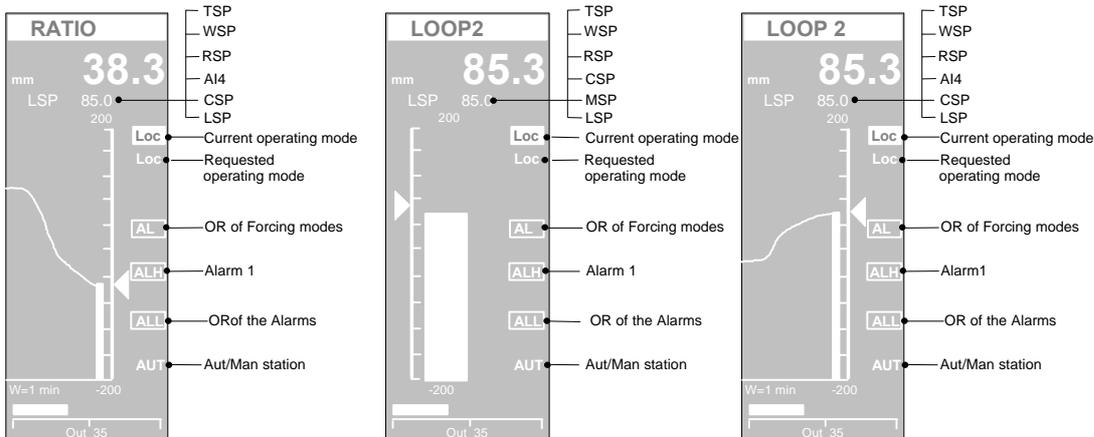
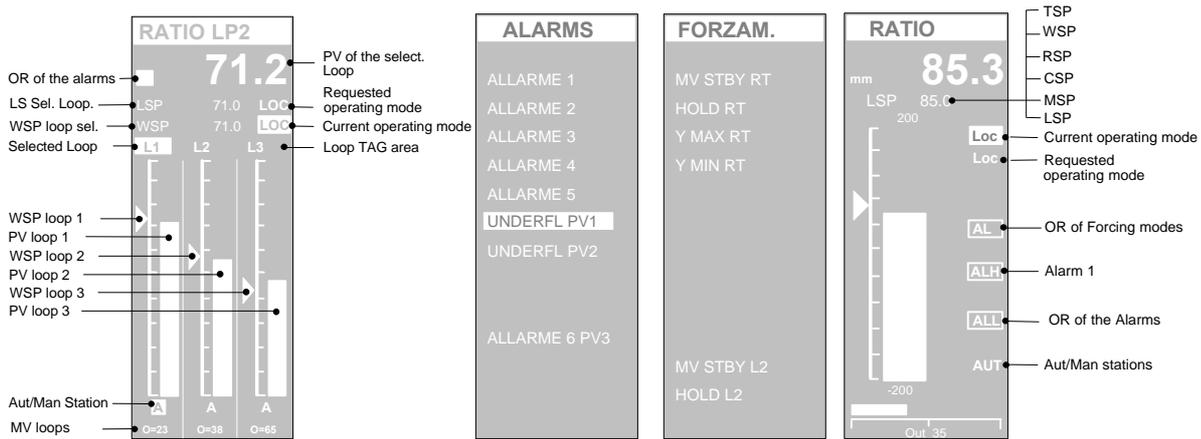
Two alarms are implemented by the additional ALM modules on the reference variable PV2. Their status is retransmitted out through the DO6 and DO5 digital outputs.

The out of range of, respectively, the variable PV1 (controlled variable) and the variable PV2 (reference variable) is detected and retransmitted out through the digital outputs DO4 and DO7.

#### *Loop Standard*

This loop is provided with an unique alarm either on the controlled variable PV3 or the deviation, according to the parameters selected in the ALM module. The module WSP-PV computes the deviation, in the same engineering units of the controlled variable PV3. The status of the alarm is retransmitted out through the DO8 module.

## 18.8 Graphic Displays



The pictures above show the different types of display panels, providing the most effective interface for this strategy configuration. The first 3 panel consisting in the 3 bargraph display, the alarm list and the Forcing mode list, provide, by themselves, a complete interface for this configuration.

Referring to the 3 bargraph display, the two bargraphs in the centre (reference variable PV2) and on the left, with the RAT tag and related to the PV1 variable, belong to the Ratio loop, while the one on the right, with the L2 tag, belongs to Loop 2.

If you want to operate on a loop, first you have to select it, by pressing the  button. The loop selected is highlighted by the fact that both the tag and the output operating mode are displayed in reverse. Once the loop has been selected, it is possible to change either the Setpoint or the A/M station operating mode. Furthermore, the parameters shown in the upper part of the panel relates to the selected loop.

The status of the alarms is flagged by the small box on the upper left part of the panel. When an alarm or a forcing mode is activated, the box blinks continuously, to alert the operator. Next, the operator can get a more detailed view of the alarms, by looking at the ALLARMS and FORZAM. panels.

Furthermore, this configuration provides other 4 additional panels, 2 for each loop, with the well know bargraph and trend displays, as shown in the pictures above.

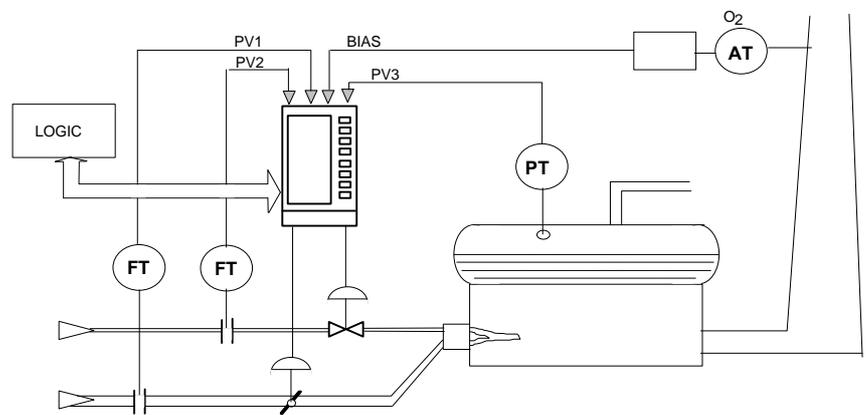
## 18.9 Applications

The purpose of the ratio loop is to control processes where it is required to keep, at a predefined set, the ratio between two controlled variables. There are plenty of examples of processes of this type: for instance, the control of the blending between two fluids and the control of the combustion (air and gas mix).

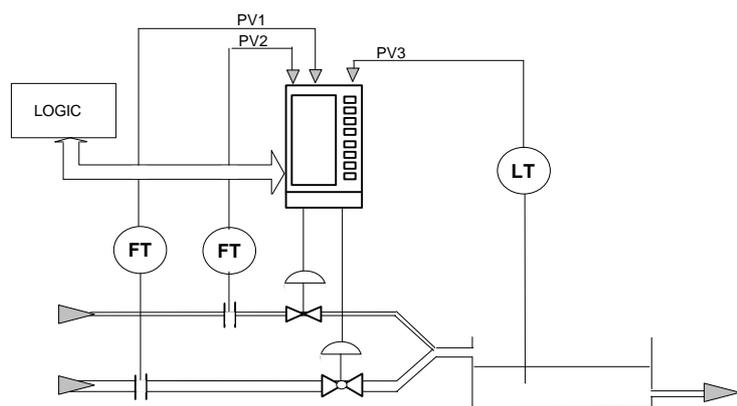
The second basic PID loop can be used to control an independent variable of the process, where the ratio control is required

An example is shown in the picture below, related to the combustion control of a steam generator. The steam pressure is controlled by the Loop2, whose output defines the energy (heat amount) to supply to the boiler, driving the gas valve. The ratio loop controls the air flow rate, that, in order to optimise the combustion, must be kept to a predefined ratio with the instantaneous gas flow rate. The ratio loop receive the gas flow rate, as PV2, and its output drives the air door. The control of combustion can be, further, improved by measuring the oxygen in the fumes and correcting, according to the measure, the air/gas ratio setpoint, by mean of the Bias input.

Furthermore, using the digital inputs, some additional functionalities, can be implemented, like forcing the closure of the gas valve, tracking the valve at the start up, and disabling the oxygen bias when the production is at the minimum level.

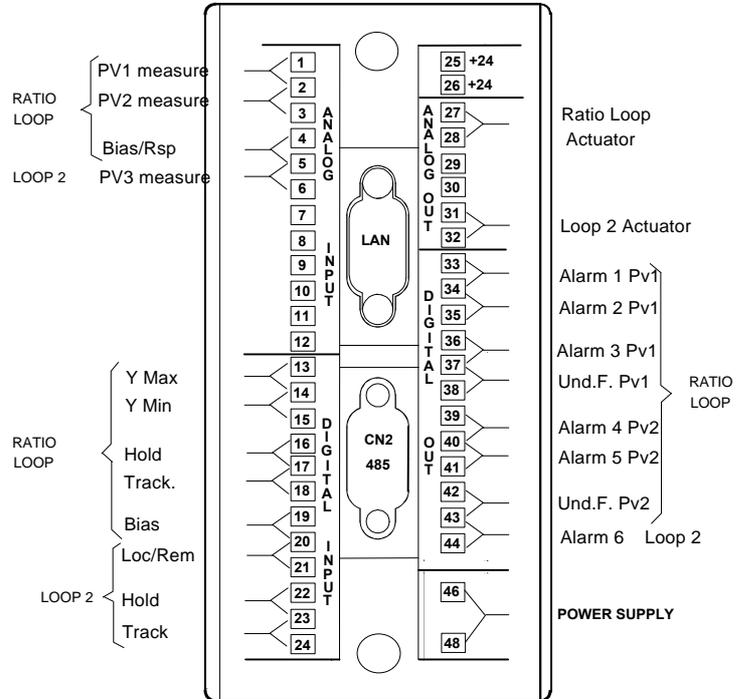


Another application of the ratio loop is in controlling the dosing of an additive to a fluid with variable flow. In this application, Loop 2 can be used for the control of the level of the tank where the fluid enters.



## 18.10 Electrical Connections

The following picture provides a clear view of all the termination blocks, with the associated functionality, and it is specific of this configuration. No signals must be connected to the termination blocks not used by the strategy. The termination blocks 25 and 26 are providing a 24V DC output, particularly suitable to supply of the 2 wires transmitters.





The process variable PV SLV is acquired by the AI4 module, providing the conversion in engineering units and the out of range detection. It is transmitted to the SET DEV module that, with the PID and CONTROL OUT modules, makes up the core PID block. The output is transmitted out on the terminal blocks, through the AO4 module, for driving the external actuator.

The controlled variable PV SLV, after being adjusted to the Master range, by the SCH TRK MAST module, is connected to the Track input of the Master Loop. Furthermore, the DB out of the Slave Loop is connected both to the Track enable of the Master loop and to the Bumpless input of the Slave loop. These two connections are required in order to perform bumpless transfers, in case of Auto/Manual and forcing modes changes. Every time there is a change, the output of the Master is aligned with the instantaneous value of the controlled variable of the Slave.

The following important functionalities are added to the basic cascade control feature:

- Remote and Memorised Setpoint for the Master
- Forcing modes on the Slave
- Alarms on the variable and deviation, both on the Master and the Slave
- Retransmission both of the PV MST and the PV SLV variable.

## 19.4 Remote Setpoint

This feature is supported in both the loops, but, while on the Slave the Remote Setpoint is completely dedicated to the implementation of the Cascade configuration and cannot be used for other purposes, on the Master, it is available for the user needs.

The Master Remote Setpoint feature is enabled both by the DI1 input active and by the priority based arbitration logic, governing the operating mode change. The Setpoint source is selected between an analog constant, stored in the MCNS module and the Remote signal from the analog input AI2, by means of the DI2 digital input. As shown in the table below, when DI2 is active, the stored constant is selected as the Remote Setpoint.

DI1	DI2	Selected value
Off	x	Set Loc
On	Off	Input AI2
On	On	Constant SP MEM

## 19.5 Forcing modes

These operations are related to the loop output, that can be driven by other sources than the straight PID algorithm. This feature is provided on the Slave loop, where the following 2 modes are supported:

- Tracking
- Hold

- a) Tracking: it is enabled by the DI8 digital input and it consists in setting the control output to a predefined constant value of the MCNS module
- b) Hold: when DI7 is active, the control output is frozen at the value it had at the time of the rising transition.

An important point to bear in mind is that all these 4 forcing modes are handled by the module, according to the following priority: A/M; Ymin, Ymax, Hold and Track

## 19.6 Alarms

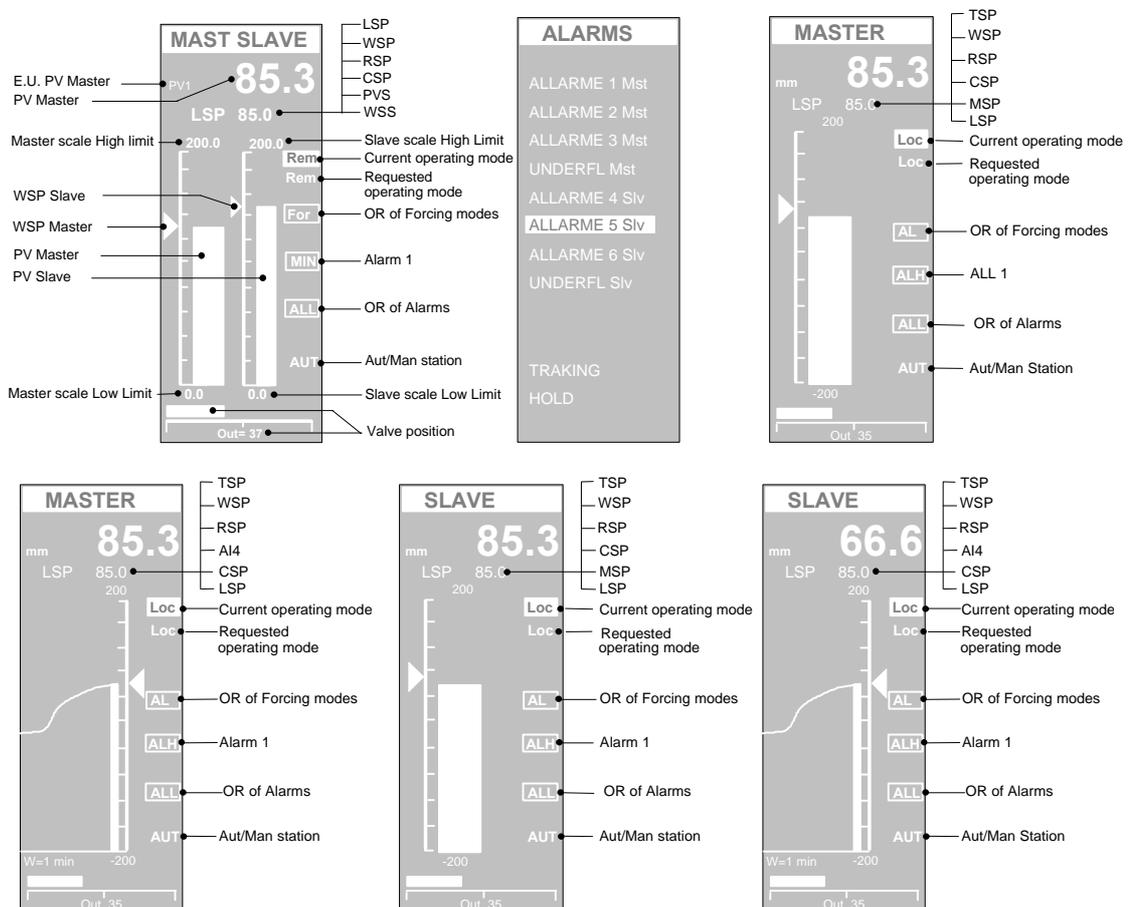
There are three alarms, for each loop, either on the controlled variables PV SLV and PV MST or the deviations, according to the parameters selected in each of the ALM modules. The module WSP-PV computes the deviation, in the same engineering units of the controlled variable PV1. The status of each alarm is retransmitted out through the DO1, DO2 and DO3 modules, for the Master loop, and DO5, DO6 and DO7, for the Slave loop. A fourth alarm, for each loop, flags

the out of range of the controlled variable (underflow, detected on 1-5V, 4-20mA inputs) and it is transmitted out on the DO4 (Master) and DO8 (Slave) modules.

## 19.7 Variables Retransmission

The Master controlled variable PV MST is transmitted out, after a rerange, operated by the SCH RTX PVM module, on the AO2 output.  
 The Slave controlled variable PV SLV is transmitted out, after the rerange, operated by the SCH RTX PV SL module, on the AO3 output.  
 The SCH modules allow the modification of the ranges of the retransmitted output, that are not, necessarily, the same of the input variable. This is achieved by setting the input range parameters of the SCH module to different values than the output range parameters. In this way, the range of the variable can be changed, in order to consider only a part of the original signal scale, with sensible advantages on the resolution of the output.

## 19.8 Graphic Displays



The pictures above show the different types of display panels, providing the most effective interface for this strategy configuration. The panel with the 2 bargraph, provides, by itself, a complete interface of both the loop.

Referring to the 2 bargraph display, the Master controlled variable is displayed both at the top, with large size digits, and with the larger bargraph on the left, while the Master Working Setpoint, WSPM, is displayed by the slider. About the Slave loop, the controlled variable PV SL is displayed by the thinner bargraph on the right and the setpoint WSP SL is displayed by the slider. The Slave control output, driving the external actuator, is displayed by the horizontal bargraph and numerically.

The following variables, consisting of the setpoints and process variables, are displayed, one at a time, in the scrollable display area:

LSP Local setpoint of the Master loop

WSm	Working setpoint of the Master loop
RSm	Remote setpoint of the Master loop
Csm	Computer setpoint of the Master loop
PVs	Process variable of the Slave loop
WSs	Working setpoint of the Slave loop

The displayed Setpoint operating mode is the one of the Master loop: its mode, indicated by the Loc, Rem and Com mnemonic is displayed in reverse, on the panel, at the same height of the L/R key, that is used to change the mode.

The squared digital indications, on the right side of the panel, are flagging the status of the alarm and the forcing mode of the loop. More precisely, they highlight the following general situations:

- 1 When an alarm is active, the label ALL is visible
- 2 When the Alarm 1 is active, the label AL1 is visible.
- 3 When a forcing mode is active the label FOR is displayed.

These are global flags: the detailed cause of the event, is shown in the ALARMS panel, where the digital status of each alarm and forcing input is clearly shown. The status of the digital signal is indicated by the type of display of the alarm message: in reverse if active, normal if inactive.

On the ALARMS panel, the following alarms and forcing status are displayed:

<i>ALM1 PV MAST</i>	Alarm 1 loop Master
<i>ALM2 PV MAST</i>	Alarm 2 loop Master
<i>ALM3 PV MAST</i>	Alarm 3 loop Master
<i>UNDERFL, MAST</i>	Out of range of the AI1 input (only for 1-5V or 4-20 mA input signals)
<i>ALM4 PV SLAV</i>	Alarm 4 loop Slave
<i>ALM5 PV SLAV</i>	Alarm 5 loop Slave
<i>ALM6 PV SLAV</i>	Alarm 6 loop Slave
<i>UNDERFL. SLAV</i>	Out of range of the AI4 input (only for 1-5V or 4-20 mA input signals)
<i>TRACKING</i>	Output forced to a predefined value
<i>HOLD</i>	Output frozen at the value of activation of the forcing condition

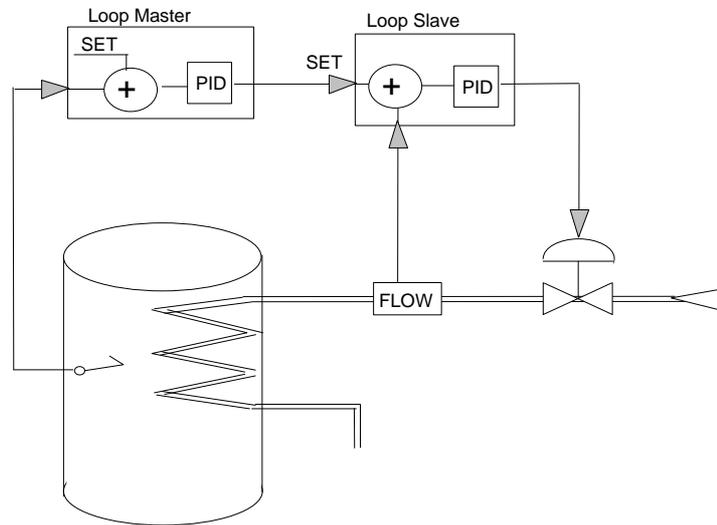
Furthermore, this configuration provides the well known single bargraph display and the single pen trend, that provides the same functionalities of the previous panel, but the addition of a programmable time width chart, with the trend profile of the controlled variables.

The picture provides details about the displayed variables.

## 19.9 Applications

A typical case, where the cascade control provides excellent results is when the manipulated variable influences the process variable indirectly, through other process variables, dynamically mismatched, whose stability is influenced by external events.

An example is shown in the picture below.



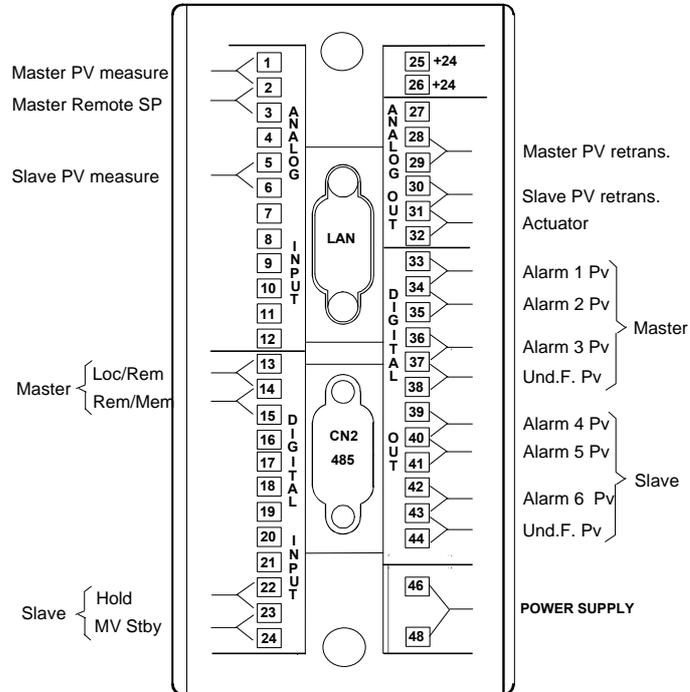
The target is to control the tank temperature, by controlling the flow rate of hot fluid to the heat exchanger.

This can be achieved, using just one loop, by measuring the temperature of the tank and controlling the valve regulating the flow rate of hot fluid. Such a solution, in most cases, is unsatisfactory, because it generates continuous instability on the controlled variable. This is due to the fact that, when the pressure of the fluid increases, the flow rate increases, but it takes a lot of time for the temperature to raise, in order to have a response on the control output to the valve. The effect is a big accumulation of heat in the tank, that creates the instability.

The Cascade control provides a perfect solution, because the Temperature loop, with its slow inertia is controlled by a separate loop, whose output defines the target flow rate of the fluid. This target flow rate is the set of the Slave loop controlling the flow rate, that having as measured variable the instantaneous flow rate, is capable to compensate immediately the changes of pressure of the fluid.

## 19.10 Electrical Connections

The following picture provides a clear view of all the termination blocks, with the associated functionality, and it is specific of this configuration. No signals must be connected to the termination blocks not used by the strategy. The termination blocks 25 and 26 are providing a 24V DC output, particularly suitable to supply of the 2 wires transmitters.



## 20. Override

### 20.1 Description

The drawings below are providing the following informations:

Block Diagram.

User interface, consisting in a set of display panels.

Termination unit for the connection to the field.

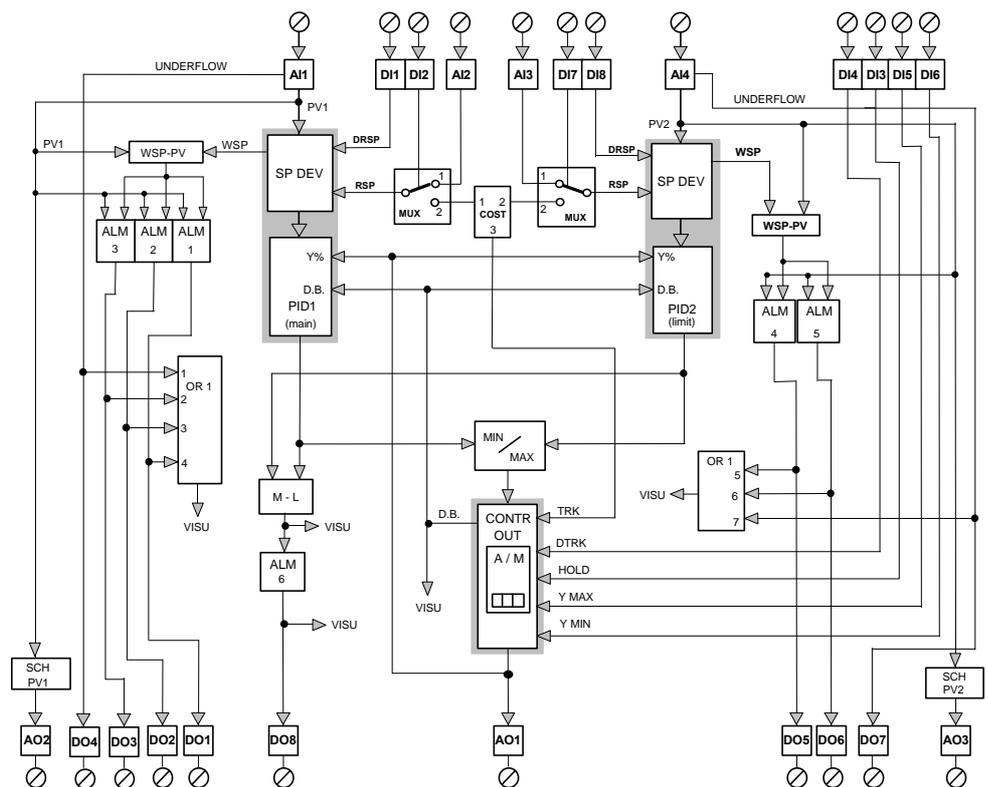
The override control is the right solution for controlling processes, where more than one variable must be controlled at the same time. For instance, the process consists of a Main variable, that must be kept at the setpoint and a Limit one, that must not exceed a predefined threshold, during normal operations, start up or when abruptly changes occurs.

This configuration controls two variables in override. It is based on 2 PID loops, each one controlling a process variable but only one output to the external actuator. The output to the actuator is computed as the minimum or the maximum of the two control output of the loops.

The two loops are dedicated to the Main variable and the Limit one.

### 20.2 Block Diagram

In the following block diagram the interconnections between the various modules and the display panels are not indicated, in order to improve the understanding of the functionality performed.



### 20.3 Control

The main variable PV1 is acquired by the AI1 module, providing the conversion in engineering units and the out of range detection. It is transmitted to the loop 1, consisting of the SET DEV and PID module.

The limit variable is acquired by the AI4 modules and it is transmitted to the loop 2.

The outputs of the two PID modules are connected to a Selector module that, according to the selection criteria configured, chooses one of the two outputs and transmits them to the CONTR OUT module, common to both the loops. The output of this module, through the AO1 module, drives the actuator. All the forcing modes are acting on the unique CONTROL OUT module and, therefore, common to both the loops. The Bumpless transfer output is common to both the loops, in order to keep the two PID aligned.

## 20.4 Remote Setpoint

This feature is supported identically by both the loops. It is enabled both by the DI1 (Main) or DI8 (Limit) and by the priority based arbitration logic, governing the Setpoint mode change. The Remote setpoint is selected between an analog constant, stored in the CONST module, and the remote signal from the analog input AI2 (Main) or AI3 (Limit).

The selection between these two Setpoint sources is operated by the inputs DI2 (Main) or DI7 (Limit), as shown in the table below.

DI1/DI8	DI2/DI7	Selected value
Off	x	Set Loc
On	Off	InputAI2/Input AI3
On	On	Constant MSP Main/MSP LMT

## 20.5 Forcing modes

These operations are related to the loop output, that can be driven by other sources than the straight PID algorithm, by mean of the DI3-4-5-6 digital inputs. These modes are related to the CONTR OUT module and, therefore, are common and influence both the loops.

- a) Tracking: it is enabled by the DI4 digital input and it consists in setting the control output to a predefined constant value of the MCNS module.
- b) Hold: when DI3 is active, the control output is frozen at the value it had at the time of the rising transition.
- c) Hold+Ymax: When both DI3 (Hold) and DI5 are active, the control output is forced to its maximum value, defined by the parameters of the CONTROL OUT module.
- d) Hold+Ymin: When both DI3 (Hold) and DI6 are active, the control output is forced to its minimum value, defined by the parameters of the CONTROL OUT module.

An important point to bear in mind is that all these 4 forcing modes are handled by the module, according to the following priority: A/M; Ymin, Ymax, Hold and Track

DI3	DI5	DI6	Selected Value
Off	x	x	A/M
On	Off	Off	Hold
On	On	Off	YMax
On	Off	On	YMin

## 20.6 Alarms

### Main Loop

There are three alarms either on the controlled variable PV1 or the deviation, according to the parameters selected in each of the ALM modules. The module WSP-PV computes the deviation, in the same engineering units of the controlled variable PV1.

The status of each alarm is retransmitted out through the DO1, DO2 and DO3 modules.

The out of range of, the variable PV1 is detected and retransmitted out through the digital output DO4.

**Limit Loop**

There are two alarms either on the controlled variable PV2 or the deviation, according to the parameters selected in each of the ALM modules. The module WSP-PV computes the deviation, in the same engineering units of the controlled variable PV2.

The status of each alarm is retransmitted out through the DO5 and DO6 modules.

An additional alarm performs the comparison between the outputs of the Main loop and the Limit one, determining which of the two loop is driving the output and flagging it out, through the DO8 output.

The out of range of the PV2 variable is detected and retransmitted out through the digital output DO7.

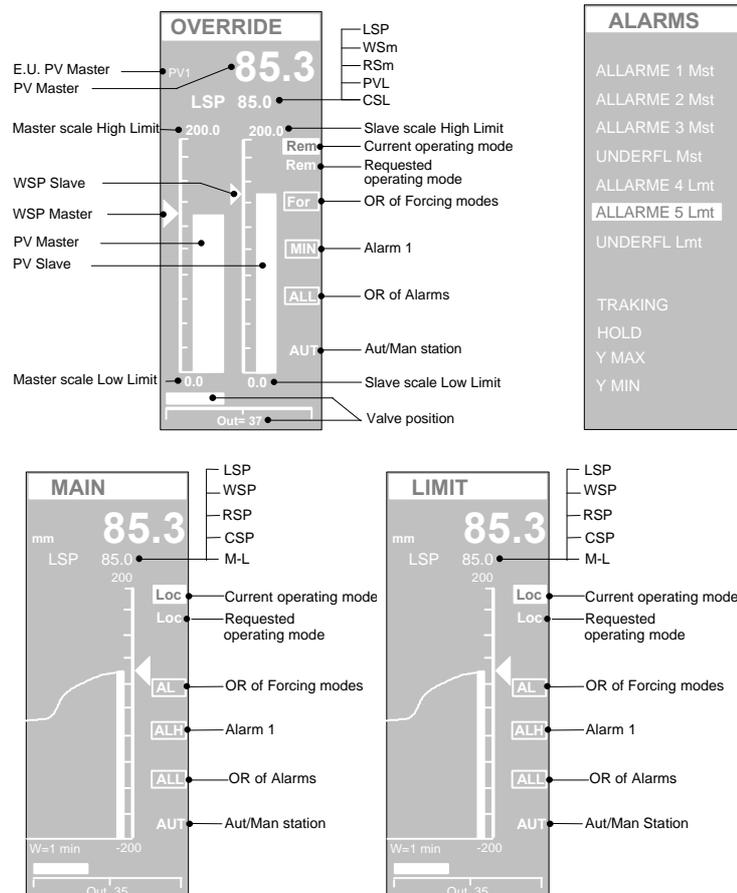
**20.7 Variable retransmissions**

The Main variable PV1 is retransmitted out to the termination unit, through the SCH PV1 Main and AO2 modules.

The Main variable PV2 is retransmitted out to the termination unit, through the SCH PV2 Main and AO3 modules.

The module SCH allows the modification of the ranges of the retransmitted output, that are not, necessarily, the same of the input. This is achieved by setting the input range parameters of the SCH module to different values than the output range parameters. In this way, the range of the variable can be changed, in order to consider only a part of the original signal scale, with sensible advantages on the resolution of the output.

**20.8 Graphic Display**



The pictures above show the different types of display panels, providing the most effective interface for this strategy configuration.

The panel with the two bargraph gives a complete overview of the main variables, involved in this configuration. The PVMain controlled variable is

displayed both in the large size digits display and through the larger bargraph on the left, while the Working Setpoint, WSPMain, is displayed by the slider. The PVLimit limit variable is displayed on the thinner bargraph on the right, while the Working Setpoint, WSPLim is displayed by the slider. The control output is displayed both numerically and by horizontal bargraph. The following variables, consisting of the Local Setpoint and other 5 analog variables, are displayed, one at a time, in the scrollable display area:

- LSP Local setpoint of the Main loop
- WSM Working setpoint of the Main loop
- RSM Remote setpoint of the Main loop
- CSM Computer setpoint of the Main loop
- PVL Limit Process variable
- WSL Limit Working setpoint

The displayed Setpoint operating mode is the one of the Main loop: its mode, indicated by the Loc, Rem and Com mnemonic is displayed in reverse, on the panel at the same height of the L/R key, that is used to change the mode. The Setpoint and its operating mode of the Limit loop are displayed and can be changed from the display panel LIMIT.

The squared digital indications, on the right side of the panel, are flagging the status of the alarm and the forcing mode of the loop. More precisely, they highlight the following general situations:

- 1 When an alarm is active, the label ALL is visible
- 2 When the Alarm 1 is active, the label AL1 is visible.
- 3 When a forcing mode is active the label FOR is displayed.

These are global flags: the detailed cause of the event, is shown in the ALARMS panel, where the digital status of each alarm and forcing input is clearly shown.

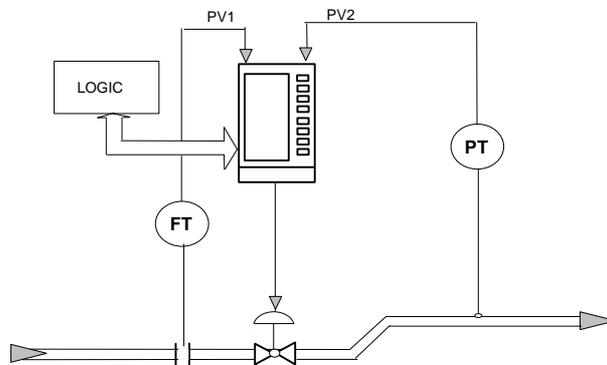
This configuration support two trend panels, one for each loop, with the trend profile of the controlled variable.

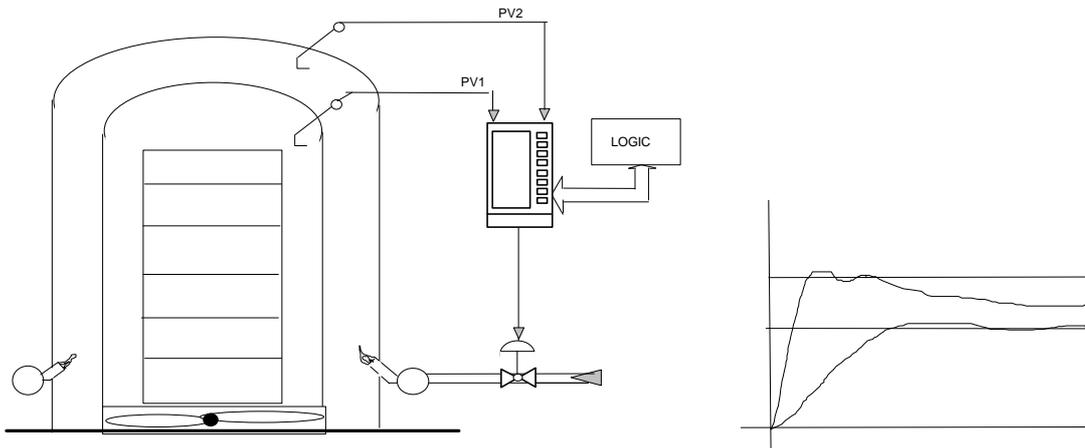
## 20.9 Applications

The override control is the right solution for controlling processes where more than one variable must be controlled at the same time. For instance, the process consists of a Main variable, that must be kept at the setpoint and a Limit one, that must not exceed a predefined threshold, during normal operations, start up or when abruptly changes occurs.

A few examples of a process requiring the override are:

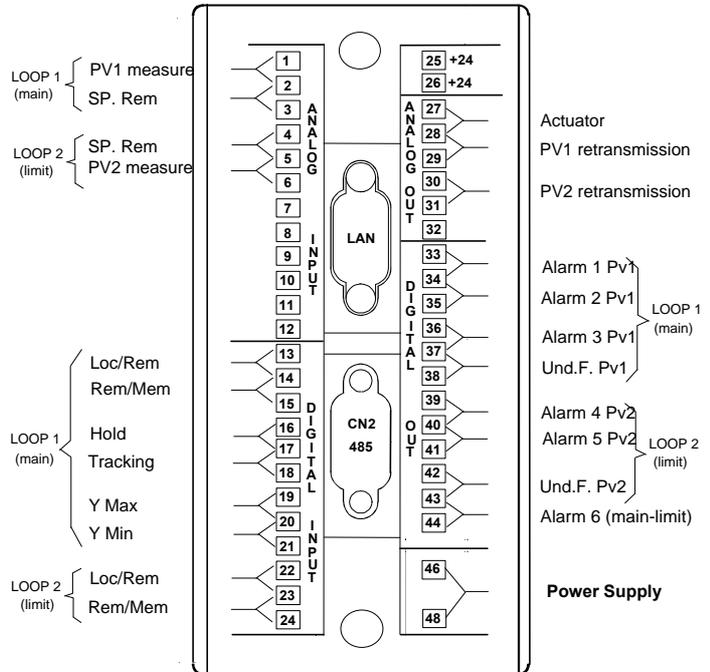
- Flow control with a maximum limit on the pressure.
- Control of the pressure with a limit on the flow.
- Control of the temperature of an object with limit on the maximum temperature of the heating elements.





### 20.10 Electrical connections

The following picture provides a clear view of all the termination blocks, with the associated functionality, and it is specific of this configuration. No signals must be connected to the termination blocks not used by the strategy. The termination blocks 25 and 26 are providing a 24V DC output, particularly suitable to supply of the 2 wires transmitters.



# 21. 4 Loops

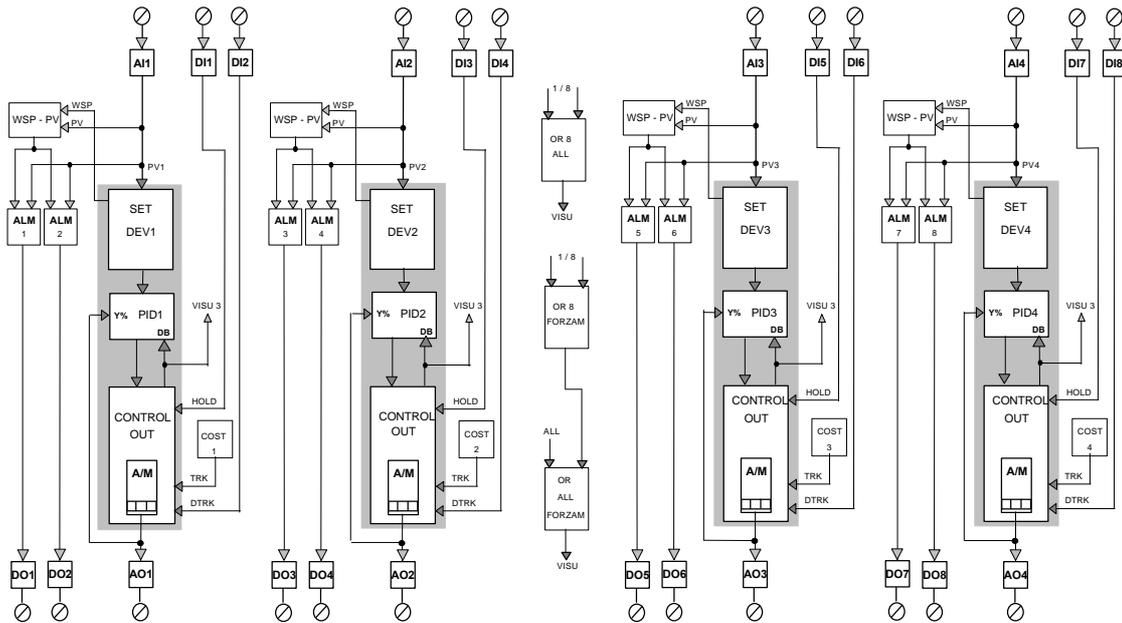
## 21.1 Description

The drawings below are providing the following informations:  
 Block Diagram.  
 User interface, consisting in a set of display panels.  
 Termination unit for the connection to the field.

This configuration provides 4 basic independent PID loops, equipped with forcing modes on the output and 2 absolute or deviation alarms, each.  
 The description of the control functionalities is reported, in the following pages, related to the loop1, only. The functionality of the other loops is perfectly identical, but with the index numbers of the modules different. To get the proper index numbers for the other loops, refer to the Block Diagram.

## 21.2 Block Diagram

In the following block diagram the interconnections between the various modules and the display panels are not indicated, in order to improve the understanding of the functionality performed.



## 21.3 Control

The AI1 module performs the A/D, the scaling and the conversion in engineering unit of the controlled variable and detects the out of range of the signal, presumably caused by a sensor failure. The output value of the AI1 module, PV1 is fed into the three modules which implement the core of the PID loop 1 (SET DEV 1, PID 1 and CONTROL OUT 1). The output of the PID 1 is connected to the terminal blocks of the instrument, through the output module AO1, in order to drive the external actuator.

## 21.4 Forcing modes

These operations are related to the loop output and consist of the Hold and Tracking mode.

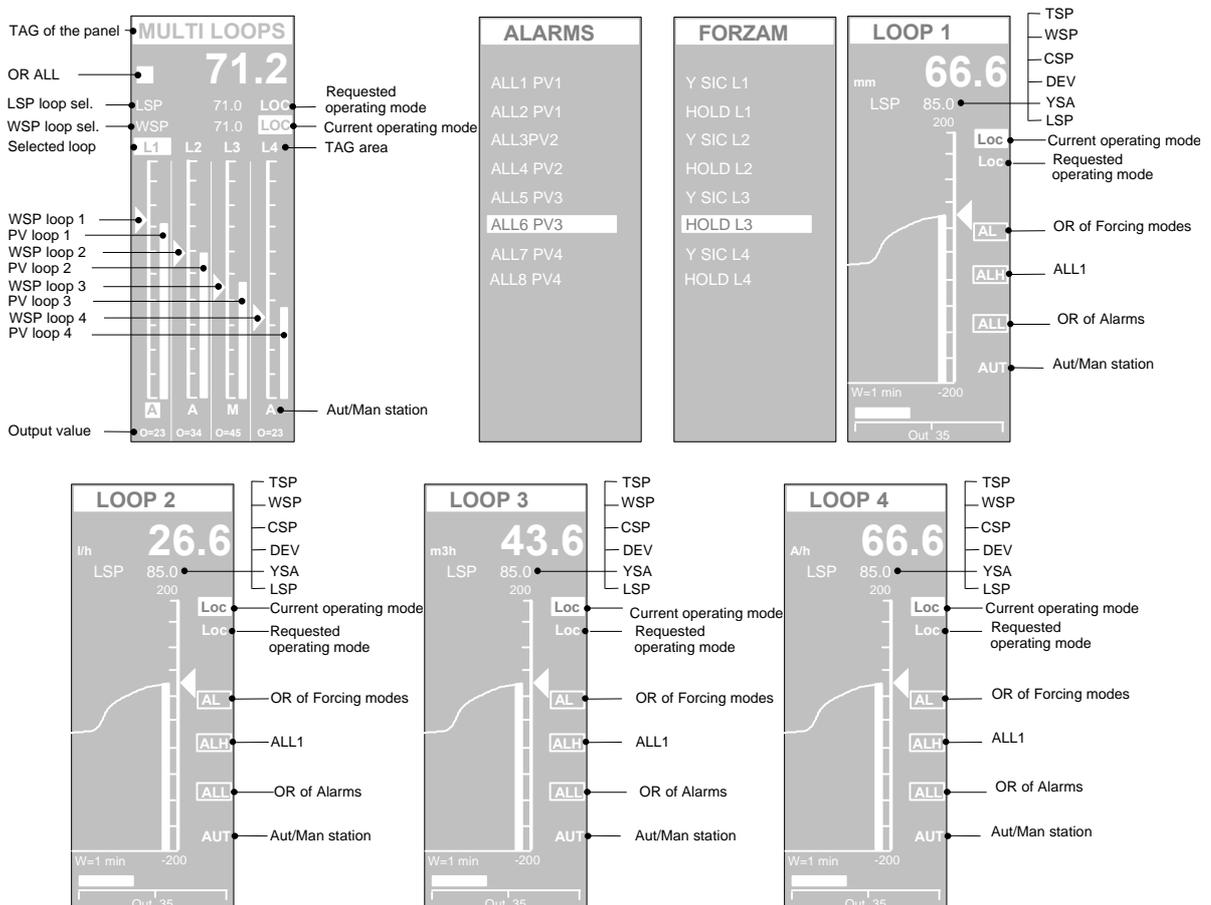
- a) Tracking: the Tracking mode sets the output to the value of constant until DI2 is active.
- b) Hold: The Hold mode freezes the loop output, until the DI1 digital input is active.

When the forcing mode cease, the transfer to the normal operating mode is bumpless.

## 21.5 Alarms

There are two alarms either on the controlled variable PV1 or the deviation, according to the parameters selected in each of the ALM modules. The module WSP-PV computes the deviation, in the same engineering units of the controlled variable PV. The status of each alarm is retransmitted out through the DO1 and DO2 modules.

## 21.6 Graphic Displays



The panel with the 4 bargraphs provides a complete view of all the 4 loops, with a fine level of details on the most important parameters.

For each loop, the PV is represented by the bargraph and the Working Setpoint by the slider. The left bargraph relates to loop 1 while the right relates to loop4. If

you want to operate on a loop, first you have to select it, by pressing the  button.

The loop selected is highlighted by the fact that both the tag and the output operating mode are displayed in reverse. Once the loop has been selected, it is

possible to change either the Setpoint or the A/M station operating mode. Furthermore, the parameters shown in the upper part of the panel relates to the selected loop.

The numeric indication with large size digits at the top of the panel, is always displaying the controlled variable value of the selected loop.

The status of the alarms is flagged by the small box on the upper left part of the panel. When an alarm or a forcing mode is activated, the box blinks continuously, to alert the operator. Next, the operator can get a more detailed view of the alarms, by looking at the ALLARMS and FORZAM panels.

Furthermore, this configuration provides other 4 additional panels with the well know bargraph and trend displays, one for each loop.

The picture above list all the parameters accessible from the various panel.

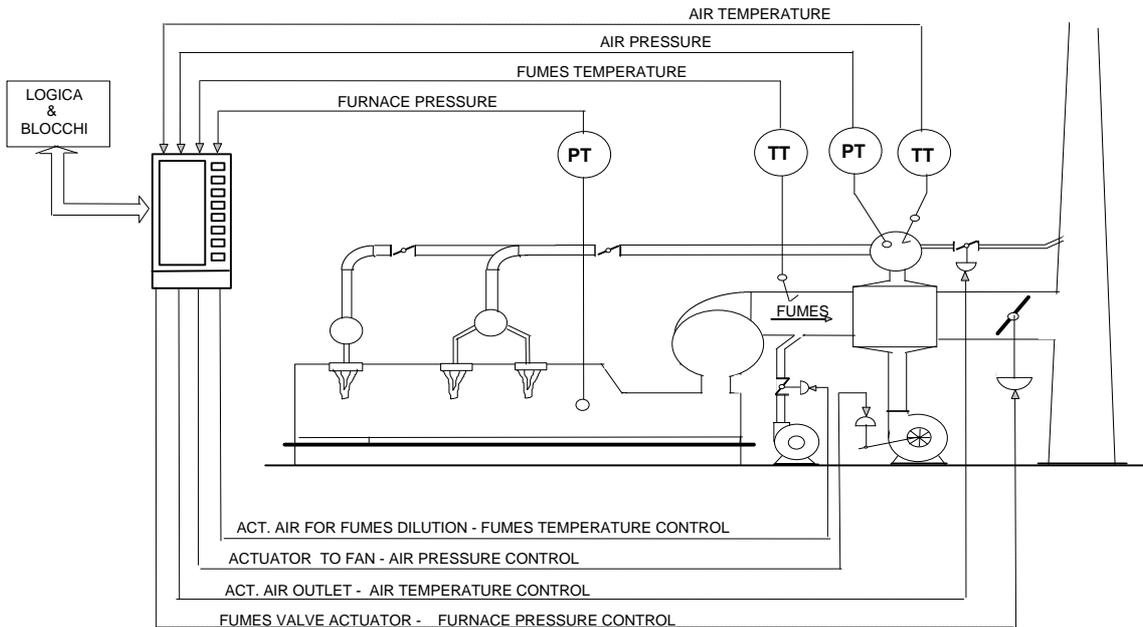
## 21.7 Applications

This easy to use configuration is for simple applications, where standard PIDs are required to control up to 4 independent variables. It has the big advantage of providing 4 loops in just one box, with perfectly identical characteristics, providing an attractive price/performance solution.

Furthermore, the loops have some additional functionality, like alarms and forcing modes, for implementing a more advanced control than the basic PID.

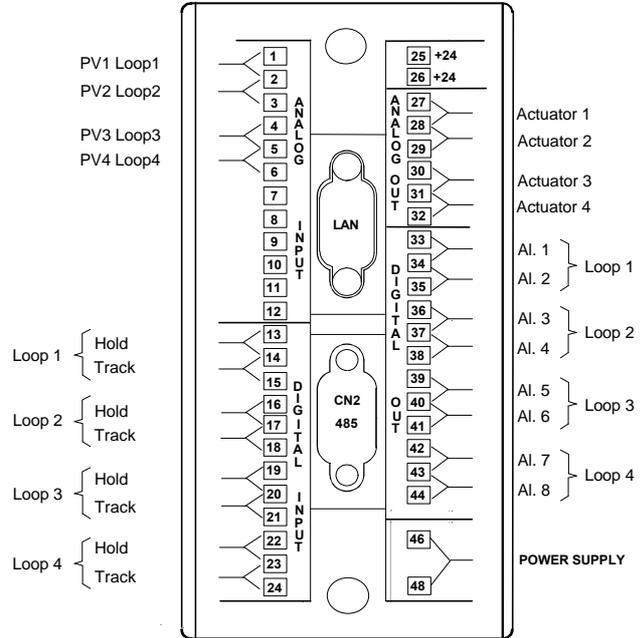
A typical example of a process where this configuration is targeted, is the control of the combustion of a reheating furnace, where the 4 loops are controlling:

- Air pressure
- Air temperature
- Furnace pressure
- Fumes temperature at the recuperator



## 21.8 Electrical Connections

The following picture provides a clear view of all the termination blocks, with the associated functionality, and it is specific of this configuration. No signals must be connected to the termination blocks not used by the strategy. The termination blocks 25 and 26 are providing a 24V DC output, particularly suitable to supply of the 2 wires transmitters.



## 22. 4 Indicators

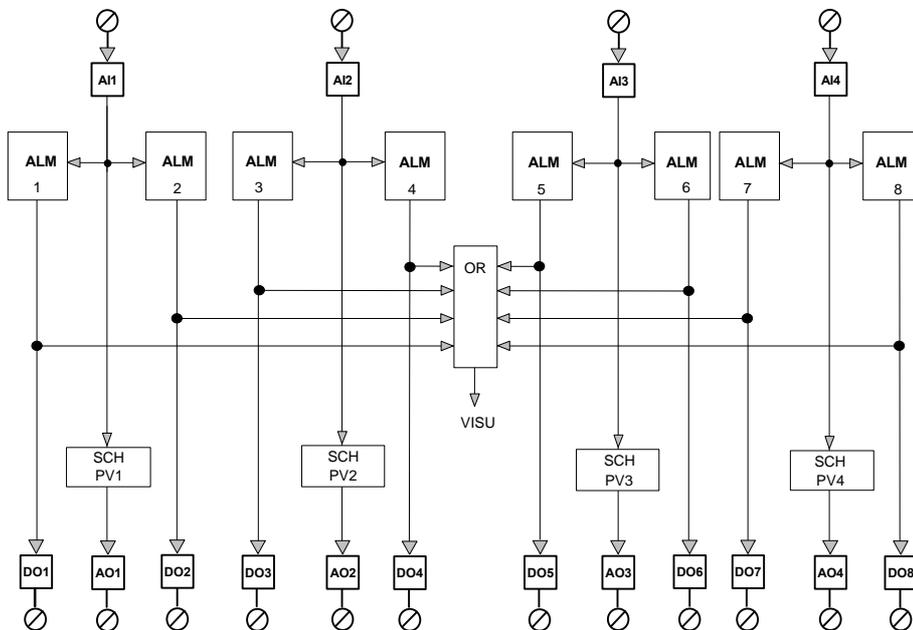
### 22.1 Description

The drawings below are providing the following informations:  
 Block Diagram.  
 User interface, consisting in a set of display panels.  
 Termination unit for the connection to the field.

This configuration provides the monitoring of 4 analog inputs with 2 associated alarms and retransmission of the variable, after an optional reranging operation. The alarms are fully configurable, but, usually, they are programmed one as a low alarm and the other as an high alarm. For this reason, this common high/low configuration has been used in the picture below.

### 22.2 Block Diagram

In the following block diagram the interconnections between the various modules and the display panels are not indicated, in order to improve the understanding of the functionality performed.



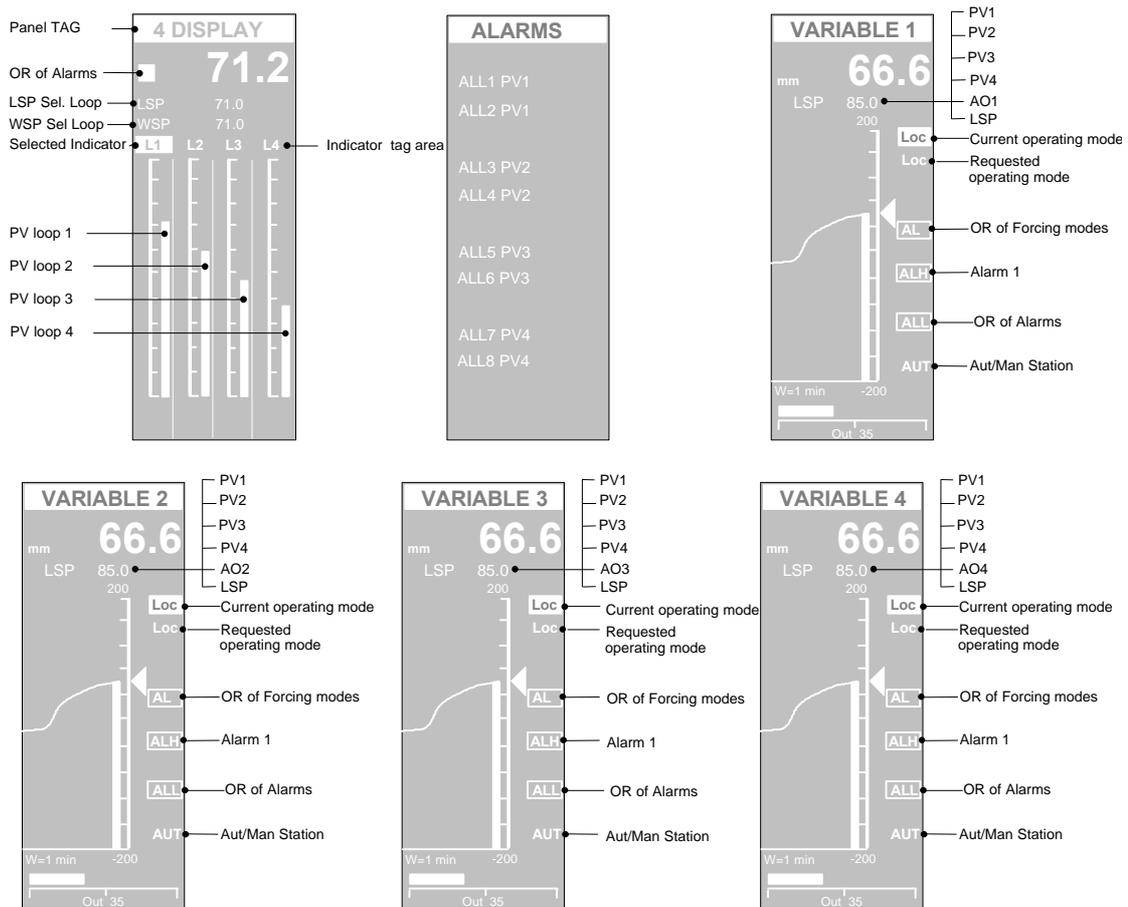
### 22.3 Alarms

Each analog input is connected to 2 alarms modules, with absolute programmable threshold. The status of the alarm is retransmitted out of the digital outputs.

### 22.4 Variables Retransmission

All the 4 analog inputs are retransmitted out, after a reranging operated by the SCH PV modules. This SCH PV modules allow the modification of the ranges of the retransmitted outputs, that are not, necessarily, the same of the inputs. This is achieved by setting the input range parameters of the SCH module to different values than the output range parameters. In this way, the retransmitted variable can be limited to a portion of the input signal scale, with the advantage of an improved resolution.

## 22.5 Graphic Displays



This configuration offers 6 display panels.

The panel with the four bargraphs gives a complete view of all the 4 input measures. It provides the bargraph indication of all the variables, plus the numeric indication, with large size digits, of the selected variable.

You select the variable, by pressing the , as you do when you operate with the configurations with multiple loops. The measure that has been selected is highlighted by the fact that the tag is displayed in reverse.

The span of the bargraph can be different to the original one of the analog input. For instance, you can display only a portion of the full span, in order to have a better resolution. This “Zoom” effect applies only to the bargraph, while the numeric indication, always reflects the full value of the variable.

The status of the alarms is flagged by the small box on the upper left part of the panel. When an alarm or a forcing mode is activated, the box blinks continuously, to alert the operator. Next, the operator can get a more detailed view of the alarms, by looking at the ALLARMS panel.

Furthermore, a trend panel is available, for each of the analog input. This page, similar to the one used for loops, has a trend chart, with programmable time width, that presents the recent trend profile of the variable. At the top of the panel the numeric indication, with large size digits, of the variable is displayed. The squared digital indications, on the right side of the panel, reports, in the order from the top: the global alarms flag, the status of the first alarm of the variable and the status of the second alarm of the variable.

By pressing  the values of the 5 variables, shown in the picture, are displayed, one at a time, in the scrollable display area.

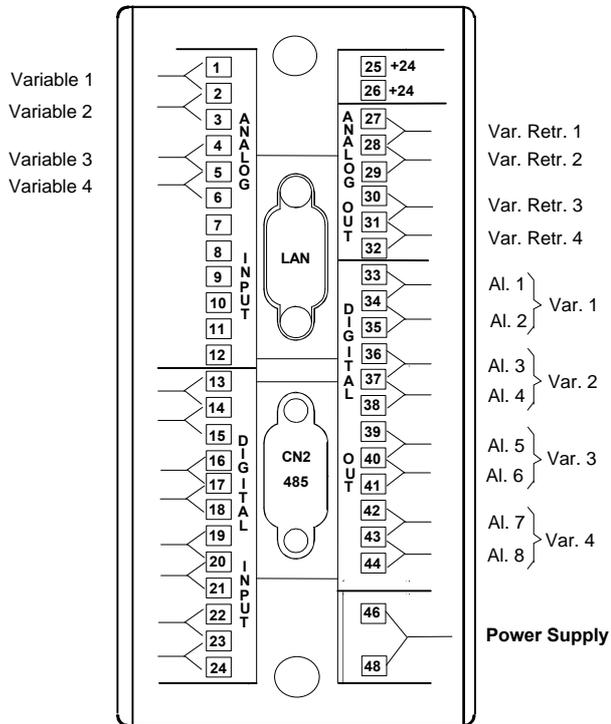
Furthermore, on the trend chart, the range of the trended profile can be a portion of the full range of the variable in order to enhance the resolution on the interesting part of the span.

## 22.6 Applications

Monitoring of 4 variables, with alarms and retransmission.

## 22.7 Electrical Connections

The following picture provides a clear view of all the termination blocks, with the associated functionality, and it is specific of this configuration. No signals must be connected to the termination blocks not used by the strategy. The termination blocks 25 and 26 are providing a 24V DC output, particularly suitable to supply of the 2 wires transmitters.



## 23. A/M Station

### 23.1 Description

The drawings below are providing the following informations:  
Block Diagram.

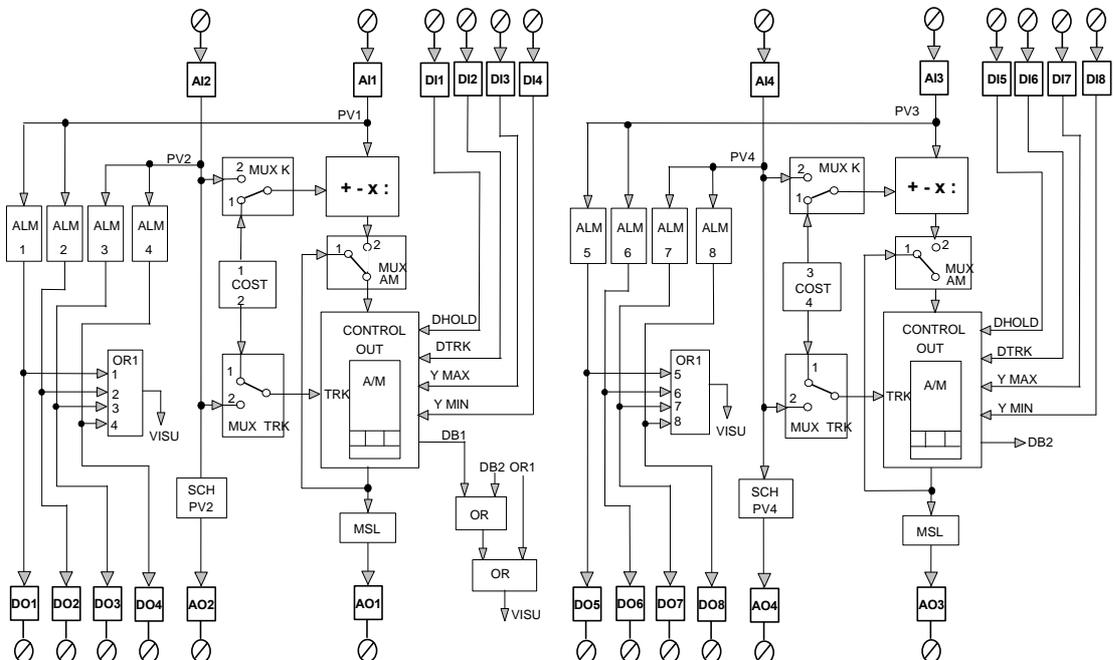
User interface, consisting in a set of display panels.

Termination unit for the connection to the field.

The description of the control functionalities is reported, in the following pages, related to the AM station 1, only. The functionality of the AM station 2 is perfectly identical but with the index numbers of the modules different. To get the proper index numbers for AM station 2, refer to the Block Diagram.

### 23.2 Block Diagram

In the following block diagram the interconnections between the various modules and the display panels are not indicated, in order to improve the understanding of the functionality performed.



This configuration offers 2 A/M station, for driving two actuators.

The features of each A/M station include, the Auto and the Manual operating mode, 4 Forcing modes, 4 alarms modules and a ratio calculation on the input variable.

When in MAN mode, the output of the A/M station is directly driven by the front panel of the instrument, while, when in Auto, the output corresponds to the analog input AI1, optionally divided by a ratio value. This ratio value can be either the AI2 analog input or a constant value store in a module.

The Forcing modes are: Tracking, Hold, Ymax and Y min.

The alarms are on the input variables and of absolute type.

### 23.3 Forcing Modes

These operations are related to the A/M station output, that can be driven by other sources than the keyboard or the input variable.

The A/M station allows the following 4 forcing modes, selected through the DI1, DI2, DI3 and DI4, when the operating mode is AUTO:

- Tracking** It is enabled by the DI2 digital input and it consists in setting the output to a predefined constant value or to the AI2 value
- Hold** When DI1 is active, the control output is frozen at the value it had at the time of the rising transition.
- Hold+Ymax** When both DI1 (Hold) is active and DI3 is active, the output is forced to its maximum value, defined by the parameters of the CONTROL OUT module.
- Hold+Ymin** When both DI1 (Hold) is active and DI4 is active, the control is forced to its minimum value, defined by the parameters of the CONTROL OUT module.

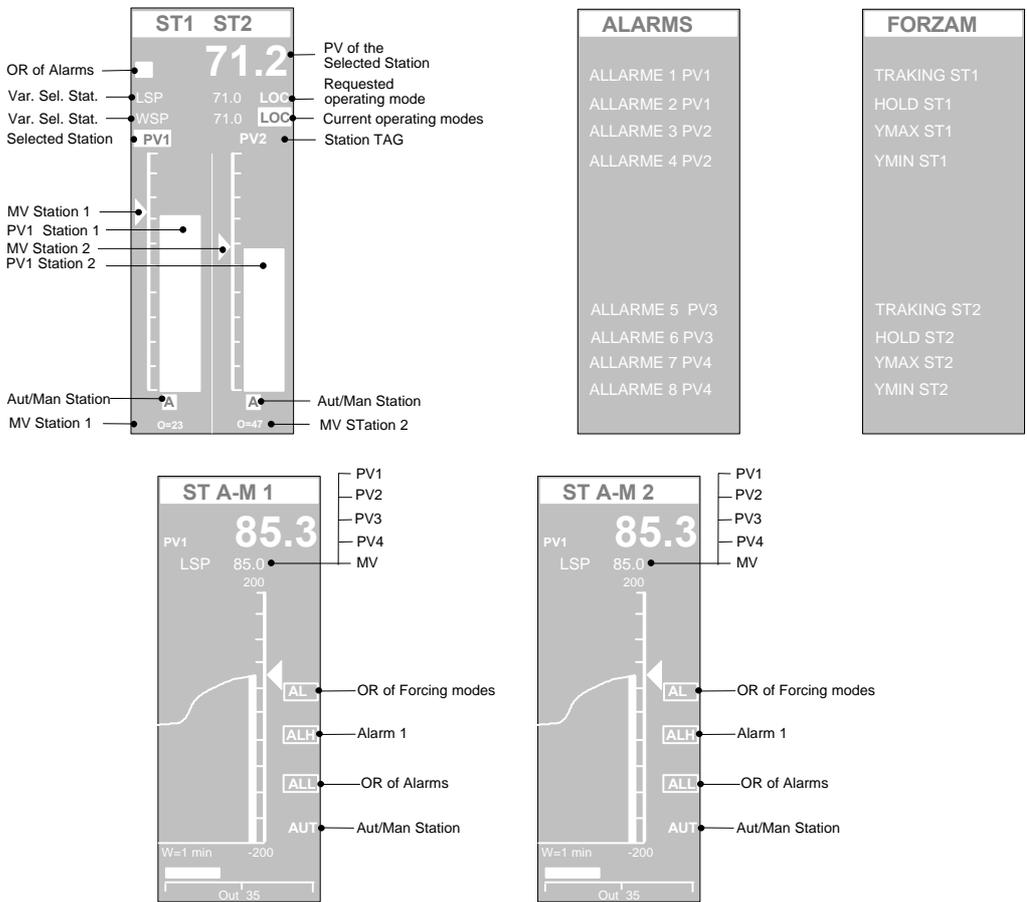
### 23.4 Alarms

Four alarm modules are provided, two for the AI1 and two for the AI2 analog input. The status of the alarms is transmitted out through the DO1-2-3-4 digital inputs.

### 23.5 Variables Retransmission

Both the input variable AI1 and AI2 are retransmitted out to the termination unit, through the SCH PV module. The SCH PV module allows the modification of the ranges of the retransmitted output, that are not, necessarily, the same of the original input. This is achieved by setting the input range parameters of the SCH module to different values than the output range parameters. In this way, the retransmitted variable can be limited to a portion of the input signal scale, with the advantage of an improved resolution.

### 23.6 Graphic Display



This configuration offers 5 display panels, providing a complete and optimal operator interface.

The two bargraph panel provides a complete view of both the A/M stations, with a fine level of details on the most important parameters. It provides the bargraph indication of the outputs, plus the numeric indication, with large size digits, of the variable of the selected A/M station.

You select the station by pressing the  key, as you do when you operate with the configurations with multiple loops. The A/M station that has been selected is highlighted by the fact that the tag is displayed in reverse.

The status of the alarms is flagged by the small box on the upper left part of the panel. When an alarm or a forcing mode is activated, the box blinks continuously, to alert the operator. Next, the operator can get a more detailed view of the alarms, by looking at the ALLARMS panel.

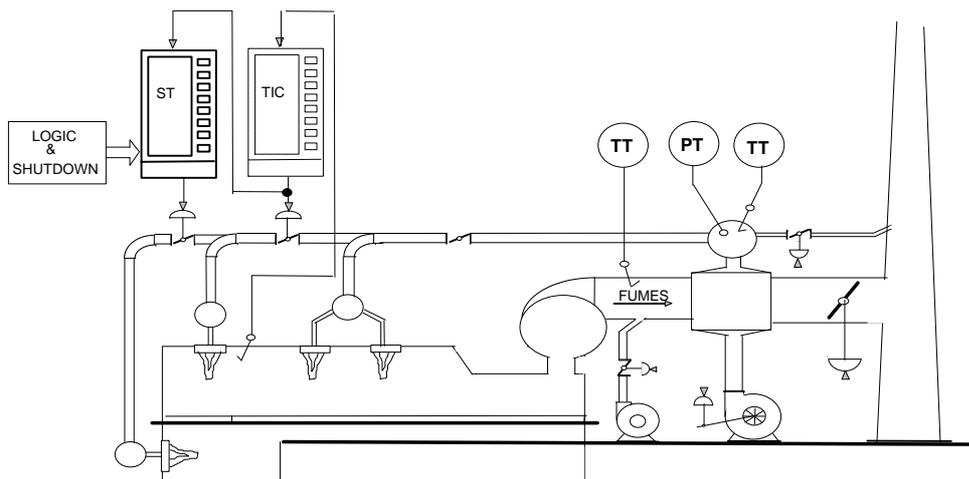
Furthermore, a trend panel is available, for each of the A/M station. This page, similar to the one used for loops, has a trend chart, with programmable time width, that presents the recent trend profile of the MV output variable. At the top of the panel the numeric indication, with large size digits, of the variable is displayed, together with all the variables of the scroll list, related to the A/M station.

## 23.7 Applications

The most common application of A/M station is when an actuator must be driven, directly or in ratio, either of an input signal or the signal from another actuator, leaving the possibility of performing manual or automatic forcing operations.

One example is the control of the lower heating zone of a furnace, that must be proportional to the heat demand of the upper zone. In this case, the PV1 input to the A/M station is the control output of the actuator of the upper zone, that, probably, is driven by a temperature PID loop. A ratio coefficient can be set in the Constant module of the A/M station, in order to define the ratio value between the level of outputs of the two actuators.

The Tracking forcing mode, that allows to bypass the normal way to control the actuator from the upper one, by driving it directly from the external signal AI2, is particularly useful for handling emergencies and start-ups.



## 23.8 Electrical Connections

The following picture provides a clear view of all the termination blocks, with the associated functionality, and it is specific of this configuration. No signals must be connected to the termination blocks not used by the strategy. The termination blocks 25 and 26 are providing a 24V DC output, particularly suitable to supply of the 2 wires transmitters.

