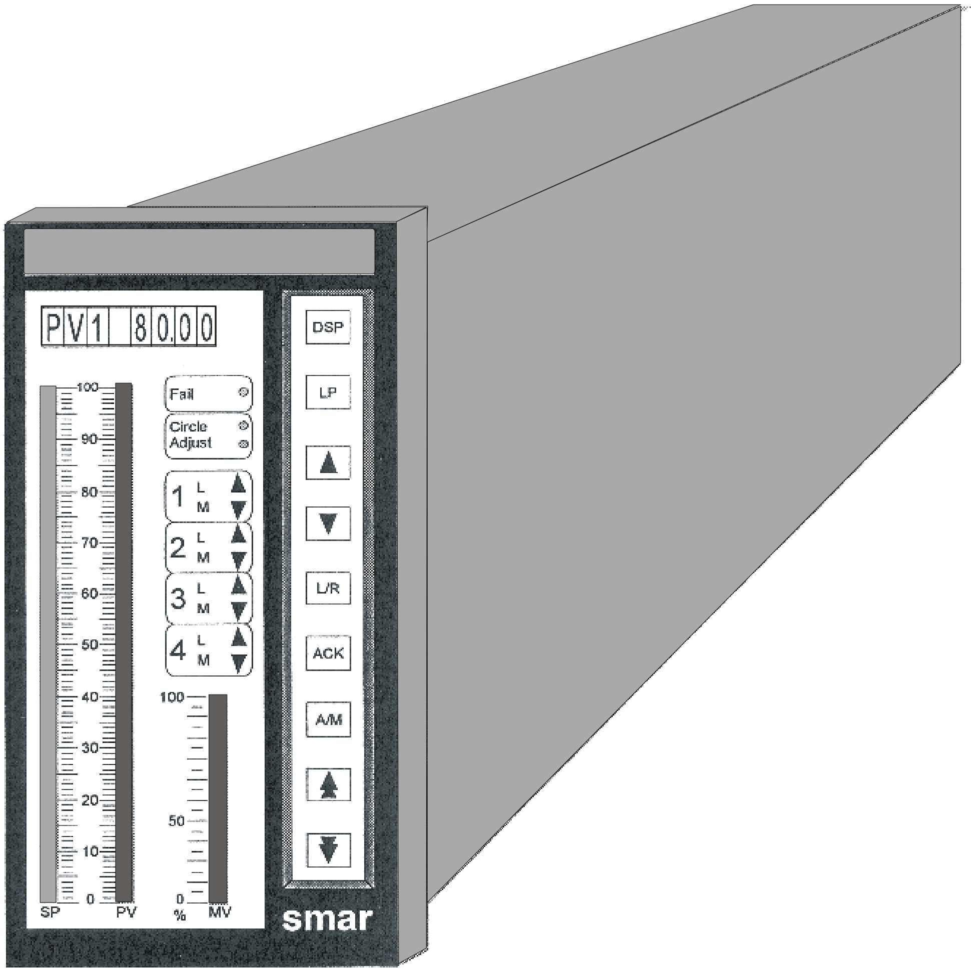
CD600 - smar

OPERATION & MAINTENANCE INSTRUCTIONS MANUAL

MULTI-LOOP CONTROLLER



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CD600

VERSION 2

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INTRODUCTION

The **CD600** Multi-Loop Digital Controller is a stand alone control station which combines the reliability of single loop control with the flexibility, loop coordination and economy of Multi-Loop control.

For the design engineer, the CD600 offers the function block concept, that combines in the same block several related functions. These function blocks provide all the computational and control functions needed for advanced control strategies but yet are very easy to use. A wide variety of preconfigured control strategies are also available in plug-in memories for the hand held terminal. New control strategies are very easy to implement.

For the operating personnel the CD600 offers na user friendly control panel with individual push buttons, an eight-digit alphanumeric display and a reliable hardware. If the controller must be reconfigured or if an unlikely Fault occurs, the controller outputs are automatically switched to the independent backup station.

And for the plant management, the CD600 offers cost effective modularity. Management information through digital communication and plant integration through CRT based operator station.

TABLE OF CONTENTS

SECTION 1 - OPERATION ... 1.1
FRONT PANEL OF THE CD600 ... 1.1
DESCRIPTION OF THE FRONT PANEL ... 1.1
BARGRAPHS DESCRIPTON ... 1.1
LOOP SELETION ... 1.2
ALARM ACKOWLEDGEMENT ... 1.2
BACKUP STATION ... 1.4

SECTION 2 - TUNING ... 2.1

SECTION 3 - PROGRAMMING ... 3.1
INTRODUCTION ... 3.1
DOWNLOAD MODE ... 3.22
OPERATION MODE ... 3.23
BLOCK ADJUSTMENT/CHARACTERIZATION ... 3.26
BLOCK MONITORING ... 3.28
UTILITY MODE ... 3.30
VS - SOFTWARE VERSION ... 3.32

SECTION 4 - LIBRARY OF FUNCTION BLOCKS ... 4.1
FUNCTION TABLE ... 4.1
FUNCTION 01 - ANALOG INPUT (AI) ... 4.2
OPERATION ... 4.2
FUNCTION 02 - CURRENT OUTPUT (CO) ... 4.3
OPERATION ... 4.3
FUNCTION 03 - VOLTAGE OUTPUT (VO) ... 4.4
OPERATION ... 4.4
FUNCTION 04 - DIGITAL INPUT (DI) ... 4.5
OPERATION ... 4.5
FUNCTION 05 - DIGITAL OUTPUT (DO) ... 4.6
OPERATION ... 4.6
FUNCTION 06 - FRONT VIEW (FV) ... 4.7
OPERATION ... 4.7
FUNCTION 07 - LOCAL/REMOTE SP SELECTOR (L/R) ... 4.9
OPERATION ... 4.9
FUNCTION 08 - AUTOMATIC/MANUAL STATION (A/M) ... 4.12
OPERATION ... 4.12
FUNCTION 09 - ADVANCED PID (PID) ... 4.16
INTRODUCTION ... 4.16
DEFAULT ... 4.29
FUNCTION 11 - STEP CONTROLLER (TEP) ... 4.30
OPERATION ... 4.30
FUNCTION 12 - MULTIPLIER-DIVIDER-ADDER-SUBTRACTOR (ARTH) ... 4.34
OPERATION ... 4.34
FUNCTION 13 - SQUARE ROOT (SQR) ... 4.39
OPERATION ... 4.39
FUNCTION 14 - LINEARIZATION (LIN) ... 4.40
OPERATION ... 4.40
FUNCTION 15 - DERIVATIVE/LEAD-LAG (LL) ... 4.42
OPERATION ... 4.42
FUNCTION 16 - PRESSURE AND TEMPERATURE COMPENSATION (PTC) ... 4.46
OPERATION ... 4.46
FUNCTION 17 - POLYNOMIAL (POL) ... 4.50
OPERATION ... 4.50
FUNCTION 18 - TOTALIZATION (TOT) ... 4.52
OPERATION ... 4.52

FUNCTION 19 - PULSE TOTALIZATION INPUT (P/DI)....4.54
OPERATION....4.54
FUNCTION 20 - BATCH COMPARATOR (BAT)....4.59
OPERATION....4.59
FUNCTION 21 - SETPOINT GENERATOR (SPG)....4.61
OPERATION....4.61
FUNCTION 22 - DOUBLE ALARM (ALM)....4.63
OPERATION....4.63
FUNCTION 23 - LIMITER WITH ALARM (LIMT)....4.65
OPERATION....4.65
FUNCTION 24 - LOGIC (LOG)....4.69
OPERATION....4.69
FUNCTION 25 - TIMER (TMR)....4.71
OPERATION....4.71
FUNCTION 26 - HIGH/LOW SELECTOR (H/L)....4.72
OPERATION....4.72
FUNCTION 27 - INTERNAL/EXTERNAL SELECTOR (SSEL)....4.73
OPERATION....4.73
FUNCTION 28 - CONSTANT ADJUSTER (ADJ)....4.73
OPERATION....4.74
FUNCTION 29 - INPUT SELECTOR (ISEL)....4.76
OPERATION....4.76
FUNCTION 30 - OUTPUT SELECTOR (OSEL)....4.78
OPERATION....4.78
FUNCTION 31 - LINEARIZATION CURVE (PNT)....480
OPERATION....4.80
FUNCTION 32 - GENERAL VISUALIZATION (GV)....4.84
OPERATION....4.84
FUNCTION 33 - CONSTANTS (K)....4.85
OPERATION....4.85
FUNCTION 34 - SCAN (SCN)....4.86
OPERATION....4.86
FUNCTION 35 - SCAN/ACTUATION OF THE PARAMETERS PID (PRM)....4.89
OPERATION....4.89
FUNCTION 36 - ACTUATION (ATU)....4.91
OPERATION....4.91

SECTION 5 - RESIDENT CONFIGURATION.... 5.1

SECTION 6 - TECHNICAL SPECIFICATIONS.... 6.1
POWER SUPPLY AND CONSUMPTION....6.1
VOLTAGE....6.1
CONNECTION DIAGRAMS....6.6
ORDERING CODE....6.8

SECTION 7 - CALIBRATION.... 7.1
ANALOG INPUT (AI)....7.1

SECTION 8 - COMMUNICATION.... 8.1
INTRODUCTION....8.1
CONTROLLER ADDRESSING....8.1
BAUD RATE....8.2
CYCLE TIME ADJUSTMENT....8.3
INTRODUCTION....8.3

SECTION 9 - INSTALLATION.... 9.1
INITIAL INSPECTION....9.1
POWER SUPPLY....9.1
EQUIPMENT INSTALLATION....9.2
PANEL LAYOUT....9.2

WIRING 9.3
COMMUNICATION 9.5
SIGNAL CABLES INTERCONNECTION 9.6
TRANSPORTATION AND STORAGE 9.8

APPENDIX A – SRF – SERVICE REQUEST FORM A.1

APPENDIX B – SMAR WARRANTY CERTIFICATE B.1

Section 1

OPERATION

Front Panel of the CD600

The front panel of the CD600 (Figure 1.1) consists of three bars of LEDs, an alphanumeric display, a group of Keys for adjustment and control, and signaling LEDs.

Description of the Front Panel

Bargraphs Descripton

SP - Indication of monitored loop's Setpoint it is indicated on the green 101 LEDs bargraph.

PV - Indication of the monitored loop's Process Variable. It is indicated on the red 101 LED's bargraph.

MV - Indication of the monitored loop's Manipulated Variable. It is indicated on the red 41 LEDs bargraph

Since the visualization of each loop can be freely configured by the user. The three bargraphs may also be used for other purposes.

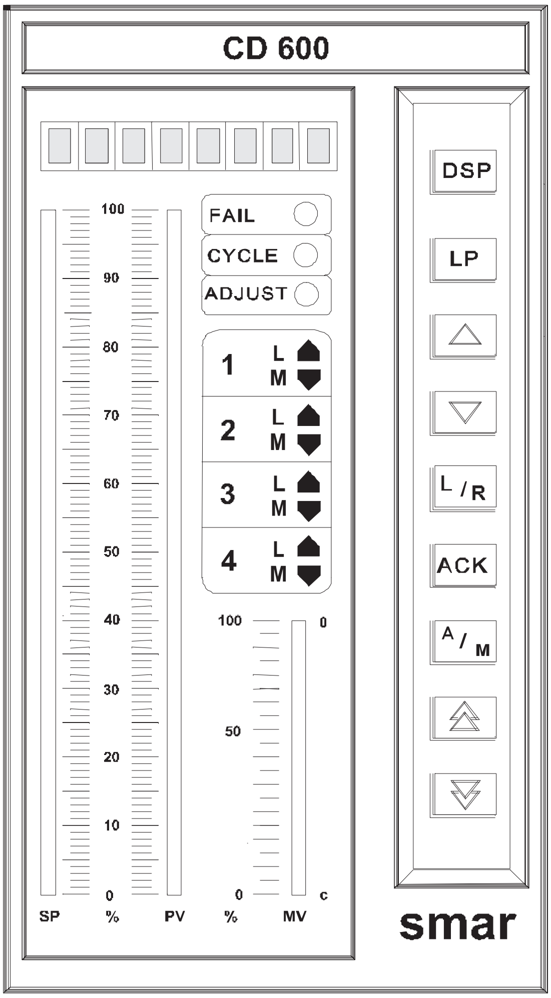


Fig 1.1 - Front Panel

KEYS	DESCRIPTION
DSP	Selects the variable to be shown in the alphanumeric display.
LP	Selects the loop to be monitored on the front panel.
△	Increases the value of the variable shown on the display.
▽	Decreases the value of the variable shown on the display.
L/R	Selects the Local Setpoint or the remote Setpoint of the monitored loop.
ACK	Alarm Acknowledgement
A/M	Selects the Automatic or Manual mode of the monitored Loop.
⇑	Increases the MV value, when the control is in Manual. When touched shows the output value on the display.
⇓	Decreases the MV value, when the control is in Manual. When touched shows the output value on the display.
FAIL ○	When lit, indicates that the controller is in fault condition.
CYCLE ○	Blinks every 10 cycles, during cycle time adjustment (refer to section 8 communication).
ADJUST○	When lit, indicates that the variable, which is being shown on the display can have its value changed by the keys <∆> and <∇>.
1 L ▲ M ▼	**1, 2, 3 or 4 -** When lit, indicates that the variables, shown on the front panel refer to the respective Loop. **L** - When lit, indicates that the respective Loop is working with Local Setpoint. **L** unlit means Remote Setpoint. **M** - When lit, indicates that the respective Loop is working in the Manual mode. **M** unlit means Automatic Operation. ▼or ▲- When lit, indicates an alarm situation.

Loop Seletion

A short touch on the <LP> key lets the display show the Tag (see below) of the loop being monitored. A longer touch transfers the monitoring to the next Loop. Initially, the new Loop's Tag is show and, after a few seconds, the monitored information.

Alarm Ackowledgement

Independently of the Loop selected and of the variable, being shown on the display, if any alarm, which has been programmed to be indicated on the front panel, occurs, the display goes on to show the information of the variable and the **"*ALARM"** information alternately. Furthermore, one of the L▼D's < ▲ or < > from the respective loop, blinks.

As soon as the operator presses the <ACK> key for the first time, the Tag, which identifies the configuration, appears on the display, followed by the mnemonic message of the alarm. The message will blink until the operator presses the <ACK> Key again, acknowledging the alarm. After acknowledgement, the message stops blinking and remains displayed if the alarm condition persists. Otherwise, will be displayed the next alarm of the stack or the "NO ALARM" message, if no alarm exists.

The alarm acknowledgement can also be made automatically. It means that when an alarm condition disappears, the message also disappears, without the acknowledgment by the <ACK> key.

While the alarm is present, the alarm message remains stored in memory stack with capacity for up to 36 alarm messages.

With the keys <∆> and <∇>, the operator can scroll the stack, checking whether there are other alarms present or not.

Among the alarm messages, which can be visualized on the display, the user can write eight, and the remainders are fixed messages. The blocks that can provide these alarms, and its characteristics, are listed in table 1.1.

BLOCK	TYPE	DEFAULT MNEMONIC	CONFIGURABLE MNEMONIC
001	BURNOUT	AI1 OUT	NO
002	BURNOUT	AI2 OUT	NO
003	BURNOUT	AI3 OUT	NO
004	BURNOUT	AI4 OUT	NO
005	BURNOUT	AI5 OUT	NO
006	BURNOUT	AI6 OUT	NO
007	BURNOUT	AI7 OUT	NO
008	DEV/BURNOUT	AI8 OUT	NO
009	DEV/BURNOUT	A01 OUT	NO
010	DEV/BURNOUT	AO2 OUT	NO
011	DEV/BURNOUT	AO3 OUT	NO
012	DEV/BURNOUT	AO4 OUT	NO
039	DEVIATION	DEV - 1	NO
040	DEVIATION	DEV - 2	NO
041	DEVIATION	DEV - 3	NO
042	DEVIATION	DEV - 4	NO
077 (1st comp)	LOW/EQUAL/HIGH	LOW COMP	YES
077 (2nd comp)	LOW/EQUAL/HIGH	HGH COMP	YES
078 (1st comp)	LOW/EQUAL/HIGH	LOW COMP	YES
078 (2nd comp)	LOW/EQUAL/HIGH	HGH COMP	YES
079 (1st comp)	LOW/EQUAL/HIGH	LOW COMP	YES
079 (2nd comp)	LOW/EQUAL/HIGH	HGH COMP	YES
080 (1st comp)	LOW/EQUAL/HIGH	LOW COMP	YES
080 (2nd comp)	LOW/EQUAL/HIGH	HGH COMP	YES
081	UPPER LIMIT	LIM H 01	NO
081	LOWER LIMIT	LIM L 01	NO
081	SPEED	VELOC 01	NO
082	UPPER LIMIT	LIM H 02	NO
082	LOWER LIMIT	LIM L 02	NO
082	SPEED	VELOC 02	NO
083	UPPER LIMIT	LIM H 03	NO
083	LOWER LIMIT	LIM L 03	NO
084	SPEED	VELOC 03	NO
085	UPPER LIMIT	LIM H 04	NO
085	LOWER LIMIT	LIM L 04	NO
085	SPEED	VELOC 04	NO

Table 1.1 - Alarm Characteristics

Backup Station

Optionally, the CD600 controller can have a backup station, whose main function is to guarantee the current signals to the final control elements connected to the controller. By pressing the lock spring on the lower part of the front frame and pulling it until the second lock, the operator has access to the backup station (Figure 1.2). This backup can take on the current signals in two distinct situations:

1. **MANUALLY** - By positioning the <**AUTO/BACKUP**> switch in the "**BACKUP**" position, the operator can adjust the four current outputs independently by means of the respective adjustment knobs. When the output current reaches the value adjusted on the knob (with a ±2.5% capturing band) the LED located close to the current is being sent to the final control element.

2. **AUTOMATICALLY** - With the <**AUTO/BACKUP**> switch in the "**AUTO**" position, a power supply fault in the controller, or a fault of the Processing Unit (CPU) switches the command to the backup station. Each one of the four current signals can remain at the last value generated by the controller or go to the value adjusted on the respective knob. Definition of the switching mode is made independently for each output by means of DIP switches on the lower part of the GLL 660 board (Figure 1.3)

OFF Position - Output freezes at the last value generated by the controller.
ON Position - Output ramp up or down to the value adjusted on the respective knob.
Access to the DIP switches is obtained by removing the front panel of the backup (Figure 1.2). If the safety position (**ON**) is chosen, when switching to the backup takes place, the output goes to the adjusted value at a rate of 10%/second. After the current equalizes with the knob adjustment, the respective LED lights up; from the on the operator can adjust the output with the knob.
If the backup is configured to "freeze" (**OFF** Position), when the output switches to the backup station, it freezes in the last controller output value. In order to adjust the output with the knob, the operator “finds” the frozen value by rotating the knob until the LED lights up. From now on the output follows the value adjusted on the Knob.

Note
Should any main board's fault occur when the output is out of the potentiometer actuation range (3.6 mA > output > 20.4 mA), it is necessary to switch the controller to backup, setting the DIP switch (on the lower part of the GLL 660 board - Figure 1.3) to **ON** position.

From top to bottom, the knobs correspond to the outputs available at the terminals **6B, 7B, 8B** and **9B** on the rear panel of the **CD600**.

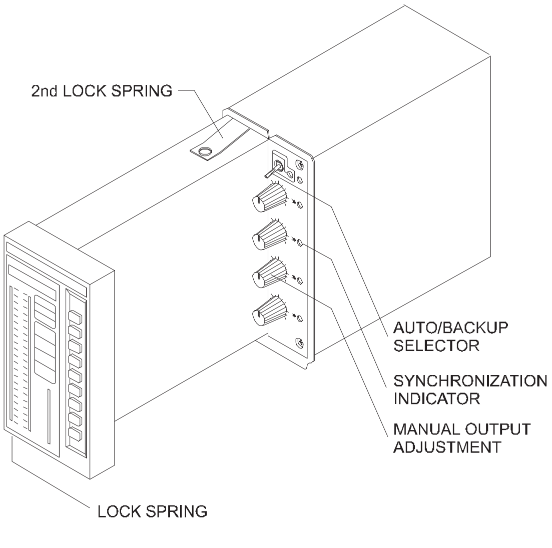


Fig. 1.2 - The Backup Station

Furthermore, when the controller is out-of-order, the backup station also defines the states of the first four digital outputs (terminals **3A, 4A, 5A** and **6A**). The state of these outputs, in case of transferring to the backup station, is defined by four DIP switches existing on the upper part of the GLL 660 board, see Figure 1.3.

ON Position - output open (output transistor cutoff).
OFF Position - output closed (output transistor conducting).

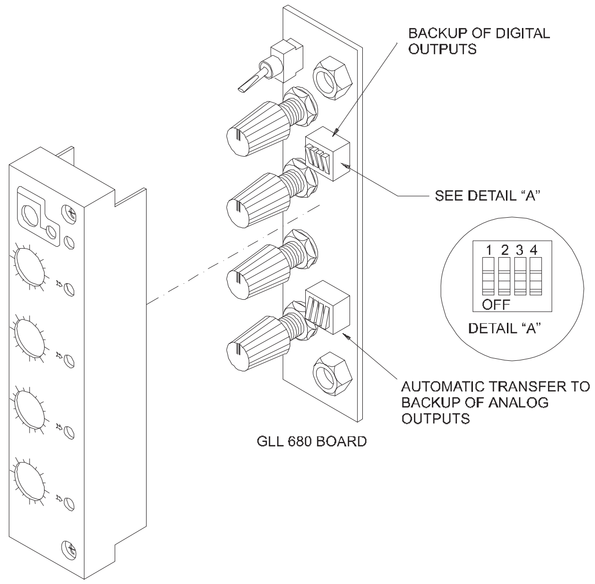

BACKUP OF DIGITAL OUTPUTS
SEE DETAIL "A"
1 2 3 4
OFF
DETAIL "A"
AUTOMATIC TRANSFER TO BACKUP OF ANALOG OUTPUTS
GLL 680 BOARD

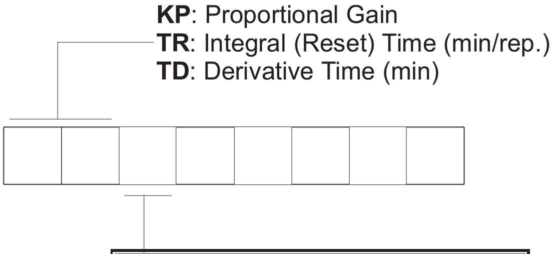
Fig. 1.3 - Dip Switches on GLL 660 Backup Station Board

TUNING

Proportional gain, Integral time and Derivative time constants of any Proportional, Integral, Derivative *(PID)* block existing in the controller's configuration may be adjusted from the front panel without using the Programmer. To make it possible, it is necessary to set the **CACT** parameter, of the respective *PID* block, to "0" or "1".

In order to use the front panel, the key <**NORM/CONF**> on the right of the programmer connecting jack, switches the display and the two adjustment keys <∆>, <∇> from normal operation to tuning mode and vice-versa. Independently of the variable which was being shown previously, the display goes on to indicate the value of the proportional constant of the *PID*, of the selected Loop. If there is more than one *PID* Block in the Loop (Cascade Control, for example), the proportional gain referring to the smallest *PID* block number appears on the display first. In this case, the user should know the blocks which comprise the Loop, in order to identify which one is the "master" and which one is the "slave".

The mnemonic of each constant consists of two letters, which identify the type of action, and one number which identifies the *PID* Block.


KP: Proportional Gain
TR: Integral (Reset) Time (min/rep.)
TD: Derivative Time (min)

1	**BLK039**	**1st**	Advanced PID
2	**BLK040**	**2nd**	
3	**BLK041**	**3rd**	
4	**BLK042**	**4th**	
5	**BLK043**	**1st**	Simple PID
6	**BLK044**	**2nd**	
7	**BLK045**	**3rd**	
8	**BLK046**	**4th**	

Table 2.1 - PID Block corresponding number for front panel Tuning

When the existing configuration has more than one Loop, the key <LP> is used to change the Loop and to obtain its *PID* parameters.

By means of the <∆>, <∇> keys, the PID constants can be adjusted as long as the <**SAFE**/**NVRAM**> switch is in "**NVRAM**" position. The scroll of all tuning parameters of all the *PID* blocks of a Loop is made by the <DSP> key.

The front panel Keys (DSP, ∆, ∇, ACK) return to their normal functions by pressing the key <**NORM**/**CONF**> or in 20 seconds, if any key frontal panel is not actuated.

Notes:

a) Using the **SMAR Hand-Held Terminal** in **OPERATION** mode (Section 3) it is also possible to tune the controller.

b) Tuning by front panel can be inhibited by the configuration or by positioning the <**SAFE**/**NVRAM**> switch in "**SAFE**" position.

c) Tuning can also be done through a computer connected to the communication port or to the jack used for the **Hand-Held Terminal**.

PROGRAMMING

Introduction

The programming of the **SMAR CD600 Digital Controller** is based on the concept of ***freely interconnectable Function Blocks***. The interconnection is done in accordance to the control strategy defined by the user.

All the function blocks already exist in a part of the memory not accessible by the user. Programming the controller means to configure it by calling the necessary blocks into the user memory, NVRAM, link them together, set their **Characterization** and **Adjustment** parameters to fit a specific application.

Exchange of information between the used control algorithm and the process is done by means of the input and output Function Blocks (both analog and digital). By these blocks the programmed configuration is "physically" connected to the controller terminal block. Therefore, for example, the **Analog Input** block **No.1** can only be used for reading and processing the signal which is connected to the terminal **18A** (first analog input).

TYPICAL DESCRIPTION OF A BLOCK
The blocks described in Section 4 have a **Control Function**, consisting of one or more mathematical and/ or logical operations. The function will relate block inputs with block outputs. The inputs are designated by letters (A, B, C...), and outputs are designated by numbers. Exceptions are the Analog and Digital input and output blocks, whose inputs, respectively outputs, are related to hardwired terminals.

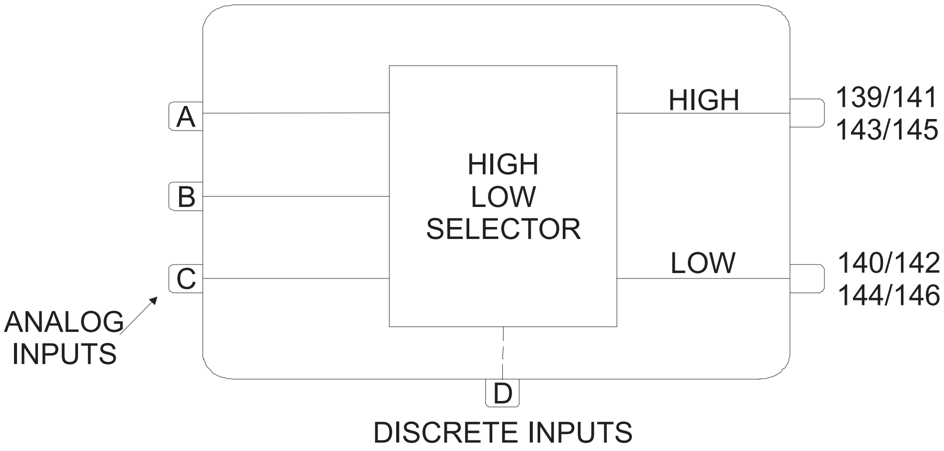


Fig 3A - Typical Block

The numbers related to the block outputs are addresses. Each number refers exclusively to a certain output of a certain block and vice versa.
Each block has one **Linking Parameter (L)** for each input. A block with three inputs has the **Linking Parameters LIA**, **LIB**, and **LIC** (Link Input **A**, **B** and **C**). If the HIGH-LOW selector block shown in Figure 3A has **LIA**=2, that means that the input **A** of that block is on.
As a block can perform several operations, the activations of these operations are defined by the **Characterization Parameters**. For example, the **Analog Input** block offers a choice of implementing **SQ**uare **R**oot extraction (**CSQR**=1) or not (**CSQR=0**). It offers also a choice to use **LIN**earization (**CLIN**=1) or not (**CLIN**=0) - (See Figure 3B).

Constants in the Function Blocks that require frequent changes during process operation are called **Adjustment Parameters** (**A** Parameters). The same **Analog Input** block has an adjustable filter, which has a time constant adjustable by **ATIM**.

There are two types of signals between blocks: scalar and discrete. Scalar are continuous signals while discrete are on-off type of signals.

The signal transfer through block links is always made in the form of percentage, even if the signal is discrete (0% for low logical level 0 and 100% for high logic level 1). A scalar signal, connected to an input prepared to receive discrete signals, will be interpreted as follows:

- less than 70%:	level 0
- more than 80%:	level 1
- between 70% and 80%:	previous state

The output signal of a block can be received by as many inputs of blocks as desired.

THE LOOPS

A Loop is a set of interconnected blocks with a certain purpose. It has a single man-machine interface for the manipulation and visualization of data by the front panel of the controller. The maximum number of loops per **CD600** is four.

The **CD600**'s program also offers a configuration workspace named **General Loop**, "**LOOP G**" which contains only blocks that may be simultaneously used by more than one loop. An example of information maintained in the General Loop are the coordinates of the points used by a linearization curve that may be used by several Analog Inputs simultaneously.

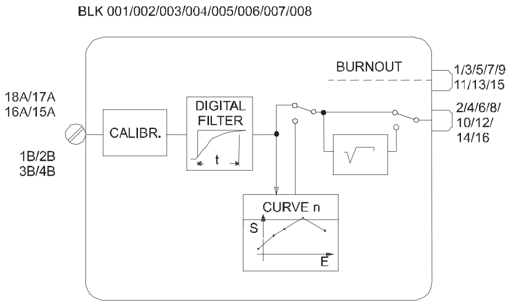
The Tag (Loop identification, see below) of the General Loop will always be the Tag of the whole configuration. All configurations **must have a General Loop**, even if the program contains only one control Loop. If no blocks are configured for the General Loop, at least a Tag must be given.

Function Name And Mnemonic

Function 01 - Analog Input (AI)

Operation

Schematic Diagram



Operational Description

All the analog inputs have a corresponding **Analog Input** block**.** The *analog input* 2, for example, which is connected to the **17A** terminal, corresponds to *block BLK002*. The input to the circuit is always a voltage signal (0-5 V or 1-5 V). If a current signal (0-20 mA or 4-20 mA) be used, a Shunt resistor shall be placed in the corresponding terminal block position.

The input signal passes through an analog second order BESSEL filter with cutoff frequency at 15 Hz.

The result is converted into a digital number and in this form, it passes through a four point calibration process in which 0V, 1V, 3V and 5V are made to correspond respectively to 0, 20, 60 and 100% for 0-20 mA/0-5 V input and -25, 0, 50 and 100% for 4-20 mA/1-5 V input. See the CALIBRATION section for further details**.**

After conditioning, the signal is digitally filtered with an adjustable time constant. It can be linearized in accordance with a curve established in the **Function 31 - Linearization Curve (Blocks 109 to 116)**, configured in Loop G. This curve is selected by **CLIN** and may be used with 13 or 26 pairs of points x, y, interconnected by straigh line segments. The curves that may be performed are show on table 4.31.1 page 4.59.

The signal can also have square root extraction, selectable by **CSQR**. The square root has an adjustable cutoff point (**ACUT**) for low signals. All values below **ACUT** will be considered 0%.

Parameter **CSQR** permits input signal selection (4-20 mA/1-5 V or 0-20 mA/0-5 V) and to decide whether square root will be extracted.

In **Burnout** (signal after calibration smaller than -2% or greater than +102%), an Alarm can be indicated on the front panel (if **CFRT**=1) and a **Burnout** alarm signal can be activated. This signal can be used, for example, to switch the process variable to another input through a block of the **Function 29 - Input Selector** or to force the controller's output to an emergency position.

Parameter List

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	CFRT	Indication of "Burnout" on front panel	0-No/1-Yes 2-Yes with Auto Ack	0
I	CLIN	Linearization (See Table 4.31.1 on Function 31 - Linearization Curve)	0-No 1?8/Curves 1?8 9-Curves 1 and 2 10-Curves 3 and 4 11-Curves 5 and 6 12-Curves 7 and 8	0
I	CSQR	Signal Selection and Square Root extraction	0-No (1 to 5V or 4 to 20mA) 1-Yes (1 to 5V or 4 to 20mA) 2-No (0 to 5V or 0 to 20mA) 3-Yes (0 to 5V or 0 to 20mA)	0
P	ACUT	Cutoff level for square root extraction	0.00 - 100.00%	1.00%
P	ATIM	Filter time constant	0.00 - 30.00s	0.20s

Used For Communication

Number of Bytes per Type of Parameter: A = 4 C = 6 L = 0

Fig. 3.B - Example of a Function Block

TAG

The Tag is the identification which must be given to each control Loop, as well as to the General Loop. It consists of up to 8 alphanumeric characters, for example:

FIC100, LI200, TIC00102, ...

The General Loop TAG is an identification of the controller, that may have up to 4 loops. The TAG can be the controller number, a name for the functions performed by the four loops or any other identification.

HOW TO PROGRAM THE CD600

When the **CD600** is delivered from the factory it already has a configuration called "4 loops" - see Section 5. This configuration may be changed to suit a particular application or replaced by a new configuration.

A program can be made, changed or have its parameters modified through a PC type computer or through the **Hand-Held Terminal**.

The PC type will require an appropriate interface and the software CONF600. More details are given in the CONF600 manual.

The programming with the **Hand-Held Terminal** is described in the following sections. The CONF600 software is a powerful graphical user interface using a mouse on the computer keyboard and menu type of data entry. The CONF600 can also run on a portable laptop or palmtop and can also be brought into the field as long as the hardware allows. Configuration is done by drawing the control blocks and their links, much in the same way as a control diagram or a wiring diagram on a CAD SYSTEM. Help windows provide parameter explanations, options and ranges. The CONF600 also works on-line with up to 29 CD600 giving continuously access to all parameters and input/output monitoring of all blocks, facilitating troubleshooting of configurations. The CONF600 package also provides for documention with hard copies of the configurations, configuration storage on disc and optionally, data transfer to, and from the HHT.

THE HAND-HELD TERMINAL

The configuration for the control to be performed by the **CD600** controller is prepared off-line with the **SMAR Hand-Held Terminal** (Figure 3.2).

The **Hand-Held Terminal** is powered by a 9V PP3 size battery or by a 9 Vdc external power supply (when it is not communicating with the controller) - see specifications on **Section 6 - Technical Specifications** - which can be connected to the jack located in the communication interface (See Figure 3.1). The **Hand-Held Terminal** can also be supplied directly by the controller, if:

a) The main board GLL600 is revision 3 or higher.
b) The communication interface has a Serial Number followed by an "A" letter (e.g.: Serial Number 01166A).

Any 9 volts "Power Pack" battery may be used. However, for longer operating life, alkaline batteries are recommended. After removal of the protective cover by pulling it downwards, insert the battery, observing the polarity (see Figure 3.2).

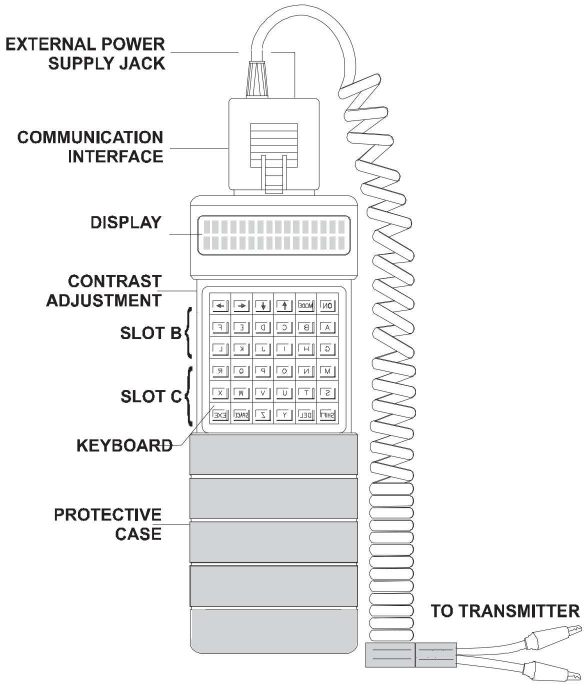


Fig 3.1 - Smar Hand-Held Terminal

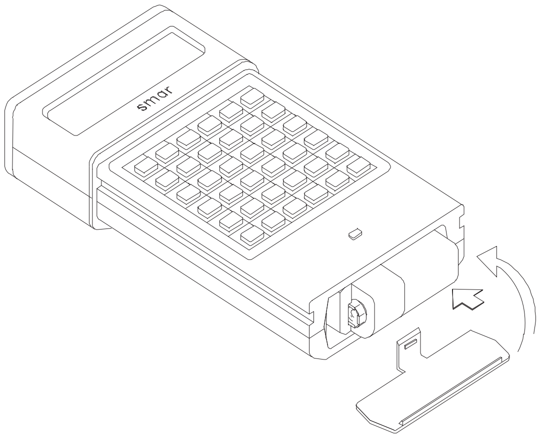


Fig 3.2 - Battery Case

The **SMAR Hand-Held Terminal** has a three-mode keyboard with double function keys. The initial mode is the alpha-uppercase mode. Switching from this mode to the alpha-lowercase or to the numeric mode is effected by pressing <**SHIFT**> and simultaneously <**CAP**> or <**NUM**>, respectively. To return, repeat the combination. The name of a respective function or character is indicated upon and above the keys. Keys with an operational function on the keyboard are described as follows:

ON

Used to switch on the **Hand-Held Terminal**. The display will show the menu, the list of available applications. It is also used to retrieve to the previous menu.

If the display is not easily readable, adjust the contrast. See Figure 3.1 to locate the contrast adjustment.

↑ ↓ ← →

Used to switch on the **Hand-Held Terminal**. The display will show the menu, the list of available applications. It is also used to retrieve to the previous menu.

SHIFT

Used to access the symbols and numbers indicated above the respective keys. When the programmer is in an alpha mode, this key should be pressed simultaneously with the desired symbol or number key. In the numeric mode, the alpha characters are reached instead of the numbers

DEL

Used to erase characters which have been pressed by mistake.

SPACE

Used to insert a blank space

EXE

Used to call a new Function Block in the **Program CD600** or to order a change in a **Linking**, **Characterization** or **Adjustment Parameter** while the old value appears on the display. Used also to confirm an action.

TO SWITCH THE HAND-HELD TERMINAL OFF, select option "**OFF**" from the **Opening Menu**, using the cursor keys and the <EXE> key, or by pressing key <0>. If the **Hand-Held Terminal** remains connected without any key having been pressed during a period of five minutes, it will switch itself Off automatically.

TO TURN THE HAND-HELD TERMINAL ON, PRESS ON
* TO TURN OFF, MOVE THE CURSOR TO OFF AND
PRESS EXE OR PRESS 0

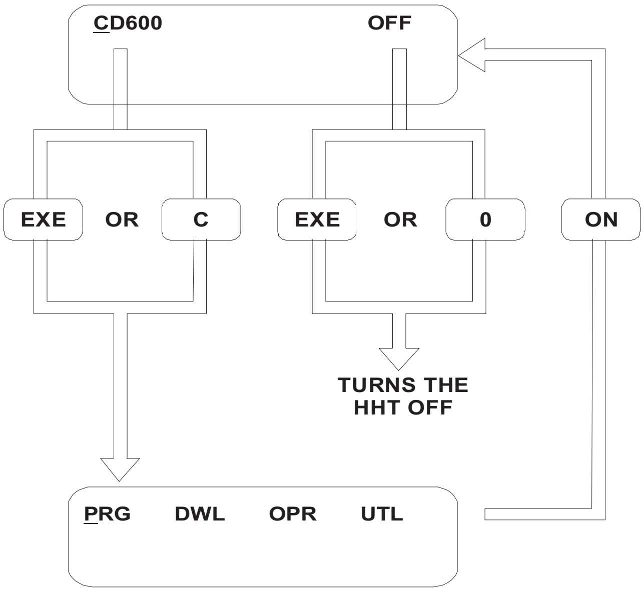


Fig 3.3 - Switching the Hand-Held Terminal On and Off

The **SMAR Hand-Held Terminal is, actually, a Microcomputer** (Figure 3.1) which, at the user's request, performs the execution of a program called "**CD600**", described in **Section 3**. This program is used to develop the control configurations for the **CD600** and to make the microcomputer "talk" with the **CD600**. The program is contained in a "**Program-Pack**", which must be inserted in slot "**B**". See Figure 3.1.

When the <EXE> key is pressed, the program is transferred from the Program Pack to the microcomputer's operational memory (Random Access Memory - RAM, device "**A**").

A second slot (slot device "**C**") is prepared for the "**Datapack**" or "**RAMPACK**" that contains or can store control configurations prepared by the user or preconfigured by **SMAR**.

The "**Datapack**" is a EPROM memory, thus it needs a EPROM Eraser to erase it.

The "**RAMPACK**" is a Nonvolatile Memory (NVRAM), but the **Hand-Held Terminal** can be used to erase it. It can be done using the FMT option from the Utility (UTL) mode. *Be sure not to connect or disconnect the "**RAMPACK**" while the Hand-Held Terminal is on*.

The **Hand-Held Terminal** also has an **Interface** used to communicate with the controller for writing or reading data.

Configurations stored in the controller or in a Data-Pack are protected against changes by unauthorized personnel by several **Passwords**. There is one for each type of operation. See **UTILITY MODE** in **Section 3**.

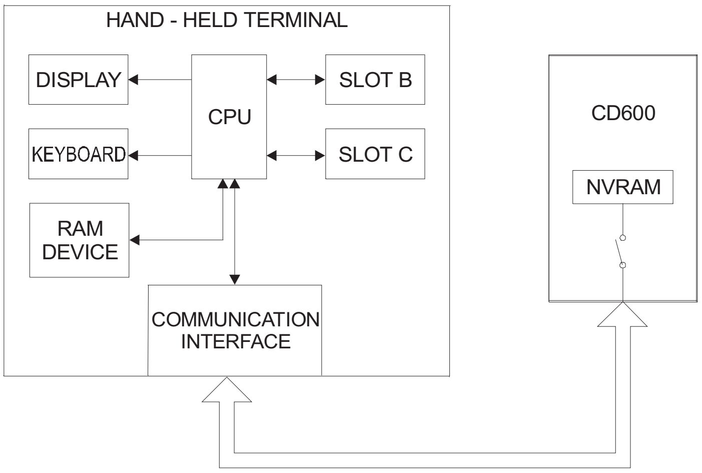


Fig 3.4 - Block Diagram of the SMAR Hand-Held Terminal

In the **CD600** controller, a configuration received from the **Hand-Held Terminal** is stored in a nonvolatile RAM memory, "**NVRAM**", which can be rewritten according to the user's requirements.

The **SMAR Hand-Held Terminal** can also be used to communicate with transmitters from the **SMAR Intelligent Transmitter Series 300 and 301**. To do so, just replace the Program-Pack containing the **Program CD600** in slot "**B**" by the respective transmitter's Program-Pack. For series 301 a HART protocol interface and a 4 line HHT are required.

THE PROGRAM CD600

When executing the **CD600** program in the **Hand-Held Terminal**, the user can use one of the four different modes, selected from the main menu:

PROGRAMMING MODE (PRG): Used for creating configurations which, when finished, checked and compiled, can be downloaded into the **CD600** controllers or into a Datapack in slot "**C**".

DOWNLOAD MODE (DWL): Used to transfer one of the configurations stored in the Data-Pack of slot "**C**" to the controller.

OPERATION MODE (OPR): In this mode, the user can access any part of the configuration existing in the controller, which allows the user to monitor the output signal of any Function Block and the signals at the terminals of any "physical" input or output block. It is also possible to change the **Characterization** and **Adjustment Parameters** of these blocks. Both monitoring, as well as eventual changes, are made "**on-line**".

UTILITY MODE (UTL): This mode allows the user to know the software version and the memory not yet used in the current Datapack. It allows also to compiling, copying and deletion of existing configurations. Several programmer functions can be tested.

In this mode the passwords (access codes) of each hierarchical level and the assignments of the respective levels to each mode are defined. There are three password levels:

Level 1
Level 2
Level 3

Where, Level 1 surpasses Level 2, and Level 2 surpasses Level 3.

Therefore, the Level 1 password is also accepted as password for Levels 2 and 3; the Level 2 password also attends Level 3, but does not attend Level 1. The Level 3 password only attends its own level.

The modes **PRG**, **DWL** and **UTL** have one password, each, and **OPR** has two passwords. Their hierarchical classification enables the user to have a division of tasks and responsibilities in his team.

If hierarchization is not desired, the user may place all the modes at the same level, or else define all the levels with the same password.

A hierarchical division of passwords could be made in the following way:

a) **PRG** Mode - Level 1 Password, since this mode is without any doubt the one which requires more knowledge, both of the controller and of the process. A person who is qualified to develop configurations should be qualified for any other task.

b) **DWL** Mode - Level 2 Password: does not demand much knowledge because it deals with configurations already done and tested. It is recommended that the shift personnel which attends to emergencies have access to this mode.

c) **OPR/ADJUSTMENT** Mode - Level 3 Password: only enables changes of constant adjustments, such as for alarm levels, filters, etc.

d) **OPR/CHARACTERIZATION** Mode: Level 2 Password, since it enables tasks of greater responsibility, such as making use or not of the square root extraction from the process signal, etc.

e) **UTL** Mode - Level 1 Password: as it enables access to all the passwords and definition of levels by mode. Since it is desired to hierarchize access to the various modes, only persons at the top of hierarchy should have access to all the passwords.

The Downloading, Operation and Utility Modes are relatively simple to work with. After an analysis of the respective **Programming Trees** (see Figure below) and a little practice with the **Hand-Held Terminal**, the user will feel comfortable to work with them. The menus are almost self-explanatory.

The Programming Mode provides the user with enormous flexibility; he can create configurations for the **CD600** using his knowledge of the process and of the library of blocks. He can use configurations stored in another controller or in the Datapack. The wide range of options, available to the user in this mode, requires a more careful reading of the next section.

A simple analysis of the **Programming Tree** of the **PRG** mode (see below) is not sufficient for a good understanding of this mode, therefore, in the following text, we are going to discuss this mode in more details, explaining the concepts involved and showing a practical example of the development of a new configuration.

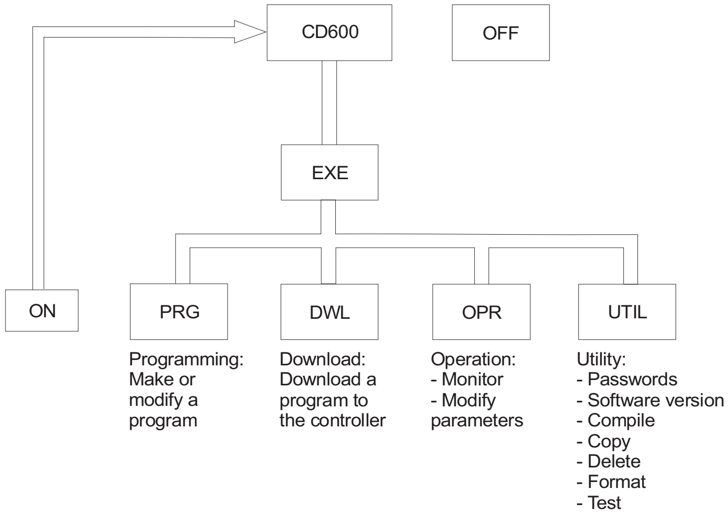

CD600
OFF
EXE
ON
PRG
DWL
OPR
UTIL
Programming: Make or modify a program
Download: Download a program to the controller
Operation: - Monitor - Modify parameters
Utility: - Passwords - Software version - Compile - Copy - Delete - Format - Test

Fig 3.5 - Programming tree: Main menu

THE PROGRAMMING MODE

A configuration for a **CD600** controller may contain up to four control **LOOP**s. In addition to these four **LOOP**s, the configuration must have a fifth LOOP, called **LOOP G**, containing the **TAG** (Identification) of the whole configuration and the blocks whose information can be shared by more than one of the control **LOOP**s.

Before starting to learn how to develop a configuration, it is necessary to understand the following concepts:

BASE - The **BASE** is the starting point of the configuration to be created. It can be of three types:

NEW - There is no configuration to be used as a starting point. It is like to start a **NEW** drawing on a blank sheet of paper.

ID - The starting point is one of the configurations found by its **ID**entification Tag in the Data-Pack inserted in slot **C:**. This configuration will be transferred to the RAM memory, where it can have blocks deleted or inserted, connections changed etc. It is like to copy a drawing and modify it accordingly.

CTR - The starting point is a configuration that is in a **C**on**TR**oller memory. This configuration will be transferred to the RAM memory of the **Hand-Held Terminal**, where it can be changed.

DESTINATION

This is the place where the new configuration should be stored after checking. There are two possible destinations:

CTR - In this case, the configuration is transferred to the NVRAM memory of the **CD600** Controller.

ID - In this case, the configuration is stored in the Programmer's Datapack **C:**. In this option, the user can store the configuration in the normal form (high level language) or in the compiled form (machine language), that allows faster download of the configuration from the Datapack to the **CD600** (**DWL** mode) later on.

The **Programming Tree** of the Figure 3.6 show the commands to be used in the **PRG** mode.

In order to understand the example more easily, the main command keys and the situations in which they are used in the **PRG** mode are listed below:

EXE In the menu, calls the function indicated by the cursor. In the program, calls open blocks (**BLK000**). In the program, inserts the block after a number is assigned to it. Inside the block, calls and confirms alteration of parameters.

ON Returns the program to the previous level, i.e., from parameter to block, from block to program tag, from configuration tag to menu.

THE PROGRAMMING MODE LEVELS

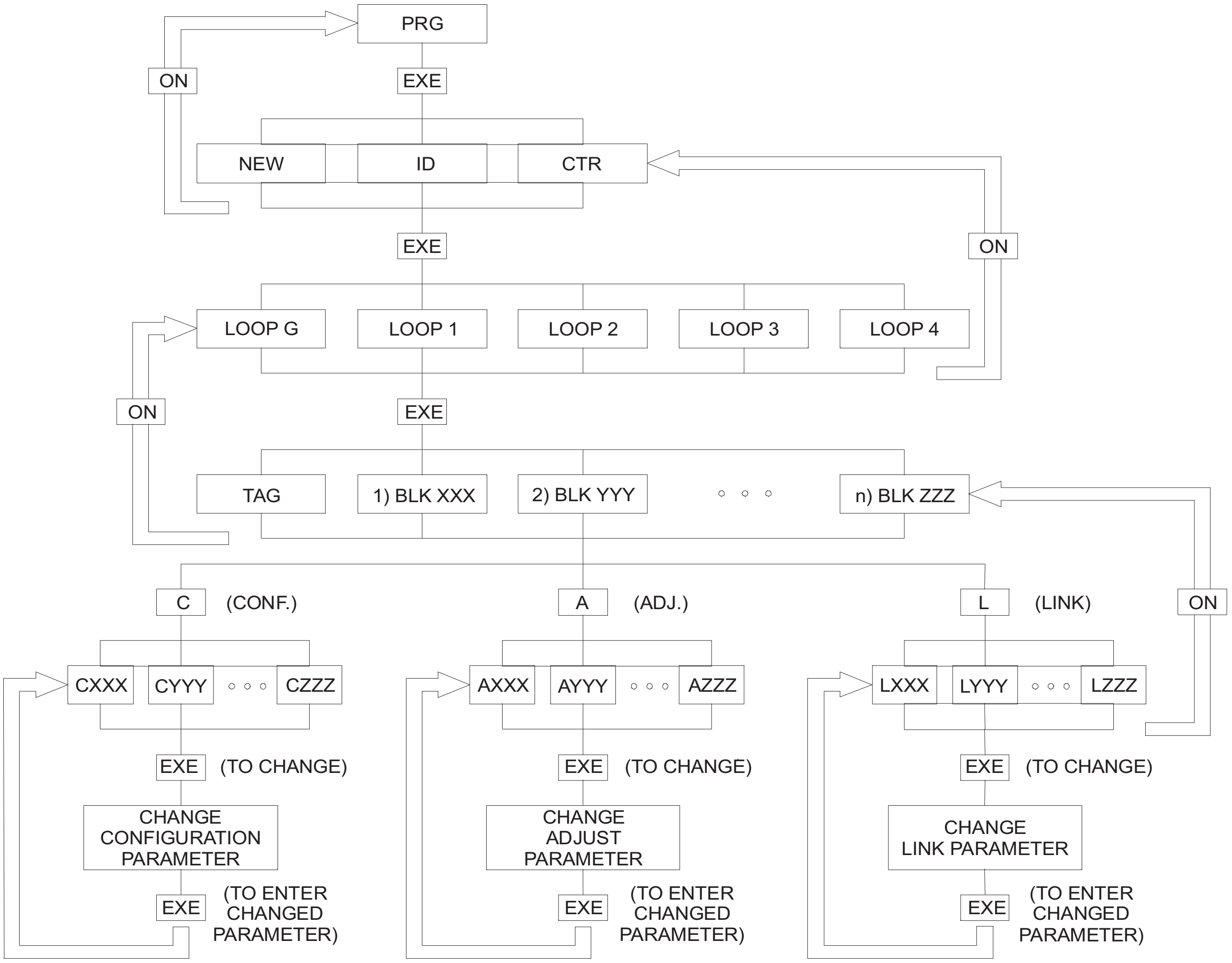


Fig 3.6 - Programming Mode Tree

MODE Used to call the checking mode.

↑ ↓ Scrolls existing configurations in the Datapack to choose the configuration used as BASE. Scrolls parameters of the same type (**L**, **C** or **A**).

Scrolls the blocks of a loop. Scrolls the LOOPs of a configuration.

Scrolls the configurations BASE.

← → Scrolls the configuration's DESTINATI-ON.

L Accesses **Linking Parameters** of the block on the display.

C Accesses **Characterization Parameters** of the block on the display.

A Accesses **Adjustment Parameters** of the block on the display.

Y N Allows the existing configuration in the **Hand-Held Terminal's** RAM to be compiled or not, transferred to the controller or not, aborted or not, depending upon the option prompted on the display.

Figure 3.6 shows the hierarchical levels of a program. The <ON> key allows return to the previous level. The <EXE> key moves to the next level. When working with the blocks, <EXE> will open new blank blocks. After a number is given to a blank block, it can be inserted in the program with <EXE>.

The next section shows a program development step by step. Follow it!

EXAMPLE OF CONFIGURATION

The following control strategy shall be implemented in the **CD600**:

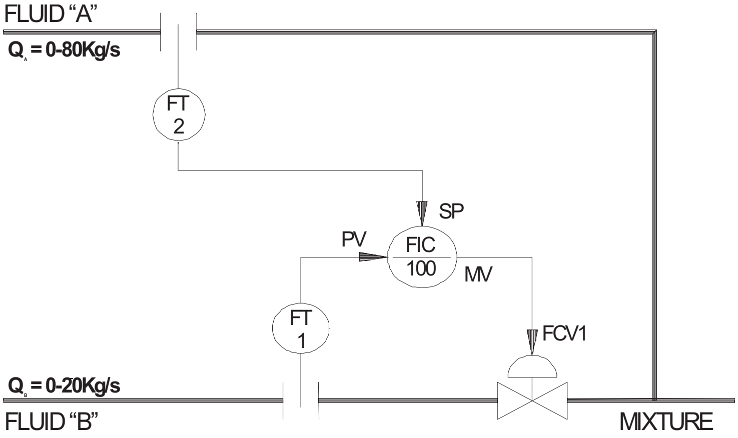
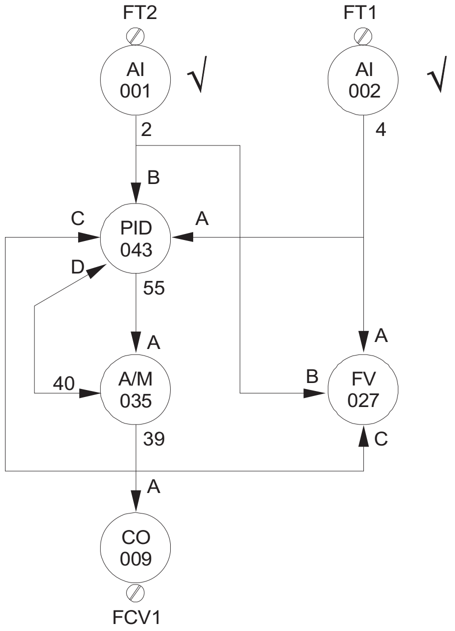


Fig 3.7 - Desired Control Loop

Fluid B must be controlled in order to be equal to flow A. In section 4, function 12-ARTH, there is an example where the ratio Q_A/Q_B is adjustable.

Before starting to work with the **Hand-Held Terminal**, it is recommended to draw the control configuration, using the library of blocks as a reference. The drawing shall contain the block numbers and the terminal numbers as shown in Figure 3.8.

The connections C and D of block 043 are explained in the block description. That is not important now. Let us see how the program is developed and downloaded to the controller.



LIST OF BLOCKS

	LOOP1	LOOP G
TAG:	FLOW	TAG: FIC 100
1:	BLK 001	
2:	BLK 002	
3:	BLK 043	
4:	BLK 035	
5:	BLK 009	
6:	BLK 027	

Fig 3.8 - Configuration of a Control Loop

The following commands, in the following sequence, shall be used to configure the controller.

The drawings show the keys pressed and the display afterwards.

```
ON
```

```
CD-600 OFF
```

```
EXE
```

```
LOANDING O.S.
PLEASE WAIT_
```

```
PRG DWL POR UTL
```

As the cursor is blinking under **PRG**, and Program Mode is desired:

```
EXE
```

```
PASSWORD:
_
```

```
C   D   6   0   0   EXE
        └─SHIFT─┘
```

```
NEW ID  CTR
BASE?
```

We will start a new program, not yet available neither in the Data-Pack (**ID**) nor in the controller (**CTR**). We choose **NEW**.

EXE

```
G          _
LOOP?
```

We have only one loop, but we must identify the controller. To do so, we must give to the **G**eneral loop an identifier (**TAG**):

EXE

```
TAG:           _
           GN
```

We may name the controller **FIC100**

F	I	C	1	0	0	EXE

SHIFT

```
TAG:
FIC100       GN
```

GN on the right lower corner means **G**eneral loop, **NEW**.

Now we must select one of the loops to place our configuration. We may select loop 1. In order to return to the loop selection level we must press <ON> (see Figure 3.6).

ON

```
G  FIC100    _
LOOP?
```

Select Loop 1.

↓

```
1          _
LOOP?
```

EXE

```
TAG:
_            1N
```

The message **1N** in the lower right hand corner of the display informs that we are working on LOOP 1 and it is **NEW**.

Let's assume the **TAG** for LOOP 1 to be **FLOW** (an asterisk * in the upper right hand corner will indicate that the tag is not entered yet.):

F	L	O	W	EXE

```
TAG:
FLOW         1N
```

To call the first block:

EXE

```
1)BLK000
              1N
```

To enter block 001:

0	0	1	EXE

```
1)BLK001 I
ANLG.INP8/001 1N
```

The first line of the display informs that block **BLK001** is inserted, [**I**] and that it is the first block of the LOOP [**1)**].

The second line informs that this is a block type Analog Input (**ANLG.INP**) and that there are eight of these blocks, being block **BLK001** the first of them (8/001). In the right hand corner of the second line, **1N** informs that this is LOOP **1**, base **NEW**.

To call the second block:

EXE

```
2)BLK000
              1N
```

To enter the second Analog Input.

0	0	2	EXE

```
2)BLK002 I
ANLG.INP8/001 1N
```

To call a new block and insert the PID block.

EXE

0	4	3	EXE

```
3)BLK043 I
PID CTR.4/043 1N
```

To call a new block and insert the fourth A/M station:

EXE

0	3	5	EXE

```
4)BLK035 I
A-M STA.4/035  1N
```

To call a new block and insert the current output:

EXE

0	0	9	EXE

```
5)BLK009 I
CUR.OUT.4/009 1N
```

To call a new block and insert the Front View:

EXE

0	2	7	EXE

```
6)BLK027 I
FRT.VIEW4/027 1N
```

To delete a block inserted in the configuration by mistake, press the key <DEL>. When the block is displayed.

In order to scroll the blocks of the Loop, use keys <↑ >, <↓>.

A block can be inserted in the Loop, between two blocks A and B, by scrolling the blocks up or down to block A and then pressing <EXE> to insert a new block.

Important: If the same block is inserted in two different points of a configuration, an indication IX will warn the user that the other block has been used in loop X. In our example, if we try to use block **BLK001** two times, for example the step 4 the display will show "**4) BLK001 I1**", which means that **BLK001** was already used in Loop 1.

Now we are ready to start linking the blocks. Only the inputs of blocks are linked. The outputs have fixed addresses. In the **DEFAULT** condition all inputs have the address "0" (No connection). We may start linking any block, at any time. For example, when entering the blocks, it is also possible to configure the respective **Linking Parameters**.

Let's start at the beginning of the configuration by pressing:

↓

Or 6 times

↑

```
 TAG:
 FLOW         1N
```

↓

```
1)BLK001 I
ANLG.INP8/001 1N
```

This block has only one input and it is associated to the controller terminal **18A**. If you try to link it by pressing the <L> key, you will read the message:

```
 1)BLK001      I

NOTHING TO CONFG
```

To go to the second block:

↓

```
 2)BLK002 I
ANLG.INP8/001 1N
```

The input is associated to the terminal 17A (like in **BLK001**, there is nothing to link).
To go to the third block:

↓

```
 3)BLK043      I

PID CTR.4/043
 1N
```

```
L
```

```
LIA  0
INPUT A
043
```

The display indicates that the input **A** of block **BLK043** has nothing connected. The block description (Section 4) shows that input **A** shall receive the Setpoint, that comes from the second analog input, block **BLK002**, output 4. In order to make the connection, you must ask to change by pressing:

```
EXE
```

```
LIA           0
    _
```

Enter the Setpoint address (4):

```
4
```

```
LIA  0
     4_
```

and confirm it

```
EXE
```

```
LIA           4
INPUT A     043
```

To move to input **B**, which is the Process Variable,

```
↓
```

```
LIB          0

INPUT        B
043
```

To change it to **2**, which is the PV address, ask to change:

```
EXE
```

```
LIB          0

     _
```

Enter 2 and confirm:

```
2  EXE
```

```
LIB  2
INPUT B     043
```

The PID block must be informed of the value of the manual output in order to follow it during manual operation (input **C**) and whether the output is in manual or in automatic mode (input **D**). The value of the actual output is in address **39**, which is an output of block **BLK035** (A/M Station). The status manual is indicated in address **40**, which is another output of block **BLK035**.

To go to input **C** press:

```
↓
```

```
LIC  0
INPUT C     043
```

To change press:

```
EXE
```

```
LIC 0
    _
```

To enter 39 and confirm press:

```
3 | 9 | EXE
```

```
LIC 39
INPUT C     043
```

...the same way for input **D**.

```
↓
```

```
EXE
```

```
4 | 0 | EXE
```

and block **BLK039** (PID) is all linked. The display will show:

```
LID          40

INPUT         D
043
```

To go back to the block level, press:

```
ON
```

```
3)BLK043 I
PID  CTR.4/043
1N
```

To go to the next block:

```
↓
```

```
4)BLK035      I

A-M  STA.4/035
1N
```

To link the block:

```
L
```

```
LIA           0

INPUT         A
035
```

```
EXE
```

```
LIA           0

       _
```

```
5 | 5 | EXE
```

```
LIA          55

INPUT         A
035
```

To return to the block level and go the next block:

```
ON | ↓
```

```
5)BLK09 I
CUR.  OUT.  4/009
1n
```

And so on...

L

EXE

3 | 9 | EXE

ON

To link the block 027 - Front View:

```
 5)BLK09 I
 CUR.  OUT.  4/009
1n
```

↓

```
 6)BLK027      I

 FRT.VIEW4/027
1N
```

L

```
 LIA           0

 INPUT         A
 027
```

EXE

```
 LIA   0
       _
```

4 | EXE

```
 LIA   4
 INPUT          A
 027
```

↓

```
 LIB   0
 INPUT         B
 027
```

EXE

```
 LIB   0
       _
```

2 | EXE

```
 LIB   2
 INPUT          B
 027
```

↓

```
 LIC   0
 INPUT         C
 027
```

EXE

```
 LIC   0
       _
```

3	9	EXE

```
LIC  39
INPUT         C
027
```

ON

All block inputs are connected. The blocks have two other types of parameters:

"**A**" Parameters - are **Adjustment Parameters**, such as: VALUE OF THE PROPORTIONAL GAIN, VALUE OF THE INTEGRAL TIME, etc.

"**C**" Parameters - are **Characterization Parameters**, such as: DIRECT/ /REVERSE MODE, PID/IP.D/I.PD, etc.

To change these parameters, press keys <A> and <C>, respectively and then proceed in the same way used for the "**L**" parameters.

In our example, the analog inputs should have square root extraction, because differential pressure transmitters are used to measure flow. The analog input should have a filter of 2s.

The output shall decrease when the PV increases and the **proportional gain** should start with K_p=1 and the **Integral time** should start with T_R=0.1min.

In order to make these adjustments, just scroll the program by using the <↑> and <↓> keys till the desired block is on the screen. The first one is the Analog Input 1.

↓	↓

```
1)BLK001      I

ANLG.INP8/001
1N
```

In order to have square root, press <C>, for configuration:

C

```
CFRT          0

FRT.INDICAT.
001
```

To move to other characterization parameters:

↓	↓

```
CSQR          0

SQUARE ROOT 001
```

To change the parameter from 0 (**NO**) to 1 (**YES**) and confirm:

EXE	↓	EXE

```
CSQR 1
SQUARE ROOT 001
```

In order to adjust the filter time constant press:

A

```
ACUT       1.00

CUT         OFF
001
```

To scroll the several adjustments possible:

↓

```
ATIM      0.20

TIME CTE.   001
```

To change 0.20s to 2s and confirm:

```
EXE | 2 | EXE
```

```
ATIM      2.00

TIME       CTE.
001
```

No more changes are necessary in this block. The changes of the Adjusting and configuration parameters could also be done as soon as the block is inserted in the program.

In order to go back to block level press:

```
ON
```

```
1)BLK001     I

ANLG.INP8/001
1N
```

The same procedures could be applied to the second block, Analog Input **002**.

Scrolling the program down the PID block, the control action and the PID tuning constants can be adjusted:

```
↓ | ↓
```

```
3)BLK043 I
PID   CTR.4/043
1N
```

```
C
```

```
CACT 0
ACTION
043
```

CACT=0 means output decreases when PV increases (see **Function 10 - Section 4**), which is exactly what we need, but it means something more:

- adjustment of the PID constants by the front panel enabled. If we intend to disable that adjustment, we should use **CACT**=2 or 6.

- PID algorithm is parallel, ideal. The noninteractive, ISA algorithm require **CACT**= 4 or 6.

We may leave it like it is. To adjust the tuning constants press:

```
A
```

```
AKp       0.30

PROP.GAIN
043
```

To change it to 1 and confirm:

```
EXE | 1 | EXE
```

```
AKp  1.00

PROP.GAIN
043
```

To move to another constant:

```
↓
```

```
Atr  10.000

RESET        TIME
043
```

To change it to 0.1 min and confirm:

EXE	.	1	EXE

```
ATr  0.1000

RESET        TIME
043
```

After the last change, go back to block level:

```
ON
```

```
3)BLK043 I

PID CTR.4/043 1N
```

The program is ready. In order to check the configuration, press:

```
MODE
```

```

CHECK?
Y/N
```

If there are no more changes to be made, press:

```
Y
```

```
CHECKING
CONFIG.
               >
```

After checking the configuration, if no mistake is detected, the following message will ask for the configuration's DESTINATION.

```
ID      CTR   QT

DESTINY ?
```

ID Stores in Datapack. (a datapack must be in slot C).

CTR Downloads into the controller's **NVRAM**. The **Hand-Held Terminal** shall be connected to the controller.

QT Quits the Configuration

If there is a mistake, the display will show the error messages. You can scroll the messages with <↑>, <↓>. To return to the program, press the <EXE> key.
You may correct the program, check it again, and reach this stage.

Suppose that we want to store the program in the Datapack:

```
EXE
```

```
SAVING        IN

DATAPACK C:...
```

```
COMPILE FIC100
Y/N_
```

The compiled configuration can be downloaded faster to the controller if <Y> is pressed.

```
COMPILING
FIC100    ..._
```

ERROR MESSAGES AT A CONFIGURATION CHECKING

When the HHT performs a CHECKING of a configuration, the following error messages may occur:

```
1 BLK#XXX LINKED
NOT USED BLOCK
```

The block xxx has one of its inputs linked to the output of a block which is not used in the configuration.

```
1 BLK#XXX LINKED
IN LOOPS 12
```

The block xxx is being used more than one time in the configuration. In this example, in the loops 1 and 2.

```
CHOOSE A TAG FOR
GENERAL LOOP
```

The configuration does not have the General Loop.

```
1 BLK#XXX  USES
NOT CONFG LINRZ.
```

The block(s) that forms the linearization curve, indicated at CLIN parameter of the block XXX, does not exist in the General Loop.

```
1 FUNC#XX  USED
MORE  ONE/LP X
```

The blocks associated with the Function XXX are used, more than once in the same loop. In this example, in the loop 1.
The Functions that can generate this message are A/M, L/R and Front View.

OBS.: During the download operation, the following message may occur:

```
RAM OVERFLOW
TOO  BIG CONFIG.
```

The memory area reserved for one of the loops is overloaded.
Return to the programming mode and share the blocks with the other loops.

Download Mode

After completing a configuration in the **PROGRAM** mode, there is an option to download it automatically to the controller, if the check results all right.

To transfer a configuration from a datapack in slot C to the controller, go to the **DWL** (Download) option of the main menu and press <EXE>.

```
PRG DWL OPR UTL
```

→	EXE

```
    PASSWORD:
        _
```

C	D	6	0	0	EXE

SHIFT

If there is a Datapack in slot C and this Datapack has one or more configurations stored, the display will show the message:

```
ID001  3 ELEM L
SELECT
```

With the <↑> and <↓> keys, all available configurations will appear on the display. The message consists of:

ID001 - Identification in the Datapack, with sequential number.

3 ELEM L - 8-character tag of the configuration. In this example: 3 Elements Level Control.

Be sure that the controller has the "**NVRAM-SAFE**" switch in the position **NVRAM** and select the desired configuration. Press:

EXE

```
COMMUNICATING
```

```
TX 3 ELEM L TO
4 LPS    ?(Y/N)
```

The question on the display is an abbreviation of the following question:

"Do you want to transmit the program "**3 ELEM L**" (3- Element Level Control) to the controller with the configuration "**4 LPS**" ? Y/N.

If you say no, by pressing <N>, you will go back to the selection level. If you say Yes, by pressing:

Y

```
COMMUNICATING
TRANSMITT / RECEIVE
```

A sound signal from the **Hand-Held Terminal** will indicate that the transmission is completed. The display will ask you to move the switch in the controller to "**SAFE**".

If you press <ON>, you will go back to the selection level. At this point you can select a configuration for another controller.

Operation Mode

The operation mode enables the user to:

Change block **C**haracterization parameters.
Change block **A**djustment parameters.
Monitor block outputs.
Monitor analog and digital inputs and outputs.
Calibrate analog inputs and outputs.

The Figure 3.9 shows the Operating Mode Tree.

The Operation mode (**OPR**) is the third option in the main menu.

```
PRG DWL OPR UTL
```

→ → EXE

```
PASSWORD:
_
```

Enter the password:

C	D	6	0	0	EXE

SHIFT

```
BLK MON CAL
_
```

BLK - Block Adjustment/Characterization/Output monitoring.
MON - Monitoring of controller inputs and outputs.
CAL - Calibration.

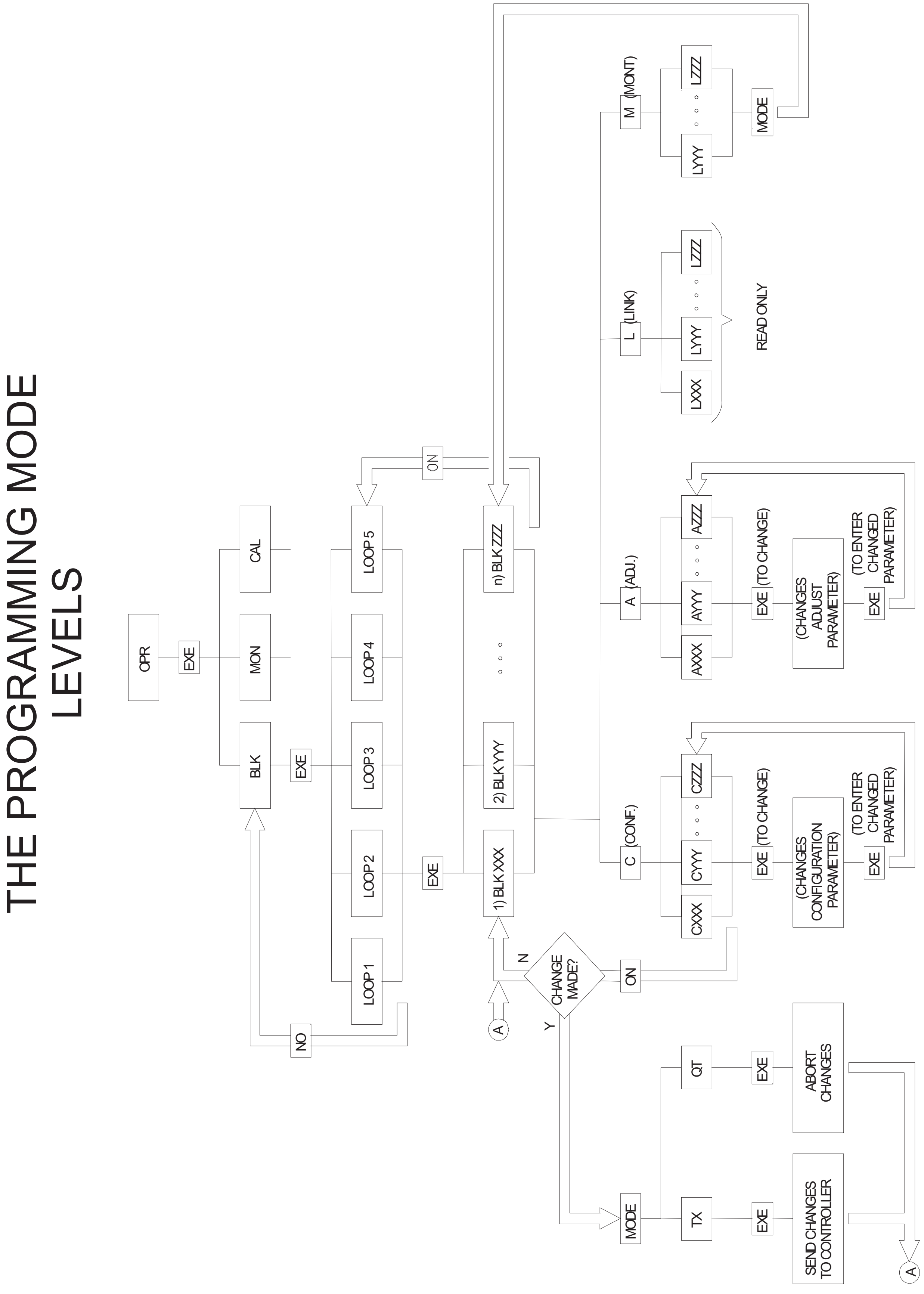


Fig 3.9 - Operating Mode Tree

Block Adjustment/Characterization

When the option **BLK** is selected, every block of the configuration can be accessed, monitored and modified. With the **Hand-Held Terminal** connected to the controller and with the switch in "**NVRAM**" position, select **BLK** and press:

EXE

```
COMMUNICATING
RECEIVING...
```

```
1  FLOW    _
```

The display indicates Loop 1 and its respective tag, FLOW.

The <↓> and <↑> keys scroll the configured loops. This is the loop level (refer to Figure 3.9 - The Operating Mode). Select the desired loop and press:

EXE

```
COMMUNICATING
RECEIVING...
```

```
TAG:
FLOW        L1
```

We are now at the block level. The blocks of this loop are in the **RAM** memory of the **Hand-Held Terminal**. The <↓> and <↑> keys scroll all the blocks of Loop 1.

↓

```
1)BLK001
ANLG.INP8/001_L1
```

To change a **C**haracterization parameter press:

C

```
CFRT 0
FRT.INDICAT. 001
```

The <↑> and <↓> keys scroll all possible options. The characterization parameters of each block are described in **section 4**.

↓ ↓

```
CSQR 0
SQUARE ROOT  001
```

This means no square root extraction. To change it to 1 (with square root).

EXE ↓

```
CSQR 0
   1_
```

To confirm it:

EXE

```
CSQR 1
SQUARE    ROOT 001
```

If you want to adjust the cut-off point of the square root from 1 to 0,5%, press:

A

```
ACUT 1.00
CUT OFF     001
```

EXE | . | 5 | EXE

```
ACUT 0.50
CUT OFF     001
```

If more changes are desired in the **A**djustment just use <↑> and <↓> keys. To change other **C**haracterization parameters use **C**.

When there are no more changes to be made in this block, return to the block level by pressing:

ON

```
1)BLK001
ANLG.INP8/001_L1
```

To send the new block settings to the controller, press:

MODE

```
TX  QT
                    001
```

TX - transmit (the information to the controller).
QT - Quit (no changes should be made in that block).
001 - Block number.

If Quit (**QT**) is selected, the display goes to the loop level.

If Transmit (**TX**) is selected,

EXE

```
COMMUNICATING
TRANSMITTING...
```

```
1)BLK001
ANLG.INP8/001_L1
```

The new data is now in the controller. If you intend to modify other blocks, just scroll the loop configuration <↑> and <↓>. To go to another loop, just press <ON> and select the desired loop.

Block Monitoring

The block outputs can be monitored while the controller is in operation and without disturbing the process. This is a very important tool to check a configuration. With the **Hand-Held Terminal** in Operation mode (**OPR**), in the Block (**BLK**) option, it can monitor the outputs of a selected block by pressing the <M> (Monitor) key.

```
BLK MON CAL
```

EXE

```
1 FLOW
```

EXE

```
COMMUNICATING
TRANSMITTING...
```

```
TAG:
FLOW                L1
```

↓ ↓ ↓ ↓

```
4)BLK035
A-M STA.4/035_L1
```

To monitor the outputs of this block, press:

M

```
OUT039 57.12_ <
A-M STA.4/035 LI
```

To monitor the OUTPUT 040, press:

↓

```
OUT040  100.00_<
A-M STA.4/035 LI
```

To go back to the block level, press <MODE>.

I/O MONITORING (MON)

The controller input and outputs can be monitored while the controller is in operation without disconnecting the wires from the terminals and therefore without disturbing the process. This is an important tool to check that signals from transmitters and sensors etc. really reach the controller and that the controller output really changes. With the HHT in operation mode (OPR), in the monitoring (MON) option, it can monitor selected inputs and outputs of the controller.

In the example below we want to monitor Analog Input 2, Current Output 4, Digital Input 2 and Digital Output 2. Their respective Blocks do not have to be configured in order to monitor the status.

```
BLK MON CAL
```

→ EXE or M

```
1)AI1
ANALOG.INPUT_
```

↓

```
2)AI2
ANALOG.INPUT_
```

To monitor the input at this terminal, press:

EXE

```
2)AI2           *
ANALOG.INPUT_
```

The asterisk * indicates that this terminal is selected.

10 x ↓

```
12)CO4
ANLG.CUR.OUT_
```

EXE

Proceed the same way for DI2 and DO2.
To start the monitoring press:

MODE

```
2 AI2  3.00
12 CO4  19.55_
```

Analog inputs are in Volts, for current inputs divide by 250 ohm.
Current outputs are in milliamperes.
In this example AI2 is 3.00V (12 mA), CO4 is 19.55 mA.

↑

↓

```
18 DI2  ON            <
22 DO2  OFF_
```

In this example DI2 is ON and DO2 is OFF. To stop the monitoring press MODE, then you will have the option to select more points to monitor or quit. To quit press <ON>.

CALIBRATION - see Section 7.

Utility Mode

The utility mode enables the user to:

CPL - Compile configuration(s) stored in the datapack plugged in the slot C:

CPY - Copy configuration(s) from controller, datapack or microcomputer PC-AT. To (other) datapack or microcomputer PC-AT.

DEL - Delete configuration(s) stored in the datapack plugged in the slot C:

VS - Returns the Software version of the HHT and of the controller.

PSW - Configure the password system in the HHT.

SPC - Show the space available in the device plugged in the slot C:

FMT - Format RAMPACK, it means to delete the contents of the whole RAMPACK and recover all memory space.

DGN - Run a diagnostic of the keyboard, DATAPACK/RAMPACK and display.

```
PRG DWL OPR UTL
```

← EXE

```
PASSWORD:
_
```

C D 6 0 0 EXE

SHIFT

```
CPL CPY DEL VS
PSW SPC FMT DGN
```

CPL - COMPILE

To compile a configuration is to put it in a form that is easily transferable from the HHT to the controller (or other device).

```
EXE
```

```
ID001  4 LPS  N
ID TO COMPILE
```

To select the configuration use the <↑> and <↓> keys, then press <EXE> to compile it. The letter on the right side of the tagname on the display means:

N - Normal: Only the normal form of the configuration is stored in the datapack C:
The normal form allows the user to see and change the configuration in the programming mode, but it takes more time to download it into the controller than when the compiled form is used.

C - Compiled: Only the compiled form is stored in the datapack C:, therefore the configuration can not be seen or changed in the programming mode.

B - Both: the normal and compiled forms are stored in the datapack C:

To compile the configuration "4 LPS"
Press <EXE>.

```
COMPILING
4 LPS   ...
```

CPY - COPY

```
CPL CPY DEL VS
PSW SPC FMT DGN
```

```
→ EXE
```

```
CTR ID PC
SOURCE TO COPY
```

Let's do an example of "copy" from controller to datapack (ID), therefore the source is "CTR" and the destiny is "ID".
Press <EXE> to select "CTR" as source.

```
COMMUNICATING
TRANSMITTING
```

```
COPY 3 ELEM L
TO PACK C: Y/N_
```

This message means:
"Do you want to copy the configuration "3 ELEM".
That is in the controller, to pack C: ?"
If yes press <Y>.

```
COMMUNICATING
TRANSMITTING
```

```
SAVING  IN
DATAPACK C:...
```

```
COMPILE 3 ELEM
Y/N
```

If you don't want the compiled form, press <N>.

DEL - DELETE

A configuration contained in the datapack can be deleted, so it will not be seen or it will be not possible to download it into a controller. Although, the configuration will still be using datapack memory.

```
CPL CPY DEL VS
PSW SPC FMT DGN
```

→	→	EXE

```
ID001 4LPS    B
ID    TO DELETE
```

Use <↑> and <↓> keys to select the configuration and press <EXE> in order to delete. The selected configuration.

```
ARE YOU SURE?Y/N
```

If yes, press <Y>.

VS - Software Version

```
CPL CPY DEL VS
PSW SPC FMT DGN
```

→	→	→	EXE

```
PRG CTR
```

To check the software version of the **Hand-Held Terminal**, press <EXE>

```
SOFT. VER.: 2.XX
```

Press any key to return to the previous menu.
The same procedure can be applied to check the software version of the controller, select the option VS, again.

→	→	→	EXE

```
PRG CTR
```

→	EXE

```
COMMUNICATING
TRANSMITTING...
```

```
SOFT. VER.: 2.XX
```

OBSERVATION:

The software version of the controller CD600, can also be checked from the front panel, proceed as follows:

a) Press the key <NORM/CONF>, located on the main board of the controller, on the right of the **Hand-Held Terminal** connecting jack;

b) Press <ACK> key;

c) and select the version indication of the controller software, in the display, by means of <DSP> key.

PSW - CONFIGURE PASSWORD

In order to avoid changes made by unauthorized people, three different passwords can be attributed to the following functions:
Programming, Download, Utility, Operation - Characterization, Operation - Adjust.
Password level 1 is hierarchilly superior to password level 2, which is superior to level 3.

```
CPL CPY DEL VS
PSW SPC FMT DGN
```

↓	EXE

```
PSW     LVL     SAV
```

PSW - Select this option if you want to see and/or to change the password(s).

LVL - This option allows the user to see and/or to change the levels of password attributed to each mode.

SAV - Selecting this option, the new configuration of password will be saved in the datapack B:

The keys <↑> and <↓> are used to scroll the passwords in the option "PSW" and the levels attributed to them in the option "LVL". The key <EXE> is used to start and to finish a modification, and the key <ON> is used to return to the previous level.

SPC - SPACE AVAILABLE IN DATAPACK / RAMPACK C:

```
CPL CPY DEL VS
PSW SPC FMT DGN
```

↓	→	EXE

```
SPACE IN C:
32733   BYTES
```

Press any key to return to the previous level.

FMT - FORMAT RAMPACK C:

```
CPL CPY DEL VS
PSW SPC FMT DGN
```

←	←	EXE

```
FORMT RAMPACK C:
ARE YOU SURE?Y/N
```

If you want to format rampack C:

Press <Y>.

```
SIZING PACK C:
PLEASE WAIT
```

DGN - DIAGNOSTIC:

```
CPL  CPY DEL VS
PSW       SPC   FMT
DGN
```

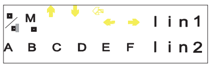
←	EXE

```
KBD PCK DSP
```

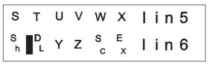
The option KBD runs a diagnostic of keyboard, if you want to run it, then press <EXE>.

```
EXIT: PRESS SHIFT
AND OTHER KEY
```

This message indicates how to EXIT from the diagnostic of the keyboard.
To start the diagnostic press any key, for example, press <A>.



To check the functioning of every key, press the corresponding key.



If you want to return, then you have to press <SHIFT> and any other key, which is a letter.

```
KBD PCK DSP
```

To run the diagnostic of datapack press.

→	EXE

```
PCKB PCKC
COM.SERIAL
```

The options PCKB and PCKC will run a diagnostic of writing and reading in DATAPACK/RAMPACK B: and C:, respectively.
The third option COM.SERIAL will check the communication with the controller.
To return to the previous level. Just press <ON>.

```
KBD PCK DSP
```

The diagnostic of the display will check all positions in the display and will return automatically to the end.
If you wan to run it, then press.

←	EXE

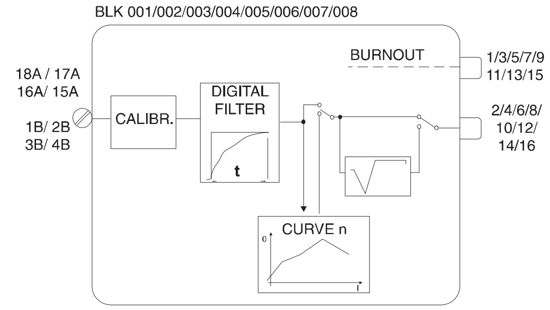
LIBRARY OF FUNCTION BLOCKS

Function Table

FUNCTION	MNEM	BLOCK NUMBER	DESCRIPTION	PAGE Nº
01	AI	001/002/003/004/005/006/007/008	ANALOG INPUT	4.2
02	CO	009/010/011/012	CURRENT OUTPUT	4.3
03	VO	013/014/015/016	VOLTAGE OUTPUT	4.4
04	DI	017/018	DIGITAL INPUT	4.5
05	DO	019/020/021/022/023/024/025/026	DIGITAL OUTPUT	4.6
06	FV	027/028/029/030	FRONT VIEW	4.7
07	L/R	031/032/033/034	LOCAL/REMOTE SP SELECTOR	4.9
08	A/M	035/036/037/038	AUTOMATIC/MANUAL STATION	4.12
09	APID	039/040/041/042	ADVANCED PID	4.14
10	PID	043/044/045/046	SIMPLE PID	4.26
11	STEP	047/048/049/050	STEP CONTROLLER	4.30
12	ARTH	051/052/053/054/055/056	MULTIPLIER-DIVIDER-ADDER-SUBTRACTOR	4.34
13	SQR	057/058	SQUARE ROOT	4.39
14	LIN	059/060	LINEARIZATION	4.40
15	LL	061/062	DERIVATIVE/LEAD-LAG	4.42
16	PTC	063/064	PRESSURE AND TEMPERATURE COMPENSATION	4.46
17	POL	065/066	POLYNOMIAL	4.50
18	TOT	067/068/069/070	TOTALIZATION	4.52
19	P/DI	071/072	PULSE TOTALIZATION INPUT	4.54
20	BAT	073/074	BATCH COMPARATOR	4.59
21	SPG	075/076	SETPOINT GENERATOR	4.61
22	ALM	077/078/079/080	DOUBLE ALARM	4.63
23	LIMT	081/082/083/084	LIMITER WITH ALARM	4.65
24	LOG	085/086/087/088/089/090	LOGIC	4.69
25	TMR	091/092	TIMER	4.71
26	H/L	093/094/095/096	HIGH/LOW SELECTOR	4.72
27	SSEL	097/098	INTERNAL/EXTERNAL SELECTOR	4.73
28	ADJ	099/100/101/102	CONSTANT ADJUSTER	4.74
29	ISEL	103/104/105/106	INPUT SELECTOR	4.76
30	OSEL	107/108	OUTPUT SELECTOR	4.78
31	PNT	109/110/111/112/113/114/115/116	LINEARIZATION CURVE	4.80
32	GV	117	GENERAL VISUALIZATION	4.84
33	K	118	CONSTANTS	4.85
34	SCN	119	SCAN	4.86
35	PRM	120	SCAN/ACTUATION OF THE PARAMETERS PID	4.89
36	ATU	121	ACTUATION	4.90

Function 01 - Analog Input (AI)

Operation



All the analog inputs have a corresponding **Analog Input** block. The *analog input 2*, for example, which is connected to the **17A** terminal, corresponds to *block BLK002*. The input to the circuit is always a voltage signal (0-5 V or 1-5 V). If a current signal (0-20 mA or 4-20 mA) be used, a Shunt resistor shall be placed in the corresponding terminal block position.

The input signal passes through an analog second order BESSEL filter with cutoff frequency at 15 Hz.

The result is converted into a digital number and in this form, it passes through a four point calibration process in which 0V, 1V, 3V and 5V are made to correspond respectively to 0, 20, 60 and 100% for 0-20 mA/0-5 V input and -25, 0, 50 and 100% for 4-20 mA/1-5 V input. See the CALIBRATION section for further details.

After conditioning, the signal is digitally filtered with an adjustable time constant. It can be linearized in accordance with a curve established in the **Function 31 - Linearization Curve (Blocks 109 to 116)**, configured in Loop G. This curve is selected by **CLIN** and may be used with 13 or 26 pairs of points x, y, interconnected by straigh line segments. The curves that may be performed are show on table 4.31.1 page 4.59.

The signal can also have square root extraction, selectable by **CSQR**. The square root has an adjustable cutoff point (**ACUT**) for low signals. All values below **ACUT** will be considered 0%.

Parameter **CSQR** permits input signal selection (4-20 mA/1-5 V or 0-20 mA/0-5 V) and to decide whether square root will be extracted.

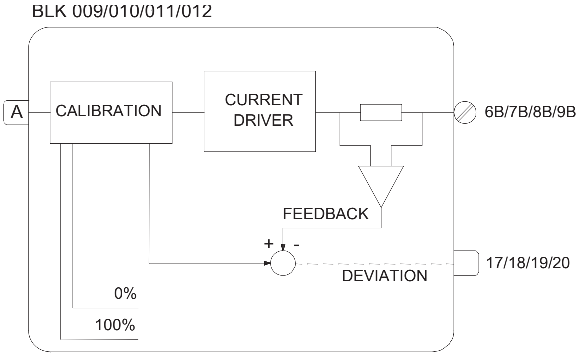
In **Burnout** (signal after calibration smaller than -2% or greater than +102%), an Alarm can be indicated on the front panel (if **CFRT**=1) and a **Burnout** alarm signal can be activated. This signal can be used, for example, to switch the process variable to another input through a block of the **Function 29 - Input Selector** or to force the controller's output to an emergency position.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	CFRT	Indication of "Burnout" on front panel	0-No/1-Yes 2-Yes with Auto Ack	0
I	CLIN	Linearization (See Table 4.31.1 on Function 31 – Linearization Curve)	0-No 1?8/Curves 1?8 9-Curves 1 and 2 10-Curves 3 and 4 11-Curves 5 and 6 12-Curves 7 and 8	0
I	CSQR	Signal Selection and Square Root extraction	0-No (1 to 5V or 4 to 20mA) 1-Yes (1 to 5V or 4 to 20mA) 2-No (0 to 5V or 0 to 20mA) 3-Yes (0 to 5V or 0 to 20mA)	0
P	ACUT	Cutoff level for square root extraction	0.00 - 100.00%	1.00%
P	ATIM	Filter time constant	0.00 - 30.00s	0.20s

Number of Bytes per Type of Parameter: A = 4 C = 6 L = 0

Function 02 - Current Output (CO)

Operation



The block input, in percentage, is calibrated and converted into an analog current signal. A **feedback** of this current is sent to a comparator, which also receives the input signal. If there is a deviation greater than the **ADEV** (allowable deviation) parameter, the discrete output **Deviation** will be activated. This signal may, for example, be connected to the input **H** of a block of **Function 06 - Front View**, in order to make the **MV** bargraph blink, warning the operator that something is wrong or to activate any other type of alarm.

This alarm indicates, for example, that the current loop has an interruption. There is a parameter in the block, which allows the output type to change according to the type of actuator used.

Actuator type:

- "Air to Open" - **CVTP** = 0 or 2 / output 0-100% corresponds to 4-20 mA

- "Air to Close" - **CVTP** = 1 or 3 / output 0-100% corresponds to 20-4 mA

This enables the operator to have always 0% corresponding to a closed valve and 100% to an open valve.

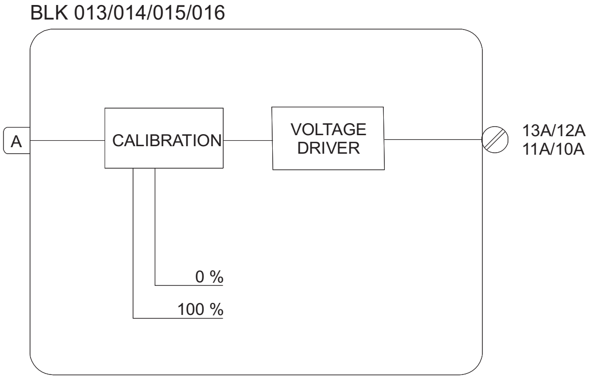
It is essential to calibrate the output according to the specifications. For example, for a 0-20 mA signal in block 011, the output current at terminal 8B shall be calibrated with 0-20 mA and **CVTP** shall have the code 2.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A - Output Signal	Address 0 to 170/225 to 240	0
I	CVTP	Type of Output	0-Direct (4 to 20 mA) 1-Reverse (20 to 4 mA) 2-Direct (0 to 20 mA) 3-Reverse (20 to 0 mA)	0
I	CFRT	Front Panel Indication of deviation between the desired and actual current	0-No/1-Yes/2-Yes with Auto Ack.	0
P	ADEV	Maximum allowable deviation	0.00 - 100.00%	5.00%

Number of Bytes per Type of Parameter: A = 2 C = 4 L = 2

Function 03 - Voltage Output (VO)

Operation



The block input in percentage is calibrated and converted into an analog voltage signal sent to the terminal block.

This block includes a parameter, which allows signal type selection, i.e., it makes 0-100% correspond to 1-5 Vdc (direct type) or to 5-1 Vdc (reverse type).

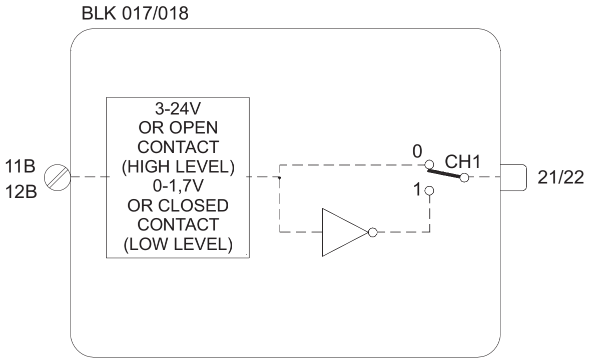
The corresponding output shall be calibrated as per the specifications to 1-5 Vdc or to 0-5 Vdc (see Calibration Section for further details).

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A - output signal	Address 0 to 170/225 to 240	0
I	CVTP	Type of output	0 - Direct (1 to 5V) 1 - Reverse (5 to 1V) 2 - Direct (0 to 5V) 3 - Reverse (5 to 0V)	0

Number of Bytes per Type of Parameter: A = 0 C = 2 L = 2

Function 04 - Digital Input (DI)

Operation



If the input block terminal is open (impedance > 10 MΩ) in relation to the Digital Ground terminal or with a voltage between 3 and 24 Vdc, the signal will be considered as high logic level and the value 100% (high logic level) will be available in the block output.

If, on the other hand, the input is short-circuited (impedance < 200Ω) or with a voltage between 0 and 1.7 V, the signal will be considered as low logic level and the value 0% (low logic level) will be at the block output.

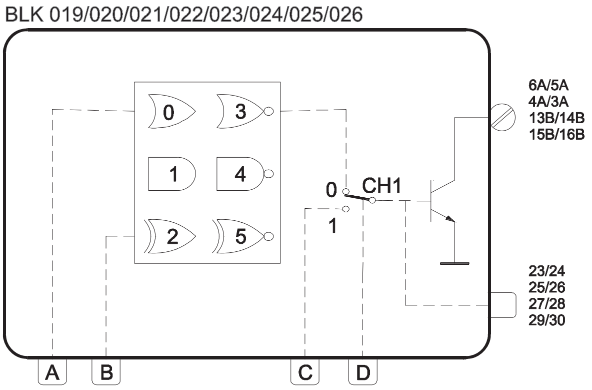
This condition can be inverted by the parameter **CNOT**.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	CNOT	Inverts Interpretation	0 - No/1 – Yes	0

Number of Bytes per Type of Parameter: A = 0 C = 2 L = 0

Function 05 - Digital Output (DO)

Operation



This block can perform a logic operation with inputs **A** and **B**. The output is sent to a two-position selector switch. The other position is connected to input **C**. A high logic level at **D**, switches CH1 to position "1", making the output equal to safety input **C**.

The logic operation to be performed by the block is defined by the parameter **CLOG** according to the table 4.5.1:

INPUT		OUTPUT					
A	**B**	**OR**	**AND**	**XOR**	**NOR**	**NAND**	**NXOR**
0	0	0	0	0	1	1	1
0	1	1	0	1	0	1	0
1	0	1	0	1	0	1	0
1	1	1	1	0	0	0	1

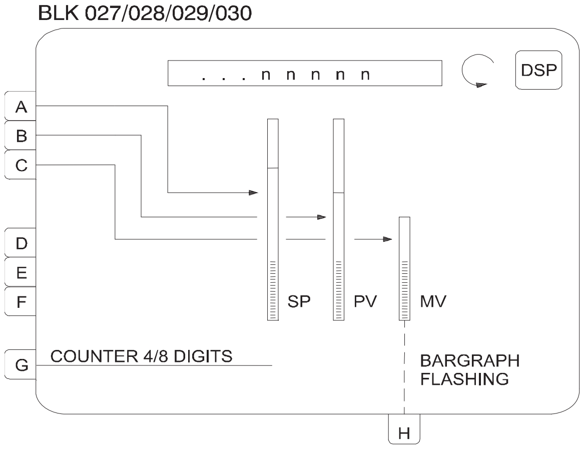
Table 4.5.1 - Truth table for digital

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A	Addresses 0 to 170/225 to 240	0
I	LIB	Input B		0
I	LIC	Safety input C		0
I	LID	Input D to activate safety input		0
I	CLOG	Logic function	0 - OR/1 - AND/2 - XOR 3 - NOR/4 - NAND/5 - NXOR	0

Number of Bytes per Type of Parameter: A = 0 C = 2 L = 8

Function 06 - Front View (FV)

Operation



This block leads inputs **A**, **B**, **C** to bargraphs **SP**, **PV** and **MV** respectively, and in the default condition, associates these inputs to the mnemonics **SP**, **PV** and **MV** on the display.

Thus, the use of this block is limited to one per loop.

Inputs **A**, **B**, **D**, **E**, **F** and **G** can be visualized on the alphanumeric display and scrolled by key <DSP>. Input **C** will be visualized only by pressing key <△> or key <▽>.

Blocks that have manual adjustment registers, operated by keys <△> or <▽> must be connected to the Loop Visualization block. An adjustment can be performed only while the variable is being visualized; the LED "Adjust" indicates that adjustment can be done.

The blocks with the manual adjustment feature are *Local/Remote Selector, Setpoint Generator, Internal/ External Selector and Constant Adjuster.*

The blocks with adjustment capability have the outputs identified by numbers equal or greater than 225. The Input Selector block also allows manual adjustment of blocks with this feature whose output is connected to the Input of the Input Selector block. Notice that its output numbering is greater than 225.

VISUALIZATION
All inputs, except **C** and **G**, may have the three-character mnemonics changed and the indication configured in engineering units.

Input **C** appears on the display when <△> or <▽> is pressed.

Input **G**, if connected to a block of the **Function 18 - Totalization or Function 19 - Pulse Totalization Input**, will show an eight-digit number. Connecting it to any other block, it will operate as a 4 digit display.

Input **H** - **Bargraph Flashing** - can be used to blink the **MV** bar. It is activated with a high logic level signal. This input can be used, for example, to show a deviation or break in the current output from a block of **Function 02 - Current Output.**

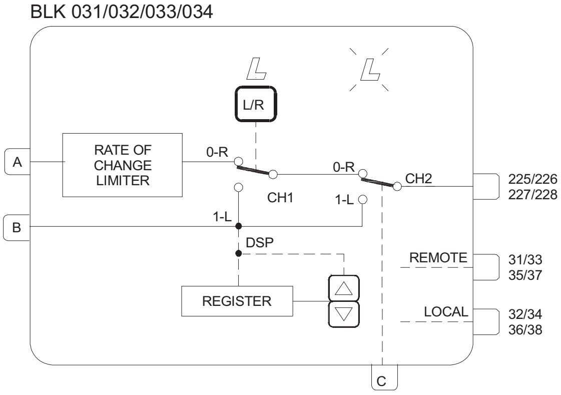
If one of the inputs **A**, **B**, **D**, **E** or **F** be shown in the Alphanumeric Display and its indication in engineering units exceeds 10000, the display will show the message "++++" instead of the input value. If this indication be lower than -10000, the message displayed will be " - - - -".

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input **A** - SP	Addresses 0 to 170 / 225 to 240	0
I	LIB	Input **B** - PV		0
I	LIC	Input **C** – MV		0
I	LID	Input **D**		0
I	LIE	Input **E**		0
I	LIF	Input **F**		0
I	LIG	Input **G** - Counter type Input		0
I	LIH	Input **H** - blink MV bargraph		0
M	AMSP	Three-character mnemonic for SP	***	SP
R	ASPZ	0% for SP in engineering units	-10000 to 10000	0
R	ASPM	100% for SP in engineering units	-10000 to 10000	100.00
M	AMPV	Three-character mnemonic for PV	***	PV
R	APVZ	0% for PV in engineering units	-10000 to 10000	0
R	APVM	100% for PV in engineering units	-10000 to 10000	100.00
M	AMND	Three-character mnemonic for D	***	MND
R	A-DZ	0% for D in engineering units	-10000 to 10000	0
R	A-DM	100% for D in engineering units	-10000 to 10000	100.00
M	AMNE	Three-character mnemonic for E	***	MNE
R	A-EZ	0% for E in engineering units	-10000 to 10000	0
R	A-EM	100% for E in engineering units	-10000 to 10000	100.00
M	AMNF	Three-character mnemonic for F	***	MNF
R	A-FZ	0% for F in engineering units	-10000 to 10000	0
R	A-FM	100% for F in engineering units	-10000 to 10000	100.00

Number of Bytes per Type of Parameter: A = 60 C = 0 L = 16

Function 07 - Local/Remote SP Selector (L/R)

Operation



This block allows Setpoint selection by pressing the key <L/R> (Local/Remote), Setpoint adjustment by pressing keys <∆> and <∇> and the selection and adjustment of several Setpoints related functions.

Actuation in Local mode is possible in two ways:

a) By the internal Register of the block, which is actuated by the <∆> and <∇> keys of the front panel, when the Set Point is selected on the display. The output of the block must be connected to a block of **Function 06 - Front View or Function 32 - General Visualization**.

b) By input **B**, that can be connected to the output of another block. The use of **B** automatically cancels the internal register action. The block becomes an input selector.

Transfer from Local to Remote and vice versa is possible in two ways:

a) By using the <L/R> key of the front panel, that actuates the switch **CH1**. In this case, the LED "L" of the corresponding loop will light up when Local mode is selected.

b) By a high logic level at input **C**, that actuates the switch CH2 and "forces" Local mode. In this case, the LED "L" of the corresponding loop will remain blinking while input **C** is with high level.

The following tables summarize the block status for the different combinations of CH1, CH2 and input B.

INPUT B CONNECTED

CH1	INPUT C	LED L	OUTPUT
R	0	-	INPUT A
R	1	FLASHING	INPUT B
L	0	LIT	INPUT B
L	1	LIT	INPUT B

Table 4.7.1 - Block output and LED action according CH1 (R/L key) and CH2 ("C" input) position, with input "B" connected.

INPUT B NOT CONNECTED

CH1	INPUT C	LED L	OUTPUT
R	0	-	INPUT A
R	1	FLASHING	INTERNAL REGISTER
L	0	LIT	INTERNAL REGISTER
L	1	LIT	INTERNAL REGISTER

Table 4.7.2 - Block output and LED action according CH1 (R/L key) and CH2 ("C" input) position, with input "B" not connected.

The controller can also be locked in Local or in Remote by the parameter **CLKR**.

After a power interruption, the controller will return to operation in the mode (Local or Remote) selected by the parameter **CTON**.

The block features bumpless Local-Remote transfer, with adjustable changing rate (Slew Rate, **ASLW**). This feature avoids abrupt changes in the Setpoint, and, consequently, in the process, when the Setpoint is switched from Local to Remote.

Remote to Local transfer is balanced, that is, the Local register tracks the Remote Setpoint, when operating in Remote mode. This can be used to implement Setpoint tracking when the loop is in manual.

In a Setpoint tracking configuration the SP=PV in manual mode. The PV is manually adjusted to the desired Setpoint by using the MV <△> and <▽>. Then he can switch back to automatic mode and the Setpoint will remain.

The LOG block inverts the MANUAL status signal to a AUTOMATIC, since Local Setpoint is desired in automatic mode.

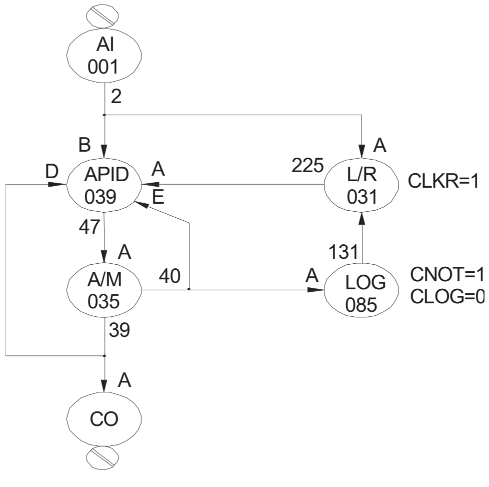


Fig 4.7.1 L/R Selector Configuration for Setpoint Tracking

The maximum and minimum limits for the Local Setpoint actuator are established in the parameters **ALOW** and **AUPP**.

If it is necessary to have limits on the Remote Setpoint, this shall be done by means of **Function 23 - Limiter with Alarm**.

In addition to the analog signal generated internally (in Local mode) or externally (in Remote Mode), the block has two discrete outputs; the first is at high logic level when the block is in Remote mode and the second is at high logic level when the operating mode is Local.

When one of the outputs 225/226/227 or 228 is visualized on the Alphanumeric Display and the block is in Local mode, the register may be actuated by the Front Panel (Local Setpoint). Besides, should this output signal be from inputs **A** or **B** (Remote Setpoint), and this input is linked to the output of an adjustment block, this adjustment block will also be actuated by the Front Panel. This feature is used in the following configuration.

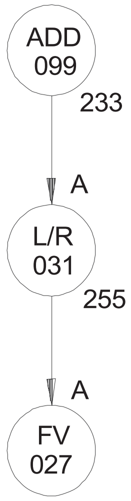


Fig 4.7.2 - L/R Selector Configuration for Internal or External Register Actuation

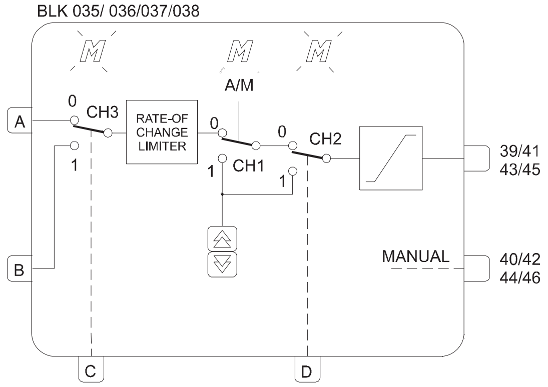
In the above configuration, when in Local mode, actuation is performed in the register of *Block 031* and, in Remote mode, in *Block 099*, although the visualized output is that of *Block 031*.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A - Variable to Remote Mode	Addresses 0 to 170 / 225 to 240	0
I	LIB	Input B - Variable to Local Mode		0
I	LIC	Input C - Forces Local Mode		0
I	CLKR	Locks switch CH1 in:	0-No Lock/1-Remote/2-Local	2
I	CTON	Starting condition after power failure	0 - Last mode 1 – Local 2 – Remote	0
P	ASLW	Maximum rate-of-change in Remote mode	1.00 - 200.00%/s	200.00%/s
P	ASPD	Register actuation speed	0.00 - 200.00%/s	10.00%/s
P	ALOW	Register lower limit	-102.00 to +102.00%	0.00%
P	AUPP	Register upper limit	-102.00 to +102.00%	100.00%

Number of Bytes per Type of Parameter: A = 8 C = 4 L = 6

Function 08 - Automatic/Manual Station (A/M)

OPERATION



This block allows the operator to actuate the controller output directly, whenever necessary.

In the most common application, the output signal of one of the *PID* blocks is linked to the input **A** of the **A/M** block, its output being linked to a current output block.

If the other inputs of this block are not used, switches CH3 and CH2 are permanently in position "0".

Switch CH1 may then be actuated by pressing the key <A/M> on the front panel, thus altering the operation mode:

a) AUTOMATIC (CH1 in position "0"): letter **M** is unlit in the corresponding loop. Input **A** signal goes to the block output after passing by a rate-of-change limiter (parameter **ASLW**) and by an output signal limiter (parameters **ALOW** and **AUPP**).

b) MANUAL (CH1 in position "1"): letter **M** is lit in the corresponding loop. Output signal may then be adjusted by the keys <△> and <▽>, its speed being determined by parameter **ASPD**, with the limits set by parameters **ALOW** and **AUPP**.

Manual to Automatic transfer may be bumpless or hard. Both modes are described in the PID block functions.

Automatic to Manual transfer is always balanceless. The register, actuated by the keys <△> and <▽>, always tracks the value available at the output of the **Rate-of-Change** limiter while in automatic operation.

After a power failure or a manual reset of the controller, switch CH1 returns to operation according to parameter **CHST**; it may return in Manual, Automatic or in the last position prior to the power failure or to the reset.

It is also possible to block the <A/M> key, locking the controller in Automatic or Manual, by means of the parameter **CCH1**.

FORCED MANUAL

Forced Manual mode is implemented by actuating switch CH2 by means of input **D**:

a) A low logic level in **D** keeps CH2 in position "0" (NORMAL OPERATION).

b) A high logic level in **D** switches CH2 to position "1" (FORCED MANUAL). In this situation, the register actuated by the keys <△> and <▽> takes the input value at position "0", just before the switching.

Other features may be added to this mode. For further information, see description of parameters **CCH1**, **CST1**, **CLAM** and **CLMV**.

SAFETY OUTPUT

The controller output may be driven to a safe value by switching CH3 to position "1", by means of input **C** of the block. The output signal will then be the input **B** signal. This may be a constant or a variable value, depending on which block it is originated.

If CH1 is in position "1" (equivalent to Manual), the letter **M** of the corresponding loop will be continuously lit and the output signal will be the signal of input **B** in the instant prior to CH3 switching.

If CH1 is in position "0" (equivalent to Automatic), the letter **M** will blink faster than when in Forced Manual and the signal at the output will be the same signal of input **B**.

The position of switch CH1 after input **C** returning to a low logic level is determined by parameter **CSA1**, with the following options: last position, position "1" and position "0". This may imply in Manual or Automatic operation if input **D** is with low logic level.

Other features may be added to this mode. For further information, see description of parameters **CCH1**, **CST1**, **CLAM** and **CLMV**.

INPUT B CONNECTED

INPUTS		SWITCHES			OUTPUT	LED M
C	D	CH3	CH1	CH2		
0	0	0	0	0	INPUT A	UNLIT
0	0	0	1	0	INTERNAL REGISTER	LIT
1	0	1	0	0	INPUT B	FAST FLASH
1	0	1	1	0	INTERNAL REGISTER	LIT
0	1	0	0	1	INTERNAL REGISTER	SLOW FLASH
0	1	0	1	1	INTERNAL REGISTER	LIT
1	1	1	0	1	INTERNAL REGISTER	SLOW FLASH
1	1	1	1	1	INTERNAL REGISTER	LIT

Table 4.8.1 - Truth table

Observe that the parameters CCHI, CST1 and CSA1 can affect the CH1 position in function of the input C and/or D status independent of the A/M key. Although, configuration of those parameters can automatically alter the table line, as it can suppress some lines.

CCH1 - ACTUATION OF CH1

This parameter determines if switch CH1 will be actuated only by the front panel or with CH2 and/or CH3, or if it will be locked in "0" (AUTO) or in "1" (MANUAL).

CH1 is actuated simultaneously with CH2 or CH3 when inputs **C** or **D**, have high logic level. CH1 position, when actuated by CH2 and/or CH3 is described in parameter **CST1**. The position of CH1, when CH3 returns to position "0", is defined in parameter **CSA1**.

CST1 - POSITION OF CH1 WITH CH2 AND CH3 ACTUATED

This parameter determines CH1 position when inputs **C** or **D** are with high logic level and parameter **CCH1** is programmed with 3, 4 or 5.

When input **C** returns to logic level "0", switch CH1 will take the position determined by parameter **CSA1**. After CH1 is actuated by input **D**, it may be free to be actuated by the <A/M> key since this is not locked (parameter **CLAM**=1 or 3). CH1 position when input **D** returns to a low logic level will be the position of CH1 just before CH2 switching.
Such position is indicated on the front panel as follows:

- "**M**" blinking: CH1 in position "0" (equivalent to automatic when CH2 returns to position "0").

- "**M**" continuously lit: CH1 in position "1" (equivalent to Manual).

CLAM - LOCKS A/M KEY

This parameter locks the front panel <A/M> key, thus preventing the actuation of switch CH1 when inputs **C** and/or **D** have high logic level.

This feature prevents the operator from actuating the <A/M> key during situations of "safety output" or "forced manual".

CLMV - LOCKS <△> AND <▽> KEYS

This parameter locks the front panel keys <△> and <▽>, thus preventing the alteration of the output value while in Manual mode, when inputs **C** and/or **D** have high logic level.

This prevents the operator from changing the output signal during situations of "safety output" or "forced manual".

CHST - RESTART CONDITION
CHST configure the operating mode of the respective loop after a power interruption.

CLIM-OUTPUT LIMITER ONLY ON AUTOMATIC
The output limiter actuates normally in both operating modes: manual and automatic. CLIM allows the limiter to actuate only on the automatic mode.

EXAMPLES:

1) As an emergency situation defined by a high logic level signal, the control output shall remain in the last value prior to the emergency, unless the operator decides to change it. If the emergency situation disappear, the control shall remain in manual mode.

Solution: This is a "Forced Manual" situation. The emergency signal shall be linked to input **D** and the following parameters shall be configured:

CST1 = 0 → CH1 goes to or remains in position "1" (Manual) whenever an emergency situation occurs.

CCH1 = 3 → Input **D** signal switches **CH1.**

CSA1 = → any value.

CLMV = 0 →The keys <△> and <▽> shall operate.

CLAM = 1→ Locks the <A/M> key, thus preventing CH1 to be switched to position "0", allowing return in Automatic mode.

2) In the same emergency situation described above, the output signal shall go to 2%, remaining in this value throughout the emergency situation. When the emergency signal disappear, the controller shall remain in manual mode.

Solution: This is a "Safety Output" situation. The emergency signal shall be linked to Input **C**, the value 2% (from an adjustment block or a constant value block) shall be linked to Input **B** and the following parameters shall be configured:

CST1 = 1 → CH1 goes to or remains in position "0" (Auto). The output will be the input **B** value in the instant of CH3 switching.

CCH1 = 4 → Input **C** signal switches CH1.

CSA1 = 1 → Controller shall remain in Manual after the emergency signal drops.

CLMV = 2 →The keys <△> and <▽> are locked as long as the emergency signal is present.

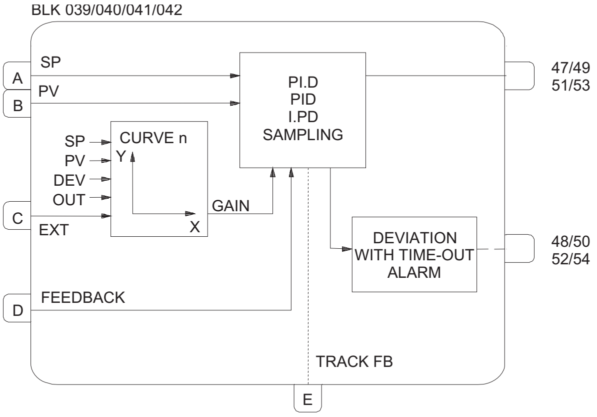
CLAM = 2 → CH1 is locked since the emergency signal is present.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A (Automatic)	Addresses 0 to 170 / 225 to 240	0
I	LIB	Input B (Safety)		0
I	LIC	Input C (Safety Switch)		0
I	LID	Input D (Forced Manual)		0
I	CST1	CH1 position when inputs C or D have a high logic level and parameter CCH1 ? 0, 1 or 2	0 - Position 1 (Manual Position in normal operation) 1 - Position 0 (Automatic Position in normal operation)	0
I	CCH1	Actuation of CH1	0 - <A/M> Key 1 - Locks in Position 0 (AUTO) 2 - Locks in Position 1 (MANUAL) 3 - <A/M> Key or Input D 4 - <A/M> Key or Input C 5 - <A/M> Key or Inputs C or D	0
I	CSA1	CH1 position when input C returns to a low logic level	0 - Last Position 1 - Position 1 - (MANUAL) 2 - Position 0 - (AUTO)	0
I	CLMV	Locks <△> and <▽> keys	0 - No Lock 1 - When Input D has a high logic level 2 - When Input C has a high logic level 3 - When Inputs C or D have a high logic level	0
I	CLAM	Locks <A/M> key	0 - No Lock 1 - When Input D has a high logic level 2 - When Input C has a high logic level 3 - When Inputs C or D have a high logic level	0
I	CHST	Restart condition - Operating mode after power interruption	0 - Last 1 - Manual 2 - Auto	0
I	CLIM	Output limiter only on Automatic	0 - Manual and Auto 1 - Auto	0
I	ASPD	Actuation Speed in Manual	0.00-200.00%/s	10.00%/s
I	ALOW	Lower Limit	-2.00 to +102.00%	-2.00%
I	AUPP	Upper Limit	-2.00 to +102.00%	+102.00%
I	ASLW	Slew Rate for the Automatic mode	1.00 to 200.00%/s	200.00%/s

Number of Bytes per Type of Parameter: A = 8 C = 14 L = 8

Function 09 - Advanced PID (PID)

Introduction



This block offers a wide range of control algorithms, using the traditional Proportional *(P)*, Integral *(I)* and Derivative *(D)* modes in various arrangements.

There are two choices of *PID* algorithm: one is the parallel, ideal and the other is noninteractive, ISA algorithm. Calculation of the *PID* prevents the saturation of the output by the integral mode (anti- reset-windup). Saturation limits are adjustable by the user, a unique feature of the **SMAR CD600 Digital Controller**, that brings more flexibility to the control strategy.

Manual to Automatic transfer may be bumpless or hard. Bumpless transfer makes the automatic mode start from the last manual value prior to the switching. Hard transfer will add to this value the proportional action: (K_p.e). In both cases the output signal of the block of **Function 08 - Automatic/Manual Station**, must be connected to input **D** (**Feedback**) and the Status signal of the Auto/Manual block must be connected to input **E** (**track FB**).

This block allows selection of the following control types: *Sample and Hold, Quadratic Error, GAP and Adaptative Gain.*

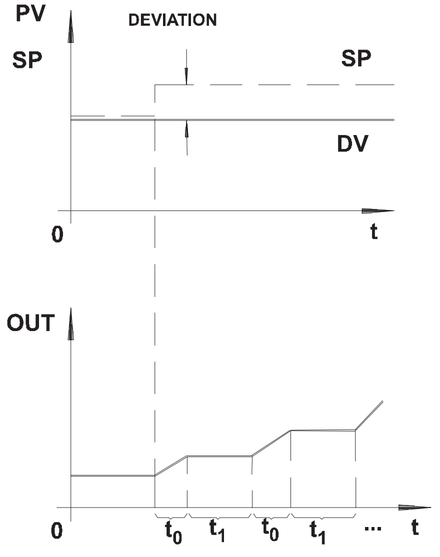
TYPE OF PID (CTYP)

PI.D - The *P* and *I* act on the deviation, and *D* on the Process Variable. In this way, the output signal follows the changes of the Setpoint according to the Proportional and Integral actions, but does not give an undesirable impulse due to the Derivative action. This option is the most recommended for the majority of applications with Setpoint adjustable by the operator.

PID - The *P*,*I* and *D* actions act on the deviation. In this way, the output signal changes when there are changes on the Process Variable or on the Setpoint. This option is recommended for ratio control or for the slave controller of a cascade.

I.PD - In this type only the Integral mode acts on the deviation. Changes on the Setpoint cause variation of the output according to the Integral mode, which is a very smooth effect. It is recommended for processes that can be upset by abrupt changes of the Setpoint. This is the case of heating processes with high proportional gain.

PI-SAMPLING - In this option, when there is a deviation, the output signal changes according to the *PI* algorithm during a time t_0. Then, the output signal is kept constant during a time t_1. If the deviation persists, the signal will vary again during t_0, and will remain constant during t_1. The period is t_0+t_1, (adjusted by **CSAM**), and the actuation time is t_0 (adjusted by **CSON**). This type is recommended for processes with high dead time.



$t_0 + t_1$ = SAMPLING PERIOD

t_0 = ACTUATION TIME

Fig 4.9.1 - PI Sampling

ACTION (CACT)

There are processes that require the output signal to increase when the Process Variable increases, while others require the other way around.

Parameter **CACT** selects the type of action:

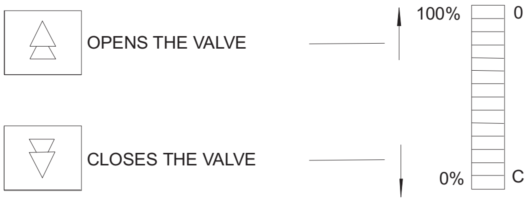
TYPE 0, 2, 4 or 6 - Output signal decreases when PV increases

$$e = (SP - PV)$$

TYPE 1, 3, 5 or 7 - Output signal ncreases when PV increases.

$$e = (PV - SP)$$

In order to standardize operation, it is recommended to consider that an output signal equal to 100% means valve open and that an output signal equal to 0% means valve closed. Operation of the front panel keys follows the same principle:



According to this procedure **MV**=100% means always valve open and **MV**=0% means always valve closed.

If the actuated valve is "Air-to-open", **MV**=100% must be equivalent to 20 mA. Valves type Air-to-close will require 100% being equivalent to 4 mA. This may be selected in **Function 02 - Current Output**.

Tuning by the Front Panel

Parameter **CACT** also defines if the block allows changes on the tuning parameters through the front panel push buttons or not (see *PID* constants ahead).

Front panel adjustment is selected when **CACT**=0, 1, 4 or 5.

Control Algorithm

The **CD600** offers two control algorithms:

Parallel or Ideal algorithm

$$MV(t\ ) = K_p e(t\ ) + \frac{1}{T_R} . \int e(t\ )dt + T_D \frac{de(t\ )}{dt}$$

Noninteractive or ISA algorithm

$$MV(t\ ) = K_p [e(t\ ) + \frac{1}{T_R} . \int e(t\ )dt + T_D \frac{de(t\ )}{dt}\ ]$$

Parameters 0, 1, 2 or 3 select the parallel or ideal.
Parameters 4, 5, 6 or 7 select the noninteractive or ISA.

For the noninteractive option, when K_p=0 the controller is automatically set as ID.

QUADRATIC ERROR (CETY)

The control deviation (or error) normally used in the **CD600** controller calculations is given by:

e = SP - PV When "Output decreases when PV increases" is selected.

e = PV -SP When "Output increases when PV increases" is selected.

There are processes where the deviations in relation to the Setpoint are preferable to disturbances caused by the controller on downstream processes. Therefore, the control actuation should be small for small deviations and increase gradually with the size of the deviation. A typical example of this type of process is the level control of a tank where the Setpoint is not as important as the flow stability downstream the tank. This type of process can be controlled with the adaptative gain, the control with gap, or the quadratic error in-stead of the linear (normal) error.

In the quadratic error (**CETY**=1), the error to be considered in the PID calculations is given by:

$$\hat{e} = \frac{e \cdot /e/}{100}$$

ê = error to be considered in the *PID* calculation.

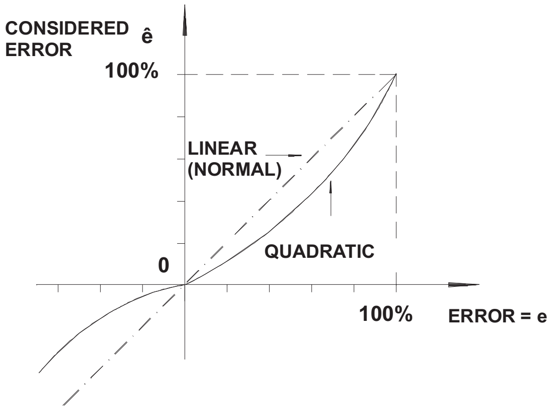


Fig 4.9.2 - Quadratic Error x Normal Error

GAP CONTROL (CBND AND CSGA)

There are applications where the control is unstable near the Setpoint due to actuator dead band, noise or other reasons. In this case, it is advisable to have a controller with a differentiated action around the Setpoint.

The gap control or gap with special gain can be used to solve this problem.

EXAMPLE:

Considered error *(ê)* for a gap control with a band equal tọ 10% (**CBND**=10) and special gain equal to zero (**CSGA**=0).

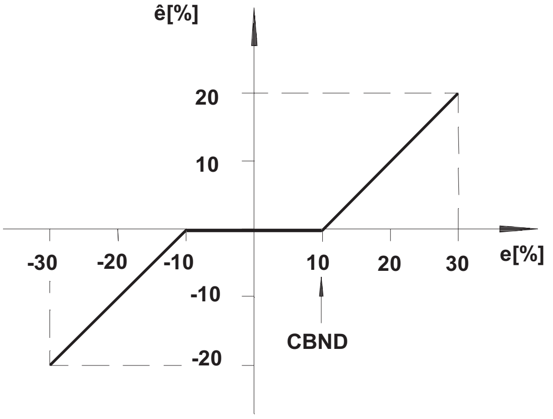


Fig 4.9.3 - Gap Control with Gain=0

Some processes may require a special gain within the band. In such cases, it is possible to select a factor at parameter **CSGA** which multiplies the error, thus making the error to be considered in the *PID* calculations to be:

ê=e.CSGA

Thus, the control action will be, within the Gap, faster when **CSGA**>1 and slower when **CSGA**<1. For **CBND**=0 (null band) the gap control is not activated.

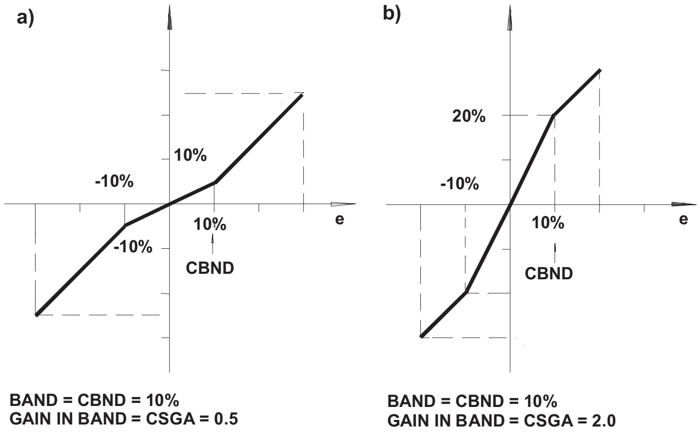


Fig 4.9.4 - Gap Control - (a) Gain < 1, (b) Gain > 1

CONTROL WITH ADAPTATIVE GAIN (CIAG, CLIN, CAAD)

The adaptative gain modifies the *PID* constants by a factor G. This factor G follows a curve of 13 or 26 points as a function of the Setpoint **SP**, of the Process Variable **PV**, of the deviation (error) **DEV**, of the output **OUT**, or of an external variable **EXT**. The type of signal that generates the gain curve is selected in parameter **CIAG**.

Curve selection is performed by **CLIN**. The points of the curve are specified in the General Loop, in blocks of the **Function 31 - Linearization Curve**. The curves that may be performed are shown on Table 4.31.1 (page 4.59).

The points of the adaptative gain curve are given as percentage of the selected variable on the axis of the abscissa **X** and by the gain **G** on the axis of ordinate **Y**. The gain modifies the tuned constants: K_P, T_R and T_D into K_P', T_R' and T_D' as follows:

$$Kp' = G \cdot Kp$$

$$Tp' = \frac{T_R}{G}$$

$$T_D' = G \cdot T_D$$

Gain **G** may affect the *PID*, *PI*, *P*, *I* and *D* actions. Selection is performed by parameter **CAAD** which also inhibits Adaptative Gain action when **CAAD**=0. The adaptative gain is recommended for highly nonlinear controls. A classic example of adaptative gain is the drum level control of a boiler.

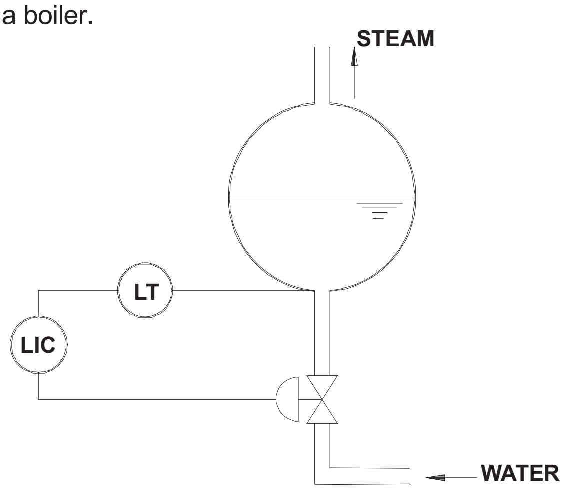


Fig 4.9.5 - Simple Drum Level Control of a Boiler

The volume variations are nonlinear with the level variations. The dotted line of Figure 4.9.6 show the volume gain with the level. Note that the volume varies slowly (low gain), around 50% level and varies very fast (high gain) around the level extremes. The control action must have a gain that is the inverse of the process gain. This is shown by the continuous line of Fig 4.9.6.
The adaptative gain characteristic can be configured as shown in Fig 4.9.7. This curve can be represented by the following points of Curve 1: (X1 = 0; Y1 = 0.2; X2 = 20; Y2 = 0.8; X3 = 40; Y3 = 0.96; etc.).

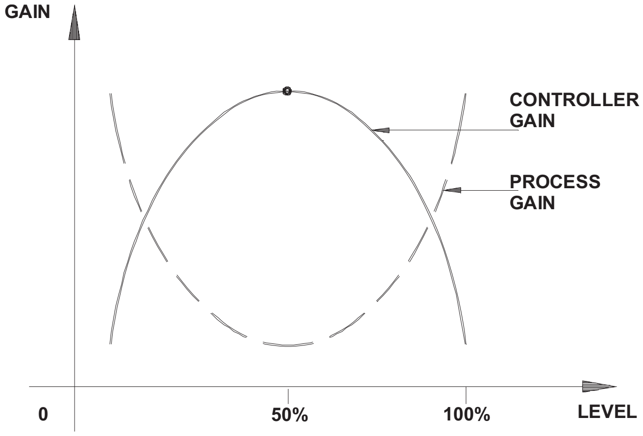


Fig 4.9.6 - Process and Controller Gain

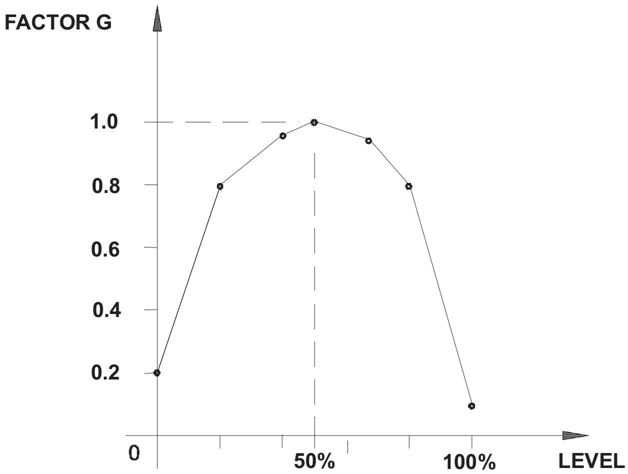


Fig 4.9.7 - Gain Curve as a Function of PV

While planning the configuration, observe the following:

1. It is not necessary to use all 13 points of the curve.

2. It is fundamental to use the 0% and the 100% of the determining variable (-100 and +100% for the Error).

3. It is recommendable to program the variable up to 102%, since the variable may be above 100%.

4. Tuning is normally done for G = 1. In the example, the control becomes slower above or below 50% of the level.

Adaptative Gain is also very useful for pH control.

ANTIRESET-WINDUP (CARL AND CARU)

The control algorithm automatically stops the contribution of the integral mode when the output signal reaches the limits of 0 or 100%. Contributions of the Proportional and Derivative modes are not affected.

The **CD600** has a unique feature: the adjustment of the limits for the integral mode saturation.

It is normally fixed at 0% (**CARL**) and 100% (**CARU**), but can be narrowed, allowing quicker responses and avoiding overshoot in heating processes, for example.

PID CONSTANTS (AKp, ATr, ATd)

The table is self-explanatory. *It is good to remember that the Proportional action is in terms of Gain and not of Proportional Band*. Bigger Kp means more action. The Integral action is in terms of minutes per repeats, not repeats per minute. Smaller T_R means more Integral action.

PID constants may be adjusted by the Hand Held Programmer or the controller's front panel (see tuning procedures). In order to inhibit tuning by the front panel, simply configure parameter **CACT** (action) with 2, 3, 6 or 7 instead of 0, 1, 4 or 5.

DEVIATION ALARM (AMXD, ATOD)

These parameters establish the alarm limit for the control deviation or error (**AMXD**) and for how long this deviation may be tolerated without alarm activation (**ATOD**).

If **AMXD**=5 and **ATOD**=0.5, the block will set the "**Dev-time-out**" output to high logic level if a 5% deviation or more persists for more than 0.5 minutes. Note that 0.00 for the time is here considered as infinite time or no alarm. The shortest time available is 0.01 minute.

CFRT specifies if the deviation alarm should appear on the front panel or not.

BIAS (ABIA)

In this parameter, it is possible to adjust an initial value for the output signal when the control is transferred from Manual to Automatic. This may be done only if the input **Feedback** is not connected (**LID**=0).

For bumpless Manual to Automatic transfer, the input **D** must be connected to the output of the A/M block and the **track FB** input **E** must be connected to the status indication of the A/M block. In this case, parameter **ABIA** is used to change the block output during automatic operation. The output signal is subjected to a step type variation whenever the **ABIA** value is modified. Amplitude and direction of this step are equivalent to the difference between the previous and the new **ABIA** value. The connection diagram for both cases are shown on the following figures:

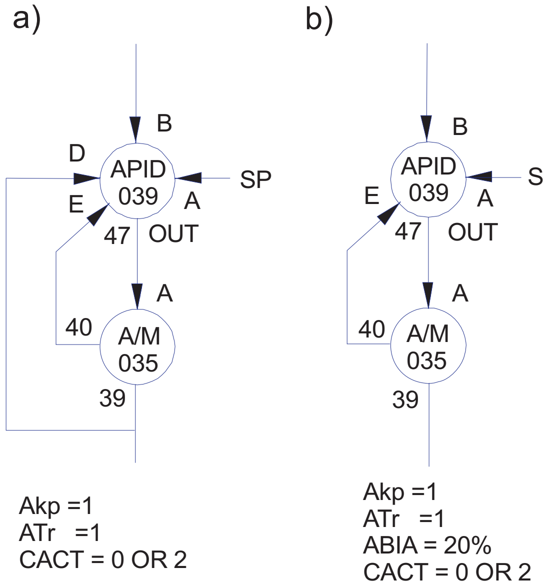


Fig 4.9.8 - Configuration for Manual to Auto Transfer.
a) Bumpless b) The Automatic Output Starts with the Bias Value

During the Manual to Auto transfer, it is possible to add, to the initial output value (in both cases above), a value equal to the proportional gain (**AKP**) multiplied by the error at that time. This is a transfer type HARD. It can be obtained with the parameter **CTYP** equal to 4, 5 or 6.

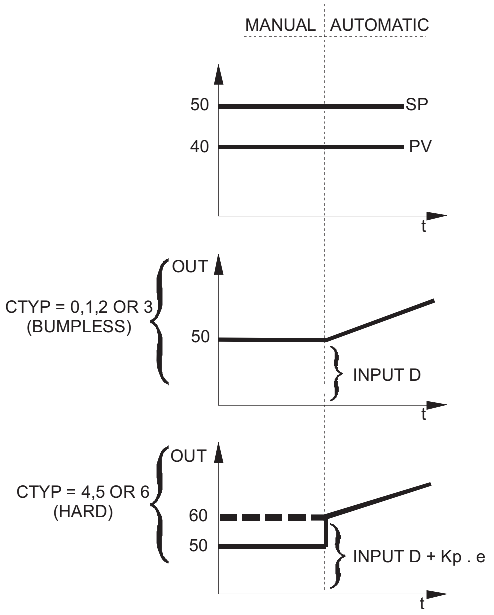


Fig 4.9.9 - Manual to Auto Transfer. The Automatic Output starts with the Last Manual Output Value

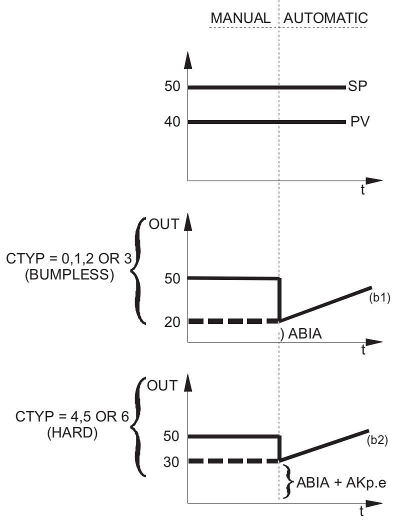


Fig 4.9.10 - Manual to Auto Transfer. The Automatic Output Starts with the Bias Value

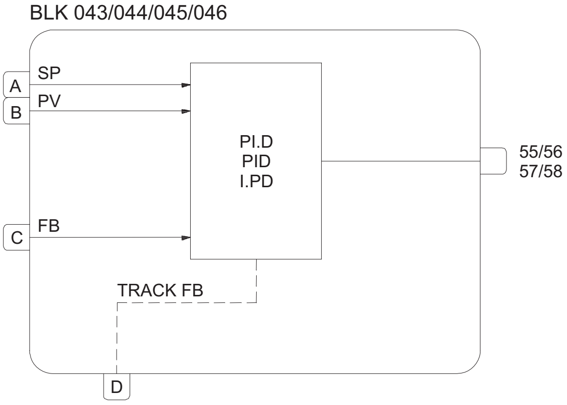
TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	SP (Setpoint) input	Addresses 0 to 170 / 225 to 240	0
I	LIB	PV (Process Variable) input		0
I	LIC	External Variable Input for Adaptative Gain		0
I	LID	Input for the control output (feedback), used for Bumpless transfer		0
I	LIE	Input for the Auto/Manual Status. Digital Interpretation		0
I	CACT	Control Action and Inhibition of tuning by the front panel and Control Algorithm REVERSE: Output decreases when PV increases DIRECT: Output increases when PV increases	Parallel or Ideal Algorithm: 0 – Reverse 1 – Direct 2 - Reverse with no tuning on front 3 - Direct with no tuning on front Noninteractive or ISA: 4 – Reverse 5 – Direct 6 - Reverse with no tuning on front 7 - Direct with no tuning on front	0
I	CTYP	PID Action on Error and Process Variable. Actions indicated before the point are on Error while the others are on the Process Variable Bumpless or Hard M → A transfer	0 - PI.D Bumpless 1 - PID Bumpless 2 - I.PD Bumpless 3 - PI Sampling Bumpless 4 - PI.D Hard 5 - PID Hard 6 - PI Sampling Hard	0

TYPE	MNEM	DESCRIPTION	RANGE	DEFAUL T
P	CETY	Type of Error to be considered	0 – Normal 1 – Quadratic	0
P	CBND	Special gain band	0.01 - 300.00% 0 - Not activated	0.00%
P	CSGA	Special Gain within the gap	0.00 - 10.00	0.00
P	CSAM	Period of PI - Sampling (t_0 + t_1)	0.00 - 180.00 min.	0.00 min
P	CSON	Time that the PI - Sampling is active (t_0) (CSON<CSAM)	0.00 - 180.00 min.	0.00 min
I	CIAG	Input variable for the Adaptative Gain	0-SP /1-PV/2-Error 3-Output/4-External	0
P	CLIN	Curve for the Adaptative Gain	0-X=Y 1→8/Curves 1 →8 9-Curves 1 and 2 10-Curves 3 and 4 11-Curves 5 and 6 12-Curves 7 and 8	0
I	CAAD	Adaptative Gain Action	0- Not Used/ 1-PID/ 2-PI/3-P/4-I/5-D	0
P	CARL	Antireset-Windup lower limit	-2.00 to +50.00%	0.00%
P	CARU	Antireset-Windup upper limit	+50.00 to +102.00%	100.00%
I	CFRT	Error alarm indication on front panel	0-No/1-Yes 2-Yes With Auto Ack.	0
P	Akp	Proportional Gain	0.00 - 100.00	0.30
R	Atr	Integral time (min./repetition)	0.01 - 1000.0	10.000
R	Atd	Derivative constant (min.)	0.00 - 100.00	0
P	ABIA	Bias	-100.00 - 100.00%	0.00
P	AMXD	Maximum deviation without alarm (%)	0.00 - 100.00%	0.00%
P	ATOD	Maximum time for deviation alarm (min.)	0.01 - 200.00 min. 0.00 - No Alarm	0.00 min

Number of Bytes per Type of Parameter: A = 16 C = 26 L = 10

Function 10 - Simple PID (PID)

Introduction



This block offers a wide range of control algorithms, using the traditional Proportional *(P)*, Integral *(I)* and Derivative *(D)* modes in various arrangements.

There are two choices of *PID* algorithm: one is the parallel, ideal and the other is noninteractive, ISA algorithm. Calculation of the *PID* prevents the saturation of the output by the integral mode (anti- reset-windup). Saturation limits are adjustable by the user, a unique feature of the **SMAR CD600 Digital Controller**, that brings more flexibility to the control strategy.

Manual to Automatic transfer may be bumpless or hard. Bumpless transfer makes the automatic mode start from the last manual value prior to the switching. Hard transfer will add to this value the proportional action: (KP.e). In both cases, it is necessary to connect the output signal of the Auto/Manual block to input **C** (**Feedback**) and the status signal of the Auto/Manual block to input **D** (**track FB**).

TYPE OF PID (CTYP)

PI.D - The *P* and *I* act on the deviation, and *D* on the Process Variable. In this way, the output signal follows the changes of the Setpoint according to the Proportional and Integral actions, but does not give an undesirable impulse due to the Derivative action. This combination is the most recommended for the majority of applications with Setpoint adjustable by the operator.

PID - The *P*, *I* and *D* actions act on the deviation. In this way, the output signal changes when there are changes in the Process Variable or on the Setpoint. This option is recommended for ratio control or for the slave control of a cascade.

I.PD - In this type only the Integral mode acts on the deviation. Changes on the Setpoint cause variation of the output according to the Integral mode, which is a very smooth effect. This combination is recommended for processes that can be upset by abrupt changes of the Setpoint. This is the case of heating processes with high proportional gain.

ACTION (CACT)
There are processes that require the output signal to increase when the Process Variable increases, while others require the other way around.

Parameter **CACT** selects the type of action:

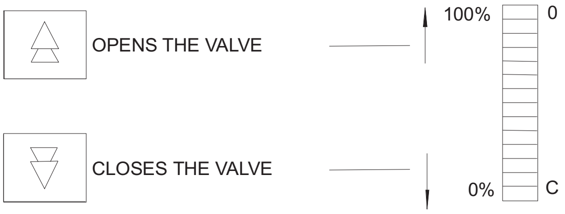
TYPE 0, 2,4 or 6 - output signal decreases when PV increases.

$$e = (SP - PV)$$

TYPE 1, 3, 5 or 7 - output signal increases when PV increases.

$$e = (PV - SP)$$

In order to standardize operation, it is recommended to consider that an output signal equal to 100% means valve open and that an output signal equal to 0% means valve closed. Operation of the front panel keys follows the same principle:



If the actuated valve is "Air-to-open", **MV**=100% must be equivalent to 20 mA. Valves type Air-to-close will require 100% being equivalent to 4 mA. This may be selected in **Function 02 - Current Output**.

Tuning by the Front Panel

Parameter **CACT** also defines if the block allows changes on the tuning parameters through the front panel push buttons or not (see "**PID Constants**" ahead).

Front panel adjustment is selected when **CACT**=0, 1, 4 or 5.

Control Algorithm

The **CD600** offers two control algorithms:

Parallel or Ideal algorithm

$$MV(t) = K_p e(t) + \frac{1}{T_R} . \int e(t) dt + T_D \frac{de(t)}{dt}$$

Noninteractive or ISA algorithm

$$MV(t) = K_p [e(t) + \frac{1}{T_R} . \int e(t) dt + T_D \frac{de(t)}{dt}]$$

Parameters 0, 1, 2 or 3 select the parallel or ideal.

Parameters 4, 5, 6 or 7 select the noninteractive or ISA.

For the noninteractive option, when K_p=0 the controller is automatically set as ID.

ANTIRESET-WINDUP (CARL AND CARU)

The control algorithm automatically stops the contribution of the integral mode when the output signal reaches the limits of 0 or 100%. Contributions of the Proportional and

Derivative modes are not affected.

The **CD600** has a unique feature: the adjustment of the limits for the integral mode saturation.

It is normally fixed at 0% (**CARL**) and 100% (**CARU**), but can be narrowed, allowing quicker responses and avoiding overshoot in heating processes, for example.

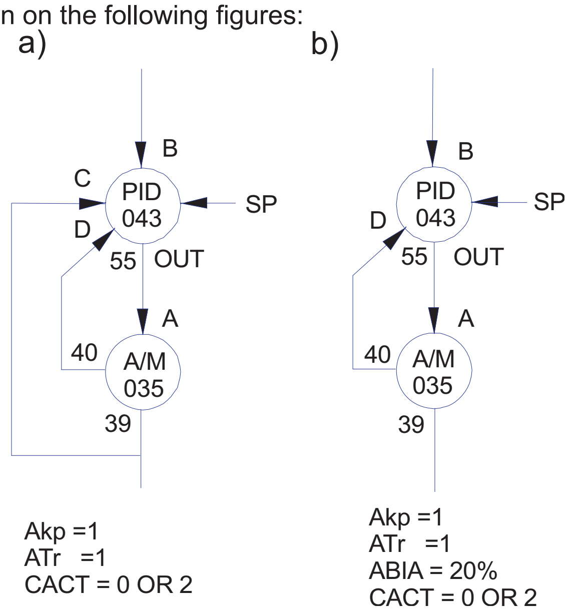
PID CONSTANTS (AKp, ATr, ATd)

The table is self-explanatory. *It is good to remember that the Proportional action is in terms of Gain and not of Proportional Band*. Bigger gain means more action. *PID* constants may be adjusted by means of the Hand Held Programmer or the controller's front panel (see tuning procedures). In order to inhibit front panel tuning, simply configure parameter **CACT** with 2 or 3 instead of 0 or 1.

BIAS (ABIA)

With this parameter it is possible to assign an initial
bias value to the output signal when the control is transferred from Manual to Automatic. This may be done only if input **Feedback** is not connected (**LIC**=0)

For bumpless Manual to Automatic transfer, the input **C** must be connected to the output of the A/M block and the input **D** (**track FB**) must be connected to the status indication of the A/M block. In this case, parameter **ABIA** is used to change the block output during automatic operation. The output signal is subjected to a step type variation whenever the **ABIA** value is modified. Amplitude and direction of this step are equivalent to the difference between the previous and the new **ABIA** value. The connection diagram for both cases are shown on the following figures:



4.10.1 - Configuration for Manual to Auto Transfer. a) Bumpless b) The Automatic Output Starts with the Bias Value

During the Manual to Auto transfer, it is possible to add to the initial output value (in both cases above), a value equal to the proportional gain (**AKp**) multiplied by the error at that time. This is a transfer type HARD. It can be obtained with the parameter **CTYP** equal to 3 or 4.

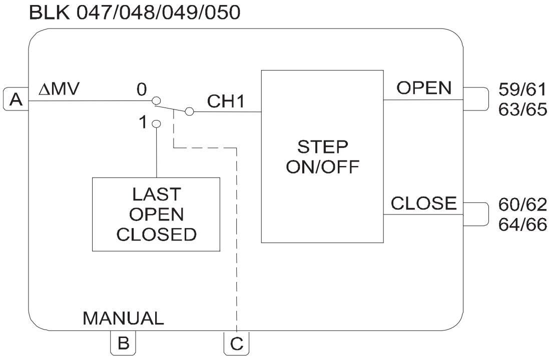
The figures **4.9.9** and **4.9.10** (**Function 09**) show the output behavior for the Bumpless and Hard transfer.

TYPE	MNEM	DESCRIPTION	RANGE	*DEFAULT*
I	LIA	SP (Setpoint) Input	Addresses□0 to 170 / 225 to 240	0
I	LIB	PV (Process Variable) Input		0
I	LIC	Input for the Control Output (Feedback), used for Bumpless transfer.		0
I	LID	Input for the Auto/Manual Status		0
I	CACT	Control Action and Inhibition of tuning by the front panel REVERSE: Output decreases when PV increases DIRECT: Output increases when PV increases	Parallel Ideal Algorithm 0 - Reverse 1 - Direct 2 - Reverse with no tuning on front 3 - Direct with no tuning on front Noninteractive or ISA 4 - Reverse 5 - Direct 6 - Reverse with no tuning on front 7 - Direct with no tuning on front	0
I	CTYP	Type of PID (see Advanced PID Controller)	0-PI.D/1-PID/2-I.PD(Bumpless)□3-PI.D/4-PID (Hard)	0
P	CARL	Antireset-Windup lower limit	-2.00 to 50.00%	0.00%
P	CARU	Antireset-Windup upper limit	50.00 to 102.00%	100.00%
P	AKp	Proportional Gain	0.00 - 100.00	0.30
R	ATr	Integral time (min./repetition)	0.01 - 1000.0	10.000
R	ATd	Derivative term constant (min.)	0.00 - 100.00	0
P	ABIA	Bias	-100.00 - 100.00%	0.00

Number of Bytes per Type of Parameter: A = 12 C = 8 L = 8

Function 11 - Step Controller (TEP)

Operation



This block is used in control loops with electrical final control element, such as rotating electric actuators.

This block always operates in conjunction with a block of the **Function 09 - Advanced PID** and one block from **Function 08 - Automatic/Manual Switch**. The *PID* and A/M blocks are connected as usual. The analog output of the A/M Station (39,41,43 or 45) is connected to the input **A** of the Step Control block and the status output (40, 42, 44 or 46) to the input **B**. The usual configuration is shown on the Figure 4.11.1.

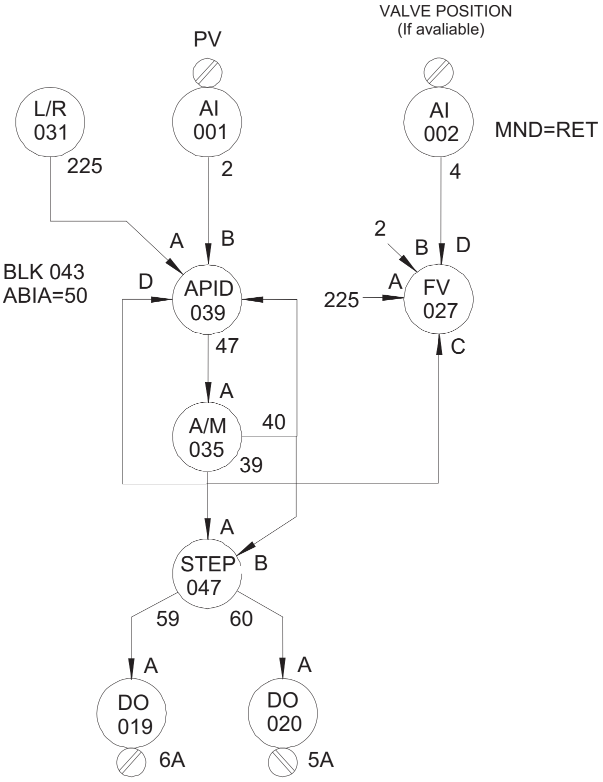


Fig 4.11.1 - Basic Configuration for a Step Control

It is recommended to use the advanced PID, because the gap control works as a dead band. This is required to avoid contact chattering, when the variable is close to the Setpoint.

When the control is in the automatic mode, the block is sensitive to incremental variations at input **A**. Output depends on this variation and on adjustments in parameter **AVOT** (Valve opening time) and **AWPL** (pulse width).

AVOT must be adjusted with the approximate time required for the valve to go from fully closed to fully open. The output characteristics also depend on **AWPL** - the minimum **pulse** width.

Proportional and Derivative actions of the *PID* are transformed into a pulse, whose duration depends on the *P* and *D* gains, on the error and on the time required by the valve for a complete excursion (**AVOT**).

Integral action is transformed into a series of pulses of minimum width **AWPL**, with a frequency determined by the integral time T_R and by the control deviation.

For example, consider a case where the *PID* is adjusted with proportional gain equal to 1, with no integral or derivative action; valve opening time = 1 minute and on instant *t*=0 there is a step error equal to 25% (Figure 4.11.2)

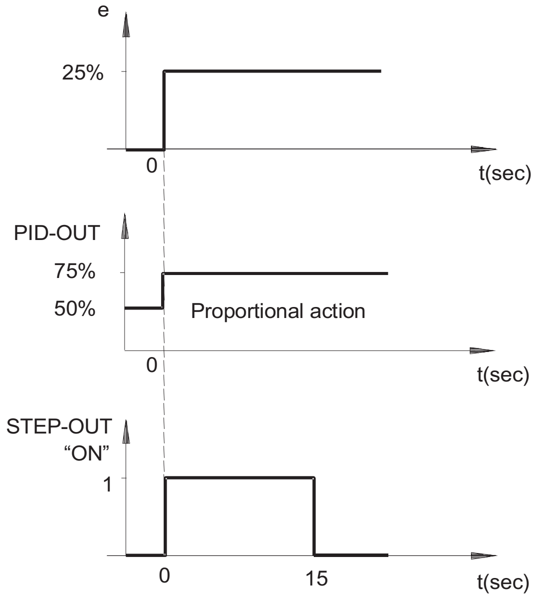


Fig 4.11.2 - Step Output for a 25% deviation with Proportional action only

In this example, 15 seconds of actuation are equivalent to 25% of the valve's excursion (0.25 min = 15 s).

The integral action works as a train of pulses with the same width. The total number of pulses in a given interval of time depends on the integral action adjustment in the *PID* and on the individual width of each pulse (**AWPL**).

Let's consider a case similar to the above example, where the *PID* has the integral action adjusted to 1 minute/repetition and each pulse has a width of 3 seconds. As **AWPL** is expressed in number of cycles and each cycle is 0.2 s, **AWPL**=3/0.2 = 15.

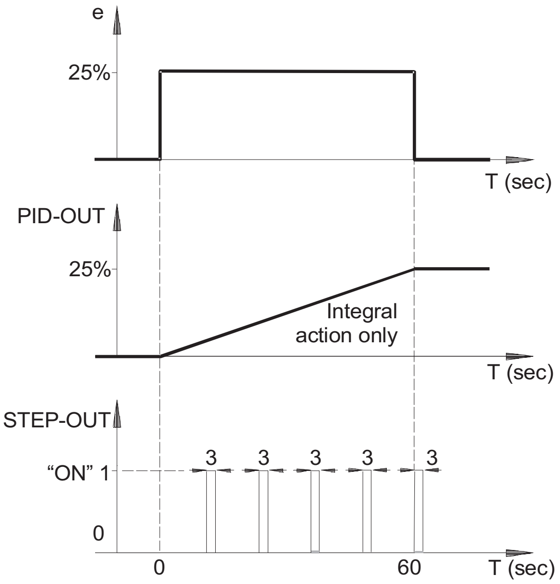


Fig 4.11.3 - Step Output for a 25% deviation with Integral action only

The error is 25%. A standard *I* controller would increase/decrease the output by 25% in 1 minute *(T_R)*.

In order to make a valve with excursion time = 1 minute open or close 25%, it is required a total time of 15 seconds (25% of 60 s).

As the minimum width (**AWPL**) was set to 3sec, the step control will give 5 pulses of 3 seconds equally distributed in a period of one minute. It will keep this rate while the PID output keeps the same rate of change. See Figure 4.11.3.

Increasing *PID* signal acts on output **OPEN** and decreasing *PID* signal acts on output **CLOSE**.

When the control is in Manual mode, the **MV** increase or decrease keys will change the block output status as follows:

Key <△ > Pressed → Output **OPEN** at high logic level

Key <▽> Pressed → Output **CLOSE** at high logic level

In order to have Manual operation, it is necessary to connect the status output of the A/M block to input **B** of the Step Control block.

When input **C** receives a high logic level signal, the block output is switched to the safety condition defined in parameter **CSAF**:

CSAF = 0 → Output **OPEN** and **CLOSE** at low logic level, the valve remains in the last position.

CSAF = 1 → Output **OPEN** at high logic level, the valve goes to the fully open position.

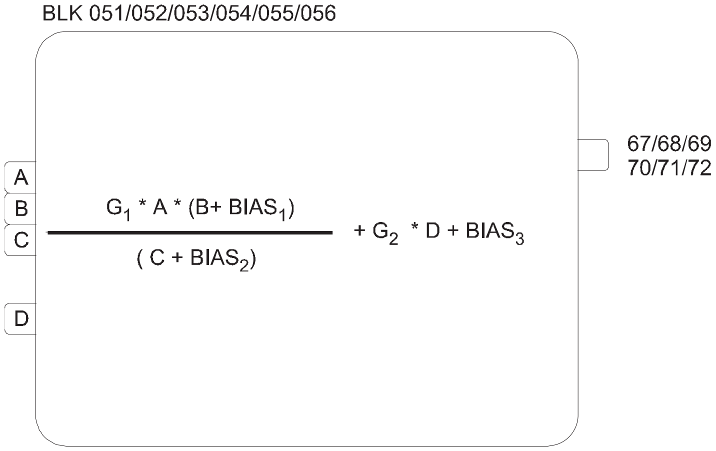
CSAF = 2 → Output **CLOSE** at high logic level, the valve goes to the fully closed position.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Incremental input (∆MV)	Addresses□0 to 170 / 225 to 240	0
I	LIB	MANUAL MODE indicative input		0
I	LIC	Input for safety position switching		0
I	CSAF	Safety Position	0 - Last value 1 - Open 2 - Closed	0
I	CTYP	Type of control	0-Open/None/Close□1-On/Off	0
I	AWPL	Minimum pulse width (in number of cycles)	1 - 1000	2
I	AVOT	Valve opening time	0 - 3200s	60s

Number of Bytes per Type of Parameter: A = 4 C = 4 L = 6

Function 12 - Multiplier-Divider-Adder-Subtractor (Arth)

Operation



This block performs the four arithmetic operations with the inputs, as shown by the formula below:

$$Output = \frac{G_1 \cdot A \cdot (B + Bias_1)}{(C + Bias_2)} + G_2 \cdot D + Bias_3$$

Where,

A, *B*, *C* and *D* = inputs (in %)
Bias1, *Bias2* and *Bias3* = constants (in %)
G1 and *G2* = gain (in real numbers)
Output = Result (in %)

Multiplication between a percentage and a real number always results in a percentage. Sum is always in percentage.

The inputs and the output of this block may range from -102 to +102%. Out of these limits, the extreme value is taken.

If the input **A** is not used, the block will assume
A= 100%.

If the inputs **B** or **C** are not used, the Bias parameters (**ABS1** and **ABS2**) shall be adjusted to 100% in order to avoid that *G1.A(B + Bias1)/(C + Bias2)* be equal to zero in the first case (multiplication by zero) or always "saturated in 100%" in the second case (division by zero).

EXAMPLE 1: Calculation

$G_1 = 2;\ A = 20\%;\ B = 30\%;\ Bias_1 = 10\%;\ Bias_2 = 100\%$

According to the formula the output should be:

$$2 \,.\, 20 \frac{(30 + 10)}{100} = \frac{40\% \times 40\%}{100} = 16\%$$

EXAMPLE 2: Ratio control with fixed ratio constant.

A very important application of **Function 12** is the ratio control. See example of configuration Section 3.

The purpose of this control is to maintain the ratio of flows Q_A and Q_B constant:

$$\frac{Q_A}{Q_B} = K$$

The best way to achieve this, is to control one of them, for example Q_B, with a Setpoint corresponding to Q_A/K. Q_B is called controlled flow and Q_A wild flow. Figure 4.12.1 shows configuration to be used.

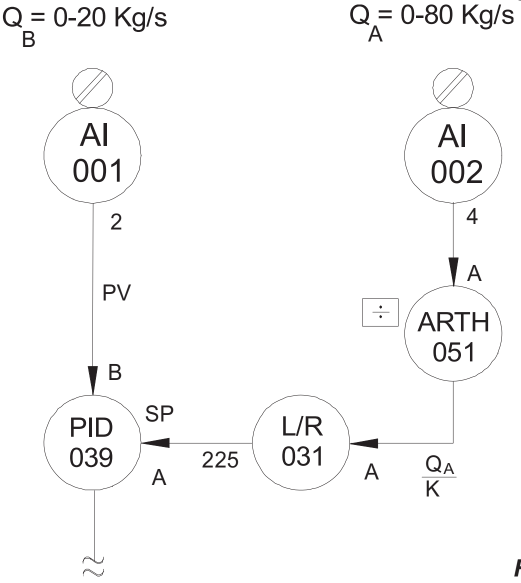


Fig 4.12.1 - Ratio Control with Fixed Ratio Constant

Lets assume that the control shall maintain $Q_A/Q_B=8$.

As the controller "sees" the signals corresponding to Q_A and Q_B as 0-100%, it is necessary to use an internal factor to show the relation between the two variables:

a) Certify that the two flows are in the same units.
b) Normalize the signals.

$[Q_A]$ = 0-100% signal, corresponding to Q_A : 0-80 kg/s.
$[Q_B]$ = 0-100% signal, corresponding to Q_B : 0-20 kg/s.

$$Q_A = \frac{80}{100} \cdot [Q_A] \quad (1) \qquad Q_B = \frac{20}{100} \cdot [Q_B] \quad (2)$$

Dividing (1) per (2):

$$\frac{Q_A}{Q_B} = \frac{80}{20} \cdot \frac{[Q_A]}{[Q_B]} \quad (3)$$

As $\boldsymbol{Q_A/Q_B=8}$ ***(4),***

Substituting it in (3):

$$8 = 4 \cdot \frac{[Q_A]}{[Q_B]} \quad \therefore\ [Q_B] = 0.5\,[Q_A] = SP \quad (5)$$

That means: when the process has the right ratio, the signal corresponding to the Setpoint of flow Q_B is the half of the signal, corresponding to flow Q_A.

c) Calculate the Arithmetic Block as follows:

$$OUTPUT = \frac{G_1 \cdot A \cdot (B + Bias_1)}{C + Bias_2} + G_2 \cdot D + Bias_3$$

(6)

$[Q_A]$ connected to input **A** makes $A=[Q_A]$. The output is the Setpoint for Q_B. Making (5) = (6).

$$SP = \frac{G_1 \cdot [Q_A] \cdot (0 + Bias_1)}{0 + Bias_2} + G_2 \cdot 0 + Bias_3$$

Bias = 100%
$Bias_2$ = 100%
$Bias_3$ = 0 $SP = 0.5[Q_A]$
G_1 = 0.5
G_2 = 0

EXAMPLE 3: Ratio Control with adjustable ratio

Many times the control requires a ratio constant adjustable by the operator. In the last example the ratio constant was fixed. In this example, it must be adjustable between 5 and 10.

In order to achieve this, add to the configuration in Figure 4.12.1 the blocks shown in Figure 4.12.2.

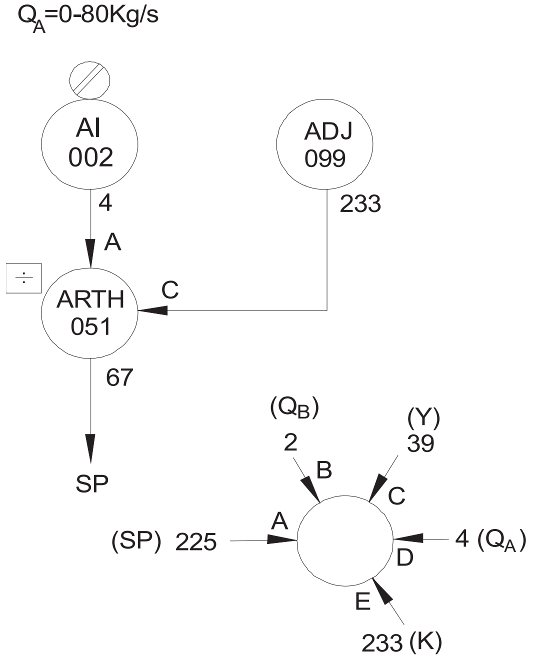


Fig 4.12.2 - Ratio Adjustment

a) In order to have the best resolution in the ratio adjustment, it is better to make the 0-100% variation of the constant adjuster block correspond to the 5-10 variation of the ratio constant.

The **Front View** block 027 may be configured with **AEZ**=5 and **AEM**=10, and have the output of the constant adjuster linked to input **E**. This allows the operator to adjust and visualize the ratio constant between 5 and 10.

b) The signals must be normalized.

As the values are the same of **example 2**, equation (2) of that example may be used:

$$\frac{Q_A}{Q_B} = \frac{80}{20} \cdot \frac{[Q_A]}{[Q_B]} \quad (2)$$

Q_A/Q_B varies from 5 to 10.

Minimum ratio:

The equation (2) turns:

$$4 \cdot \frac{[Q_A]}{[Q_B]} = 5 \cdot [Q_B] = \frac{4}{5} \cdot [Q_A]$$

; *$[Q_B] = 0.8[Q_A] \Rightarrow [Q_B] = SP$ (7)*

Maximum ratio:

The equation (2) turns:

$$4 \cdot \frac{[Q_A]}{[Q_B]} = 10 \qquad [Q_B] = \frac{4}{10} \cdot [Q_A]$$

$[Q_B] = 0.4[Q_A] \Rightarrow [Q_B] = SP$ (8)

c) The Arithmetic Block may have the adjustable ratio connected to input **C** and *$[Q_A]$* to input **A**.

If $Bias_3 = G_2 = 0$

$$OUTPUT = G_1 \cdot A \cdot \frac{(Bias_1)}{(C + Bias_2)} = SP \quad (9)$$

For minimum ratio B = 0% and equation (7) is applied. Making (7) = (9).

$$0.8 \cdot [Q_A] = G_1 \cdot \frac{[Q_A] \cdot (Bias_1)}{(0 + Bias_2)}$$

$$0.8 = G_1 \cdot \frac{Bias_1}{Bias_2} \quad (10)$$

For maximum ratio C=100% and equation (8) is applied. Making (8) = (9).

$$0.4 \cdot [Q_A] = G_1 \cdot [Q_A] \cdot \frac{(Bias_1)}{(100 + Bias_2)}$$

$$0.4 = G_1 \cdot \frac{(Bias_1)}{(100 + Bias_2)} \quad (11)$$

Making $G_1 = 1$ and substituting (10) in (11):

$$0.8\ BIAS_2 = 0.4\ (\ BIAS_2 + 100\ )$$

$BIAS_2 = 100$
$BIAS_1 = 80$

Block configuration:

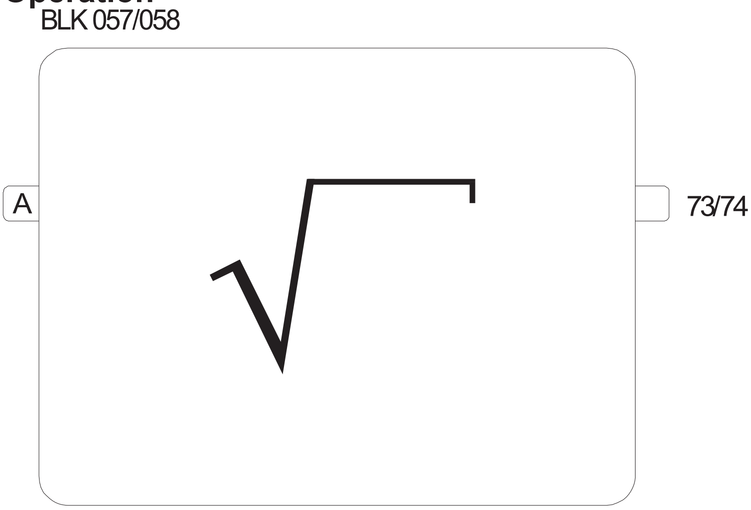
AGN1 = 1   **ABS2** = -250
AGN2 = 0   **ABS3** = 0
ABS1 = -200

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A	Addresses□0 to 170 / 225 to 240	0
I	LIB	Input B		0
I	LIC	Input C		0
I	LID	Input D		0
C	AGN1	Gain G_1	-30.000 to +30.000	1.000
C	AGN2	Gain G_2	-30.000 to +30.000	0.000
P	ABS1	Bias 1	-300.00 to +300.00%	0.00%
P	ABS2	Bias 2	-300.00 to +300.00%	100.00%
P	ABS3	Bias 3	-300.00 to +300.00%	0.00%

Number of Bytes per Type of Parameter: A = 10   C = 0   L = 8

Function 13 - Square Root (SQR)

Operation



This block gives the square root of the input signal.

Since treatment is in percentage values, the formula is:

$Output = 10\sqrt{A(\%)}$

EXAMPLE:

$50(\%) = 10\,.\sqrt{25(\%)}$

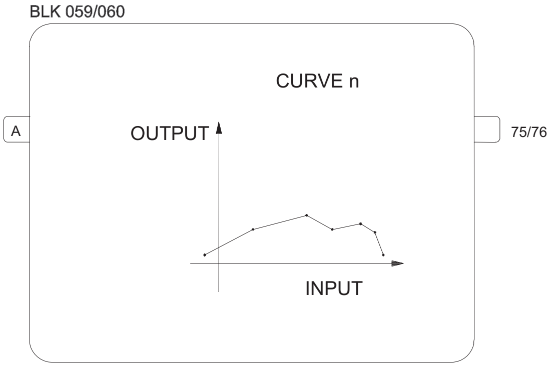
The block offers an adjustable cutoff level (**ACUT**). Below this value the output is set to 0%.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A	Address 0 to 170/225 to 240	0
P	ACUT	Cutoff value	0.00 - 100.00%	0.00%

Number of Bytes per Type of Parameter: A = 2 C = 0 L = 2

Function 14 - Linearization (LIN)

OPERATION



This block linearizes the input signal in accordance with a curve established in the **Function 31 - Linearization Curve (Blocks 109 to 116)**, configured in loop G. This curve may be used with 13, 26, 52, 78 or 104 pairs of points X, Y, interconnected by straight line segments. The curves that may be performed are shown on Table 4.31.1.

Input (X) and output (Y) variables may take the following values:

Input - axis X → -102.00 to +102.00%
Output - axis Y → -300.00 to +300.00%

It is not necessary to adjust all points available (13, 26, 52, 78 or 104). Should a curve be performed by only 4 points, it is possible to adjust only these four points.

EXAMPLE:

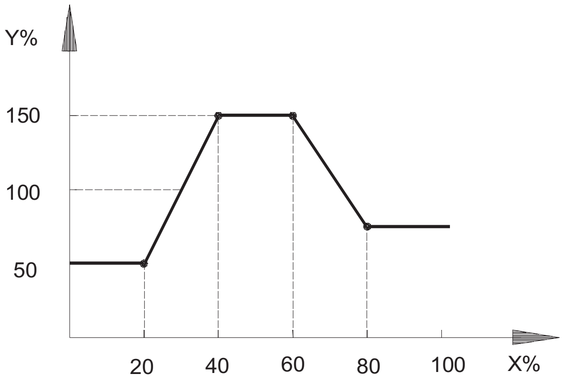


Fig 4.14.1 - Typical Curve

Considering parameter **CLIN**=1, the curve may be adjusted in block 109 of loop G with the following pairs of points:

X1 = 20	Y1 = 50
X2 = 40	Y2 = 150
X3 = 60	Y3 = 150
X4 = 80	Y4 = 75

X1 is the minimum value considered. Even when the input is smaller than the value of X1, in the example 20%, the output will be the corresponding Y1, in the example 50%.

The same principle does not apply for the maximum value! In the example, X4 = 80% is the last point. If the input is bigger than 80%, the program will search for this value at the remaining points (X_5 to X_{13}). If the value is not found, the program would assume the next higher X, for example X_{12} = 55. The output would be the value of Y_{12}.

In order to avoid this problem, it is always convenient to configure the last point of the curve with Xi = 102%, and Yi with the applied value.

In the example:

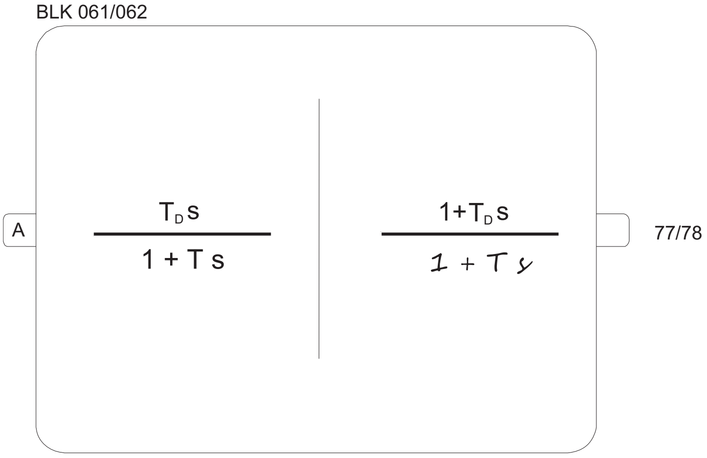
X5 = 102 Y5 = 75

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A - Abscissa of the curve	Address 0 to 170/225 to 240	0
P	CLIN	Linearization curve	0-None 1→8/Curves 1→8 9-Curves 1 and 2 10-Curves 3 and 4 11-Curves 5 and 6 12-Curves 7 and 8 13-Curves 1 to 4 14-Curves 5 to 8 15-Curves 1 to 6 16-Curves 1 to 8	0

Number of Bytes per Type of Parameter:A = 0 C = 2 L = 2

Function 15 - Derivative/Lead-Lag (LL)

Operation



This is a dynamic compensation block that may operate with a derivative function as well as with a lead-lag compensation function. Selection of either function is done with parameter **CDLL**.

This block reads inputs from -2 to 102% and provides output signals from -102 to +102%.

DERIVATIVE FUNCTION

While operating in the derivative mode, the block performs the following transfer function:

$$O(s) = \frac{T_D s}{1 + Ts} I(s)$$

Where,

O(s) and I(s) - are the Laplace transform of input and output functions, respectively.

T_D - derivative constant, adjusted by parameter **ATLE** (min.)

T - lag constant, adjusted by parameter **ATLA** (min.)

When *T*=0, the output signal represents the input variation rate in the period determined by T_D. For example, if the input signal increases according to a slope of 15% per second and *TD*=6 s (0.1 min.), the output signal will be 15 . 6=90% while the slope lasts, returning to zero when there is a constant input value.

When *T*=0, the output signal is submitted to a lag. The response to a step function with amplitude A is shown in Figure 4.15.1.

This function is used when the rate of change of a variable is desired.

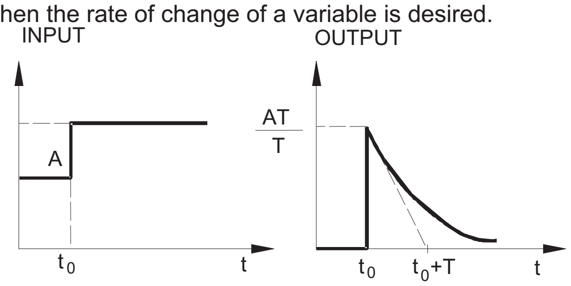


Fig 4.15.1 - Response of Derivative Function with a Lag to an Input Step

LEAD-LAG FUNCTION AND TIME CONSTANT

When operating in the lead-lag mode, the block implements the following transfer function:

$$O(s) = \frac{1 + T_D s}{1 + Ts} I(s)$$

Where,

T_D - Lead constant, adjusted by parameter **ATLE** (min.)

T - Lag constant, adjusted by parameter **ATLA** (min.)

The response to a step function with amplitude A in the input is shown in Figure 4.15.2 for a lag constant **ATLA**=1 and several lead constants (**ATLE**).

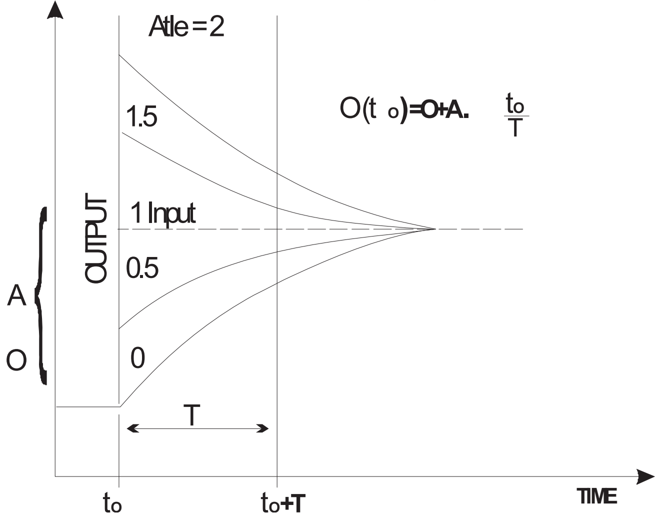


Fig 4.15.2 - Response of the Lead-Lag function to a Step

This block is often used in control loops with feedforward control. Its function is to compensate differences between time constants of the disturbance and the manipulated variable on the controlled variable. The following figure shows a lead/lag block inserted between the disturbance signal (input flow) and the adder which performs the loop's feedforward.

Figure 4.15.4 shows the response of the open loop system to a step variation in the steam flow rate.

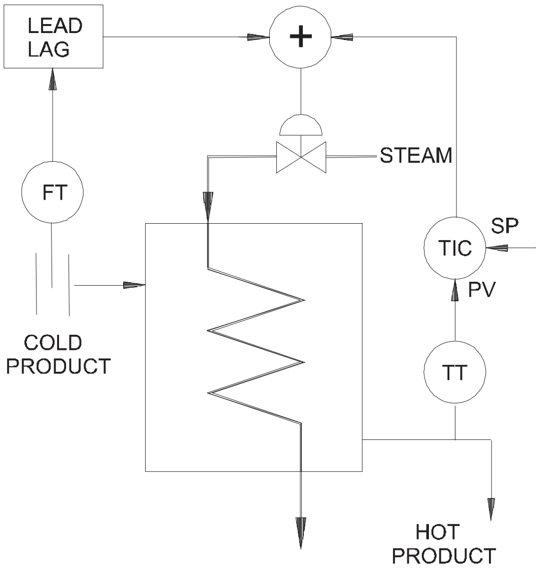
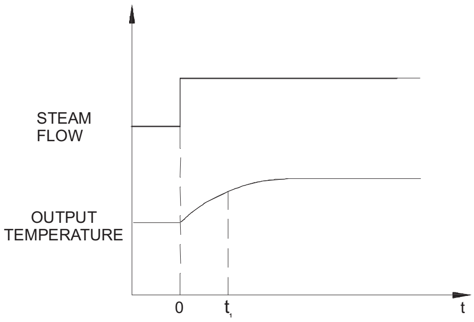


Fig 4.15.3 - Steam flow rate control loop with Lead-Lag

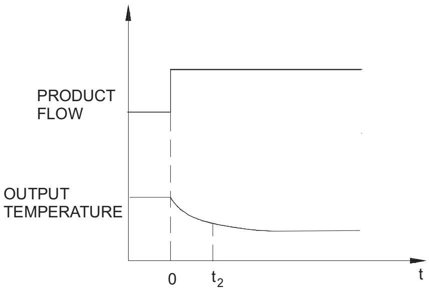


τ_1 - Time constant of the manipulated variable.

Fig 4.15.4 - Open loop response to a step change in steam flow rate (Manipulated Variable).

Note: Time constant is the time required for the variable to reach 63.2% of the end value for a step change.

Figure 4.15.5 shows the response of the open loop system to a step variation in the load.



τ_2 - Time constant for a step variation in the product flow rate.

Fig 4.15.5 - Open loop response to a step variation in product flow rate (disturbance)

By comparing τ_1 and τ_2, it is possible to determine how the lead-lag block shall work:

- if $\tau_1 > \tau_2$ the block should anticipate the disturbance signal (Lead)

- if $\tau_1<\tau_2$ the block should delay the disturbance signal (Lag)

The block may also be used to generate a first order Lag.

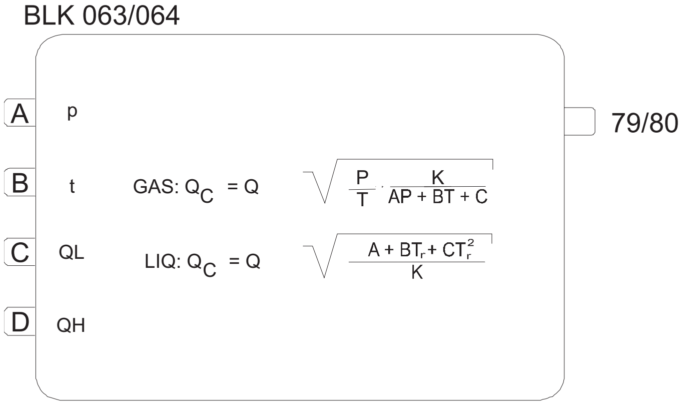
In this case, use **ATLE**=0 and **ATLA** = desired time constant in the lead lag function.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A	Address 0 to 170/225 to 240	0
I	CDLL	Lead-Lag, time constant or derivative	0 - Derivative 1 - Lead-Lag and time constant	1
P	ATLE	Lead time - Td (min.)	0.00 - 300.00 min.	0.00 min.
P	ATLA	Lag time - T (min.)	0.00 - 200.00 min.	0.00 min.

Number of Bytes per Type of Parameter: A = 4 C = 2 L = 2

Function 16 - Pressure and Temperature Compensation (PTC)

Operation


BLK 063/064
A
p
B
t
C
QL
D
QH
79/80
GAS: $Q_C = Q \sqrt{\frac{P}{T} \cdot \frac{K}{AP + BT + C}}$
LIQ: $Q_C = Q \sqrt{\frac{A + BT_r + CT_r^2}{K}}$

This block can compensate gas flow for pressure and temperature variation, liquid flow for temperature variation and saturated steam flow for pressure or temperature variation.

The flow transmitter signal shall reach the block input as a linear signal, i.e., should the signal be from a differential pressure transmitter, the square root must be extracted in the analog input block.

It is possible to have higher rangeability measurement, by using signals from two transmitters calibrated in different ranges. For this reason, the block has a parameter (**ALL**) which determines the percentage of the range corresponding to the highest value of the lower range.

$$ALL = \frac{\text{Flow corresponding to } Q_L = 100\%}{\text{Maximum Flow rate}}$$

The lower range transmitter shall be connected to the input **C** and the higher range transmitter shall be connected to input **D**.

When **QH**>**ALL** **Q = QH**

If **QH ≤ALL Q = QL . $\frac{\textbf{ALL}}{\textbf{100}}$**

Input values may vary between -102.00 and +102.00%. Output may go from -2 to +102%.

FORMULA FOR GASES

$$Q_c = Q.\sqrt{\frac{P}{T}} \frac{K}{AP + BT + C}$$

Where,

Q_c - Compensated flow rate

Q - Noncompensated flow rate

P - Absolute pressure in engineering units

T - Absolute temperature in engineering units

A, *B* and *C* - Coefficients which express the gas compressibility factor *(Z)*. For ideal gases, *A* = *B* = 0 and *C* =1.

K - Constant which defines the project conditions of the flow primary element. K is calculated as follows:

$$K = \frac{T_P}{P_P} . (AP_P + BT_P + C)$$

Where,

T_P and P_P are respectively the absolute temperature and absolute pressure, in engineering units, used in the calculation of the flow primary element.

As the block inputs are in percent and the signals from the pressure and temperature transmitters are seldom in absolute units, the block transforms all measurements in absolute units, as follows:

Where,

$$P = P_0 + \alpha_P . p \ / \ 100$$

$$T = T_0 + \alpha_T .t \ / \ 100$$

P_0 - Value corresponding to 0% of the absolute pressure signal. If the pressure transmitter is of the gage pressure type, the atmospheric pressure shall be added to the value corresponding to 0%.

For example:

Absolute transmitter calibrated from 2 to 10 bar: P_0=2

Gage transmitter calibrated from 2 to 10 bar: P_0=2+1.013=3.013

α_p - Span of the pressure transmitter (in engineering units). From the above example α_p=10-2=8

p - Pressure transmitter signal (in %).

T_o - Value corresponding to 0% of the temperature transmitter + 273.15 Kelvin or + 459.67 Rankine.

α_T - Span of the temperature transmitter (in engineering units).

t - Temperature transmitter signal (in %).

The compressibility factor must be calculated for the particular gas over the particular operating range. Three representative points of operation must be selected from the product thermodynamic table:

P_1, T_1 - corresponding to density d_1.
P_2, T_2 - corresponding to density d_2.
P_3, T_3 - corresponding to density d_3.

These values must be substituted in the following formula:

$$W = \frac{P}{T} \frac{1}{AP + BT + C}$$

originating three equations that enable the calculation of *A*, *B* and *C*.

Sometimes,

$$\frac{P}{T} . \frac{1}{AP + C} \quad or \quad \frac{p}{T} . \frac{1}{BT + C}$$

are more appropriate to describe the product behavior and are easier to calculate. For many applications P/T is good enough.

Using the normal operating conditions, P_P and T_p, as used for the flow primary element calculation, calculate d_p.

In order to cancel the density for normal flowing conditions:

$$k = \frac{1}{d\,p}$$

FORMULA FOR LIQUIDS

$$Q_C = Q \,.\, \sqrt{\frac{(A + BT_r + CT_r{}^2)}{K}}$$

Where,

T_R - Reduced temperature = $\dfrac{\mathrm{T}_0 + \alpha_T \,.\, t}{T_C}$

T_C - Critical temperature of the liquid.

K - Density of the liquid at the design temperature of the primary element.

The fluid density is given by:

$$\boldsymbol{d = A + BT_r + CT_r^2}$$

Constants A, B and C may be found in chemical manuals for some products or may be calculated using three points of operation as described for gas compensation.

In order to cancel the density for normal flowing conditions:

$$\boldsymbol{K = d_p}$$

FORMULA FOR SATURATED STEAM

The characteristic curve of saturated steam is almost linear in some operation sections.

EXAMPLE:

$d = 0.49315P + 0.2155$ *for* $10 \leq P \leq 35$

P expressed in bar absolute, d in kg/m^3

In this case is better to use the formula for liquids. The pressure signal must be connected to input **B** so that T_R becomes P. Furthermore, the following shall be done:

T_o = Value equivalent to P_o.

α_T = Value equivalent to α_P.

T_C = 1.

and, in the case presented as an example,

A = 0.2155

B = 0.49315

C = 0

If the orifice plate was calculated for *P* = 20 bar abs, in order to cancel the density when the pressure is 20 bar abs:

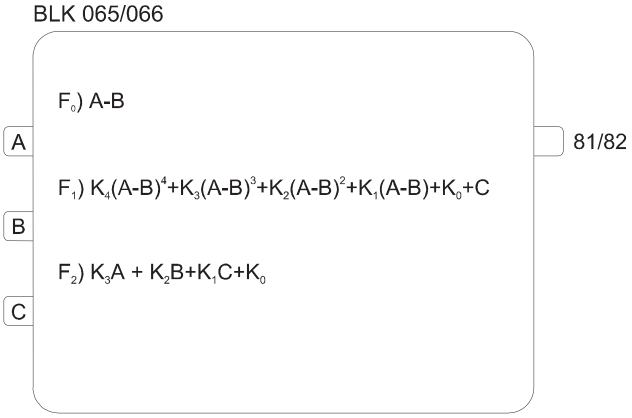
K = 10.08, this being the density of steam at 20 bar absolute. Coefficients A, B and C may be investigated for other operating ranges.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A (Pressure or Specific Gravity)	Addresses 0 to 170/225 to 240	0
I	LIB	Input B (Temperature)		0
I	LIC	Input C (Lower range flow rate)		0
I	LID	Input D (Upper range flow rate)		0
I	CTYP	Type of compensation	0-Gas; 1-Liq. 2-Gas without √; 3-Liq. without √	0
R	C-PO	P_0 for Gas /T_c for Liquid	0 to 10 E 37	1.0000
R	C-AP	αp	0 to 10 E 37	0
R	C-TO	T_0	0 to 10 E 37	273.15
R	C-AT	$\propto t$	0 to 10 E 37	0
R	C-CA	Coefficient A	-10 E 37 to 10 E 37	0
R	C-CB	Coefficient B	-10 E 37 to 10 E 37	0
R	C-CC	Coefficient C	-10 E 37 to 10 E 37	1.0000
R	C-KK	Constant K	0 to 10 E 37	273.15
P	A-LL	Maximum Low Flow	0.00% - 100.00%	0.00%

Number of Bytes per Type of Parameter: A = 2 C = 34 L = 8

Function 17 - Polynomial (POL)

Operation


BLK 065/066
F_o) A-B
A
F_1) $K_4(A\text{-}B)^4+K_3(A\text{-}B)^3+K_2(A\text{-}B)^2+K_1(A\text{-}B)+K_0+C$
B
F_2) $K_3A + K_2B+K_1C+K_0$
C
81/82

This block executes mathematical operations established by the functions 0, 1 or 2, as shown in the Figure. The function is selected in parameter **CTYP**:

CTYP = 0 **A-B** difference.
CTYP = 1 4th-order polynomial.
CTYP = 2 3-input sum.

Inputs **A**, **B**, **C** and coefficient K_0 are interpreted as percentages, while coefficients K_1 to K_4 are real numbers. Inputs and output may range from -102.00 to +102.00%.

Inputs are standardized as follows:

$$A=\frac{Input\ A\%}{Input\ 100}$$

$$B=\frac{Input\ B\%}{100}$$

$$C=\frac{Input\ C\%}{100}$$

The output signal will be the result of the equation multiplied by 100%.

EXAMPLE 1:

Input **A** = 80%
Input **B** = 55%
Input **C** = 10%

K_0 = 30; K_1 = 1; K_2 = 0.5; K_3 = 2; K_4 = 0.1

$$A=\frac{80}{100}=0.8;\quad B=\frac{55}{100}=0.55;\quad C=\frac{10}{100}=0.10$$

$$For\quad CTYP=0$$

$$Output=A-B=0.80-0.55=0.25$$

$$Output\ =25\%$$

$$For\quad CTYP=1$$

$$Output=[\ 0.1\,(0.25\ )^4+2\,(0.25)^3+0.5\,(0.25\ )^2+1\,(0.25\ )+0.10\ ]100+30$$

$$Output=71.29\%$$

EXAMPLE 2:

Using the Taylor Series, the 4th-order polynomial can be used to represent functions as:

$$e^x = 1 + x + \frac{x^2}{2} + \frac{x^3}{6} + \frac{x^4}{24}$$

$$a^x = 1 + x.\ \ln\ a + \frac{(x\ .\ \ln\ a)^2}{2} + \frac{(x.\ \ln\ a)^3}{6} + \frac{(x.\ \ln\ a)^4}{24}$$

$$\ln\ x = (x-1) - \frac{(x-1)^2}{2} + \frac{(x-1)^3}{3} - \frac{(x-1)^4}{24}$$

The coefficients must be adjusted keeping in mind that they will be multiplied by 100. For example, if the polynomial is used to represent e^x, "x" would be given by the input varying from -100 to +100%. Therefore $-1 \leq x \leq 1$ and $0.368 \leq {}'e^x \leq 2.718$.

If the coefficients are used like in the Taylor Series, the output would vary between 36.89% and 271.8%. In order to avoid this, the coefficients must be divided by 2.718:

K0 = 36.79%
K1 = 0.3679
K2 = 0.1839
K3 = 0.06131
K4 = 0.01533

Gives:
13.5% ≤ output ≤ 100%

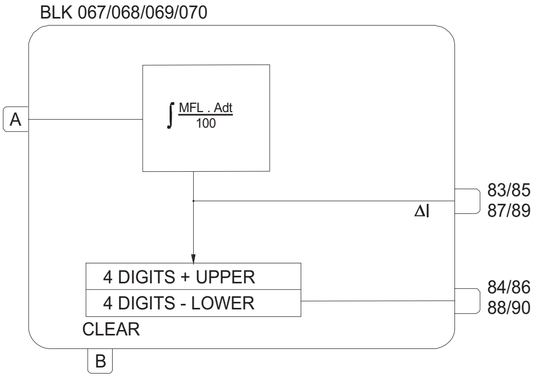
If input represents other values than -1 to 1 an output of 0-100% is desired, other coefficients must be calculated.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A	Addresses 0 to 170/225 to 240	0
I	LIB	Input B		0
I	LIC	Input C		0
P	CTYP	Type of desired equation	0 - A-B difference (F_0) 1 - 4th-order polynomial (F_1) 2 - 3-input sum (F_2)	0
R	A-K0	Coefficient K_0	-300.00% to 300.00%	0.00%
R	A-K1	Coefficient K_1	-10 E 37 to 10 E 37	0
R	A-K2	Coefficient K_2	-10 E 37 to 10 E 37	0
R	A-K3	Coefficient K_3	-10 E 37 to 10 E 37	0
R	A-K4	Coefficient K_4	-10 E 37 to 10 E 37	0

Number of Bytes per Type of Parameter: A = 20 C = 2 L = 6

Function 18 - Totalization (TOT)

Operation



This block is used for flow totalization.

The block integrator provides a ΔI pulse whenever the result of the integration reaches the value pre-adjusted in parameter **ATU**.

The time required for the integrator to provide a pulse depends on **ATU** and on the instantaneous flow rate, which is given by:

$$Q = \frac{MFL\,.\,A}{100}$$

Where,

Q - Instantaneous flow rate in volume or mass engineering units per second.

MFL - Maximum flow rate in volume or mass engineering units per second. This should be equivalent to A=100%.

MFL is adjusted in parameter **AMFL.**

A - Input **A** signal. It is the percent signal corresponding to the flow rate to be totalized.

EXAMPLE:

- Maximum flow rate = 3600 m^3/h = 1 m^3/s.
- The counter indicating totalized flow rate shall have an increment every 10 m^3 of fluid.

The Analog Totalization block shall be adjusted as follows:

- **ATU** = 10 (10 m^3 to generate one pulse)
- **AMFL** = 1 (m^3/s)

At maximum flow, the period between the counting pulses is given by:

$$t = \frac{ATU}{Q} = \frac{10\,m^3}{1\,m^3\,/s} = 10s$$

If the flow rate is 1800m^3/h, which is equivalent to 0,5m^3/s, the period between pulses would be:

$$t = \frac{10}{0.5} = 20s$$

Therefore, for a steady flow rate of 1800m^3/h, every 20s there will be an increment of the counter and a pulse ∆I will be available at output ∆I (83, 85, 87 and 89).

The output ∆I can only be connected to the input of the blocks F20 - "Batch Comparator" (input **A**) and F19 - "Pulse Totalization Input" (input **B**). If it is intended to use a counter external to the **CD600**, the output ∆I shall be connected to input **A** of the Batch Comparator block. The first output of blocks 073/074 (Address 99 and 103) provides pulses with a duration of one cycle time. These pulses may be connected to a digital output block, that will drive an external counter.

The other output of this block provides the value to the internal counter. The counter has 8 digits. These 8 digits are available only for input G of the visualization blocks. The four digits less significant are available for the regular analog input (0,00% to 99.99%) of any block.The counting is divided by 100. For example, the counting 09827125 shown in input G of the visualization block would read 71.25% at the input of the other blocks.

The counter actualization capacity is limited to 120 countings per cycle. For a cycle of 0.2 s, the maximum actualization capacity would be of 600 countings per second. The counting per cycle which exceeds this value is stored, to be unloaded later. The number of countings per cycle should be kept below the limit, in order to prevent a batch from being interrupted after the real value has been passed. In order to avoid this problem, always keep:

$$\frac{AMFL}{ATU} x\,(cycle \quad time\,) < 120$$

For cycle time adjustment, refer to **Section 8**.

This block may also be used to generate pulses in a frequency adjustable by input **A**. Maximum frequency occurs when **A**=100% and it depends on **AMFL** and **ATU** values.

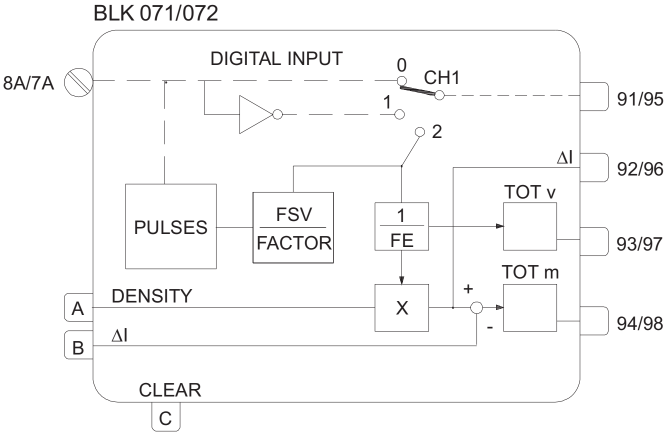
Pulses thus generated may be used as Setpoint for a flow controller, where PV is measured with a Turbine flow element. See example in **Function 19**. The
counting is zeroed when there is a high level signal at input **B**. The counting starts when input **B** is back to the low logic level.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A (to be totalized)	Addresses	0
I	LIB	Input B (clears totalizer)	0 to 170/225 to 240	0
R	A-TU	Totalization value in volume units or mass units, corresponding to one counting unit.	0 to 10 E 37	1.0000
R	AMFL	Flow rate corresponding to 100% at input A, in volume or mass units (the same units used in ATU) per second.	0 to 10 E 37	10.000

Number of Bytes per Type of Parameter: A = 8 C = 0 L = 4

Function 19 - Pulse Totalization Input (P/DI)

Operation



This block can be used as a digital input or for the input of pulses coming from turbine flow meters, or almost any type of pulsing signal for frequency measurement.

Working as a pulse input, it allows the frequency correction by the turbine factor and by the density.

The pulse subtractor input allows totalization of the deviation between two frequencies in one bidirectional totalizer.

DEFINITION OF THE BLOCK FUNCTION (CTYP)

The block is normally used as digital input, **CTYP**=0. If **CTYP**=1, it can be used to receive pulses, and convert the frequency to an analog signal.

TURBINE FREQUENCY RANGE (CMFR)

In order to optimize the microprocessor time distribution, it is recommended to specify the turbine's frequency range. There are two ranges: one below and another above 500 Hz.

If **CMFR**=0 the update time for the frequency to analog conversion is one input cycle.

Example: An instantaneous input of 400 Hz.

$$t = \frac{1}{400} = 2.5ms$$

If **CMFR**=1 the update time for the frequency to analog conversion is eight input cycles.

Example: An instantaneous input of 1000 Hz.

$$t = 8 \,.\, \frac{1}{1000} = 8\ ms$$

Note: As the frequency approaches 0 Hz the update time will be longer. However it is only for very low frequencies that the update time is longer than the controller cycle.

TURBINE FACTOR (AFSV) AND ADJUSTMENT FACTOR (AFTR)

In turbine or vortex type meters, a factor for each type of fluid determines the number of pulses per unit of volume.

This factor is provided directly by the meter manufacturer or is calculated as follows:
FTR is normally called the turbine K-factor.

$$FTR = \frac{f\ [\ Hz\ ]}{q_V\ [\ units\ of\ vol\ ]} = \frac{[\ pulses\ ]}{[units\ of\ vol\ ]} \qquad (1)$$

The conversion of frequency into flow is done by dividing the input frequency by **FTR**:

$$q_V = \frac{f}{FTR} \qquad (\ 2\ )$$

Some manufacturers, however, use the so-called turbine factor, which is the reciprocal of the previous factor:

$$FSV = \frac{q_V\ [\ units\ of\ vol\ ]}{f\ [Hz]} = \frac{[\ units\ of\ vol\ ]}{[\ pulse\ ]} \qquad (\ 3\ )$$

Thus,

$$q_V = FSV\ .\ f \qquad (\ 4\ )$$

The **CD600** combines equations (2) and (4), allowing the use of both factors with no need for additional calculations:

$$q_V = \frac{FSV}{FTR}\ .\ f \qquad (\ 5\ )$$

Should the factor be given in [pulses/unit volume], the **FTR** value shall be adjusted in parameter **AFTR** and **FSV** shall be equal to 1 in parameter **AFSV.**

If, otherwise, the factor is given in [units of volume /pulse], **FSV** is adjusted in **AFSV** and it is necessary to make **FTR**=1 in **AFTR**.

INSTANTANEOUS FLOW INDICATION (AMFL)

When the block is selected as a pulse input, output 91/95 provide a signal Q which varies from 0 to 100% proportionally to the flow rate in accordance with the following equation:

$$Q = \frac{q_V}{MFL}\ .\ 100\ [\ \%\ ] \qquad (\ 6\ )$$

Where, MFL is the frequency for the highest expected flow rate. MFL shall be adjusted in parameter **AMFL.**

TOTALIZATION FACTOR (AFE)

This factor determines the number of units of volume or mass corresponding to one totalization unit.

If **AFE**=10, there will be one totalization increment every 10 engineering units of volume.

CORRECTION BY DENSITY (AZDN and AMDN)

Flow rate may be totalized in volume or in volume corrected by the density, which corresponds to mass flow or volume at reference conditions.

Density, which may be calculated by the flow correction block or by the polynomial, is linked to input **A**. Input value, which varies from 0% to 100%, is transformed in engineering units by parameters **AZDN** and **AMDN**.

The density value multiplies the pulses rate, thus implementing the correction for density variation.

NUMBER OF PULSES FOR CALCULATION (APLS)

This is the maximum number of pulses processed per controller processing cycle. This value is applied to optimize the microprocessor time distribution. Larger numbers should be applied for large flows.

$$\mathbf{APLS=fmax\ .\ t_{cycle}}$$

fmax = highest expected input frequency
t_{cycle} = controller cycle time

COUNTING LIMIT

Notice that, as in Function 18, the maximum number of countings sent to the counter in one cycle is 120. The exceeding pulses are stored to be unloaded later. In order to avoid this problem keep:

$$\frac{AMFL}{AFE} x(\ cycle\quad time\ ) < 120$$

CLEAR TOTALIZER

A high logic level at input **C** clears the totalizers and keeps them at zero value while present.

The totalizer outputs TOT_V (Total Volume) and TOT_n (Total mass) are 8 digit numbers available only for input G of the Front View blocks. See block F18 - Totalization for more details on these outputs.

EXAMPLE 1:

A turbine measures flow rates of up to 6 m^3/min with a maximum frequency of 600 Hz. The 4-20 mA signal from the density meter corresponds to a density variation of 0.1 to 1.1 g/m^3. The counter increment shall be 1 count for every 1m^3.

q_v = 6 m^3/min = 0,1 m^3/s *f = 600 Hz*

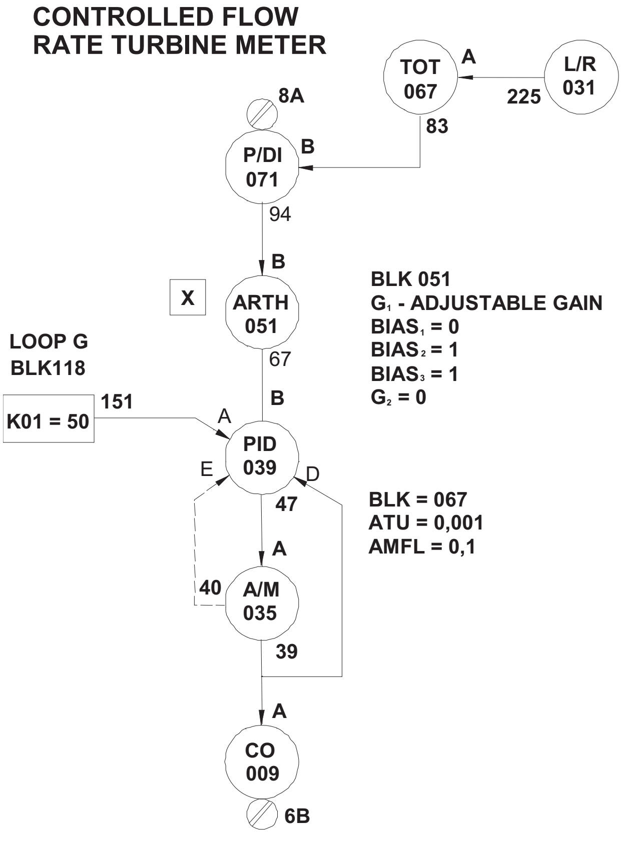
$$FTR - \frac{600}{0.1} = 6000\,\text{pulses/m}^3$$

$$FSV - \frac{0.1}{600} = 0.0001666$$

It is more convenient to use FTR, because FSV is a periodic decimal. Configuration is as follows:

AFTR=6000
AFSV=1
AFE= 1
AMFL=0.1
AZDN=0.1
AMDN=1.1
APLS=32
CTYP=2
CMFR=1

EXAMPLE 2:
An important application of this block is the ratio control of two flow rates or even the control of a single flow rate. It is possible to obtain a more precise control if the Setpoint is in pulse frequency and if it is connected to input **B.** Using the same block of example 1, the following configuration may be used:



BLK 051
G_1 - ADJUSTABLE GAIN
$BIAS_1$ = 0
$BIAS_2$ = 1
$BIAS_3$ = 1
G_2 = 0

BLK = 067
ATU = 0,001
AMFL = 0,1

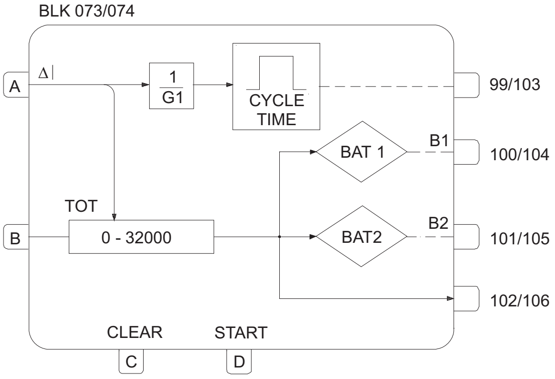
Fig 4.19.1 - Ratio Control

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A (Density)	Addresses 0 to 170 / 225 to 240	0
I	LIB	Input B (Counting decrement)		0
I	LIC	Input C (Resets totalizer)		0
I	CTYP	Definition of the block function	0 - Digital 1 - Inverted Digital 2 – Totalizer	0
I	CMFR	Turbine maximum frequency	0→f<500 Hz 1→f>500 Hz	1
R	AFSV	Turbine Factor	0 to 10 E 37	1.0000
R	AFTR	Adjusting factor (K-factor)	0 to 10 E 37	1.0000
R	A-FE	Factor FE (totalization unit)	0 to 10 E 37	1.0000
R	AZDN	Density at 0%	0 to 10 E 37	0.2000
R	AMDN	Density at 100%	0 to 10 E 37	0.4000
R	AMFL	Maximum Flow rate in engineering units	0 to 10 E 37	250.00
I	APLS	Number of pulses per cycle	0-32000	32

Number of Bytes per Type of Parameter: A = 26 C = 4 L = 6

Function 20 - Batch Comparator (BAT)

Operation



The batch comparator block counts pulses and compares the count with two preset values, **BAT1** and **BAT2**. When the count reaches the value **BAT1**, the corresponding digital output of the block goes to a high logic level and remains this way, until the counter is zeroed. The same is valid for **BAT2**, which shall be programmed with a value greater than **BAT1**.

BAT1 and **BAT2** are adjusted in parameters, **ABT1** and **ABT2**, respectively.

This block also conditions output pulses for external counters, since pulses ∆**I** can only be used as input for the internal blocks of the **CD600**. The duration of the pulses for external counters is determined by the Cycle Time Adjustment (see **Section 8 - Communication**).

The parameter G1 determines the number of pulses at the input equivalent to one pulse at the output. For example, if G1 = 10, there will be one pulse at the output for every 10 pulses at the input.

A high logic level at input **C** zeroes the counter and
stops the count which will only start again if there is a high logic level signal in **D**. The return of **D** to a low logic level does not stop the count.

The counter may start from zero or from the value at input **B**. As input **B** accepts signals ranging from 0.00 to 100.00, the start value of the counter is given by (B value x 100).

EXAMPLE:

The flow rate through a pipe line varies from 0 to a maximum of 72 Nm^3/h. This pipe feeds a batch reactor, that shall receive 10 Nm^3 of fluid. After totalizing 9.8 Nm^3, the valve shall reduce the flow rate to 10%. This is done to decrease the error caused by the system dead time.

For accounting purpose, the controller shall generate one pulse each 1 Nm^3, to an external counter.

Configuration:

The analog totalization block (**Function 18**) was programmed to provide one pulse ∆**I** each 0.01 Nm^3. As the batch counter counts pulses, 10 Nm^3 correspond to 10/0.01 = 1000 pulses and 9.8/0.01 = 980 pulses. Each pulse for the external counter shall correspond to 1 Nm^3.

Therefore, one pulse at the output (1Nm^3) will correspond to G1 pulses at input (0.01Nm^3).

$$G1 = \frac{1\,Nm^3}{0.01\,Nm^3} = 100$$

Therefore, the block shall be programmed as follows:

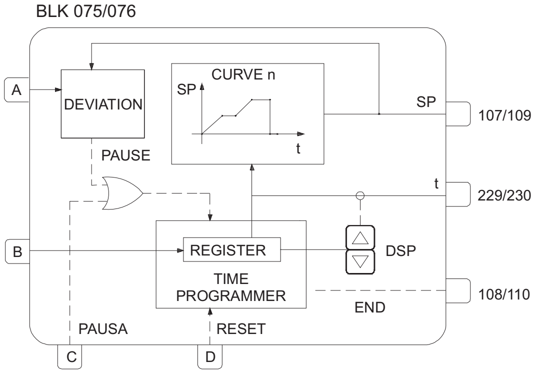
ANOP = 100
ABT1 = 980
ABT2 = 1000

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A - Increment	Addresses 0 to 170 / 225 to 240	0
I	LIB	Input B - Counter start value		0
I	LIC	Input C - Clears counter		0
I	LID	Input D - Starts Counting		0
I	ANOP	Number of input pulses corresponding to one output pulse	0 - +32000	0
I	ABT1	Preset value in BAT 1	0 - +32000	0
I	ABT2	Preset value in BAT 2	0 - +32000	0

Number of Bytes per Type of Parameter: A = 6 C = 0 L = 8

Function 21 - Setpoint Generator (SPG)

Operation



The function of this block is to make a variable follow a pattern along the time, in accordance with a pre-established curve selected by (**CLIN**). The time variation is plotted along the axis X and the variable is plotted along the axis Y. This variable is available at output "**O**" of the block.

Output **t** informs the time elapsed as percentage of the maximum time programmed for the pattern (**CTME** and **CUNI**).

When the configurated time is reached, output **"END"** goes to a "high logic level", thus indicating the end of the pattern. At this point, the time count stops in 100%, the variable stops in the value corresponding to the maximum time and the output **"END"** remain with high logic level until a high logic level signal in input **D** (RESET) returns the pattern to its initial point. The return of input **D** to a low logic level restarts the pattern.

The pattern always starts in the point of axis X established by input **B**. If nothing is connected to **B** or the signal in **B** is 0%, the pattern starts at t=0%. In case there is a signal of 25% connected to **B** and the maximum programmed time is 2 min., the pattern starts in the point equivalent to 30 sec. (the 0 to 30 sec. track is suppressed).

This block also compares the value of the generated variable with the value of input **A**. Should the deviation be greater than the value adjusted in **ADEV**, the time generation stops until **A** is back to the allowable range. This function can be used to compare the Setpoint with the Process Variable. Should the deviation be greater than an allowable range, the time stops running until the control is effective again. If this function is not desirable, simply make **ADEV**=100, or connect output **"O"** to input "**A**". Thus, there will be no deviation and the time generator will not be interrupted.

The time generator stops in two particular situations:

- When there is a high logic level at input **C** (**PAUSE**).

- When the deviation between output **"O"** and input **A** exceeds the adjusted limit value (parameter **ADEV**).

The time count may be manually advanced or delayed with the keys <∆> and <∇> as long as the time (outputs 229 or 230) is on the display.

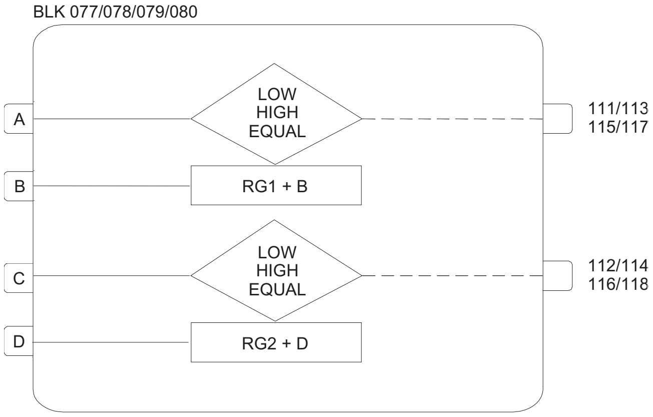
Parameter **CLIN** selects the curve or the curves of the General Loop which will be used to generate the pattern. The curves are established in the **Function 31 - Linearization Curve (blocks 109 to 116)**. This curve may be used with 13, 26, 52, 78 or 104 pairs of points x, y, interconnected by straight line segments. The curves that may be performed are shown on table 4.31.1 - page 4.59. **CUNI** establishes the unit of time (hours or minutes) and **CTME** adjusts maximum time, i.e., the time equivalent to X=100%.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A (input to comparator)	Addresses 0 to 170 / 225 to 240	0
I	LIB	Input B (stall time)		0
I	LIC	Input C (Pause)		0
I	LID	Input D (Reset)		0
I	CLIN	Curve(s) used to determine the time pattern	0 - None (output - 0) 1 to 8 -Curves 1 to 8 9 - Curves 1 and 2 10 - Curves 3 and 4 11 - Curves 5 and 6 12 - Curves 7 and 8 13 - Curves 1 to 4 14 - Curves 5 to 8 15 - Curves 1 to 6 16 - Curves 1 to 8	0
I	CUNI	Time unit	0 - Minutes 1 - Hours	0
P	CTME	Time corresponding to 100%	0.00 - 300.00	60.00
P	ASPD	Time register Actuation Speed	0.00%/s - 200.00%/s	10.00%/s
P	ALOW	Lower time register limit	-102.00% to +102.00%	0.00%
P	AUPP	Upper time register limit	-102.00% to +102.00%	100.00%
P	ADEV	Deviation (in modules)	0.00 - 100.00%	100.00%

Number of Bytes per Type of Parameter: A = 8 C = 6 L = 8

Function 22 - Double Alarm (ALM)

Operation



This block has two separated and independent alarm comparators.

At the first comparator the variable to be compared is linked to the input **A**, and the reference signal is connected to input **B**. When a constant reference signal is desired, it can be adjusted through RG1, using the parameter **ARG1**, and leaving the input **B** free. The second comparator is similar to the first one, i.e., the inputs **C** and **D** are used in the same way as inputs **A** and **B**. Similarly, if the reference signal is a constant, it can be adjusted through RG2, using the parameter **ARG2**.

All the inputs may range from -102.00 to +102.00%. Each comparator can be independently configured in order to generate a discrete alarm output according to the following options:

- Variable ≤ Reference → Low Alarm
- Variable ≥ Reference → High Alarm
- Variable = Reference → Equal Alarm

The reference is the sum of the input **B** (or **D**) value in % and the value of the parameter **ARG1** (or **ARG2**).

To avoid an oscillation of the output signal when the variable is very near the alarm point, the hysteresis can be used, which is adjusted at the parameter **ADB1** (or **ADB2**).

The actuation work as follows:

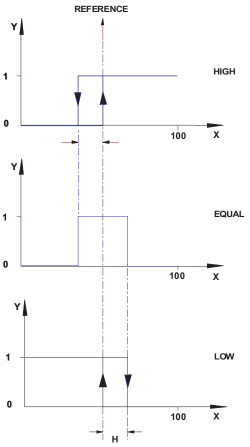


Fig 4.22.1 - Alarm Action with Hysteresis

Where:

X - Variable (input **A** or **C**)
Y - Output logic level: 0 = 0%; 1 = 100%
H - Hysteresis

It is mandatory to set the hysteresis when using the Equal Alarm. The minimum hysteresis value is 0.01%.

Besides giving the corresponding high logic level output, the alarm status can also be shown on the front panel display (see **SECTION 1 - ALARMS ACKNOWLEDGMENT**). It can be configured through the parameter **CFRT**.

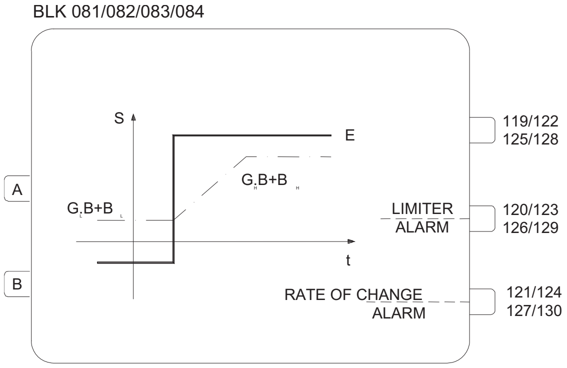
It is also possible to program an eight-characters alarm message, using the parameter **CMN1** (or **CMN2**).

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A	Addresses 0 to 170/225 to 240	0
I	LIB	Input B (Comparator Reference)		0
I	LIC	Input C		0
I	LID	Input D (Comparator Reference)		0
I	CTY1	First Comparator	0-Low/1-High/2-Equal	0
S	CMN1	First Comparator Message	******	LOW COMP
I	CTY2	Second Comparator	0-Low/1-High/2-Equal	1
S	CMN2	2nd Comparator Message	******	HGH COMP
I	CFRT	Indication on Front Panel	0 - None 1 - Indicates 1 2 - Indicates 2 3 - Indicates 1 and 2 4 - Indicates 1 with Auto Ack. 5 - Indicates 2 with Auto Ack. 6 - Indicates 1 and 2 with Auto Ack.	0
P	ARG1	1st Comparator Limit	-102.00% to +102.00%	0.00%
P	ADB1	1st Comparator Hysteresis	0.00% to 100.00%	0.00%
P	ARG2	2nd Comparator Limit	-102.00% to +102.00%	100.0%
P	ADB2	2nd Comparator Hysteresis	0.00% to 100.00%	0.00%

Number of Bytes per Type of Parameter: A = 8 C = 22 L = 8

Function 23 - Limiter With Alarm (LIMT)

Operation



The function of this block is to limit a signal within static or dynamic limits. As the variable reaches one of these limits, it can generate a high logic level signal. The block also generates an alarm every time the variable **"Rate-of-Change"** reaches a preset limit.

The inputs can vary from -102.00 to +102.00% and the output from 0 to 100%.

STATIC LIMITS

By connecting the variable *A* to the input **A** and keeping the input **B** disconnected or with 0%, the signal *A* will be limited between B_L and B_H, i. e., the output signal *Y* will be:

$Y = B_L$ if $A \leq B_L$
$Y = A$ if $B_L < A < B_H$
$Y = B_H$ if $A \geq B_H$

B_L and B_H are adjusted at the parameters **ABL** and **ABH**, respectively.

DYNAMIC LIMITS

In this case, the limit is set by the variable *B*, which is connected to the input **B**. In order to give more flexibility, the limits can be established with individual gains and polarities.

$Y = B \,.\, G_L + B_L$ if $A \leq B \,.\, G_L + B_L$
$Y = A$ if $B \,.\, G_L + B_L < A < B \,.\, G_H + B_H$
$Y = B \,.\, G_H + B_H$ if $A \geq B \,.\, G_H + B_H$

LIMIT ALARM

Whenever the variable reaches the limit, the digital output "**Limiter Alarm**" goes to a high logic level. At the parameter **CLIM**, it can be specified which limit actuates the digital output: the low limit, the high limit or both.

The alarm can also be annunciated on the instrument Front Panel. To do that, the parameter **CFRT**=1, 3, 4, or 6 shall be programmed, according to the desired effect.

In order to avoid an output oscillation of the discrete output signal, as the variable is very near to the limit value, the hysteresis can be used, which acts in the same way of the **Function 22 - Alarm**. The hysteresis is adjusted in the parameter **ADB**.

RATE-OF-CHANGE LIMIT AND RATE-OF-CHANGE ALARM

The output **Rate-of-Change** can be limited through the parameter **ASLW**.

The digital output "**Rate-of-Change Alarm**" switches to a high logic level whenever the **Rate-of-Change** reaches the limit value introduced at the **ASLW** parameter. At the same time, the alarm can be shown on the Front Panel when **CFRT** is 2, 3, 5, or 6.

Note that when A changes faster than **ASLW**, the output changes at the "**Rate-of-Change Limit**" value, and it keeps this rate until the output A reaches the new A value or one of the limits. Within this period, the output "**Rate-of-Change Alarm**" keeps the high logic level.

The **Rate-of-Change Limit** can be applied in modules, i.e, the limit applies for both increasing or decreasing signals or it can be applied for a particular direction.

When the limit is for any direction, **CLIM** must be configured with 0, 1 or 2.

If the limit is for a particular direction, **CLIM** must be configured with 3, 4 or 5 and **ASLW** must be adjusted with the respective signal:

+ for increasing signal
– for decreasing signal

OTHER APPLICATIONS

This block can also be used to compute the equation:

$$Output = G_L . B + B_L$$

To do that, it is just enough to make A = 0% or to keep the input **A** free. The block is also used to generate alarms. The dynamic limits are extremely useful in one of its most important applications: combustion control with double cross limits.

This type of control tries to keep the air-fuel ratio strictly within the limits. A sudden change on the load would require a corresponding air and fuel variation. The "double cross limits" prevents that the fastest variable unbalance the desired ratio.

On conventional controllers it is done using relays to select high and low values plus the adder/subtractor stations. Typically, this control is implemented as shown in the Figure 4.23.1.

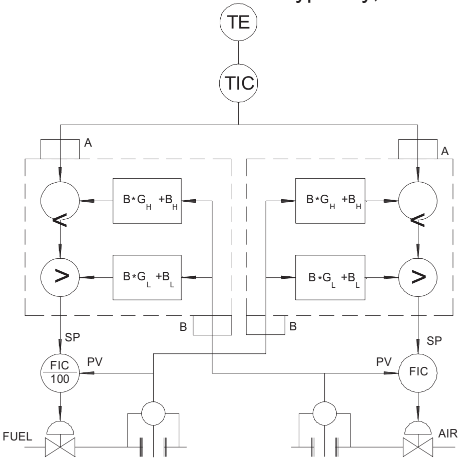


Fig 4.23.1 - Combustion Control with double cross limits

This configuration allows the air flow (Q_a) to vary just between $(Q_c - B_2)$ and $(Q_c - B_1)$ and the fuel flow (Q_c) to vary just between $(Q_a - B_4)$ and $(Q_a - B_3)$.

In this manner, even when there are large transients on the Master signal, the air and fuel flow keeps the required ratio.

The limiter block perform the functions indicated inside the broken line area, i.e., two of these blocks can implement the double cross limits function. The Figure 4.23.2 shows one of these blocks.

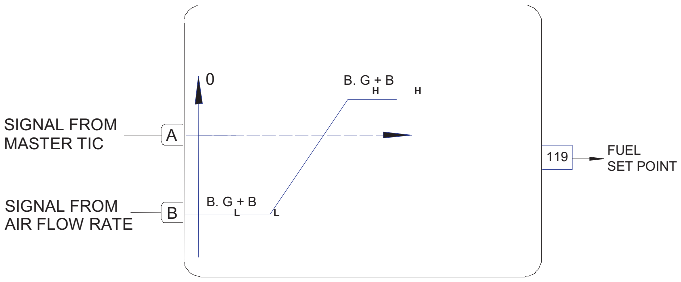


Fig 4.23.2 - Fuel Setpoint from a double cross limit configuration (TIC)

The Table 4.23.1 shows the block response to a Master signal variation and the air flow for $G_H = G_L = 1$, $B_L = -10\%$, and $B_H = 5\%$. The table rows show the instants in which the air flow or the fuel flow have changed 5%.

The air flow valve is slower than the fuel flow valve.

INSTANTS	TIC OUTPUT	AIR FLOW	LOW LIMIT	HIGH LIMIT	FUEL SETPOINT
1	50	50	40	55	50
2	60	50	40	55	55
3	60	55	45	60	60
4	60	60	50	65	60
5	60	60	50	65	60
6	45	60	50	5	50
7	45	55	45	60	45
8	45	50	40	55	45
9	45	45	35	50	45

Table 4.23.1 - Block response to master signal variations

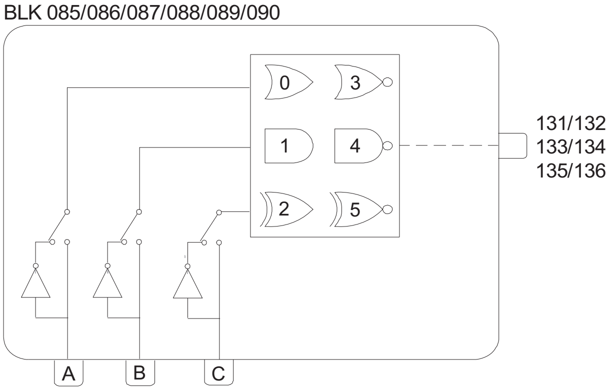
Note that the output for the fuel Setpoint is always between the low and high limits. It is supposed that the fuel flow follows the Setpoint change within a very narrow time interval. The air flow follows the fuel flow but more slowly, as the air Setpoint is function of the fuel flow, according to a similar table, but with $|B_L| < |B_H|$.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A (Variable)	Addresses	0
I	LIB	Input B (dynamic limit)	0 to 170/225 to 240	0
I	CLIM	Limiter Alarm Output Actuation and Rate-of-Change Alarm	Rate-of-Change alarm in modules and: 0 - Limiter alarm LOW 1 - Limiter alarm HIGH 2 - Limiter alarm LOW and HIGH Rate-of-Change considering (+)increase/ (–) decrease signal and: 3 - Limiter alarm LOW 4 - Limiter alarm HIGH 5 - Limiter alarm LOW and HIGH	0
I	CFRT	Alarm(s) on the Frontal	0 - None 1 - Limit 2 - Rate-of-Change 3 - Limit/Rate-of-Change 4 - Limit Alarm Auto Ack. 5 - Rate-of-Change Alarm Auto Ack. 6 - Limit Alarm/Rate-of-Change Auto Ack.	0
C	A-GL	Low Limit Gain	0.000 - 30.000	0.000
P	A-BL	Low Limit Bias	-300.00% to +300.00%	0.00
C	A-GH	High Limit Gain	0.000 to 30.000	0.000
P	A-BH	High Limit Bias	-300.00% to +300.00%	100.00%
P	A-DB	Comparison Alarm Hysteresis	0.00% - 100.00%	0.00%
P	ASLW	Maximum Rate-of-Change	-200.00 to +200.00%	200.00%/s

Number of Bytes per Type of Parameter: A = 12 C = 4 L = 4

Function 24 - Logic (LOG)

Operation



This block performs several types of three input logic operations with the inputs **A**, **B** and **C**. If one input is not connected it is not considered in the operation, i.e, the logical operation will be performed with only two inputs.

The table 4.24.1 shows the results of the several logic operations available. The choice is made with **CLOG**.

When the result of the logic performed is a high logic level or "1", the output is 100%, and when the result is a low logic level, the output is 0%.

INPUTS*			OUTPUT					
A	**B**	**C**	**OR(0)**	**AND(1)**	**XOR(2)**	**NOR(3)**	**NAND(4)**	**NXOR(5)**
0	0	0	0	0	0	1	1	1
0	0	1	1	0	1	0	1	0
0	1	0	1	0	1	0	1	0
0	1	1	1	0	0	0	1	1
1	0	0	1	0	1	0	1	0
1	0	1	1	0	0	0	1	1
1	1	0	1	0	0	0	1	1
1	1	1	1	1	1	0	0	0
0	0		0	0	0	1	1	1
0	1		1	0	1	0	1	0
1	0		1	0	1	0	1	0
1	1		1	1	0	0	0	1
0			0	0	0	1	1	1
1			1	1	1	0	0	0

*With no inversion (CNOT = 0)

Table 4.24.1 - Truth Table for 3-Input Logic Block

A signal ranging from 0 to 100% connected to one of the inputs of this block will be interpreted as follows:

- Less than 70%:	level 0
- More than 80%:	level 1
- Between 70% and 80%:	previous state

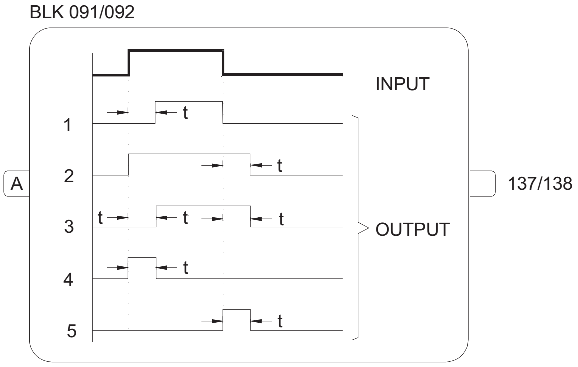
The inputs can be inverted with parameter **CNOT**.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A (Digital Interpretation)	Addresses 0 to 170 / 225 to 240	0
I	LIB	Input B (Digital Interpretation)		0
I	LIC	Input C (Digital Interpretation)		0
I	CLOG	Defines the logic operation between connected inputs	0 - OR 3 - NOR 1 - AND 4 - NAND 2 - XOR 5 - NXOR	0
I	CNOT	Inverts the input	0 - No inversion 1 - Inverts input A 2 - Inverts input B 3 - Inverts input A and B 4 - Inverts input C 5 - Inverts input A and C 6 - Inverts input B and C 7 - Inverts input A, B and C	0

Number of Bytes per Type of Parameter: A = 0 C = 4 L = 6

Function 25 - Timer (TMR)

Operation



This block gives a delay on a digital signal as defined in parameter **CACT**. The time of delay is established by parameter **ADEL.**

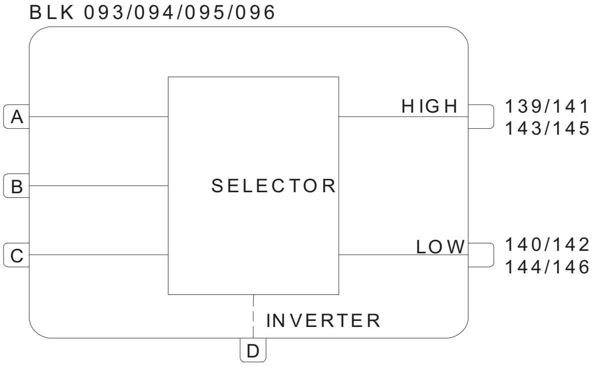
The timing diagrams of the block show the several types of actuation available.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A - Binary Signal	Address 0 to 170/225 to 240	0
I	CACT	Type of actuation	0 - None 1 - Delay on Operate 2 - Delay on Release 3 - Delay on Operate and Release 4 - Monostable, triggered positive flank 5 - Monostable, triggered negative flank	0
P	ADEL	Delay Time	0.01 min to 180.00 min	1.00 min

Number of Bytes per Type of Parameter: A = 2 C = 2 L = 2

Function 26 - High/Low Selector (H/L)

Operation



The two outputs supply the largest and the smaller value of the three inputs **A**, **B** and **C**. Any unconnected input is disregarded.

Input **D** inverts the meaning of the outputs. When **D** is at high logic level, the first output supplies the lower value and the second, the higher.

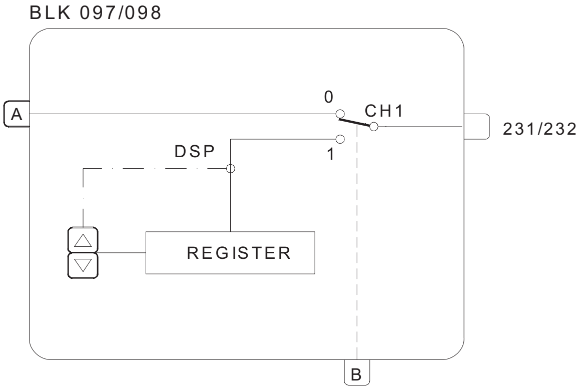
The inputs and outputs of this block may range from -102.00 to +102.00%.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A	Addresses 0 to 170/225 to 240	0
I	LIB	Input B		0
I	LIC	Input C		0
I	LID	Input D - Inverts the meaning of the outputs		0

Number of Bytes per Type of Parameter: A = 0 C = 0 L = 8

Function 27 - Internal/External Selector (SSEL)

Operation



When the switch CH1 is at the position "0", the signal from input **A** goes directly to the output. When CH1 is switched to position "1" through a high logic level signal at input **B**. This switching is balanced, i.e., the last value of input **A** goes to the register, which takes over the output of the block. The output can then be activated by the <∆> and <∇> keys, as long as the output of this block is selected to be indicated on the front panel display.

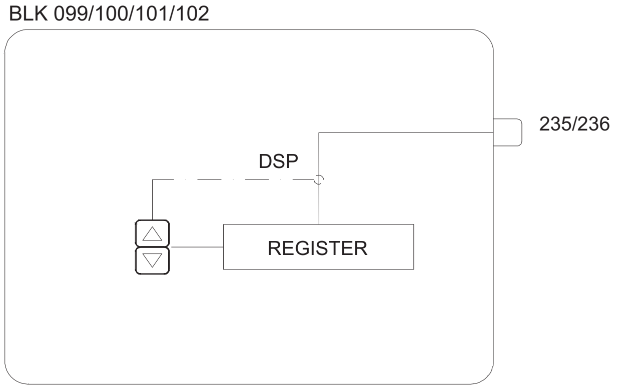
The input and output of this block may range from -102.00 to +102.00%.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A	Addresses 0 to 170/225 to 240	0
I	LIB	Input B - Switches CH1		0
P	ASPD	Register Actuation Speed	0.00%/s to 200.00%/s	10.00%/s
P	ALOW	Lower Register Limit	-102.00% to 102.00%	0.00%
P	AUPP	Upper Register Limit	-102.00% to 102.00%	100.00%

Number of Bytes per parameter: A = 6 C = 0 L = 4

Function 28 - Constant Adjuster (ADJ)

Operation



This block contains a register which can have its value changed by the <Δ> and <∇> keys, as long as one of the following two conditions is fulfilled:

a) The block output is connected to a block of **Function 06 -Loop Visualization** (*BLK027* through *BLK030*) or of **Function 32 - General View** (*BLK117*) and is selected to be indicated on the front panel display.

b) The block output is connected to a block of the **Function 29 - Input Selector** (BLK103 through BLK106) or of **Function 27 - Internal/External Signal Selector** (*BLK097* through *BLK098*), whose internal switch guides the register signal directly.

to its output. This output must be connected to any of the visualization blocks mentioned in item a), and must be selected to be indicated on the display.

The output may range from -102.00 to +102.00%. The lower limit is adjusted in the parameter **ALOW** and the upper limit in the parameter **AUPP**. The actuation speed is adjusted in the parameter **ASPD**.

There are three actuation forms:

1) **CTYP=0 Continuous Actuator**
The output is changed by the <Δ> and <∇> keys, with continuous increment/decrements of 0.01%. The maximum changing speed is adjusted by **ASLW**. The output will range from the lower limit (**ALOW**) to the upper limit (**AUPP**).

2) **CTYP=1 Discrete Command Type Switch**
The keys <Δ> and <∇> act as a push-button station.
<Δ> - Put the value adjusted in **AUPP**, e.g., 100%, in the block output
<∇> - Put the value adjusted in **ALOW**, e.g., 0%, in the block output

3) **CTYP=2 Discrete Command Type Push-Button**
When <Δ> is pressed, the output signal goes to the Upper Register Limit (**AUPP**) (normally 100%).

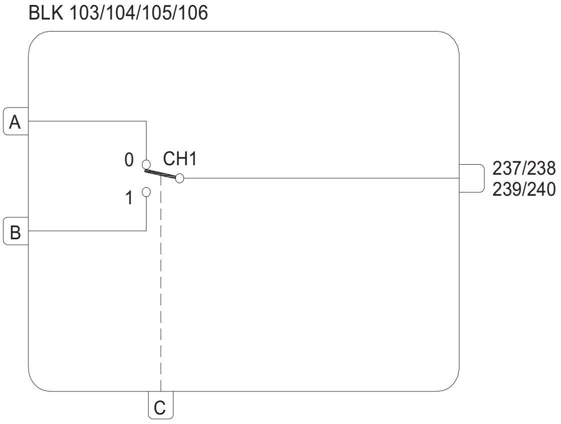
When <Δ> is released, the output signal returns to the Lower Register Limit (**ALOW**) (normally 0%).

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	CTYP	Actuation Type	0 - Analog Value 1 - Binary Command 2 - Push Button	0
P	ASPD	Register Actuation Speed	0.00%/s to 200.00%/s	10.00%/s
P	ALOW	Lower Register Limit	-102.00% to +102.00%	0.00%
P	AUPP	Upper Register Limit	-102.00% to +102.00%	100.00%

Number of Bytes per Type of Parameter: A = 6 C = 2 L = 0

Function 29 - Input Selector (ISEL)

Operation



This block selects one of the two inputs to be the output signal, by means of switch CH1. The switch is activated by a high logic level at input **C**.

The inputs and the output may range from -102.00 to +102.00%. A high logic level at C switches CH1 to position "1".

It is possible to lock the switch in position "0" with the parameter **CLCK**.

If the block output is linked to a visualization block (**Front View or General View**), any register actuator linked to either one of the block inputs, can be actuated as it would be, if it were directly linked to the visualization block. An example where that applies is shown in Figure 4.29.1.

EXAMPLE:

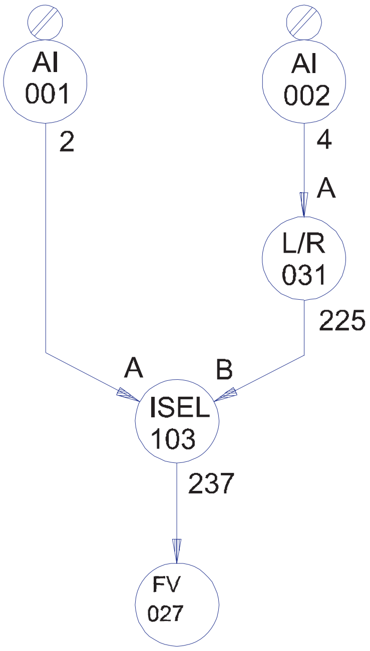


Fig 4.29.1 - Control Loop with two-setpoint actuators

In that configuration, if the switch CH1 of the block 103 is at position "0", the register actuator cannot be actuated.

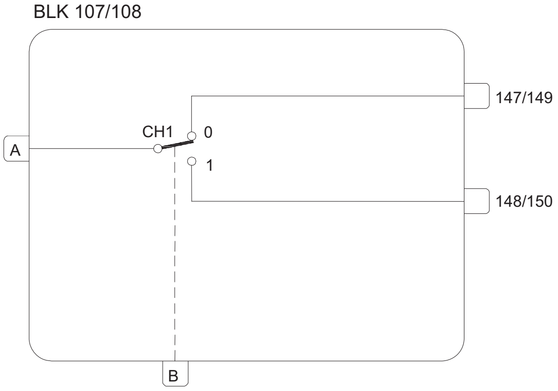
But if CH1 is at position "1" and the block 031 is in Local mode, the register actuator of the block 031 can be actuated.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A	Addresses 0 to 170/225 to 240	0
I	LIB	Input B		0
I	LIC	Input C - Switches CH1		0
I	CLCK	Locks switch CH1 in position 0	0 - No/1 - Yes	0

Number of Bytes per Type of Parameter: A = 0 C = 2 L = 6

Function 30 - Output Selector (OSEL)

Operation



This block directs the input signal to one of the two outputs through switch CH1. When CH1 is activated (high level at input **B**), it directs the input to output 148 or 150.

When there is an output switching, the output not selected can hold the last signal value, or it can be forced to go to 0 or 100%, as determined by parameter **CLST**.

It is possible to lock the switch at position "0" with parameter **CLCK**.

EXAMPLE:

In pH control it is after useful to freeze the input while calibrating the pH - transmitter which is a rather frequent procedure.

For this case the OSEL block can be used as a Sample-and-hold switch.

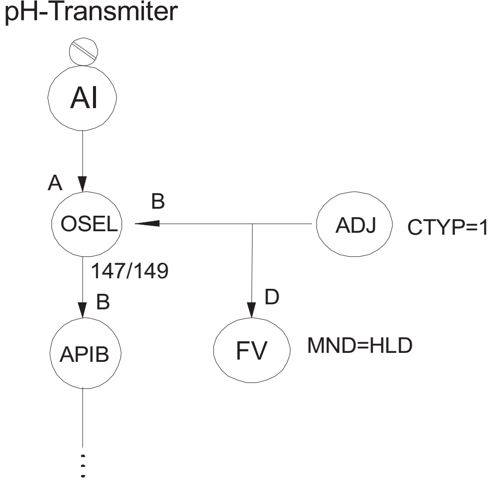


Fig 4.30.1 - L/R Selector Configuration for setpoint tracking

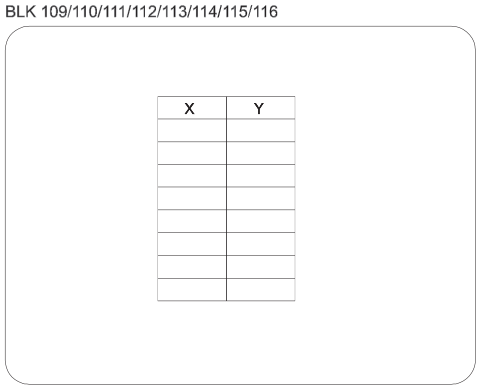
The ADJ block is here used to turn the hold ON or OFF, when it is OFF (OSEL block input B is low) the signal passes straight through the OSEL block, but when the OSEL block input B is high the hold function is ON and the last value remains the input to the APID block. Hence the pH - transmitter may be calibrated without disturbances.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A	Addresses 0 to 170/225 to 240	0
I	LIB	Input B - Selects the output		0
I	CLST	Condition of output when not connected to the input	0 - Holds last value 1 - 0% / 2 - 100%	0
I	CLCK	Locks switch CH1 in position 0	0 - No/1 - Yes	0

Number of Bytes per Type of Parameter: A = 0 C = 4 L = 4

Function 31 - Linearization Curve (PNT)

Operation



The function of these blocks is to store pairs X, Y for the curves used in the following blocks:

Function 01 - Analog Input

Function 14 - Linearization Curve

Function 21 - Setpoint Generator

Function 09 - Advanced PID Controller (Adaptative Gain)

As the same curve may be used by different blocks of different loops, it must be allocated in the General Loop (Loop G).

Each block contains 13 points, defined through pairs X, Y. The curve is determined by these points interconnected by straight segments.

If a curve requires more than 13 points, the blocks can be grouped as shown in Table 4.31.1.

For example, a Setpoint Generator requires a curve with 70 points. The Setpoint Generator block has an option that groups 6 blocks. That will give 6 x 13=78 points.

When more than one block is used to represent a curve, the first portion of the curve is defined by the first block, the following section by the second and so on.

CURVE	DEFINED BY PAIRS X, Y IN BLOCK#	No. OF POINTS
1	109	13
2	110	
3	111	
4	112	
5	113	
6	114	
7	115	
8	116	
9	109 + 110	26
10	111 + 112	
11	113 + 114	
12	115 + 116	
13	109 to 112	52
14	113 to 116	
15	109 to 114	78
16	109 to 116	104

Table 4.31.1 - Linearization Curves

EXAMPLE:

A Setpoint Generator with the following pattern:

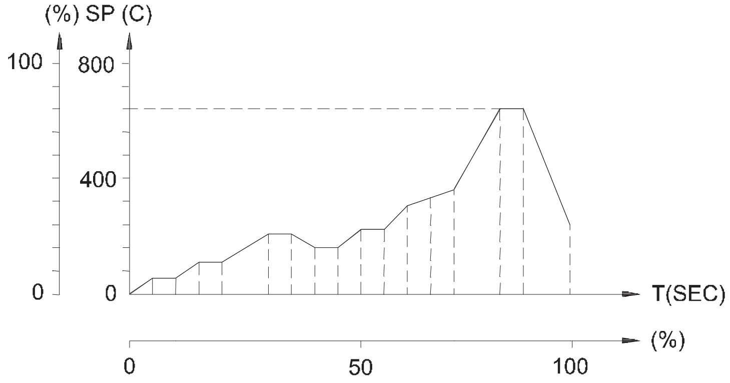


Fig 4.31.1 - Pattern for setpoint generator

In order to represent this curve of 17 points, two blocks are necessary. If the Setpoint Generator block is configured with **CLIN**=9, the blocks 109 and 110 shall be configured as shown on the Table 4.31.2.

POINT No.	T (X)	SP (Y)	BLOCK
1	0	0	BLK 109
2	5	5	
3	10	5	
4	15	10	
5	20	10	
6	30	20	
7	35	20	
8	40	15	
9	45	15	
10	50	25	
11	55	25	
12	60	30	
13	65	33	
14	72	42	BLK110
15	80	80	
16	90	80	
17	100	25	
18	102	25	

Table 4.31.2 - Points of the Curve

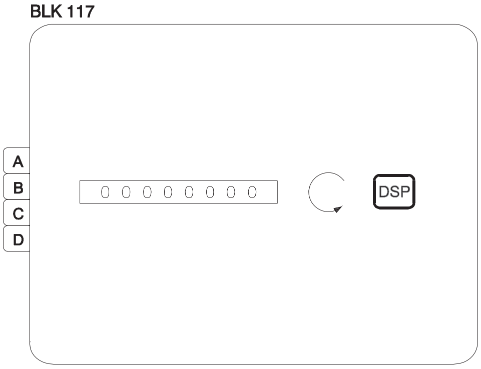
It is recommended to program the last point of the curve with the maximum value possible for the input (X). To be in the safe side, it is good to program the last X with 102% and the last Y with the appropriate value.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
P	AX01	X1	-300.00 to +300.00%	0.00%
P	AY01	Y1	-300.00 to +300.00%	0.00%
P	AX02	X2	-300.00 to +300.00%	5.00%
P	AY02	Y2	-300.00 to +300.00%	5.00%
P	AX03	X3	-300.00 to +300.00%	10.00%
P	AY03	Y3	-300.00 to +300.00%	10.00%
P	AX04	X4	-300.00 to +300.00%	15.00%
P	AY04	Y4	-300.00 to +300.00%	15.00%
P	AX05	X5	-300.00 to +300.00%	20.00%
P	AY05	Y5	-300.00 to +300.00%	20.00%
P	AX06	X6	-300.00 to +300.00%	25.00%
P	AY06	Y6	-300.00 to +300.00%	25.00%
P	AX07	X7	-300.00 to +300.00%	30.00%
P	AY07	Y7	-300.00 to +300.00%	30.00%
P	AX08	X8	-300.00 to +300.00%	35.00%
P	AY08	Y8	-300.00 to +300.00%	35.00%
P	AX09	X9	-300.00 to +300.00%	40.00%
P	AY09	Y9	-300.00 to +300.00%	40.00%
P	AX10	X10	-300.00 to +300.00%	45.00%
P	AY10	Y10	-300.00 to +300.00%	45.00%
P	AX11	X11	-300.00 to +300.00%	50.00%
P	AY11	Y11	-300.00 to +300.00%	50.00%
P	AX12	X12	-300.00 to +300.00%	55.00%
P	AY12	Y12	-300.00 to +300.00%	55.00%
P	AX13	X13	-300.00 to +300.00%	105.00%
P	AY13	Y13	-300.00 to +300.00%	105.00%

Number of Bytes per Type of Parameter: A = 52 C = 0 L = 0

Function 32 - General Visualization (GV)

Operation



This block is used to display variables common to all loops configured. The variables connected to A, B, C and D of this block will be on the display of any loop, in the scroll sequence after the variables of that particular loop. Therefore this block must always work associated to a loop visualization block.

As it is common to more than one loop, it must be configured in the General Loop (Loop G).

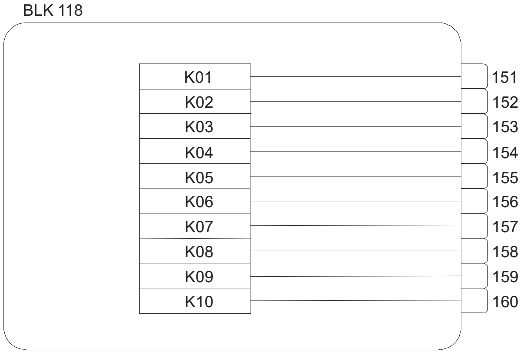
The variables are shown on the display, in engineering units, and with a programmable 3-character mnemonic.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LIA	Input A	Addresses 0 to 170 / 225 to 240	0
I	LIB	Input B		0
I	LIC	Input C		0
I	LID	Input D		0
M	AMNA	Mnemonic for A	***	VGA
R	A-AZ	0% for input A in engineering units	-10000 to +10000	0
R	A-AM	100% for input A in engineering units	-10000 to +10000	100.00
M	AMNB	Mnemonic for B	***	VGB
R	A-BZ	0% for input B in engineering units	-10000 to +10000	0
R	A-BM	100% for input B in engineering units	-10000 to +10000	100.00
M	AMNC	Mnemonic for C	***	VGC
R	A-CZ	0% for input C in engineering units	-10000 to +10000	0
R	A-CM	100% for input C in engineering units	-10000 to +10000	100.00
M	AMND	Mnemonic for D	***	VGD
R	A-DZ	0% for input D in engineering units	-10000 to +10000	0
R	A-DM	100% for input D in engineering units	-10000 to +10000	100.00

Number of Bytes per Type of Parameter: A = 48 C = 0 L = 8

Function 33 - Constants (K)

Operation



This block generates a constant value to be used at any point of the configuration. As the same constant may be used in more than one loop, this block must be configured in the General Loop (Loop G). It has ten adjustable constants, each one being available at one output. These outputs can be connected to blocks located in any loop.

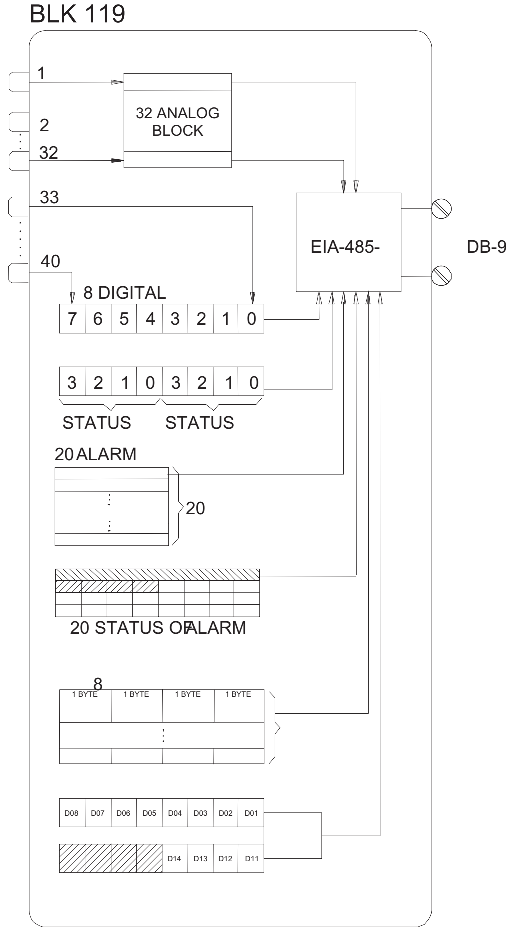
This block should be used when it is necessary to generate a constant value for the other blocks of the configuration. An example of this type of application is a process which demands that the controller output should go to 10% when a digital signal changes from Low to high logic level.

The constant value 10% can be adjusted in **AK01** of this block and its output (151) connected to the input **B** of a block of the **Function 08 - Automatic/Manual Station**. The digital signal is connected to input **C** of the A/M block.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
P	AK01	Constant K01	-300.00 to +300.00%	10.00%
P	AK02	Constant K02	-300.00 to +300.00%	20.00%
P	AK03	Constant K03	-300.00 to +300.00%	30.00%
P	AK04	Constant K04	-300.00 to +300.00%	40.00%
P	AK05	Constant K05	-300.00 to +300.00%	50.00%
P	AK06	Constant K06	-300.00 to +300.00%	60.00%
P	AK07	Constant K07	-300.00 to +300.00%	70.00%
P	AK08	Constant K08	-300.00 to +300.00%	80.00%
P	AK09	Constant K09	-300.00 to +300.00%	90.00%
P	AK10	Constant K10	-300.00 to +300.00%	100.00%

Number of Bytes per Type of Parameter: A = 20 C = 0 L = 0

Function 34 - Scan (SCN)



Operation

This block is used for the digital communication. As it deals with variables of more than one loop, it must be allocated in the General Loop (LOOP G).

This block enables the selection of analog or digital variables used in the **CD600** configuration and makes them accessible by the digital communication bus.

The variables can be classified into five groups:

I. ANALOG VARIABLES

Up to 32 analog variables can be allocated in this group, chosen freely among the outputs of the blocks used in a configuration. These variables are defined by the linking parameters **LI01** through **LI32**, and contain the output addresses of the blocks of the respective variables. For example, **LI01**=2 means that the analog input 1 is accessible for the communication bus at **LI01**.

Each variable is reported in a word form.

The digital communication reads the **Linking Parameters** in sequence. When the scan reaches a **LIxx** Parameter with zero (0), the scan of the analog block outputs is interrupted.

II. DIGITAL VARIABLES

Up to eight digital output signals can be allocated to this group, chosen freely among the outputs with digital interpretation of the blocks used in the current configuration. These digital outputs are defined by the linking parameters **LI33** through **LI40**. The status of the blocks Local/Remote and Auto/Manual are specified in the block for digital communication (*BLK121*) of **Function 36 - Actuation**.

Each variable is reported in a bit form.

III. STATUS AND ALARM LIMITS

Up to 20 alarm points, with their respective limits, can be allocated in this group.

Status will be reported in bit form and alarm limits in word form.

The reading sequence of the alarms is defined in the Actuation block (*BLK121*), by the parameters **AL01** through **AL20**.

IV. TOTALIZATIONS

The eight totalizations corresponding to the blocks of **Function 18 - "Totalization"** and **Function 19 - Pulse Input** are allocated in this group.

It is not necessary to list the totalization parameters. They will be included in the digital communication automatically, in the same order they appear in the configuration.

The Pulse Input block has two totalization registers. The totalization register occupies 4 bytes.

V. DIGITAL INPUTS AND OUTPUTS

The status of the four inputs and the eight digital outputs, in a fixed order, are located in this group.

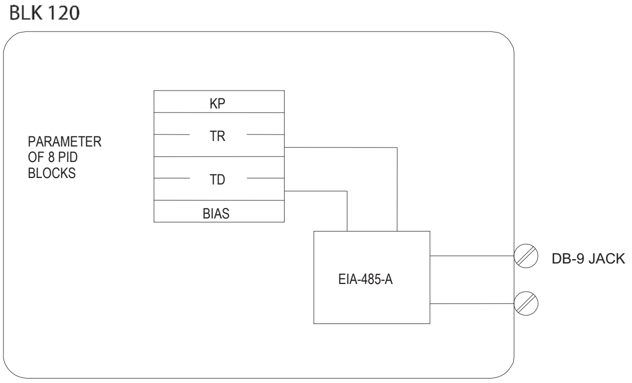
They are represented in bit form, and are not necessary to list.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	LI01	Address of analog block output	Addresses 0 to 170/225 to 240	0
I	LI02	Address of analog block output		0
I	LI03	Address of analog block output		0
I	LI04	Address of analog block output		0
I	LI05	Address of analog block output		0
I	LI06	Address of analog block output		0
I	LI07	Address of analog block output		0
I	LI08	Address of analog block output		0
I	LI09	Address of analog block output		0
I	LI10	Address of analog block output		0
I	LI11	Address of analog block output		0
I	LI12	Address of analog block output		0
I	LI13	Address of analog block output		0
I	LI14	Address of analog block output		0
I	LI15	Address of analog block output		0
I	LI16	Address of analog block output		0
I	LI17	Address of analog block output		0
I	LI18	Address of analog block output		0
I	LI19	Address of analog block output		0
I	LI20	Address of analog block output		0
I	LI21	Address of analog block output		0
I	LI22	Address of analog block output		0
I	LI23	Address of analog block output		0
I	LI24	Address of analog block output		0
I	LI25	Address of analog block output		0
I	LI26	Address of analog block output		0
I	LI27	Address of analog block output		0
I	LI28	Address of analog block output		0
I	LI29	Address of analog block output		0
I	LI30	Address of analog block output		0
I	LI31	Address of analog block output		0
I	LI32	Address of analog block output		0
I	LI33	Address of logic level block output		0
I	LI34	Address of logic level block output		0
I	LI35	Address of logic level block output		0
I	LI36	Address of logic level block output		0
I	LI37	Address of logic level block output		0
I	LI38	Address of logic level block output		0
I	LI39	Address of logic level block output		0
I	LI40	Address of logic level block output		0
I	CBID	User free identification number		0

Number of Bytes per Type of Parameter: A = 0 C = 2 L = 80

Function 35 - Scan/Actuation Of The Parameters PID (PRM)

Operation



This block allows the actuation and reading of the parameters K_P, T_R, T_D and Bias of the *PID* and advanced *PID* blocks through the communication bus.

The order of the information in the scan communication buffer is also the order of actuation. It will be determined by the parameters **CTR1** through **CTR8**, with the values from 0 to 8, each number corresponding to a block, according to the Table 4.35.1.

0	***Interrupts the Scan***	
1	BLK039	**Function 09**
2	BLK040	
3	BLK041	
4	BLK042	
5	BLK043	**Function 10**
6	BLK044	
7	BLK045	
8	BLK046	

Table 4.35.1 - PID Block Corresponding numbers

If a parameter is found with the **DEFAULT** value ("0"), the scan is interrupted.

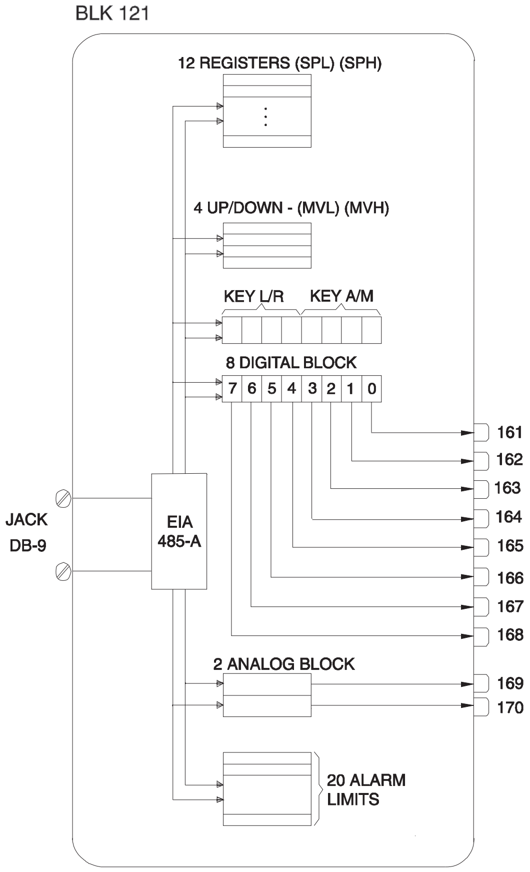
TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
P	CBID	User free identification number	0 - 100	0
P	CTR1	Number of 1st PID	0 - 8	0
P	CTR2	Number of 2nd PID	0 - 8	0

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
P	CTR3	Number of 3rd PID	0 - 8	0
P	CTR4	Number of 4th PID	0 - 8	0
P	CTR5	Number of 5th PID	0 - 8	0
P	CTR6	Number of 6th PID	0 - 8	0
P	CTR7	Number of 7th PID	0 - 8	0
P	CTR8	Number of 8th PID	0 - 8	0

Number of Bytes per Type of Parameter: A = 0 C = 18 L = 0

Function 36 - Actuation (ATU)

Operation



This block allows actuation of digital and analog variables of the **CD600** blocks by the commands received via the communication bus.

These variables are classified into 6 groups:

I. REGISTER ACTUATORS

The register actuators correspond to the keys <∆> and <∇ > on the **CD600** front panel.

The twelve analog registers contained in the Constant Adjuster, Internal/External Signal Selector, Local/Remote SP and Setpoint Generator blocks are defined by the parameters **CR01** through **CR12**. In order to establish the actuation sequence, the **CRxx** parameters must be set with the numbers corresponding to the blocks as shown in Table 4.36.1.

CR	BLOCK No.	BLOCK NAME
0	BLK031	**Function 07** **Local/Remote SP Selector**
1	BLK032	
2	BLK033	
3	BLK034	
4	BLK075	**Function 21** **Setpoint Generator**
5	BLK076	
6	BLK097	**Function 27** **Internal/External Signal Selector**
7	BLK098	
8	BLK099	**Function 28** **Constant Adjuster**
9	BLK100	
10	BLK101	
11	BLK102	

Table 4.36.1 - Block Corresponding numbers for CR Parameters

II. AUTO MANUAL KEYS

The actuation sequence for the A/M stations is established by the parameters **CMV1** through **CMV4**. These parameters are used for both analog (increase and decrease) and digital (Automatic/Manual) signals.

The blocks corresponding numbers are given in Table 4.36.2.

CMV	BLOCK No.	BLOCK NAME
0	BLK035	**Function 08** **A/M Station**
1	BLK036	
2	BLK037	
3	BLK038	

Table 4.36.2 - A/M Block Corresponding numbers for CMV Parameters

III. LOCAL/REMOTE KEYS

The actuation sequence of the digital (Local/Remote) signals of the L/R SP Selector blocks is established by the parameters **CLR1** through **CLR4**. The Table 4.36.3 shows numbers related to the blocks.

IV. DIGITAL VARIABLES

Up to eight digital signals can be accessed via the communication bus. These variables are available at the gates 161 through 168, and can be used by any block of the configuration.

Remember that the digital actuation of the L/R and A/M front panel keys is done through parameters **CLRx** and **CMVx**, respectively.

Representation of digital variables is in bit form.

V. ANALOG VARIABLES

Up to two analog variables can be received in this group. They are available at the outputs 169 and 170, and can be used by any block of the configuration.

Representation is in word form.

VI. ALARM LIMITS

The commands for actuation on the individual alarm limits can be received in this group, in the sequence determined in the parameters **AL01** through **AL20**. The selection range of these parameters is from 0 to 20, as shown in Table 4.36.4.

AL	BLOCK No.	BLOCK NAME	BLOCK IDENTIFICATION
0	-	**Interrupts the Scan**	-
1	BLK039	**Function 09 Advanced PID Control**	Parameter AMXD
2	BLK040		
3	BLK041		
4	BLK042		
5	BLK077	**Function 22 Double Alarm**	Parameters ARG1; ARG2
6	BLK077		
7	BLK078		
8	BLK078		
9	BLK079		
10	BLK079		
11	BLK080		
12	BLK080		
13	BLK081	**Function 23 Limiter with Alarm**	Parameters A-BL; A-BH
14	BLK081		
15	BLK082		
16	BLK082		
17	BLK083		
18	BLK083		
19	BLK084		
20	BLK084		

Table 4.36.4 - Alarm Corresponding numbers for AL Parameters

If a parameter is found with the **DEFAULT** value "0", the scan sequence is interrupted.

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	CBID	User free identification number	0 – 100	0
I	CR01	Number of 1st register	0 – 11	0
I	CR02	Number of 2nd register	0 – 11	0
I	CR03	Number of 3rd register	0 – 11	0
I	CR04	Number of 4th register	0 – 11	0
I	CR05	Number of 5th register	0 – 11	0
I	CR06	Number of 6th register	0 – 11	0
I	CR07	Number of 7th register	0 – 11	0
I	CR08	Number of 8th register	0 – 11	0
I	CR09	Number of 9th register	0 – 11	0
I	CR10	Number of 10th register	0 – 11	0
I	CR11	Number of 11th register	0 – 11	0
I	CR12	Number of 12th register	0 – 11	0
I	CMV1	Number of 1st A/M Station	0 – 3	0
I	CMV2	Number of 2nd A/M Station	0 – 3	1
I	CMV3	Number of 3rd A/M Station	0 – 3	2
I	CMV4	Number of 4th A/M Station	0 - 3	3
I	CLR1	Number of 1st L/R Selector	0 - 3	0

TYPE	MNEM	DESCRIPTION	RANGE	DEFAULT
I	CLR2	Number of 2nd L/R Selector	0 - 3	1
I	CLR3	Number of 3rd L/R Selector	0 - 3	2
I	CLR4	Number of 4th L/R Selector	0 - 3	3
I	AL01	1st Alarm	0 - 20	0
I	AL02	2nd Alarm	0 - 20	0
I	AL03	3rd Alarm	0 - 20	0
I	AL04	4th Alarm	0 - 20	0
I	AL05	5th Alarm	0 - 20	0
I	AL06	6th Alarm	0 - 20	0
I	AL07	7th Alarm	0 - 20	0
I	AL08	8th Alarm	0 - 20	0
I	AL09	9th Alarm	0 - 20	0
I	AL10	10th Alarm	0 - 20	0
I	AL11	11th Alarm	0 - 20	0
I	AL12	12th Alarm	0 - 20	0
I	AL13	13th Alarm	0 - 20	0
I	AL14	14th Alarm	0 - 20	0
I	AL15	15th Alarm	0 - 20	0
I	AL16	16th Alarm	0 - 20	0
I	AL17	17th Alarm	0 - 20	0
I	AL18	18th Alarm	0 - 20	0
I	AL19	19th Alarm	0 - 20	0
I	AL20	20th Alarm	0 - 20	0

Number of Bytes per Type of Parameter: A = 40 C = 42 L = 0

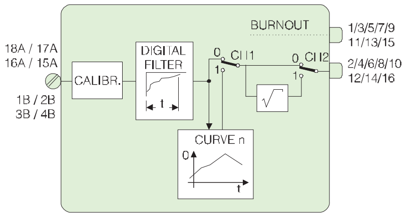
Control Function Blocks

TERMINALS

F01 - ANALOG INPUT (AI)

P. 4.2

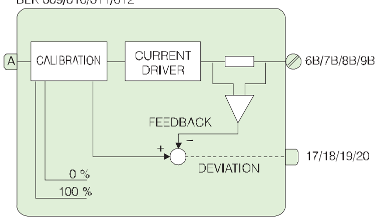
BLK 001/002/003/004/005/006/007/008



F02 - CURRENT OUTPUT (CO)

P. 4.3

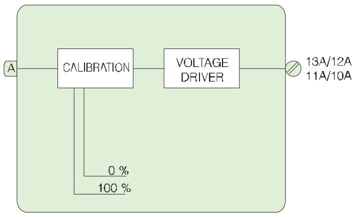
BLK 009/010/011/012



F03 - VOLTAGE OUTPUT (VO)

P. 4.4

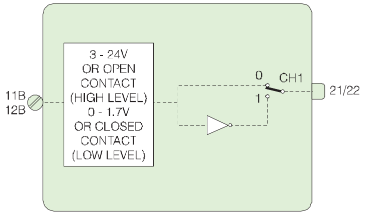
BLK 013/014/015/016



F04 - DIGITAL INPUT (DI)

P. 4.5

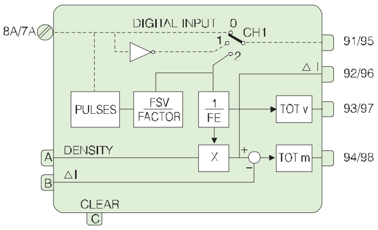
BLK 017/018



F19 - PULSE TOTALIZATION INPUT (P/DI)

P. 4.54

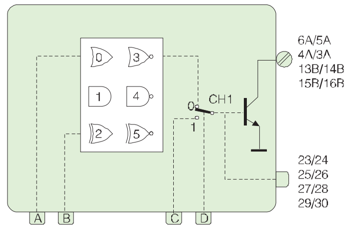
BLK 071/072



F05 - DIGITAL OUTPUT (DO)

P. 4.6

BLK 019/020/021/022/023/024/025/026

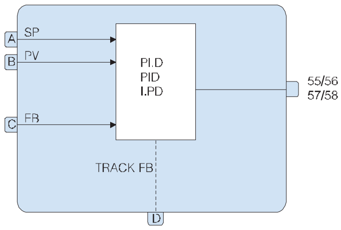


LOOPS

F10 - SIMPLE PID (PID)

P. 4.26

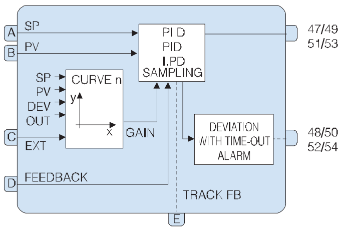
BLK 043/044/045/046



F09 - ADVANCED PID (APID)

P. 4.16

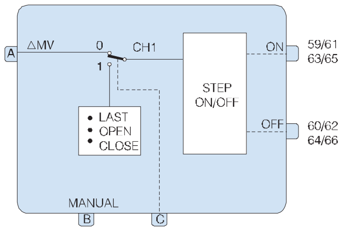
BLK 039/040/041/042



F11 - STEP CONTROLLER (STEP)

P. 4.30

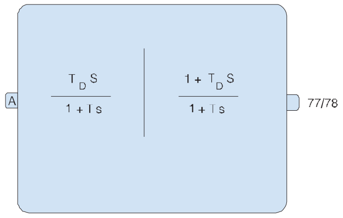
BLK 047/048/049/050



F15 - DERIVATIVE / LEAD-LAG (LL)

P. 4.42

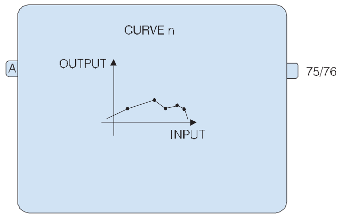
BLK 061/062



F14 - LINEARIZATION (LIN)

P. 4.40

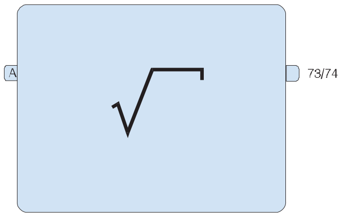
BLK 059/060



F13 - SQUARE ROOT (SQR)

P. 4.39

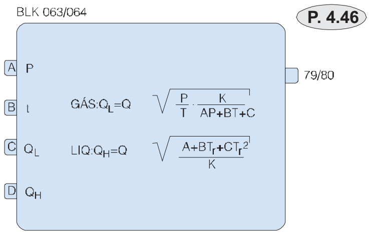
BLK 057/058



F16 - PRESSURE AND TEMP. COMPENSATION (PTC)

P. 4.46

BLK 063/064

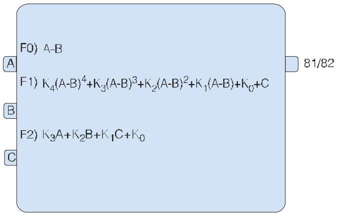


A P
B t
C Q_L
D Q_H
GÁS:Q_L=Q $\sqrt{\frac{P}{T} \cdot \frac{K}{AP+BT+C}}$
LIQ:Q_H=Q $\sqrt{\frac{A+BT_r+CT_r^2}{K}}$
79/80

F17 - POLYNOMIAL (POL)

P. 4.50

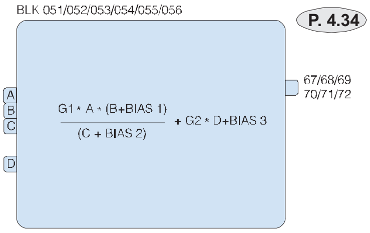
BLK 065/066



F12 - MULTIPLIER-DIVIDER-ADDER-SUBTRACTOR (ARTH)

P. 4.34

BLK 051/052/053/054/055/056

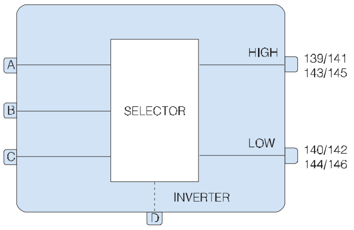


A
B
C
D
$\frac{G1 * A * (B+BIAS\ 1)}{(C + BIAS\ 2)}$ + G2 * D+BIAS 3
67/68/69
70/71/72

F26 - HIGH / LOW SELECTOR (H/L)

P. 4.72

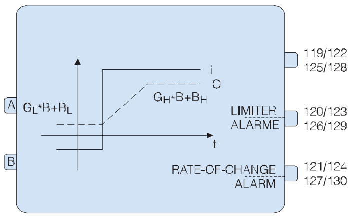
BLK 093/094/095/096



F23 - LIMITER WITH ALARM (LIMT)

P. 4.65

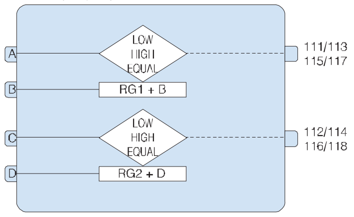
BLK 081/082/083/084



F22 - DOUBLE ALARM (ALM)

P. 4.63

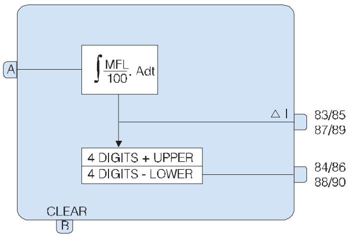
BLK 077/078/079/080



F18 - TOTALIZATION (TOT)

P. 4.52

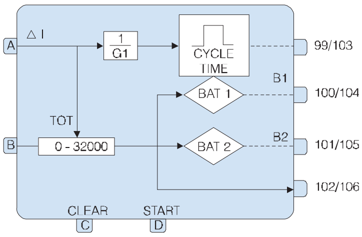
BLK 067/068/069/070



F20 - BATCH COMPARATOR (BAT)

P. 4.59

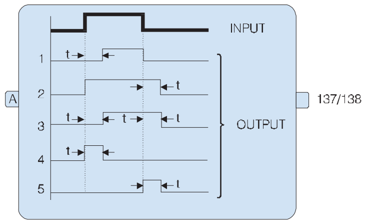
BLK 073/074



F25 - TIMER (TMR)

P. 4.71

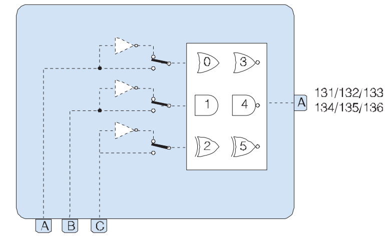
BLK 091/092



F24 - LOGIC (LOG)

P. 4.69

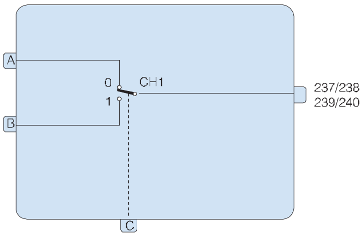
BLK 085/086/087/088/089/090



F29 - INPUT SELECTOR (ISEL)

P. 4.76

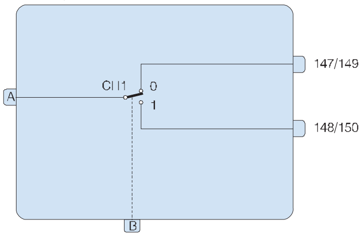
BLK 103/104/105/106



F30 - OUTPUT SELECTOR (OSEL)

P. 4.78

BLK 107/108

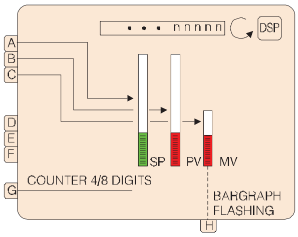


PANEL

F06 - FRONT VIEW (FV)

P. 4.7

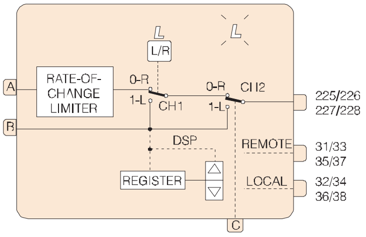
BLK 027/028/029/030



F07 - LOCAL / REMOTE SP SELECTOR (L/R)

P. 4.9

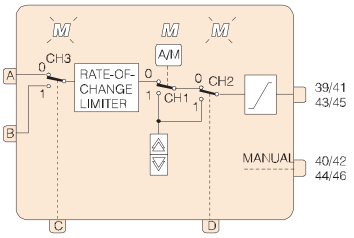
BLK 031/032/033/034



F08 - AUTOMATIC / MANUAL STATION (A/M)

P. 4.12

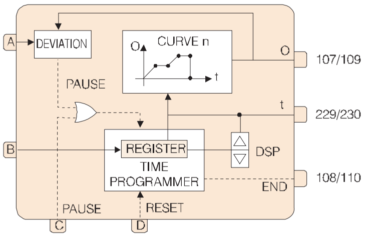
BLK 035/036/037/038



F21 - SETPOINT GENERATOR (SPG)

P. 4.61

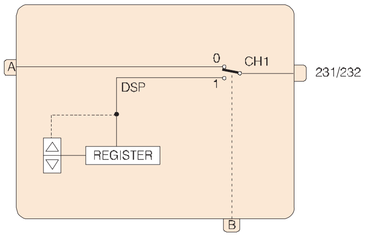
BLK 075/076



F27 - INTERNAL / EXTERNAL SELECTOR (SSEL)

P. 4.73

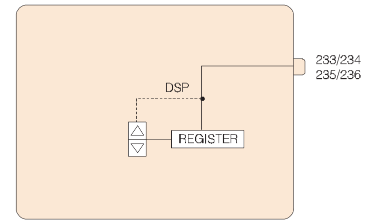
BLK 097/098



F28 - CONSTANT ADJUSTER (ADJ)

P. 4.74

BLK 099/100/101/102

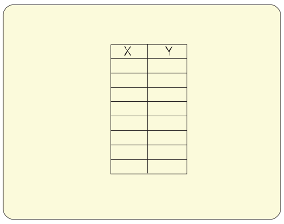


GENERAL

F31 - LINEARIZATION CURVE (PNT)

P. 4.80

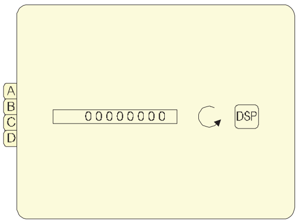
BLK 109/110/111/112/113/114/115/116



F32 - GENERAL VISUALIZATION (GV)

P. 4.84

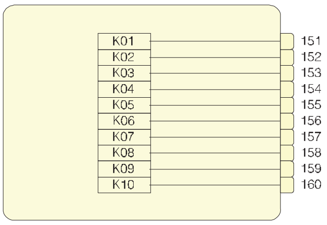
BLK 117



F33 - CONSTANTS (K)

P. 4.85

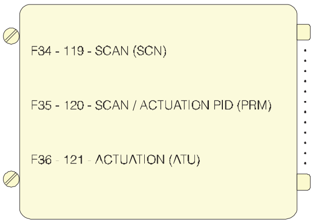
BLK 118



COMMUNICATION

P. 4.86, 4.89, 4.90

BLK 119/120/121


F34 - 119 - SCAN (SCN)
F35 - 120 - SCAN / ACTUATION PID (PRM)
F36 - 121 - ACTUATION (ATU)

Section 5

RESIDENT CONFIGURATION

A control configuration consists of a set of instructions that define the blocks to be used, the connections between them, the internal configuration of each block and the required adjustments.

The control configuration instructions are stored in the NVRAM (Non Volatile Random Access Memory). These instructions will remain in the memory even if the controller power is switched off.

When a new configuration is downloaded into the controller, it takes the place of the old one.

The **CD600** leaves the factory with a resident configuration that performs a Four Loop Control. This configuration handles most of the applications normally used in process control. It can be copied in a DATA-PACK or a DATAPACK already containing it can be ordered.

The configuration name (General Loop Tag) is "4 LOOPS". Its main features are:

- Execution of four independent control loops;
- Each loop is implemented with an Advanced PID function block (see Advanced PID features);

- Each loop may have Local Adjustment Setpoint or Remote Setpoint for ratio control. The ratio constant may be adjusted by the front panel;

- Loops 1 and 2 have additionally a Lead-Lag dynamic compensator for feedforward control;

- The front panel enables the operator to visualize the Setpoint, the Process Variable, the manipulated variable signal, Totalized value (if the PV is flow) and the ratio constant of each individual loop;

- Each loop has two alarms for the Process Variable (any type, any level) and one deviation alarm with time-out;

- Each loop has forced manual input.

The configuration overview is shown in Figure 5.1 and the individual loop detailed configuration is shown in Figures 5.2 through 5.6.

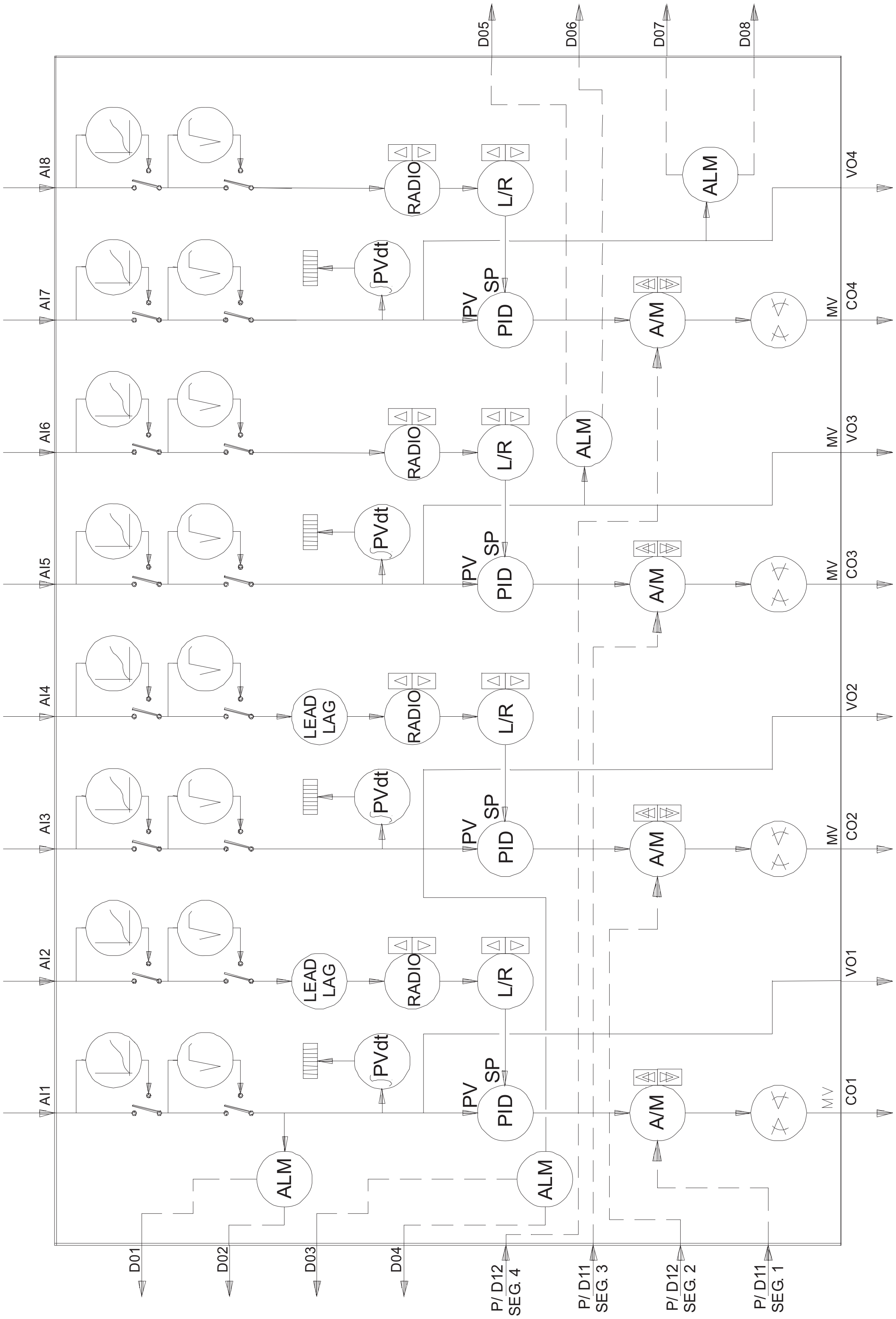
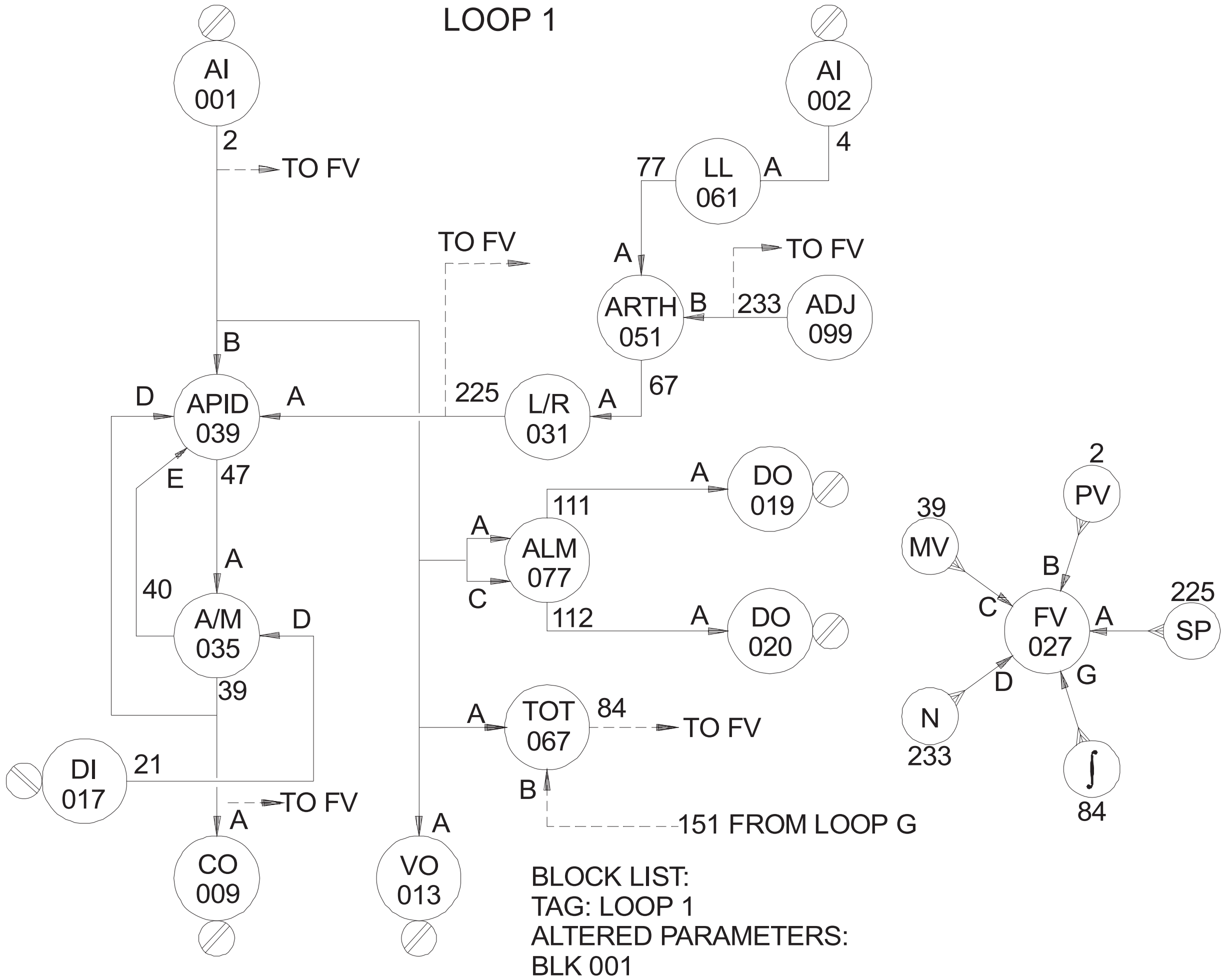
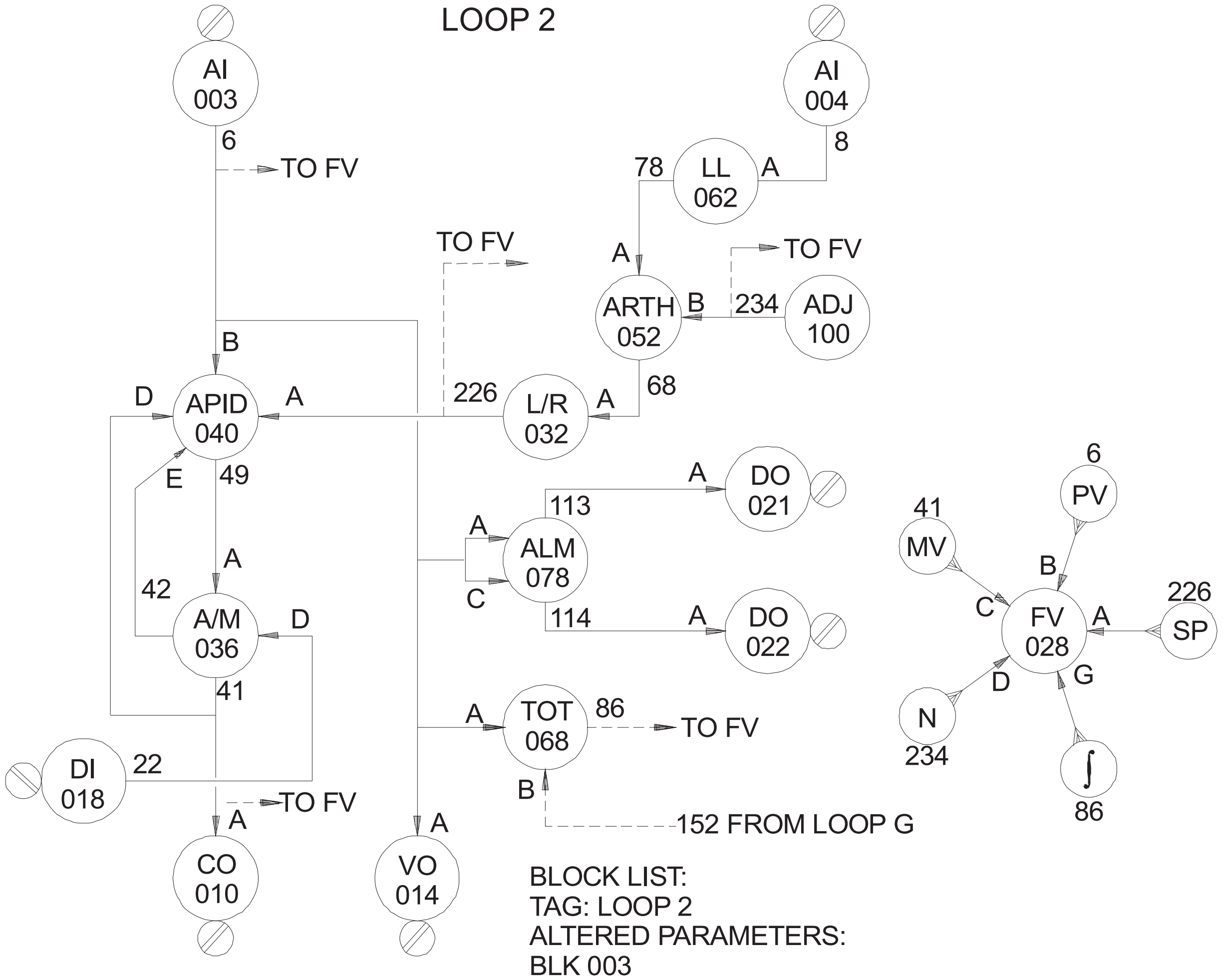


Fig 5.1 - Functional Diagram of the "4 LOOPS"configuration (Resident Configuration)



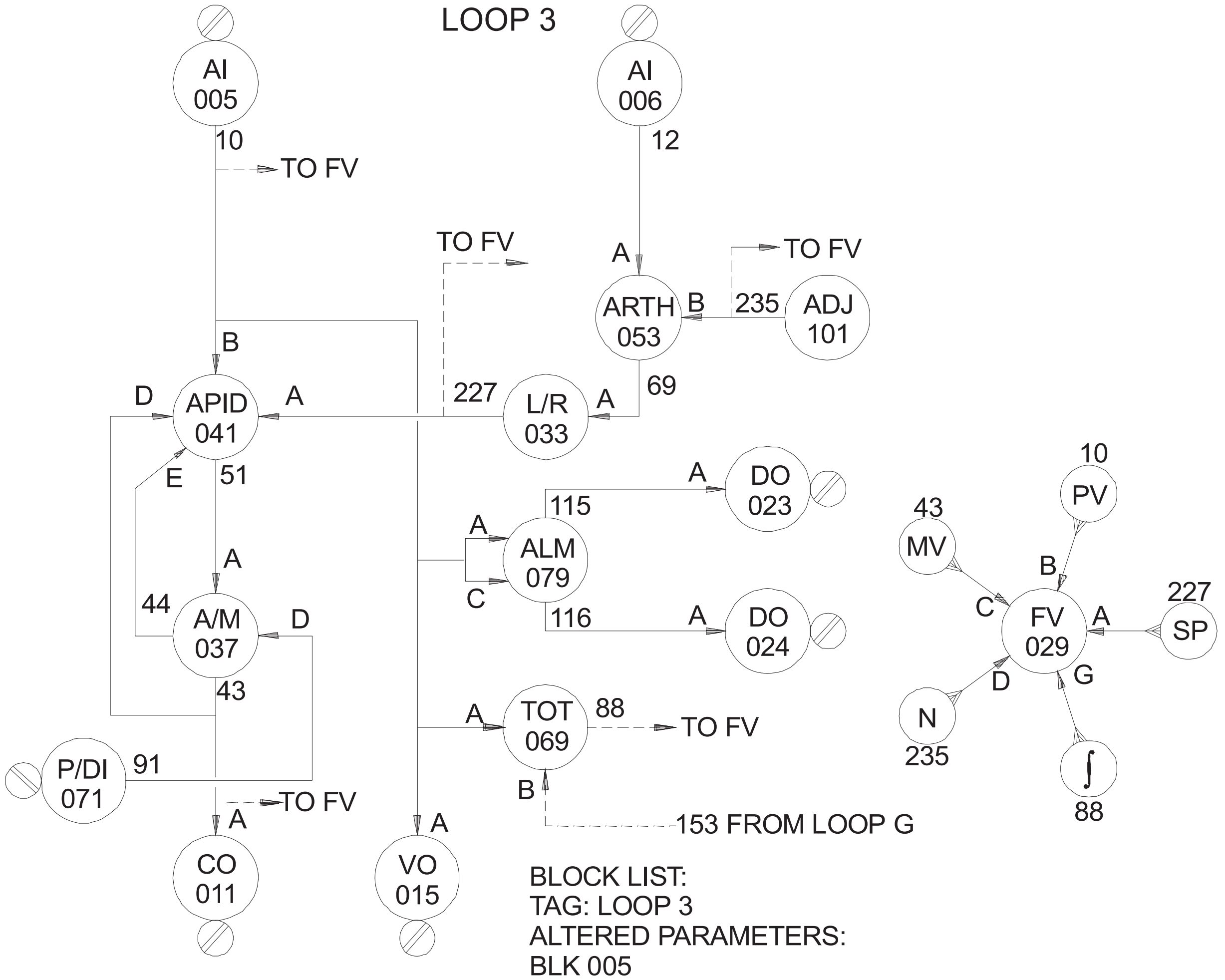
BLOCK LIST:
TAG: LOOP 1
ALTERED PARAMETERS:
BLK 001
002
061 LIA = 4
099 ALOW = 6,00%; AUPP = 60,00%
051 LIA = 77; LIB = 233; ABS2 = 20,00%
031 LIA = 67
039 LIA = 255; LIB = 2; LID = 39; LIE = 40
017 CNOT = 1
035 LIA = 47; LID = 21
009 LIA = 39
077 LIA = 2; LIC = 2; CFRT = 3
019 LIA = 111
020 LIA = 112
067 LIA = 2; LIB = 151
013 LIA = 2
027 LIA = 225; LIB = 2; LIC = 39; LID = 233;
LIG = 84; AMND = R1; ADM = 5,0000

Fig 5.2 - Block Listing of "4 LOOPS" - LOOP 1



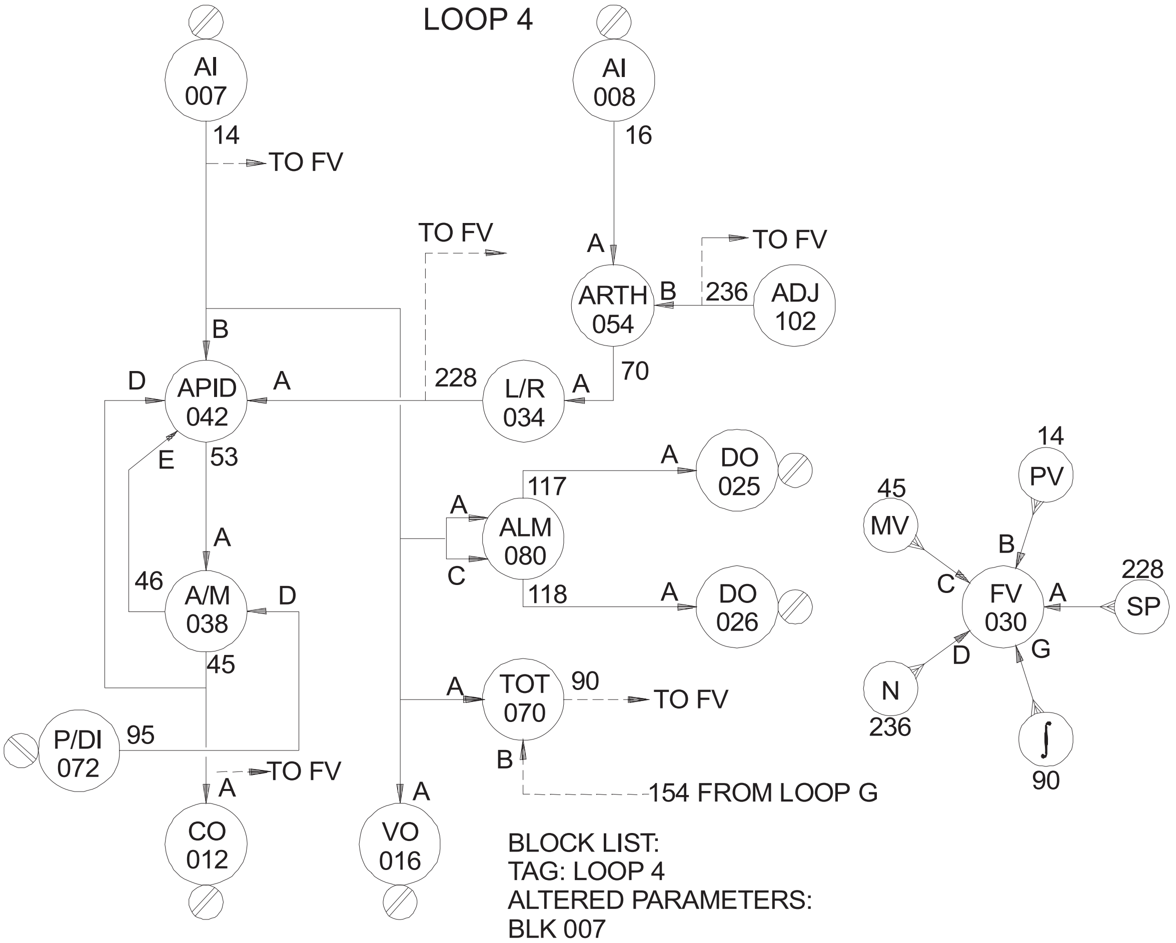
BLOCK LIST:
TAG: LOOP 2
ALTERED PARAMETERS:
BLK 003
004
062 LIA = 48
100 ALOW = 6,00%; AUPP = 60,00%
052 LIA = 78; LIB = 234; ABS2 = 20,00%
032 LIA = 68
040 LIA = 226; LIB = 6; LID = 41; LIE = 42
018 CNOT = 1
036 LIA = 49; LID = 22
010 LIA = 41
078 LIA = 6; LIC = 6; CFRT = 3
021 LIA = 113
022 LIA = 114
068 LIA = 6; LIB = 152
014 LIA = 6
028 LIA = 226; LIB = 6; LIC = 41; LID = 234;
LIG = 86; AMND = R2; ADM = 5,0000

Fig 5.3 - Block Listing of "4 LOOPS - LOOP 2



BLOCK LIST:
TAG: LOOP 3
ALTERED PARAMETERS:
BLK 005
006
101 ALOW = 6,00%; AUPP = 60,00%
053 LIA = 12; LIB = 235; ABS2 = 20,00%
033 LIA = 69
041 LIA = 227; LIB = 10; LID = 43; LIE = 44
071 CTYP = 1
037 LIA = 51; LID = 91
011 LIA = 43
079 LIA = 10; LIC = 10; CFRT = 3
023 LIA = 115
024 LIA = 116
069 LIA = 10; LIB = 153
015 LIA = 10
029 LIA = 227; LIB = 10; LIC = 43; LID = 235;
LIG = 88; AMND = R3; ADM = 5,0000

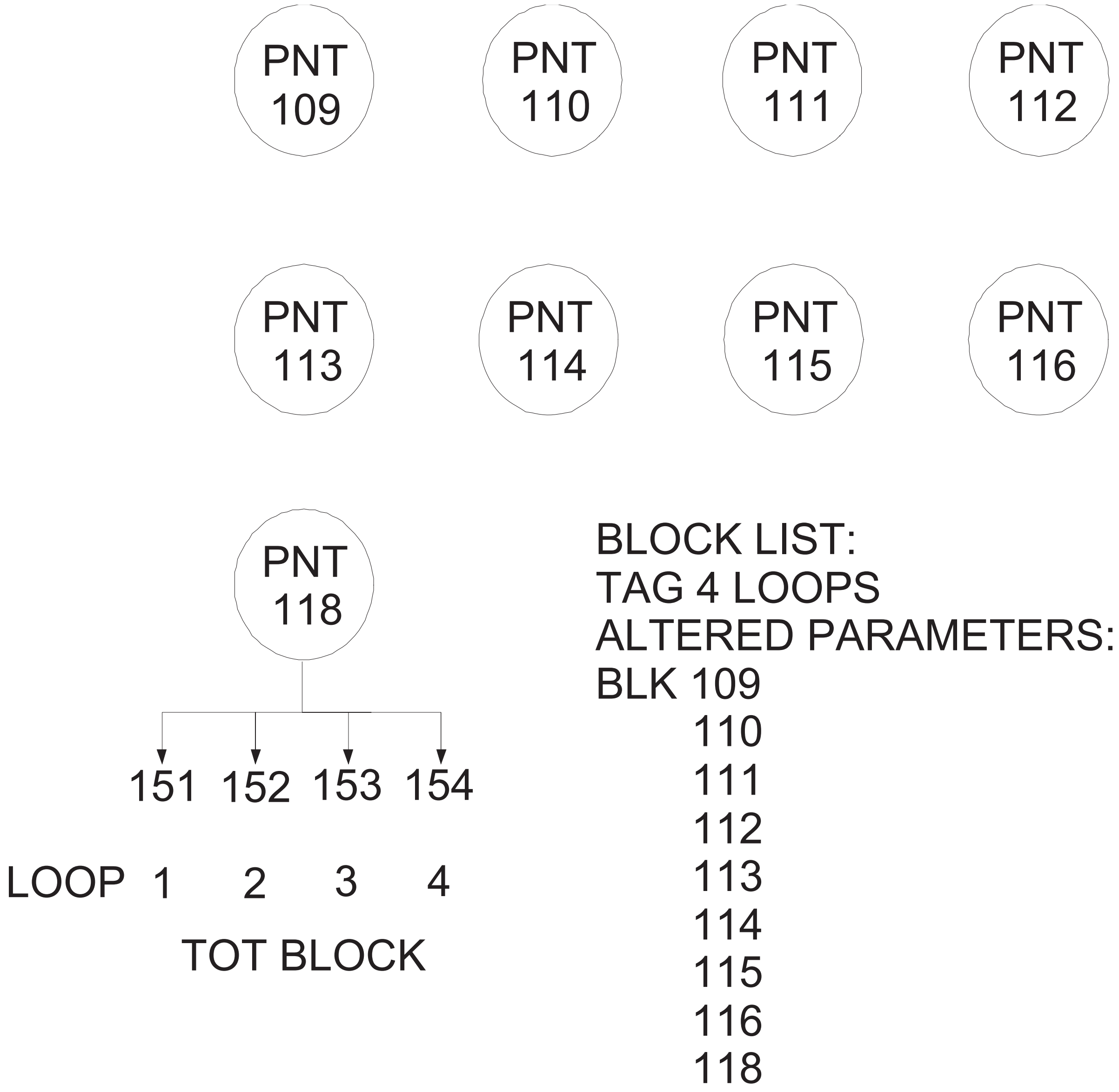
Fig 5.4 - Block Listing of 4 LOOPS" - LOOP



BLOCK LIST:
TAG: LOOP 4
ALTERED PARAMETERS:
BLK 007
008
102 ALOW = 6,00%; AUPP = 60,00%
054 LIA = 12; LIB = 236; ABS2 = 20,00%
034 LIA = 70
042 LIA = 228; LIB = 14; LID = 45; LIE = 46
072 CTYP = 1
038 LIA = 53; LID = 95
012 LIA = 45
080 LIA = 14; LIC = 14; CFRT = 3
025 LIA = 117
026 LIA = 118
070 LIA = 14; LIB = 154
016 LIA = 14
030 LIA = 228; LIB = 14; LIC = 45; LID = 236;
LIG = 90; AMND = R4; ADM = 5,0000

3

Fig 5.5 - Block Listing of "4 LOOPS - LOOP 4



BLOCK LIST:
TAG 4 LOOPS
ALTERED PARAMETERS:
BLK 109
110
111
112
113
114
115
116
118

Fig 5.6 - Block Listing of "4 LOOPS" - LOOP G

TECHNICAL SPECIFICATIONS

Power Supply and Consumption

The table below specifies the maximum current values.

POWER SUPPLY *VOLTAGE*	WITHOUT BACKUP (1)	WITH BACKUP (1)-(2)	WITH BACKUP AND 08 TRANSMITTERS SUPPLIED BY THE CONTROLLER (1),(2) & (3)
220 Vac ± 10% 50/60 Hz	58 mA	104 mA	130 mA
127 Vac ± 10% 50/60 Hz	95 mA	156 mA	194 mA
110 Vac ± 10% 50/60 Hz	111 mA	200 mA	243 mA
24 Vdc - 5% +25%	390 mA	720 mA	883 mA

Table 6.1 - Power Consumption

NOTES:
(1) Front panel fully lit up and all outputs at 100.00%.
(2) The "**AUTO**"-"**BACKUP**" switch in "**BACKUP**" position and all outputs at 100.00%.
(3) All transmitters with output at 100.00% (20 mA/transmitter).
(For Vac models only).

INTEGRAL POWER SUPPLY FOR TRANSMITTERS (FOR Vac MODELS ONLY)

-Regulated Output Voltage: 24 V ±10%
-Maximum Output Current: 160 mA
-Short Circuit Current Limitation

EXTERNAL POWER SUPPLY FOR HAND-HELD TERMINAL

- Output: 9 Vdc/500 mA

NOTE 1: The external Power Supply cannot be used when communicating with the controller.

NOTE 2: The **Hand-Held Terminal** can also be supplied directly by the controller, if:
a) The main board GLL600 is revision 3 or higher.
b) The communication interface has a serial number followed by an "A" letter (e.g.: Serial number 01166A).

NVRAM (NONVOLATILE MEMORY)

The data retention in the memory is obtained with a built in battery. This is a lithium battery, non- rechargeable, and has a minimum data retention of 10 years in normal operation.

ANALOG INPUTS AND OUTPUTS

	Q	TYPE	IMPEDANCE/LOAD	ACCURACY
Analog Input	8	4-20mA/0-20mA(1)	250 Ω	± 0.010V
		1-5V/0-5V	1 M Ω	
Current Output	4	4-20mA/0-20mA(2)	Máx. 750 Ω	± 0.050mA
Voltage Output	4	1-5V/0-5V	Mín. 1.5 KΩ	± 0.015V(3)

NOTES:

(1) In order to change a current input to voltage and vice-versa, it is enough to remove/insert a 250-Ohm shunt resistor located on the back panel, above the terminal boards. Each shunt resistor position is marked with the corresponding input number.

(2) When the controller has a backup station, 0-20 mA current outputs cannot be used.

(3) For cycle time < 200ms, accuracy: 0.020V.

DIGITAL INPUTS (**DI1**, **DI2**, **DI3** and **DI4**)

Quantity:	04
Type:	Dry contact or Voltage (**DI1**, **DI2**, **DI3** and **DI4**)
Frequency:	0 to 10 KHz (**DI1** and **DI2**)
Accuracy:	0.05% (10 Hz < f < 10 KHz) 0.3%(1Hz ≤ f ≤10 Hz)

Recognition of Low Logic Level "0":

- Closed Contact with maximum 200 Ω resistance or Voltage from 0 to 1.7 Vdc

Recognition of High Logic Level "1":

- Open Contact with minimum 1.5 MΩ resistance or Voltage from 3 to 24 Vdc

NOTE: When using the pulse input connected to a relay (electro-mechanical switch), a "DEBOUNCING CIRCUIT" is necessary. The actual mechanical behavior of a switch does not generate a clear, crisp level change instantly, therefore the signal to the digital input "oscillates" for a few milliseconds, causing a misreading of the relay state.

DIGITAL OUTPUTS (**DO1** through **DO8**)

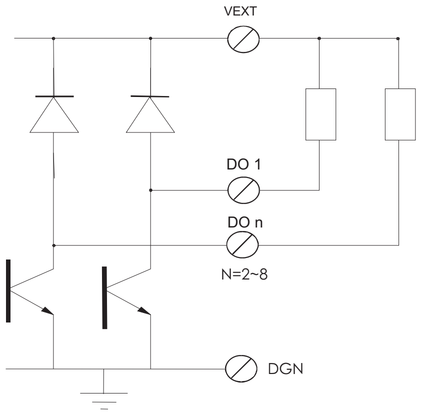
Quantity: 08
Type: Open Collector (max. Vce = 45 Vdc; max. Ice = 100 mA)

DIGITAL OUTPUT TO INDICATE CONTROLLER FAILURE

In case of failure of the main electronic board the transistor referring to this output is in the "cut" state. Must be connected as the digital outputs (see above).

Warning:

Always use the "External V" when connecting inductive loads to the digital output. Refer to connection diagrams, Figure 6.4 and to Vext, Figure 6.1.
The use of the "External V", even when an external power supply is available, is recommended to prevent damage due to over voltage during load switching.



Observation: The "External V" provides protection through built-in diodes in parallel with the load. See Figure 6.1.

Fig 6.1 - External V

CENTRAL PROCESSING UNIT

Microprocessor: 80C196, 16 bits
Memory: 48 Kbytes (PROM) + 8 Kbytes (NVRAM)
Control Cycle: adjustable from 100 to 250 ms

INSTALLATION CONDITION

Environment: 0 to 43 ^{0}C, 20 a 90% RH

FRONT PANEL

Led Bargraphs (101 dots): 2
Led Bargraph (41 dots): 1
State indicator: 23 leds
Alphanumeric display: 8 characters
Keyboard: 9 keys

PHYSICAL CHARACTERISTICS

Housing: SAE1020 steel with electrostatic painting

Color: Black

Body: Extruded Aluminum and electrostatic painting

Front Panel: PBT with 20% of injected thermoplastic fiberglass

Circuit Boards: Reinforced polyester with fiberglass

Front Dimensions: 72x144x494 mm

Weight: Models DC: - set with backup - 3,14 Kg
- set without backup - 2,83 Kg

Models AC: - set with backup - 4,12 Kg
- set without backup - 3,60 Kg

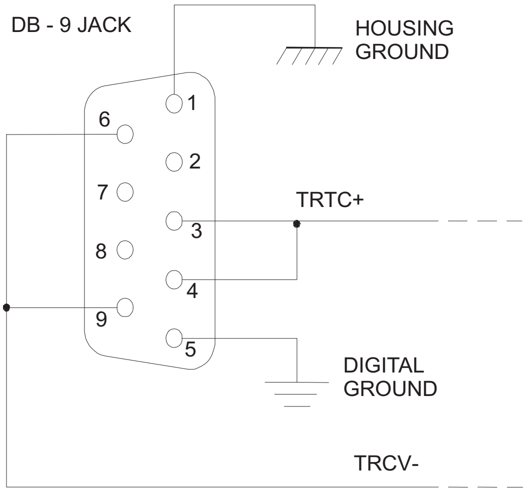


Fig 6.2 - Communication Connector

***CAUTION**: Inverting the digital outputs polarity will damage the equipment.

TERMINAL BLOCK A		TERMINAL BLOCK B	
18	Analog Input 1	1	Analog Input 5
17	Analog Input 2	2	Analog Input 6
16	Analog Input 3	3	Analog Input 7
15	Analog Input 4	4	Analog Input 8
14	24 Vdc/160 mA PWR. SPLY.	5	Analog Ground
13	Voltage Output 1	6	Current Output 1
12	Voltage Output 2	7	Current Output 2
11	Voltage Output 3	8	Current Output 3
10	Voltage Output 4	9	Current Output 4
9	Analog Ground	10	Analog Ground
8	Digital Input 1	11	Digital Input 3
7	Digital Input 2	12	Digital Input 4
6	Digital Output 1	13	Digital Output 5
5	Digital Output 2	14	Digital Output 6
4	Digital Output 3	15	Digital Output 7
3	Digital Output 4	16	Digital Output 8
2	External V	17	Digital Ground
1	Controller Failure Alarm	18	Digital Ground

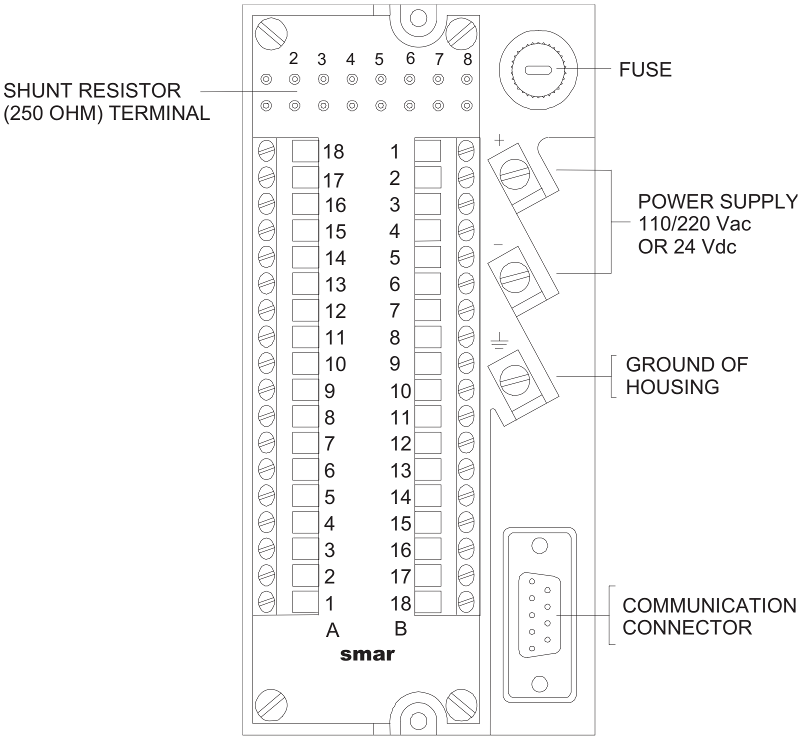
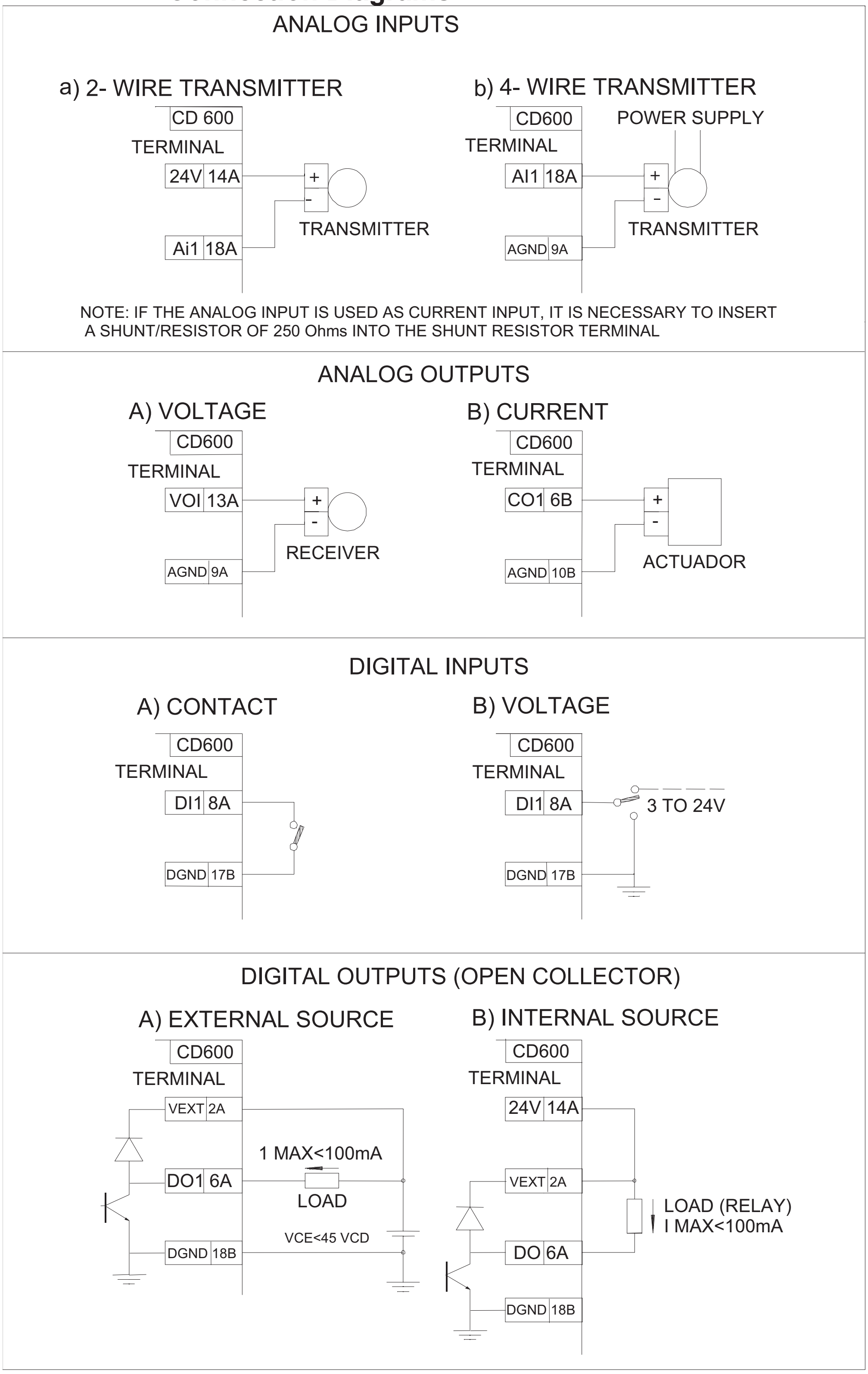


Table 6.2 - Terminal Block Identification

Fig 6.3 - Rear Panel with Terminals

Connection Diagrams



NOTE: IF THE ANALOG INPUT IS USED AS CURRENT INPUT, IT IS NECESSARY TO INSERT A SHUNT/RESISTOR OF 250 Ohms INTO THE SHUNT RESISTOR TERMINAL

Fig 6.4 - Wiring Diagrams for Inputs and Outputs

SPARE PARTS LIST

DESCRIPTION	POS.	CODE
SMAR Hand-Held Terminal	-	HT1
Communication Interface	-	IF1
Connector for Alligator Clip	-	203-1503
Alkaline Battery 9 V	-	203-1505
Battery Eliminator 9 V 110/220 Vac	-	BE1
Tag holder	1	206-0101
Front panel cover	2	206-0102
Scale	4	206-0103
Acrylic window	3	206-0105
Main board and complete front panel set	1 to 7	400-0633
Complete front panel set *	1 to 5	400-0634
Front panel board set **	5	400-0635
Main Board (New Version)	7	400-0640
Shunt Resistor (250 Ω)	-	206-0108
Cutout filler box	2	206-0109
Complete back panel 110 Vac 50-60 Hz 127 Vac 50-60 Hz 220 Vac 50-60 Hz 240 Vac 50-60 Hz 24 Vdc	 9 and 10 9 and 10 9 and 10 9 and 10 9 and 10	 206-0120 206-0125 206-0130 206-0135 206-0140
Terminal board	9	206-0201
Back panel without terminal board 110 Vac 127 Vac 220 Vac 240 Vac 24 Vdc	 10 10 10 10 10	 206-0202 206-0203 206-0204 206-0205 206-0206
Controller housing	11	206-0300
Fixing clip	12	206-0400
Main board (Old Version)	7	206-0500
Non volatile RAM	8	206-0600
AC power supply with backup 110/220 Vac 50-60 Hz 127/240 Vac 50-60 Hz AC power supply without backup 110/220 Vac 50-60 Hz 127/240 Vac 50-60 Hz	 14 14 14 14	 206-0700-1 206-0700-2 206-0700-3 206-0700-4
Auxiliary board - GLL602 AC power supply DC power supply	 13 13	 206-0805 206-0810

DESCRIPTION	POS.	CODE
Backup panel	16	206-0901
Potentiometer board-GLL 720	15	206-0902
Complete backup station		
110/220 Vac 50-60 Hz	14 to 17	206-0910
127/240 Vac 50-60 Hz	14 to 17	206-0911
24 Vdc	14 to 17	206-0912
Backup board-GLL 603		
AC power supply	17	206-0920
DC power supply	17	206-0921
Main board fuse - 1A	-	206-1000
Power fuse 110/127 V 50-60 Hz - 0.5A	-	206-1100-1
Power fuse 220/240 V 50-60 Hz - 0.315A	-	206-1100-2
Power fuse 24 Vdc - 2A	-	206-1100-3
Program Datapack for CD600	-	DP08
Datapack 128K	-	DP02
RAMPACK 32K	-	DP03

* This code applies for clients with updated hardware
** This code applies for clients that only need the corresponding boards

Ordering Code

CD600						
	1	....	....	....	....	110 V / 60 Hz
	2	....	....	....	....	127 V / 60 Hz
	3	....	....	....	....	220 V / 50 - 60 Hz
	4	....	....	....	....	24 Vdc
		0	....	....	....	Without Backup
		B	....	....	....	With Backup Station

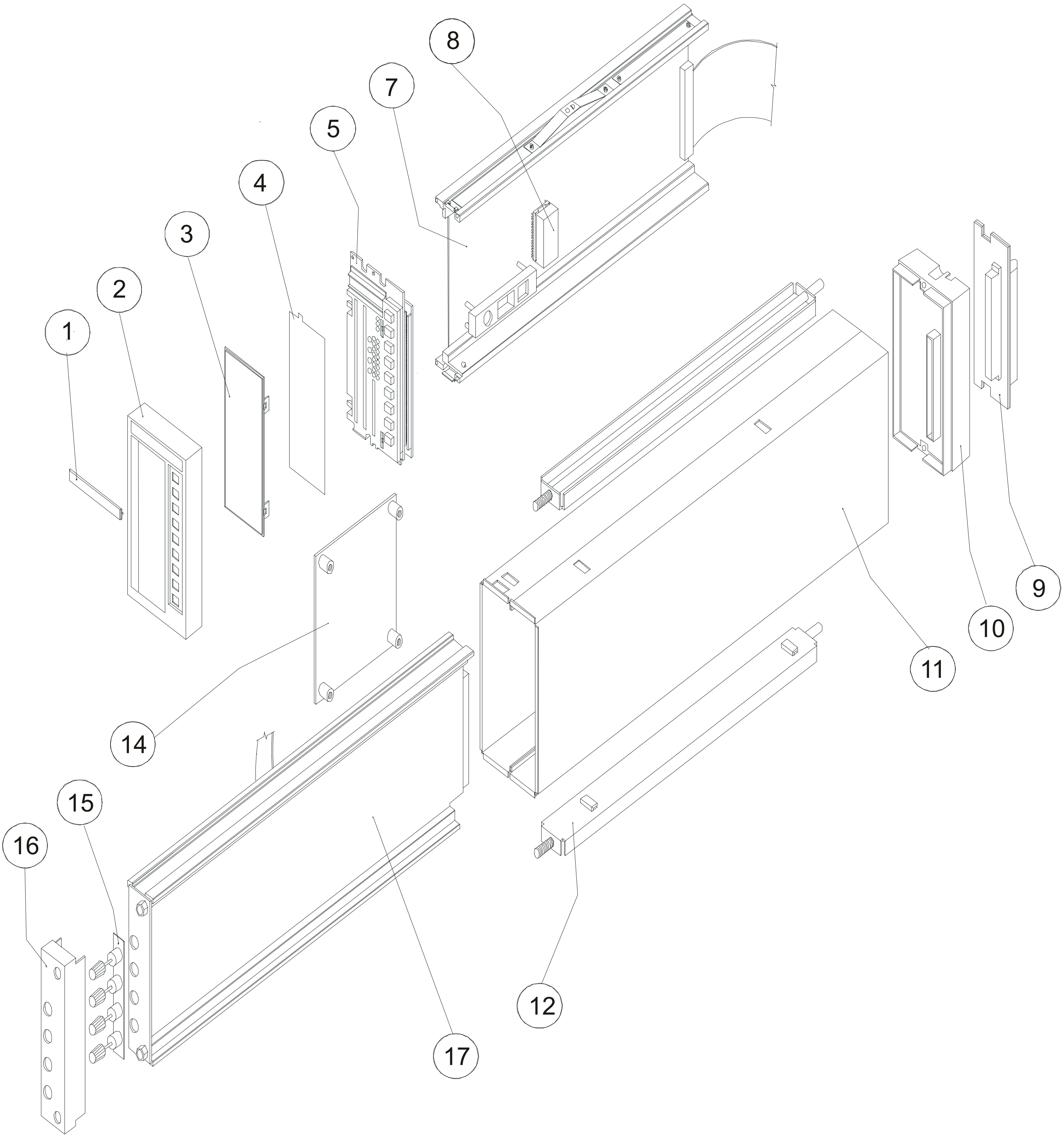


Fig 6.5 - CD600 Digital Controller with Backup

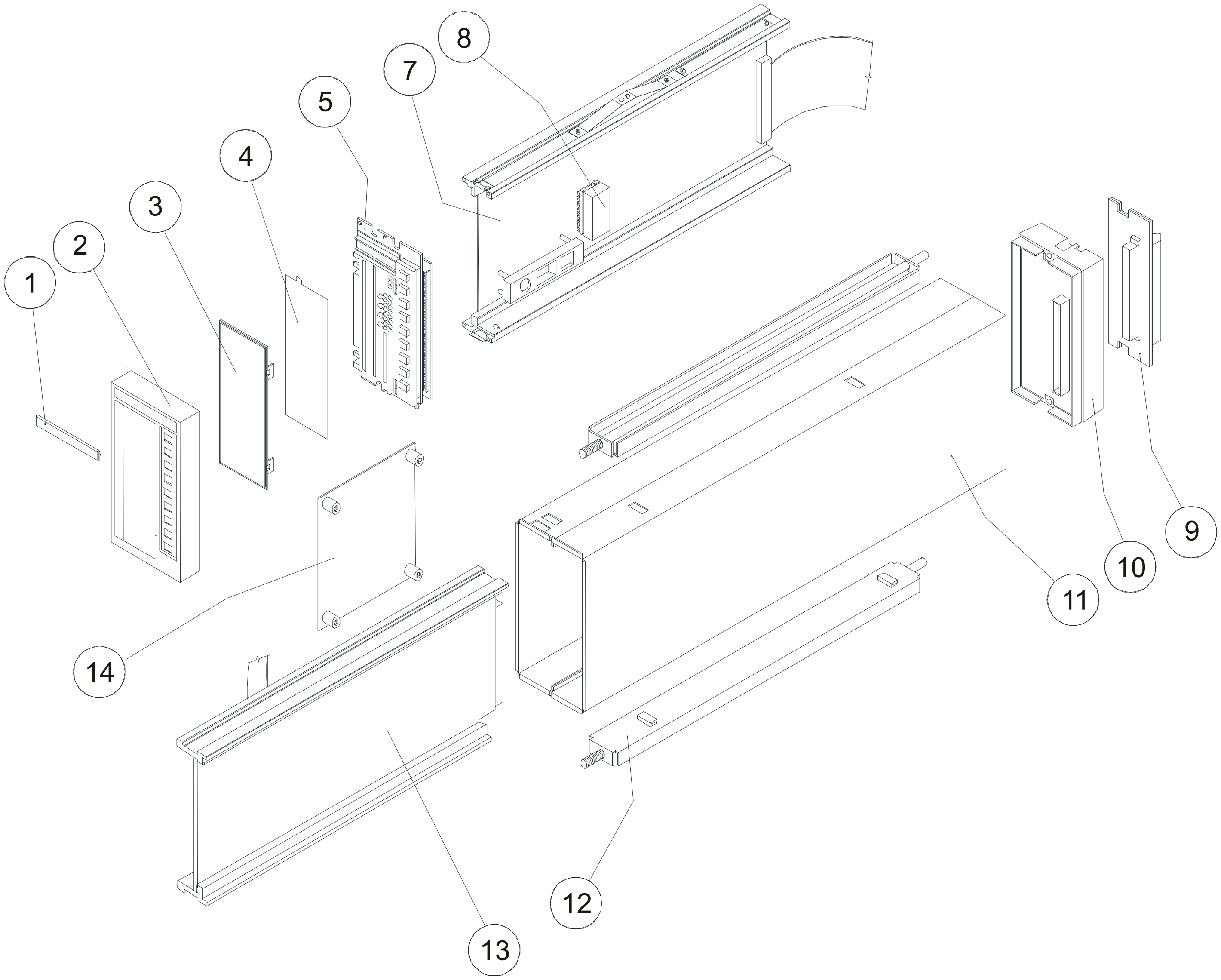


Fig 6.6 - CD600 Digital Controller without Backup

CALIBRATION

The **CD600** is factory calibrated according to procedures complying with the ISO9000 Standards. If a new calibration is required, it can be easily done through the Hand-Held Terminal.

The controller must have a program that allows the reading of all analog inputs to be calibrated and the reading and adjustment of all voltage and current outputs to be calibrated.

The analog input must be linear, i.e., no square root extraction or linearization is allowed for calibration. The voltage and current outputs must be direct action, i.e., 0-100% corresponds to 0-5 V (0-20 mA) or 1-5 V (4-20 mA).

It is recommended to use a current/voltage indicator with, at least, 0,03% accuracy and a low drift current/voltage generator.

Analog Input (AI)

The analog inputs are 0-5 V voltage inputs .With the 250 Ω shunt resistor plugged in, these inputs are converted from voltage into current.

The software of the Analog Input Block allows two types of input signals:

a) Dead Zero:
- 0-5 Vdc or 0-20 mA, corresponding to 0-100% block output.

b) Live Zero:
- 1-5 Vdc or 4-20 mA, corresponding to 0-100% block output.

In order to calibrate the analog input **J** (**J**=1 to 8) proceed as follows:

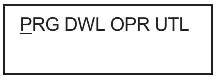
a) - Verify if the input to be calibrated will work as current or voltage output. If it will work as current input, it is recommended to use the same shunt resistor that will actually be used in operation.

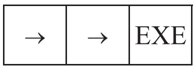
b) - Connect the voltage or current generator with indicator to the terminals corresponding to the input **J**.

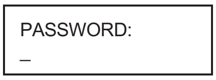
c) - Select the output of Analog Input Block **J** to be on the display of the controller. Be sure that the square root extraction or linearizations are not activated.

d) - Connect the Hand-Held Terminal to the controller. Move the switch, located near the HHT jack, to "**NVRAM**" position.

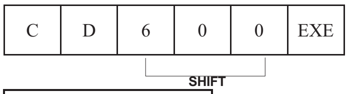
e) - Select "**OPR**" (OPERATION) in the main menu and press the key <EXE>.

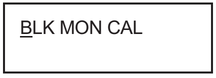

PRG DWL OPR UTL




PASSWORD:
_

f) Enter the password




BLK MON CAL

BLK-Block configuration, MON-Monitoring, CAL-Calibration

g) - Select CAL

→	→	EXE

```
AI  CO  VO
CALIBRATION ?
```

AI-Analog Input, CO-Current Output, VO-Voltage Output

h) - Select AI and press <EXE>

```
AUT MDF
                  AI
```

AUT-Automatic calibration, MDF-Modify Calibration

The controller offers two options: **AUT** (AUTOMATIC) and **MDF** (MODIFY). The Automatic is the fastest way while the **MDF** enables the operator to read the calibration parameters.

CALIBRATION OF ANALOG INPUTS - AUTOMATIC (AUT) OPTION

If the **AUT** option is selected and the <EXE> key is pressed:

ACTION/HHT DISPLAY **CONTROLLER DISPLAY**

a) - Select AUT

EXE	

```
1)AI1
ANALOG INP.
```

XXX ----

b) - Select the desired Analog Input **J** with <↑> and <↓> and press <EXE>. A (*) will show that this input was selected.

```
1)AI1
ANALOG INP.
```

XXX ----

c) - Press

MODE

```
0V 1V 3V 5V
```

XXX ----

d) - Apply 0V or 0 mA with the voltage/current generator and select 0V.

EXE

```
0V 1V 3V 5V
↑
```

XXX -25,00% for live zero
XXX = 0.000% for dead zero

e) - Apply 1 V or 4 mA and select 1 V.
EXE

→	EXE

```
0V 1V 3V 5V
   ↑
```

0.000% for live zero
20.000% for dead zero

f) - Apply 3 V or 12 mA and select 3 V.

→	→	EXE

```
0V 1V 3V 5V
      ↑
```

50.00% for live zero
60.00% for dead zero

g) - Apply 5 V or 20 mA and select 5 V.

→	→	→	EXE

```
0V 1V 3V 5V
         ↑
```

100.0 for both live and
dead zero

h) - Press <ON> to select another input, connect the current/voltage generator to this input and *repeat procedure from **c** to **h** till all desired inputs are calibrated*.

```
1)AI1
ANALOG INP.
```

XXX ----

The automatic mode is fast and easy to operate.

If the input signal differs from the calibration point, the Hand-Held Terminal displays the input reading and does not accept it. This feature enables the user to know that there is a mistake or something wrong at the input.

CALIBRATION OF ANALOG INPUTS - MODIFY (MDF) OPTION

The Analog Inputs can be calibrated automatically (AUT) as described in the **previous Section** or can have the calibration parameters modified by the operator (MDF).

This option enables the user to read and eventually to record the calibration parameters. It is not so fast and straightforward as the **AUT** option, but it is safer.

In order to make this calibration easier, it is recommended to adjust the respective visualization block parameters to indicate 1-5 V or 0-5 V, depending on the type of input desired (live or dead zero). If the indication is not changed into voltage, you may correct the percentage indication, using the following formula:

Live Zero

$$V = 1 + \frac{(ind\%)4}{100}(Vdc)$$

Dead Zero

$$V = \frac{ind\%)5}{100}(Vdc)$$

The calibration parameters of the input(s) to be calibrated must be default values, in order to use the valve shown on the front panel as the correct calibration.

a) - If the MDF option is selected and the Key <EXE> is pressed:

ACTION/HHT DISPLAY **CONTROLLER DISPLAY**

```
CAL1 0.005
VOLT.    0V     001
```

XXX ----

b) - Apply 0 V or 0 mA to the input **J**.

```
CAL1 0.000
VOLT.  0 V   001
```

live zero
XXX 0.003 (V)

c) - Press <EXE>, enter the new calibration data (0.003, and press <EXE>.

```
CAL1 0.003
VOLT.  0 V   001
```

XXX 0.003 (V)

d) - Press <↓> to roll down and go to the next calibration point.

```
CAL2 1.0
VOLT.  1 V   001
```

XXX ----

e) - Apply 1 V or 4 mA.

```
CAL2 1.0
VOLT.  1 V   001
```

XXX 0.996 (V)

f) - Press <EXE>, enter with the new data and press <EXE>.

```
CAL2 0.996
VOLT.  1 V   001
```

XXX 0.996

Repeat steps **d** to **f** for 3 V and 5 V. If the key <↓> is kept pressed, all calibration points of all inputs will be scrolled.
Press <EXE>.

```
TX QT
```

TX-Transmit, QT-Quit
Press <EXE> to transmit the new calibration parameters.

CURRENT OUTPUT (CO)

The current output may be 4-20 mA (live zero) or 0-20 mA (dead zero). Selection is made in the blocks 009 to 012.

Connect a current indicator (mA) to the output to be calibrated (see table 6.2 - Terminal Block Identification) and select the output to be adjusted on the front panel. The program used in the controller has the current output 1 (BLK009) driven by the A/M station of Loop 1. Thus, with the controller in Loop 1 and in Manual mode, it is possible to adjust the current output.

ACTION/HHT DISPLAY **CONTROLLER DISPLAY**

a) - Select CAL

→	→	EXE	

```
AI  C0  VO
CALIBRATION ?
```

XXX ----

b) - Select CO

→	EXE

```
CAL1 4.100
CURRENT0%    009
```

XXX ----

The Hand-Held Terminal shows that the calibration point 1 was 4.100 mA. That means that in the previous calibration, the digital part of the controller had to use 4.100 mA, in order to have the actual 4.000 mA.

c) - Adjust 0% output via the keys <⇧ > or <⇩>.

```
CAL1 4.000
CURRENT0%    009
```

MVJ 0.000%

The mA indicator should be reading 4.000 mA. If the reading is, for example, 3.980 mA then this is the correct procedure.

Current indicator: 3.980 mA

d) - Press <EXE>, enter the new calibration value (3.980) and press <EXE>, again.

```
CAL1 3.980
CURRENT0%    009
```

XXX ----

e) - Scroll down by pressing

```
CAL2 20.100
CURRENT100%
009
```

XXX ----

f) - Adjust the output with 100%

```
CAL2 20.100
CURRENT100%
009                                        MVJ 100.0 (%)
```

The current indicator should read 20.00 mA. If the reading is, for example, 19.93 mA, then this is the correct procedure.

g) - Press <EXE>, enter the new calibration value and press <EXE>.

```
CAL2 19.930
CURRENT100%
009                                        XXX ----
```

Current indicator: 19.93 mA.

h) - Press <MODE> and <EXE> to transmit the new calibration of the Block 009.

```
CAL2 19.930
CURRENT100%
009                                        XXX ----
```

Current indicator: 20.00 mA.

k) - By pressing <↓>, you can scroll down all calibration points of all outputs. Just repeat the same procedures **c** to **h**. Remember to connect the indicator to the new output.

```
CAL1 4.000
CURRENT0%   010                            XXX ----
```

VOLTAGE OUTPUT (VO)

The voltage output is calibrated like the current output. The only difference is that a voltage meter instead of a current meter shall be connected to the output to be calibrated.

Section 8

COMMUNICATION

Introduction

The data to be sent or received by the **CD600** is defined by the communication blocks BLK119, BLK120 and BLK121.

These blocks should be allocated in the loop **G** of the configuration, each one with a specific function:

- BLK119 (**SCAN**) - All data required by the communication bus are available in this block. The block contains: analog and/or digital outputs from any functional block used in a configuration, alarm limits and status, digital inputs and outputs, status of L/R and A/M selectors and totalizations.
- BLK 120 (**PID**) - The values of Proportional Gain (K_P), Integral Time Constant (T_R), Derivative Time (T_D) and Bias (B) of the PID Controller blocks can be read and changed by the communication bus with this block.
- BLK 121 (**ACTUATION**) - This block is used to actuate the controller's commands, such as L/R and A/M selectors and to change values such as SP, manual output and registers of the controller. It changes the alarm limits and generation of analog and discrete variables.

Figure 8.1 illustrates the information exchange between the **MASTER** (e.g. Supervisory) and the **SLAVE**, i.e., the controller.

NOTE: **Communication requires that the controller configuration contains all three communication blocks, even if they are not used, i.e., they hold no information. They must also be configured in the order 119, 120 and 121.**

Controller Addressing

The **CD600** has a channel for serial communication using the **EIA-485-A** standard, and functional blocks in the software for the implementation of a communica-tion type <**MASTER/SLAVE**>.

The controllers should be interconnected in "**multi-drop**" form, i.e, connected in parallel, up to a maximum number of 29 per channel. Each controller present in the network, shall have a specific address to enable the master to access it. The procedure for addressing a controller is the following:

a) Position the <**SAFE/NVRAM**> switch at "**NVRAM**".

b) Press the <**NORM/CONF**> key to change the functions of the display and of the front panel keyboard.

c) Press the <ACK> key on the front panel of the instrument. At this point, the display will show:

I	A					0	1

(Default condition).

d) Change the numerical value of the display with keys <∆> or <∇>.
When the value of the display is "**1**", it means that the controller accepts communication with the Hand-Held Terminal only. Values from "**2**" up to "**30**", on the display, are the programmed controller addresses in the serial communication network.

e) After 20 seconds, if the front panel keys or the <**NORM/CONF**> key are not actuated, the display and front keyboard will return to normal operation function, automatically.

IMPORTANT: **During controller address setting or changing, it is recommended to disconnect the communication connector or to have the communication network OFF.**
This procedure avoids that, during address setting, a controller assume the address of another control-ler in the network. If two control-lers have the same address, the communication will collide and the communication hardware may be damaged.

Baud Rate

The **"Baud Rate"** is also adjusted through the front panel. The procedure is as follows:

a) Repeat the first, the second and the third steps of the procedure used to address the controller.

b) Press the <DSP> key. The display will show:

B	R		1	9.	2	0

c) With the <∆> and <∇> keys, adjust the desired Baud Rate.

d) If the front panel keyboard or the "**NORM⇔CONF**" key are not touched during 20 seconds, the display and the front keyboard will return to normal function automatically.

USING THE HAND-HELD TERMINAL WITH A CONTROLLER IN A COMMUNICATION NETWORK

The controller does not communicate simultaneously with the **SMAR Hand-Held Terminal** and the Masters of the communication network. In order to communicate with the **Hand-Held Terminal**, the controller address must be changed to **01**. To do so, proceed as follows:

a) Position the <**SAFE/NVRAM**> switch at "**NVRAM**".

b) Press the <**NORM/CONF**> key to change the functions of the display and of the front panel keyboard.

c) Press the <ACK> key on the front panel of the instrument. The display will show:

I	A					X	X

Where **XX** = controller address in the communication network.

d) Press the <ACK> key and, **with this key pressed**, press also <∇> key. The display should indicate:

I	A					0	1

That means that the controller address is 01 and that it will communicate only with the **Hand-Held Terminal**.

e) To return the controller to the communication network, press <ACK> and, **with this key pressed**, press **also** the <∆> key. The display will show the controller address.

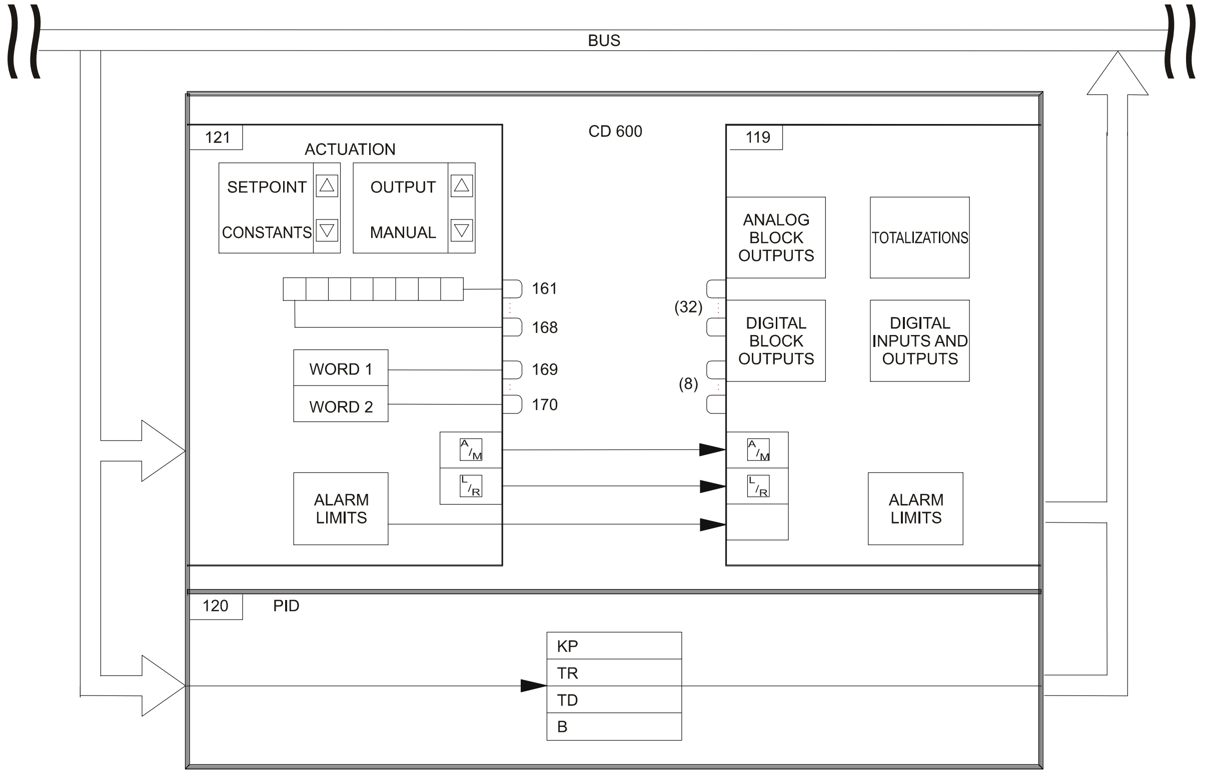


Fig 8.1 Communication Block Diagram

Cycle Time Adjustment

Introduction

The Cycle Time is the time required by the controller to perform the following functions:

- Scan the inputs.
- Execute the functions of all blocks belonging to the configuration.
- Scan the outputs.
- Update the Front Panel indications and read the keys status.
- Communicate with the Hand Held Programmer or with the Supervisory System.

The cycle time may be adjusted between 100 and 250 ms, at 5 ms. intervals.

Short cycle time is required for applications with fast response time, like antisurge control for compressors.

Long cycle time is recommended for process with very long response time like some temperature controls.

For the great majority of the applications, it is recommended to adjust the cycle time in 200 ms, which is the default condition.

CYCLE TIME CHECKING

There are two ways to check if the controller has a cycle time bigger than the adjusted one:

MODE A: USING THE FRONT PANEL

1 - Repeat the steps 1 to 4 of the "CYCLE TIME ADJUSTMENT".

The LED "**CYC**" will blink each 10 cycles.

2 - Define a number of blinks (n) to be counted (it is recommended to use n # 10). With a chronometer, measure the time interval between the "n" blinks.

3 - Thus, the controller cycle time can be calculated by the formula:

$$CYC = \frac{t_m}{10 . n}$$

Where,
CYC = Controller cycle time (ms)
n = Number of blinks of the Led "**CYC**"
t_m = Time interval between "n" blinks.

MODE B: USING AN OSCILLOSCOPE

1 - Use a controller configuration with a Digital Output block linked and parametrized as follow:

2 - Download this configuration into the controller.

3 - Measure the signal frequency at 16B and 17B terminals.

CYCLE TIME ADJUSTMENT

Adjust the cycle time and proceed as follows:

1 - Place the <**SAFE/NVRAM**> switch at **NVRAM**.

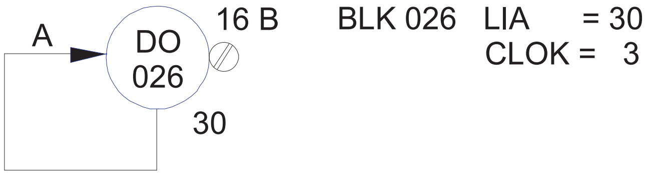


Fig 8.2 - Configuration for cycle time checking using an oscilloscope

2 - Press the <**NORM/CONF**> key to modify the display and frontal keyboard function.

3 - Press the <**ACK**> key on the front panel.

4 - Press and release the <**DSP**> key several times, until the display shows "CYC 0,200" (Default condition).

C	Y	C		0	2	0	0

The LED, identified with "**CYC**" on the front panel, will blink each 10 cycles of the controller.

5 - Adjust the desired value by the keys <∆> or <∇>. The cycle can be adjusted from 100 to 250 ms.

6 - Press the key <**NORM/CONF**> to return the display and frontal keyboard to its normal operation Function.

Section 9

INSTALLATION

Initial Inspection

Receiving the controller **CD600**, check for:

- The model corresponding to the purchase order;
- External damages during shipment;
- Operation manual, Hand-Held Terminal and   interface annexed as per the purchase order.

ENVIRONMENTAL REQUIREMENTS

Power Supply

A high-quality power supply is indispensable for a stable and reliable operation of the system. The power facilities for the present system are required to fulfill the requirements specified in Table 9.1.

AC Power Supply 110, 127, 220 Vac	Voltage variation	± 10%
	Frequency variation	48 to 64 Hz
	Maximum allowable momentary power interruption period	14 ms (100 Vac)
CD Power Supply 24 Vdc	Voltage variation	-5% + 25%
	Maximum allowable momentary power interruption period	0.5 ms (24 Vdc)
	Maximum ripple	1 Vpp

Table 9.1 - Power Supply Requirements

Ambient Conditions

The temperature and humidity in the control room should be controlled within the ranges specified below:

- Temperature: 0 to 43 ºC
- Humidity: 5 to 90% RH (noncondensing)

Air Purity

The amount of dust in the air of the control room should preferably be controlled to below 0.2 mg/m^3. It is particularly desirable to minimize the corrosive gases and other conductive particles in the air.

Vibration

The equipment should be located where it is not subjected to vibration greater than:

Acceleration: $g \leq 0.3$ g;
Frequency: $f \leq 100$ Hz;
Amplitude: $a = 500^*g/f^2$ (mm).

Noise

Noise should be minimized as it affects the instruments and may cause malfunction.

Examples:

a) Transceiver

When using a transceiver in the control room, the following precautions should be observed:

- Never use the transceiver in the proximity (less than one meter) of any instrument or within any panel;

- The antenna of the transceiver should be set at least one meter away from the instrument or the wiring of the instrument.

- Do not use the transceiver when the **CD600** is open (outside of the enclosure).

- The output of the transceiver should be limited to 1 W or less.

b) Noise from Relays

To prevent noise and protect contacts, be sure to attach a surge absorber across every coil, solenoid or the like. See item "Precautions on the Use of Relays", page 9.5.

c) Grounding Quality

The quality of grounding work has a great bearing on noise suppression. The equipment, cable shields and cases should be grounded perfectly as specified under item "Grounding" - page 9.2. Noise suppression can also be improved substantially if the signal cables are arranged properly. For details, refer to item "Signal Cables Interconnection" - page 9.6.

Equipment Installation

Dimensions:

Figure 9.1 shows the **CD600** controller dimensions and cross-sectional view of the panel.

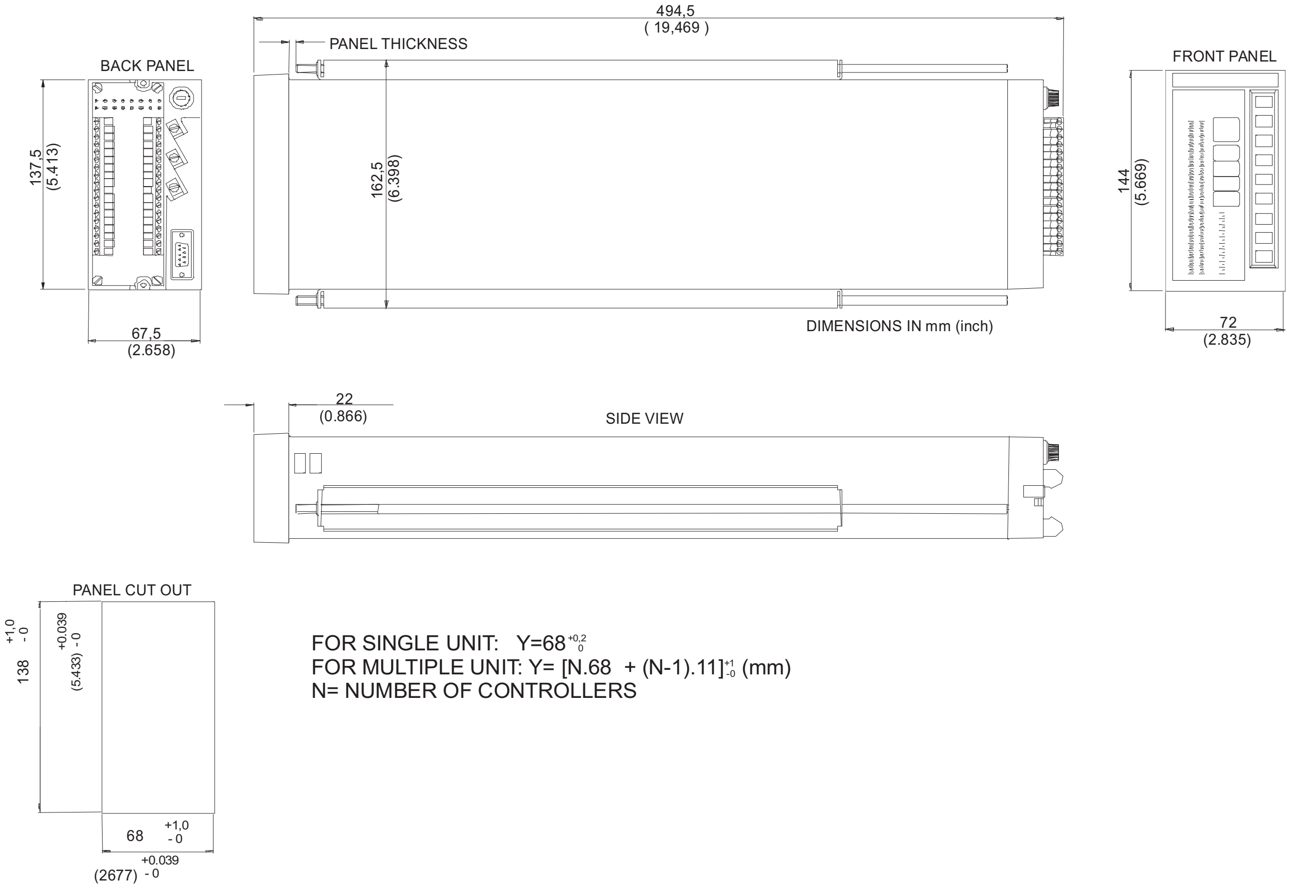


Fig. 9.1 - Dimensional Drawing

Panel Layout

The factors that determine the layout of instruments on panel are operability and maintainability. In this respect the following points should be observed:

- Distribution in groups of systems and subsystems following an order related to the actual position or operational sequence of the equipment;

- High proper levels following the operability principle;

- Operation priority, user's frequency, quantity and dimensions of the instrument;

- Operator's needs, risks and tasks.

Wiring

Grounding

The purpose of grounding is to keep the potential of the equipment at the same level as the ground not only to protect the human body from electrical shocks, but also to stabilize the circuit potential for stable system operations. Any noise that has invaded the system is drained through a low-impedance circuit into the ground, and is prevented from affecting the system's control and signal circuits.

Two different grounding systems should be mounted on the panel in which controllers will be installed. They are:

- Housing ground bar: is the one where the plant ground is done. The housing ground of every **CD600** (see fig. 6.3 - page 6.3) should be connected to this bar (see fig. 9.2).

- Analog ground bar: is the one where the analog input and outputs returns (-) and also where the internal source of 24 Vdc are connected. The analog ground of every **CD600** (see fig. 6.3 - page 6.3) should be also connected to this bar (see fig. 9.3).

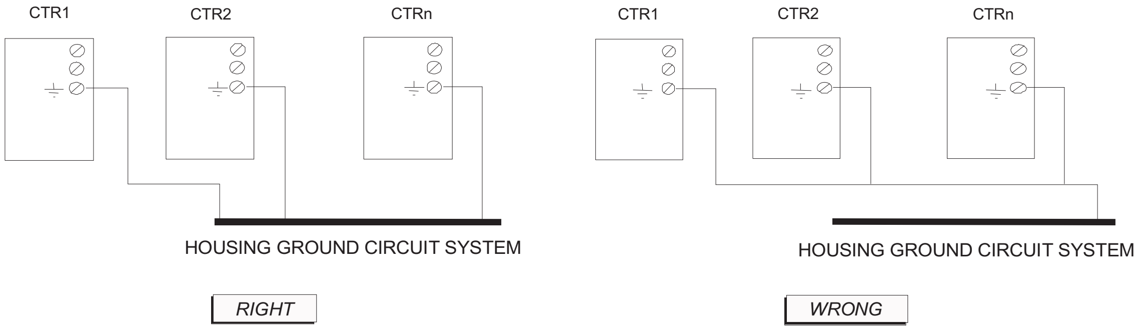


Fig. 9.2 - Housing Ground Connection

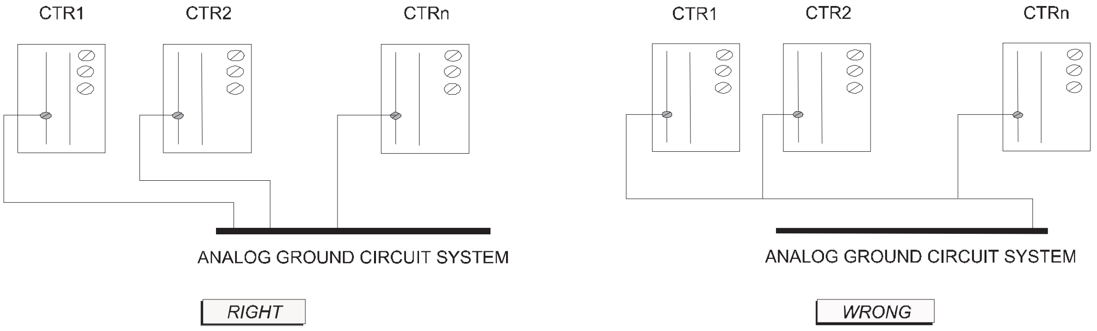


Fig. 9.3 - Analog Ground Connection (Bornes: 5B, 10B, 9A)

Notes:

- The digital ground (terminal DGND) is internally interconnected to the analog ground (terminal AGND);

- When using the same 24 Vdc power supply to supply the controller, digital output charges and /or transmitters, the power supply ground (-) should be only connected to the power supply terminal (-) of the **CD600**. This power supply ground should be insulated from its housing.

- The equipments connected to the analog inputs and/or outputs in voltage should be insulated from the digital ground. If not, it is desirable the use of signal isolators.

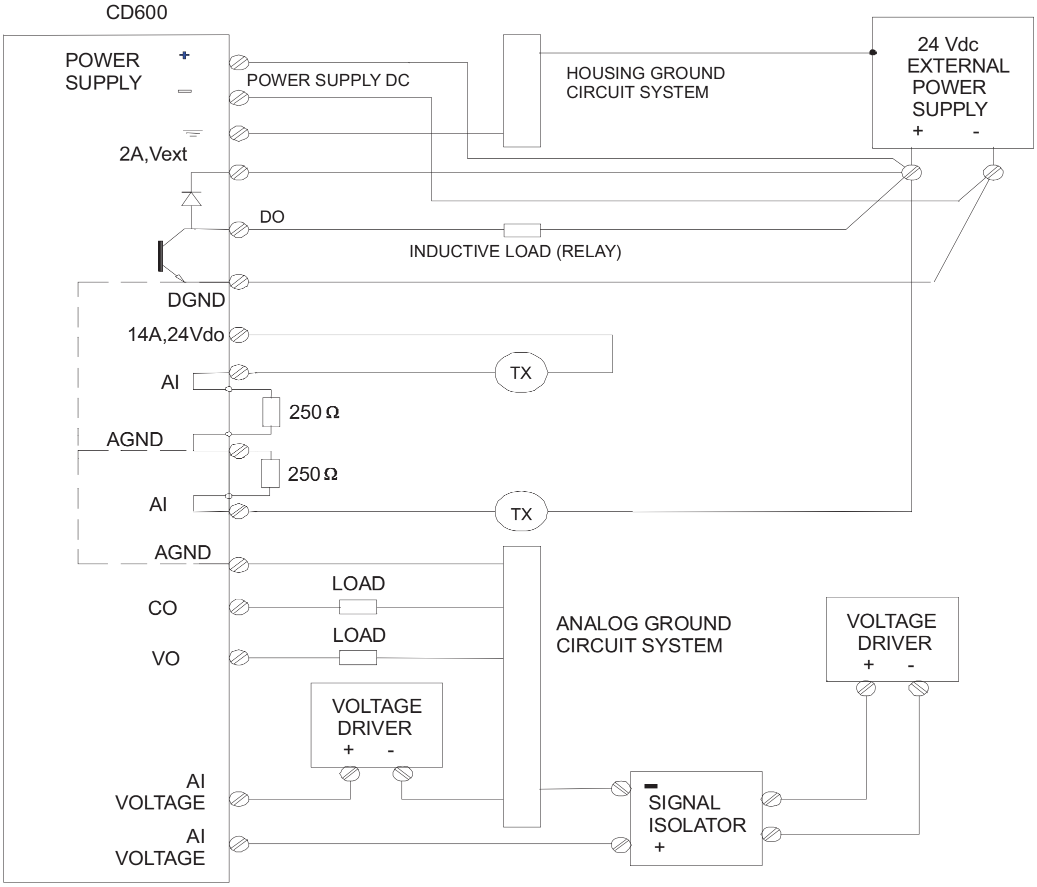


Fig. 9.4 – CD600 with DC Power Supply

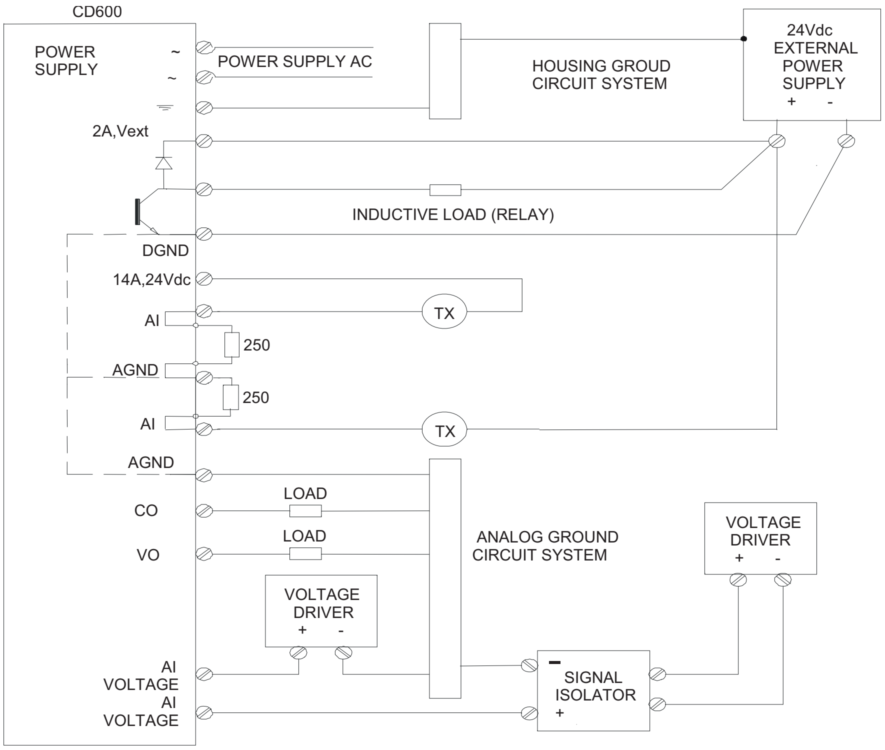


Fig. 9.5 - CD600 with AC Power Supply

Communication

For every controller connected on the communication line, a type-DB9 connector should be mounted, as shown on figure 9.6.

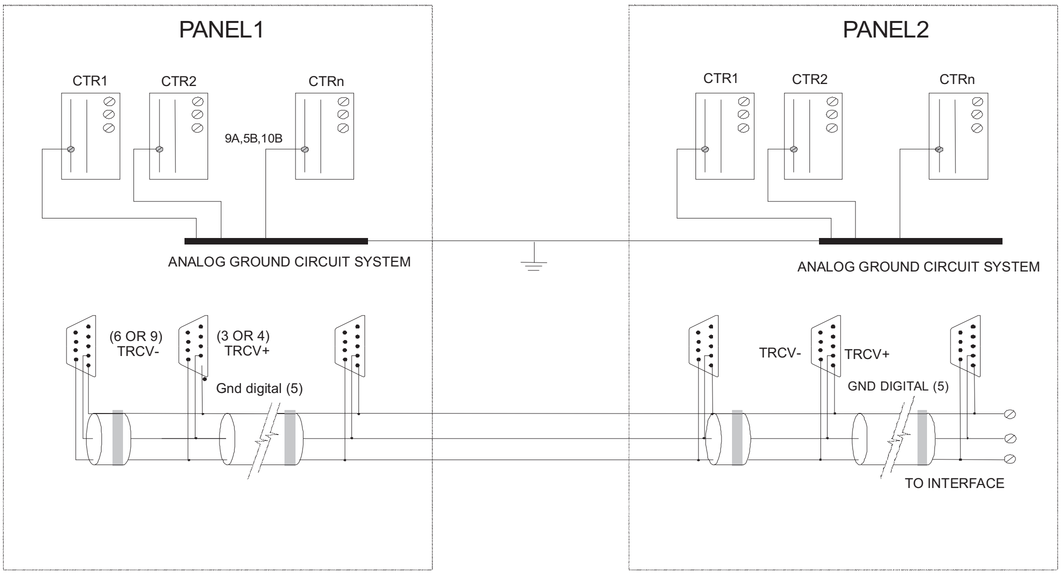


Fig 9.6 – Communication Connection

Note: Note that the digital grounds of all controllers in this installation are interconnected via communication cable. Thus, in order to avoid any voltage loop, panels analog ground bars should be grounded at the same point.

Alarm

When the digital and/or failure outputs are used for driving relays, lamps, etc., pay attention on the following:

a) Precautions on the Use of Lamps.

The lamp ratings should be determinated in accordance with the following points.

- The rated voltage of the lamp must not exceed the rated voltage of the controller's digital outputs open collector (45 Vdc).

- Usually, the rush current of the incandescent lamp is 10 to 15 times as much as its rated current. In case the rush current exceeds the rated current of the digital output (maximum current of 100 mA) use a current-limiting resistor with the circuit.

b) Precautions on the Use of Relays and Solenoids.

When driving relays and solenoids by making use of the contacts of the controller (digital outputs and failure outputs of the controller) pay attention to:

- all the loads commanded by digital and failure outputs should be designed only for DC voltage (maximum voltage of 45 Vdc);

- The maximum current is to be 100 mA;

- Use relay and solenoid circuit rated at as low a voltage as possible for the purpose of increasing the operating reliability.

- Connect the positive terminal of the source to the terminal 2A (Vext), and a diode in parallel with the relays and solenoids coil. The charges connected to the digital output of the same controller should have the same power supply.

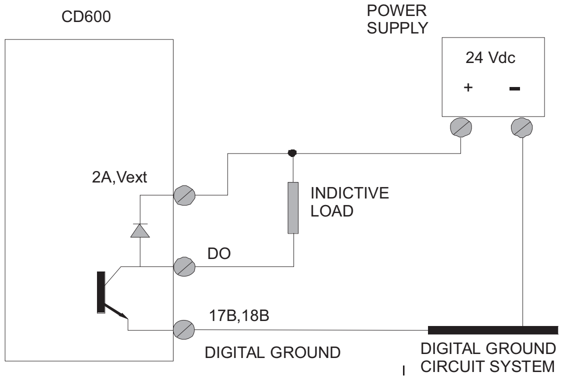


Fig.9.7 - Inductive Load Connection in Digital Outputs

Note: The configuration above can be used since the source negative(s) be insulated from the analog ground (terminal AGND).

When possible, install the signal cables separated.

The installation of signal cables and equipment power cables should satisfy the following three conditions:

1 - Install a grounded metallic separator as shown in Figure 9.8.

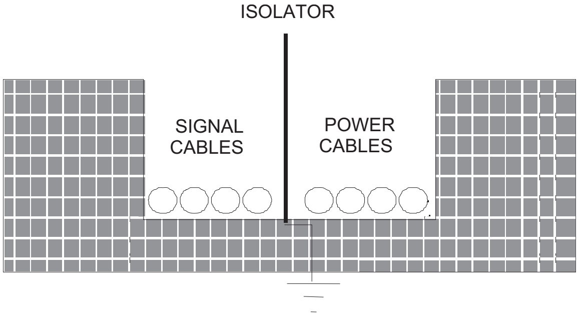


Fig. 9.8 - Separator in Duct and Pit

2 - Provide a clearance between signal and power cables by making use of a cable rack as shown in Figure 9.9 and 9.10.

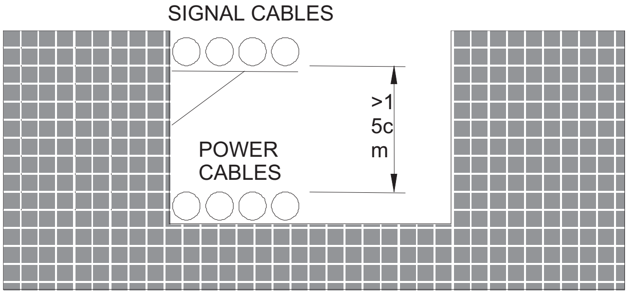


Fig. 9.9 - Cable Rack in Pit

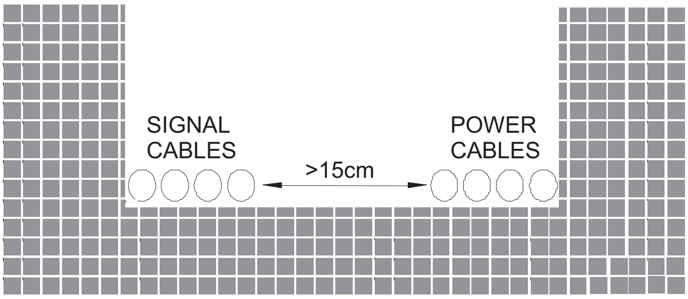


Fig. 9.10 - Clearance Between Signal and Power Cables

Note: If power cables operating at a voltage of up to 220 V and a current of more than 10 A are not shielded, their clearance from the signal cables should be at least 60 cm.

3-Cross the signal and power cables as shown in figure 9.11.

Note: If unshielded cables are used, it is desirable to set an iron sheet of at least 1.6 mm thickness between the power and signal cables as indicated in figure 9.11.

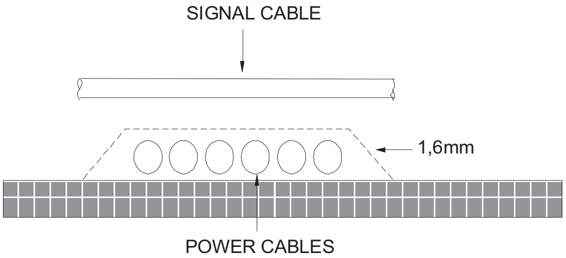


Fig. 9.11 - Right- angled Intersection between Power and Signal

Transportation and Storage

Requirements for Transportation and Storage

Transportation, storage and temporary shutdown of the controllers should be carried out under the ambient conditions specified in the following table:

	Transportation and shortterm storage of the system components as packaged by SMAR.	Long-term storage of system components as packaged by SMAR.
Ambient Temperature	-40 to 65º C	-10 to 60º C
Ambient Humidity	5 to 95% RH	5 to 95% RH (Noncondensing)

Table 9.2 - Ambient Conditions for Transportation and Storage

Precautions for Transportation

- Carry the controllers in the position specified on the **SMAR** packages;

- Use a shipping method that will protect the cargo from vibration and shock.

- If the packages are opened and repackaged for further transportation, be sure to follow the same packaging procedure as used by **SMAR**.

- Be sure to protect the cargo from water and direct sunlight with a canvas sheet or the like during transportation.

Precautions for Storage

- Keep the packages indoors. The place should be free from direct sunlight, corrosive gases, vibration and shock.

- When keeping the packages as delivered, be sure to store them in the position specified.

- If the packages are opened and repackaged for storage, be sure to follow the same packaging procedure as used by **SMAR**.

When it is necessary to store the controllers out of their packages, be sure to keep them in their installation positions, protected with a dust cover, in a well-ventilated place.

smar

SRF – SERVICE REQUEST FORM

CD600 – Multi-loop Controller

Proposal Nº:

COMPANY INFORMATION

Company: ____

Unit: ____

Invoice: ____

COMMERCIAL CONTACT

Full Name: ____

Phone: _________ ________________________ _________ ________________________ **Fax:** ____________________

E-mail: ____

TECHNICAL CONTACT

Full Name: ____

Phone: _________ ________________________ _________ ________________________ **Extension:** ____________________

E-mail: ____

EQUIPMENT DATA

Model: ____

Serial Number: ____

PROCESS DATA

Process Type (Ex. boiler control)**:** ____

Operation Time: ____

Failure Date: ____

FAILURE DESCRIPTON

(Please, describe the failure, if it is repetitive, how it reproduces, etc.)

____

____

____

____

OBSERVATIONS

____

____

____

____

USER INFORMATION

Company: ____

Contact: ____

Section: ____

Title: ________________________________ **Signature:** ________________________________

Phone: _________ ________________________ _________ ________________________ **Extension:** ____________________

E-mail: ____ **Date:** ______/ ______/ _________

For warranty or non-warranty repair, please contact your representative.
Further information about address and contacts can be found on www.smar.com/contactus.asp.

Appendix B

SMAR WARRANTY CERTIFICATE

1. SMAR guarantees its products for a period of 24 (twenty four) months, starting on the day of issuance of the invoice. The guarantee is valid regardless of the day that the product was installed.

2. SMAR products are guaranteed against any defect originating from manufacturing, mounting, whether of a material or manpower nature, provided that the technical analysis reveals the existence of a quality failure liable to be classified under the meaning of the word, duly verified by the technical team within the warranty terms.

3. Exceptions are proven cases of inappropriate use, wrong handling or lack of basic maintenance compliant to the equipment manual provisions. SMAR does not guarantee any defect or damage caused by an uncontrolled situation, including but not limited to negligence, user imprudence or negligence, natural forces, wars or civil unrest, accidents, inadequate transportation or packaging due to the user's responsibility, defects caused by fire, theft or stray shipment, improper electric voltage or power source connection, electric surges, violations, modifications not described on the instructions manual, and/or if the serial number was altered or removed, substitution of parts, adjustments or repairs carried out by non-authorized personnel; inappropriate product use and/or application that cause corrosion, risks or deformation on the product, damages on parts or components, inadequate cleaning with incompatible chemical products, solvent and abrasive products incompatible with construction materials, chemical or electrolytic influences, parts and components susceptible to decay from regular use, use of equipment beyond operational limits (temperature, humidity, etc.) according to the instructions manual. In addition, this Warranty Certificate excludes expenses with transportation, freight, insurance, all of which are the customer's responsibility.

4. For warranty or non-warranty repair, please contact your representative.

   Further information about address and contacts can be found on www.smar.com/contactus.asp

5. In cases needing technical assistance at the customer's facilities during the warranty period, the hours effectively worked will not be billed, although SMAR shall be reimbursed from the service technician's transportation, meals and lodging expenses, as well dismounting/mounting costs, if any.

6. The repair and/or substitution of defective parts do not extend, under any circumstance, the original warranty term, unless this extension is granted and communicated in writing by SMAR.

7. No Collaborator, Representative or any third party has the right, on SMAR's behalf, to grant warranty or assume some responsibility for SMAR products. If any warranty would be granted or assumed without SMAR's written consent, it will be declared void beforehand.

8. Cases of Extended Warranty acquisition must be negotiated with and documented by SMAR.

9. If necessary to return the equipment or product for repair or analysis, contact us.
   See item 4.

10. In cases of repair or analysis, the customer must fill out the Revision Requisition Form (FSR) included in the instructions manual, which contains details on the failure observed on the field, the circumstances it occurred, in addition to information on the installation site and process conditions. Equipments and products excluded from the warranty clauses must be approved by the client prior to the service execution.

11. In cases of repairs, the client shall be responsible for the proper product packaging and SMAR will not cover any damage occurred in shipment.

12. In cases of repairs under warranty, recall or outside warranty, the client is responsible for the correct packaging and packing and SMAR shall not cover any damage caused during transportation. Service expenses or any costs related to installing and uninstalling the product are the client´s sole responsibility and SMAR does not assume any accountability before the buyer.

13. It is the customer's responsibility to clean and decontaminate products and accessories prior to shipping them for repair, and SMAR and its dealer reserve themselves the right to refuse the service in cases not compliant to those conditions. It is the customer's responsibility to tell SMAR and its dealer when the product was utilized in applications that contaminate the equipment with harmful products during its handling and repair. Any other damages, consequences, indemnity claims, expenses and other costs caused by the lack of decontamination will be attributed to the client. Kindly, fill out the Declaration of Decontamination prior to shipping products to SMAR or its dealers, which can be accessed at www.smar.com/doc/declarationofcontamination.pdf and include in the packaging.

14. This warranty certificate is valid only when accompanying the purchase invoice.