Digital Thyristor Trigger Module

MP410T

MP410 MODULE MANUAL
2 July 2001

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Three-phase thyristor gate control module, microprocessor-controlled, with two programmable feedback signals

- 150 to 440Vac (between lines)   20%, 50-400 Hz power supply, self-adjustable (switched power supply)
- Trouble-free operation under inductive loads
- Operation as a W3C, B6C and Soft Starter
- Digital phase control through keyboard or by means of external 0-5V, 0-10V, 0-20mA or 4-20mA signals
- 5-digit display
- Rise and fall ramps programmable independently by an optional threshold.
- Final ramp output to control a bypass contactor
- Current regulation or limitation function with two current transformer or Hall-effect sensor inputs.
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- The P, I and D values for both feedback signals can be programmed
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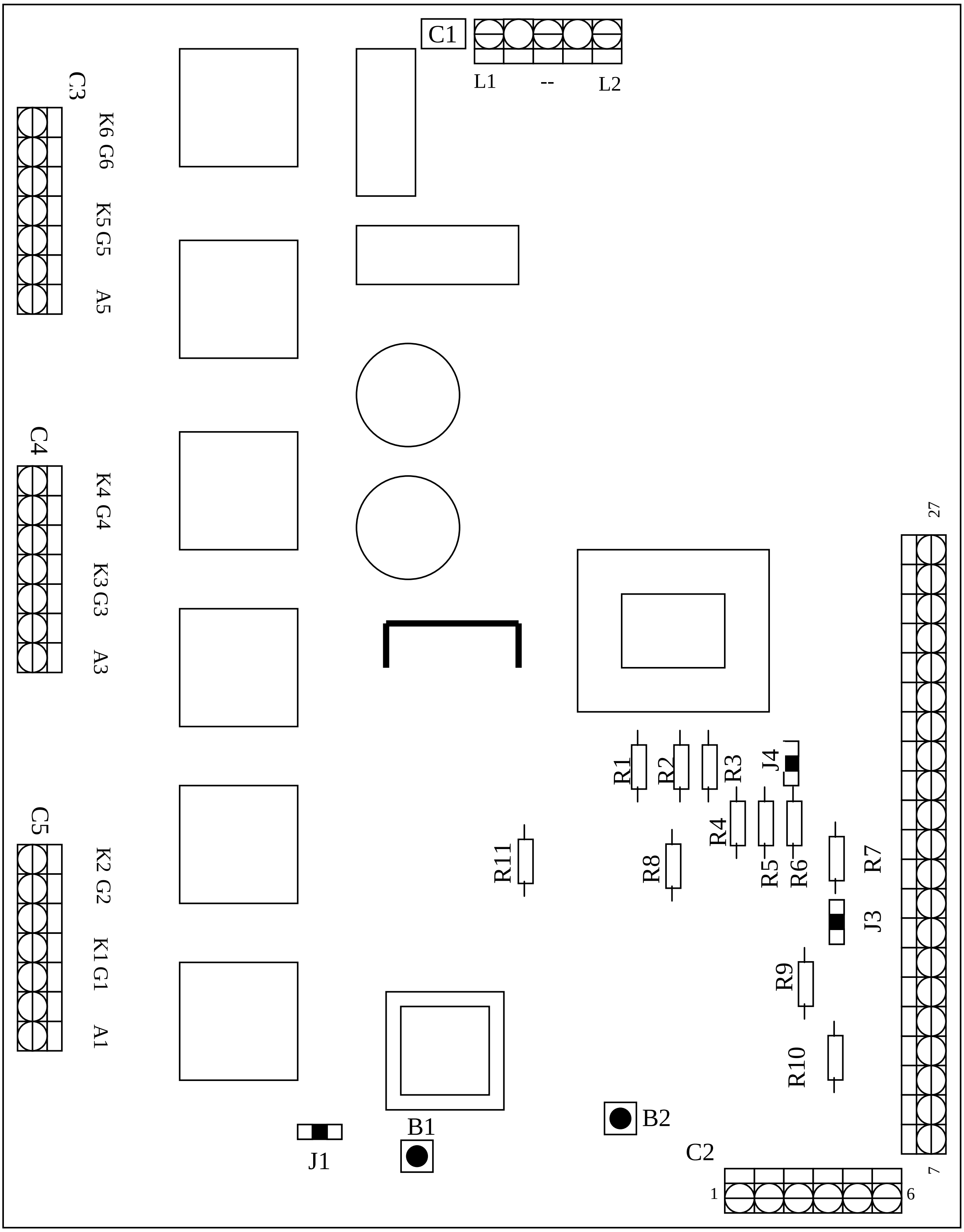
- Phase failure detection with (programmable) stop and correct phase sequence with alarm
- Thyristor failure detection
- Overtemperature protection with stop by means of a temperature switch and/or a thermoresistor (0 to 150° C) with temperature indication on the display
- External disable input
- Remote control option from a PC through RS485 (up to 31 units can be controlled)
- An additional display can be mounted on the cabinet front panel

TECHNICAL DATA

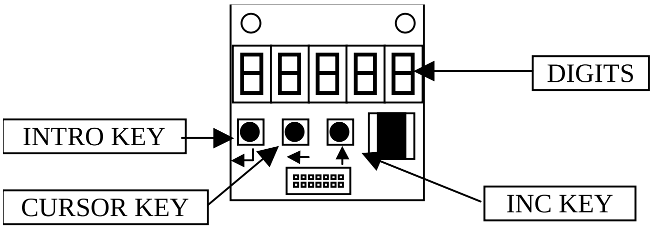
Power supply voltage		150 to 440V ±20% 50 to 400 Hz ±10%
Power consumption		10 W max.
Input voltages	INHI-IN, TERMO	4 - 12 Vdc
	0-5 V IN	0 - 5 Vdc (15 Vdc max.)
	0-10 V IN	0 - 10 Vdc (15 Vdc max.)
Input signals	+10V OUT	10 Vdc 10 mA max.
	+5V	5 Vdc 10 mA max.
	-5V	-5 Vdc 10 mA max.
	LINT, FRAMP, INHI-O	Open-collector. 30 Vdc max., 50 mA max.
Voltage feedback		6 Vrms (Default value) @ 50 Hz Input impedance 26 kΩ
Current feedback		2 × 12.6 mA (Default value)@50 Hz (L1,L2, COMM) 6 Vrms (Default value) (INT)
Temperature indication		0 – 150ºC
Trigger current		300 mA @ VGT = 5V
Operation temperature		0 – 60ºC
Humidity level		10 - 95% without condensation
Power-on		1 second
Weight		1 kg

Physical Description

Baseboard description



Display board description



The device does not need the display board in order to work. This board is only used as an interface between the MP410 and the user. Therefore, it may be connected any time you need dialogue or to view data and disconnected afterwards without affecting the operation.

The board features five digits for viewing data and showing messages, three keys to input commands and values and one connector for communication with the baseboard.

Connecting

C1: Power

Pin	Name
1	Phase
2	Ground
3	Phase

C2: Outputs/Inputs

Pin	Name	Description
1	+10	10-volt power output for outputs 3 to 5.
2	VCC	5-volt power output for outputs 3 to 5.
3	LIM	Limitation display.
4	F_RAMP	Running display.
5	INHI_OUT	Inhibition display.
6	GND	Ground for outputs 3 to 5.
7	INHI_IN	Inhibition input.
8	TERMO	Thermostat input.
9	START_STOP	Start/stop input.
10	POT_KEY	Reference value is entered through a potentiometer or keyboard. In *STARTER* configuration, deactivation of *ENERGY_SAVE* mode.
11	GND	Ground for inputs 1 to 4.
12	RS485+	Bus RS485 positive terminal.
13	RS485-	Bus RS485 negative terminal.
14	+5	5-volt power output for inputs.
15	-5	-5-volt power output for inputs.
16	CON_IN_TEMPE	Input for temperature sensor.
17	AGND	Ground for temperature sensor.
18	IN_0_5	Reference value input of 0

		to 5 volts.
19	IN_0_10	Reference value input of 0 to 10-volts.
20	AGND	Ground for the reference value input.
21	INT1+	Positive terminal of the differential analog input of the current.
22	INT1-	Negative terminal of the differential analog input of the current.
23	VOLT	Analog input of the voltage.
24	AGND	Ground for the analog input of the voltage.
25	L1	Analog input of the current for the current transformer.
26	L2	Analog input of the current for the current transformer.
27	COM	Common for the analog input of the current for the current transformer.

C3: Thyristors 5 and 6

Pin	Name	Description
1	A5	Thyristor anode 5.
2		
3	G5	Thyristor gate 5.
4	K5	Thyristor cathode 5.
5		
6	G6	Thyristor gate 6.
7	K6	Thyristor cathode 6.

C4: Thyristors 3 and 4

Pin	Name	Description
1	A3	Thyristor anode 3.
2		
3	G3	Thyristor gate 3.
4	K3	Thyristor cathode 3.
5		
6	G4	Thyristor gate 4.
7	K4	Thyristor cathode 4.

C5: Thyristors 1 and 2

Pin	Name	Description
1	A1	Anode thyristor 1.
2		
3	G1	Gate thyristor 1.
4	K1	Cathode thyristor 1.
5		
6	G2	Gate thyristor 2.
7	K2	Cathode thyristor 2.

Power Features

V	AC 125-525 volts
Frequency	33-400 Hz.
Maximum consumption	10 W

Supported configurations and frequency

This device supports the following rectifier bridge or regulator configurations:

1. *USER DELAY*: Line synchronism. The phase difference between the synchronism and the first firing is established by the user through the *PHASE DIFFERENCE* parameter.
2. *B6C*: Configured as a complete three-phase converter. Synchronous line voltage. The phase difference between the synchronism and the first firing is 60º.
3. *W3C*: Configured as a three-phase bi-directional controller. Synchronous line voltage. The phase difference between the synchronism and the first firing is 30º.
4. *STARTER*: Starter of asynchronous motors. Voltage phase synchronism. The phase lag between the synchronism and the first firing is 0º.

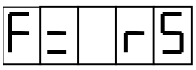
The parameter for selecting the desired configuration is *CONFIGURATION*. Depending on the configuration the device performs differently. If the device is configured as *STARTER*, please refer to *STARTER Configuration*. If the device is configured as any other option, please see *USER_DELAY*, *B6c or W3C Configuration*.

The working frequency range is 50 to 400 Hz. Adjustment is automatic and constant, permitting frequency variations during operation. If the applied frequency is less than 50 Hz or higher than 400 Hz the device will not apply ignition pulses to the thyristors.

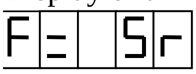
Start and Reset

While powered, the device will keep running. If a *reset* is applied, the device starts operating as if it had been plugged into the power source again. To apply a reset, push the *B1* button.

When the device starts working, it displays the phase order it has detected:



Display of an RST order.



Display of a TSR order.

Outputs

Features

Output Name	Type	Maximums
+10	10-volt power for outputs.	Imax: 10 mA
VCC	5-volt power for outputs.	I max: 10 mA
LIM	Open-collector digital output.	Vmax: 30 v c.c. Imax: 50 mA
F_RAMP	Open-collector digital output.	Vmax: 30 v c.c. Imax: 50 mA
INHI_OUT	Open-collector digital output.	Vmax: 30 v c.c. Imax: 50 mA
+5	5-volt power for inputs.	Imax: 10 mA.
-5	5-volt power for inputs.	Imax: 10 mA.

Functionality

LIM

Shows that the device is limiting the output to avoid exceeding any of the imposed limits in the current or voltage.

F_RAMP

Shows that the device is in *RUNNING* status, that is, it is running and has completed the *PEAK* and *RAMP UP* statuses *(see Operating Statuses).*

INHI_OUT

Shows that an alarm has been activated (see Alarms).

Inputs

Features

Input Name	Type	Features	Maximums
INHI_IN	Digital voltage input	Iin max: 2mA	Vmax. Low Level: 0.5 v Vmin. High level: 4 v V max: 12 v
THERMO	Digital voltage input	Iin max: 2mA	Vmax. Low Level: 0.5 v Vmin. High Level: 4 v V max: 12 v
START_STOP	Digital voltage input	Iin max: 2mA	Vmax. Low Level: 0.5 v Vmin. High Level: 4 v V max: 12 v
POT_KEY	Digital voltage input	Iin max: 2mA	Vmax. Low Level: 0.5 v Vmin. High Level: 4 v V max: 12 v
CON_IN_TEMPE	Ohm input for temperature sensor	Sensor KTY-81.	
IN_0_5	Analog voltage input.	Rin: 10 KOhms	Vmin: 0 v Vmax: 5 v
IN_0_10	Analog voltage input.	Rin: 20 KOhms	Vmin: 0 v Vmax: 10 v
INT1+	Analog voltage input.	Rin: 16 KOhms (Relative to AGND)	Vrms max: 6v Vmed max: 5.4v Vinst max: 8.5v (For 50 Hz)

Functionality

INHI_IN

Allows the device to switch to *ALARM* status from an external source. It is activated at high level.

THERMO

Allows the device to switch to *ALARM* status when a thermostat is activated. It is activated at Low Level.

START_STOP

Allows the device to stop and start from the exterior when the device is in *AUTOMATIC (see Parameters)* mode and in *LOCAL* mode. At high level it is commanded to start and at low level it is commanded to stop.

POT_KEY

Input for selecting how the reference value is entered *(see USER_DELAY, B6C or W3C Configuration).* If input is at high level the device is instructed that the reference value is entered through the display board keyboard in *local* mode and through communications in *remote* mode *(see LOCAL mode and REMOTE mode).* If at low level, the device is instructed that the reference value must be entered through the *IN_0_5* or *IN_0_10* input.

When the device is configured as a STARTER *(see Supported configurations and frequency)*, this input is used for deactivating the *ENERGY_SAVING* mode *(see STARTER Configuration).* When entry is at high level, the *ENERGY_SAVING* mode will be deactivated in case this mode was activated.

CON_IN_TEMPE

Ohm input for the temperature sensor. This input is used to measure the temperature of where the sensor is located within the device. It allows readings from 0 to 150 ºC.

IN_0_5

Input of external reference value. 0 volts corresponds to a reference value of 0.0% and 5 volts corresponds to a reference value of 100.0%. With a shunt of 250 Ohms, the reference value can be entered through a 0-20 mA current loop. By deactivating *J3 (see MP410T*

Digital phase control through keyboard or by means of external 0-5V, 0-10V, 0-20mA or 4-20mA signals
• 5-digit display
Rise and fall ramps programmable independently by an optional threshold.
Final ramp output to control a bypass contactor
Current regulation or limitation function with two current transformer or Hall-effect sensor inputs.
Voltage regulation or limitation function with a voltage transformer input
• The P, I and D values for both feedback signals can be programmed
4 kV galvanic isolation
Phase failure detection with (programmable) stop and correct phase sequence with alarm
• Thyristor failure detection
• Overtemperature protection with stop by means of a temperature switch and/or a thermoresistor (0 to 150° C) with temperature indication on the display
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	-5V	-5 Vdc 10 mA max.
	LINT, FRAMP, INHI-O	Open-collector. 30 Vdc max., 50 mA max.
Voltage feedback		6 Vrms (Default value) @ 50 Hz
		Input impedance 26 kΩ
Current feedback		2 × 12.6 mA (Default value)@50 Hz (L1,L2, COMM)
		6 Vrms (Default value) (INT)
Temperature indication		0 – 150ºC
Trigger current		300 mA @ VGT = 5V
Operation temperature		0 – 60ºC
Humidity level		10 - 95% without condensation
Power-on		1 second
Weight		1 kg

Physical *)* and replacing the *R9* and *R10* value (100K-1%) with 80K6-1%, a 4-20 mA current loop can be used.

IN_0_10

Input of external reference value. 0 volt corresponds to a reference value of 0.0% and 10 volts corresponds to a reference value of 100.0%. With a shunt of 500 Ohms, the reference value can be entered through a 0-20 mA current loop. By deactivating *J3 (see MP410T*

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Trigger current	300 mA @ VGT = 5V
Operation temperature	0 – 60ºC
Humidity level	10 - 95% without condensation
Power-on	1 second
Weight	1 kg

Physical *)* and replacing the value of *R9* and *R10* (100K-1%) with 80K6-1%, a 4-20 mA current loop can be used.

INT1+/INT1-

Differential voltage input for measuring current. This input allows for the measuring of the average rectified current circulating through the bridge being regulated.

Through *J4* a floating measure may be done (open *J4*), or with respect to the ground (closed *J4* unites *INT1-* to the device ground).

This input may be used by connecting the output of a current transformer to its respective shunt or connecting this input in parallel to a shunt through which the current to be measured is circulating.

Input ranges may be adjusted with the values in *R4*, *R5*, *R6* and *R8*. Default values (6K65-1%, 10K-1%, 47K-1% and 47K-1% respectively) are adjusted to show 100.0% of current with an average voltage input of 5.4 v at 50 Hz. The sequence to follow for adjusting these values is:

1. Establish the value of the impedance variables of the input (*Rin* Ohms), working frequency (*F* Hz) and the average voltage value corresponding to 100.0% (*V* v).
2. Set the value of *R4* to less than 10 KOhms and less than *Rin*.
3. $R5 = Rin - R4$
4. $R8 = R6 = \dfrac{F \times 2026 \times Rin}{V \times R4}$
5. Check that the value of *R8* and *R6* is not higher than 200 KOhms. If values are higher, repeat the sequence with a higher value of *R4* or a lower Rin value.
6. The instantaneous voltage input value must be lower than $\dfrac{164500 \times (R5 + R4)}{R8 \times R4}$. If it is not lower, the sequence must be repeated with a higher V. That is, the device will measure less than 100.0% of current when the original V voltage is applied.

All resistances used must have a tolerance of 1%.

VOLT:

Voltage input. This input allows for the measurement of the average rectified voltage that is applied to the bridge being regulated.

This input may be used by connecting the output of a transformer, or connecting this input in parallel to the voltage that is being measured.

Input ranges may be adjusted with the values of *R1*, *R2*, *R3* and *R11*. Default values (47K-1%, 10K-1%, 16K5-1% and 47K-1% respectively) are adjusted to show 100.0% of voltage with an input of 5.4 v of average voltage. The sequence to follow in order to adjust these values is as follows:

1. Establish the value of the impedance variables of the input (*Rin* Ohms) and average voltage value corresponding to 100.0% (*V* v).
2. Set the value of *R2* to less than 10 KOhms and less than *Rin*.
3. $R3 = Rin - R2$
4. $R1 = R11 = \frac{95784 \times Rin}{V \times R2}$
5. Check that the value of *R1* and *R11* is not higher than 200 KOhms. If values are higher, then the sequence must be repeated with a greater *R2* value or a lower Rin value.
6. The instantaneous voltage input must be lower than $\frac{164500 \times (R3 + R2)}{R1 \times R2}$. If it is not lower, the sequence must be repeated with a higher V. That is, the device will measure less than 100.0% when the original V voltage is applied.

All resistances used must have a tolerance of 1%.

L1/L2/COM:

Double current input with an internal shunt. This input allows for the measurement of the average rectified current circulating through the bridge being regulated.

This input may be used by connecting one or two current transformers. If only one current transformer (L1/COM) is connected, the current can be measured through one of the phases of the rectifying bridge. If a second transformer (L2/COM) is connected which was derived from another phase, the total circulating current can be measured.

The input ranges can be adjusted with the internal shunt value *R7*. The default value (475 Ohms) is adjusted to show 100.0% of current with an input of 11.3 mA (IL1 + IL2) of average current at 50 Hz. The sequence to follow in order to adjust this value is as follows:

1. Set the value of the working frequency variables (*F* Hz) and the value of the total average current corresponding to 100.0% (I A).
2. $R7 = \frac{F}{I \times 9.262}$
3. Check that the *R7* value is not higher than 1 KOhm. If the value is higher, repeat the sequence with a higher *I* value; that is, increase the I.output/I.input ratio of the applied current transformers.

4. The value of the instantaneous input of the current (IL1 + IL2) must be lower than $\frac{8.5}{R7}$. If it is not lower, the sequence must be repeated with a greater I. That is, the device will measure less than 100.0% of current when the original I current is applied.

The resistance used must have a tolerance of 1%.

Current inputs

As described in the section above, the device features two current inputs: *INT1+/INT1-* and *L1/L2/COM*. Only one of them may be used. Through the parameter *INPUT_INTENSITY (see Parameters)* the device is instructed about the input that has been connected. If the value is set to *R_INT_DIF*, it shows that *INT1+/INT1* has been connected. By contrast, if the value is set to *R_INT*, it shows that *L1/L2/COM* has been connected.

LOCAL mode and REMOTE mode

The device can be governed from the display board in *LOCAL* mode. In *REMOTE* mode, the device can be governed from a *Host* via an RS-485 communication (*see Communications*).

Switch to REMOTE mode

To switch to remote mode, the *LOCAL_REMOTE* parameter must be set to the *REMOTE* value *(see Parameters).*

Switch to LOCAL mode

To switch to local mode, one of the following operations must be done:

1. The *LOCAL_REMOTE* parameter must be set to the *LOCAL* value through communications (*see Communications*).
2. Loading the default parameters (*see Parameters*).

Working in LOCAL mode

In local mode the device does not accept commands or parameter changes coming through its communications port. However, the device does respond to data requests through communications. Because of this, the device cannot be governed remotely but its variables may be monitored in the remote Host.

In *LOCAL* mode, the display board is operational for managing the dialogue, showing displays and governing the device.

Working in REMOTE mode

In remote mode, the display board is left inhibited and shows the following message:

r	E			1

Where 1 represents the communications address. In remote mode, the device is governed solely through communications; therefore, the device cannot be set to *AUTOMATIC* mode *(see Operating statuses).*

Operating statuses

The device will always be in one of the following operating statuses, regardless of its set configuration:

STOPPED

The device is stopped. No pulses are applied to the thyristors. The display shows:

	O	F	F	

To start the device the following operation must be performed based on the value of the *AUTO_MANUAL* parameter*:*

AUTO_MANUAL = AUTO

Automatic operation. To start the device, activate the *START_STOP* input.

AUTO_MANUAL = MANUAL

Manual operation. To start the device, the *INC* and *INTRO* keys must be pressed at the same time if the device is in *LOCAL* mode. If the device is in *REMOTE* mode, you must send a *STOP_START* writing *(see Communications).*

When the device starts operating, it switches to *PEAK* status.

PEAK

The device is running. Pulses are applied to the thyristors. The display shows:

E	1	0	0.	0

Where 100.0 blinks and represents the working point *(see STARTER Configuration and USER_DELAY, B6C or W3C Configuration)* that has been set as the *PEAK*. This working point is applied every time the regulation is started. The length of this status depends on the *TIME_PEAK* parameter.

To switch to *STOPPED* mode the following operation must be performed based on the value of the *AUTO_MANUAL* parameter*:*

AUTO_MANUAL = AUTO

Automatic operation. To stop the device the *START_STOP* input must be deactivated.

AUTO_MANUAL = MANUAL

Manual operation. To stop the device the *CURSOR* and *INTRO* keys must be pressed at the same time if the device is in *LOCAL* mode. If the device is in *REMOTE* mode, a *STOP_START* writing must be sent *(see Communications)*.

When this status finishes, the device switches to *RAMP UP* status.

RAMP UP

The device is running; pulses are applied to the thyristors. The display shows:
Where 100.0 is blinking and is the working point that is being applied. This working point

E 100.0

will vary linearly from the *PEDESTAL* value up to the working reference value set during a period of time equal to *RAMP_UP*. If the current limitation is activated, through the *LIM_INTENSITY* parameter *(see Parameters*), the working point is not increased any more if the measured current exceeds the value of the *MAX_INTENSITY* parameter.

To switch to *STOPPED* mode the following operation must be performed based on the value of the *AUTO_MANUAL* parameter*:*

AUTO_MANUAL = AUTO

Automatic operation. To stop the device the *START_STOP* input must be deactivated.

AUTO_MANUAL = MANUAL

Manual operation. To stop the device the *CURSOR* and *INTRO* keys must be pressed at the same time if the device is in *LOCAL* mode. If the device is in *REMOTE* mode, a *STOP_START* writing must be sent *(see Communications)*.

When this status finishes, the device switches to *RUNNING* status. When the device is stopped through one of the two methods above, the device switches to *RAMP DOWN* status before reaching the *STOPPED* status.

RUNNING

The device is running; pulses are applied to the thyristors. The working point is equal to the set reference value *(see STARTER Configuration and USER_DELAY, B6C or W3C Configuration)*. The display shows:
Where 100.0 is the working point that is being applied.

E 100.0

U 100.0

Where 100.0 indicates the voltage in % as measured in the *VOLT* input. This indication is not displayed if the device is configured as a starter *(see Supported configurations and frequency)*.

I 100.0

Where 100.0 indicates the current in % as measured in the *INT1+/INT1-* or *L1/L2/COM* input depending on the *INPUT_INTENSITY* parameter.

H 100

Where 100 indicates the temperature in ºC as measured in the *CON_IN_TEMPE* input.

To switch back and forth between the displays above press the *INC* or *CURSOR* key.

To switch to *STOPPED* mode one of the following operations must be performed based on the value of the *AUTO_MANUAL* parameter:

AUTO_MANUAL = AUTO

Automatic operation. To stop the device the *START_STOP* input must be deactivated.

AUTO_MANUAL = MANUAL

Manual operation. To stop the device the *CURSOR* and *INTRO* keys must be pressed at the same time if the device is in *LOCAL* mode. If the device is in *REMOTE* mode, a *STOP_START* writing must be sent *(see Communications)*.

When the device is stopped using one of the two methods above, the device switches to *RAMP DOWN* status before reaching the *STOPPED* status.

RAMP DOWN

The device is running; pulses are applied to the thyristors. The display shows:

E 100.0

Where 100.0 blinks and is the working point that is being applied. This working point will vary linearly from the value when the stop was commanded until the *PEDESTAL* value during a period of time equal to *RAMP_DOWN*.

To switch to *RUNNING* mode one of the following operations must be performed based on the value of the *AUTO_MANUAL* parameter:

AUTO_MANUAL = AUTO

Automatic operation. To start the device the *START_STOP* input must be activated.

AUTO_MANUAL = MANUAL

Manual operation. To start the device the *INC* and *INTRO* keys must be pressed at the same time if the device is in *LOCAL* mode. If the device is in *REMOTE* mode, a *STOP_START* writing must be sent *(see Communications).*

When this status is complete, the device switches to *STOPPED* status.

ALARM

This status is identical to the *STOPPED* status. The only difference is that the stop has been provoked by an alarm *(see Alarms)*. The potential display messages are:

A	L		0	1

All of the display is blinking. Where 01 is the alarm number that has been activated *(see Alarms).*

A	L	1	0	0

All of the display is blinking. Where 100 is the temperature measured in the *CON_IN_TEMPE* input.
It shows that the *OVER HOT* alarm has been activated.

To switch to *STOPPED* mode from any of these two types of alarm one of the following operations must be performed based on the value of the *AUTO_MANUAL* parameter*:*

AUTO_MANUAL = AUTO

Automatic operation. To stop the device the *START_STOP* input must be deactivated.

AUTO_MANUAL = MANUAL

Manual operation. To stop the device the *CURSOR* and *INTRO* keys must be pressed at the same time if the device is in *LOCAL* mode. If the device is in *REMOTE* mode, a *STOP_START* writing must be sent *(see Communications).*

A	L		0	5

All of the display is blinking. It indicates that the *OVER_CURRENT* alarm has been activated. To exit this status a *reset* must be applied *(see Start and Reset).*

A	L		c	1

All of the display is blinking. It indicates a *SCR_FAILURE* alarm. Where 1 shows the thyristor that has failed. To exit this status a *reset* must be applied *(see Start and Reset).*

STARTER Configuration

In this operating mode, you can control the start and stop of an asynchronous motor. The regulation is direct. The percentage value that we see as the working point *(see Operating statuses)* is the percentage value of the conduction angle. By programming the appropriate levels of *PEAK*, *TIME_PEAK*, *PEDESTAL*, *RAMP_UP* and *RAMP_DOWN*, soft-starter ramps, stop ramps and initial start peaks can be generated *(see Operating statuses)*. If a current input is connected, the current circulating in the motor can be monitored and limited.

Current limitation

If the current limitation is activated through the *LIM_INTENSITY* parameter *(see Parameters)* and the average current exceeds the value of the *MAX_INTENSITY* parameter for 25 seconds, the *OVER CURRENT* alarm will be activated *(see Alarms)*.

Energy saving

This mode is activated by setting the *ENERGY_SAVING* parameter to a *YES* value. When this mode is active the device regulates the working point based on the load of the motor. The same speed is thus achieved with less power dissipation. To perform this regulation, the device measures the phase difference, at the time of starting the motor, between the thyristors voltage and the line voltage. Then, while running, the device diminishes the working point for as long as the present phase difference is higher than the start phase difference.

When the energy saving mode is activated, it can be deactivated externally through the POT_KEY input. If energy saving was activated and this input is set at high level, the energy saving is deactivated.

USER_DELAY, B6C or W3C Configuration

In this operating mode, the device regulates, through the firing angle of the thyristors, the voltage in the load. There are four types of regulation that can be chosen through the *MODE_REGULATOR* parameter*: DIRECT*, *VOLTAGE*, *INTENSITY*, *SERIES*. Described below are several concepts used in this operating mode.

Reference value

In any of the regulating modes we will always use the reference value variable. This variable is represented by the *REFERENCE VALUE* parameter *(see Parameters)*. The reference value is the value of the variable to be regulated that the user wishes to obtain in the load. The variable to be regulated depends on the regulation type. In fact, the device regulates with respect to the working point. The working point derives directly from the reference value and is equal to the latter except when the ramp up, peaks and ramp down statuses are occurring or the device is indicating an alarm *(see Operating statuses and Alarms)*. Both the reference value and the working point are expressed in % to one decimal.

Reference value modification

Described below are the different existing ways to modify the reference value:

MODIFICATION FROM THE OUTSIDE

The reference value may be an image of the *IN_0_5* or *IN_0_10* input *(see* Inputs*).* To this effect, the *POT_KEY* input must be at low level.

MODIFICATION BY KEYBOARD

If the *POT_KEY* input is at high level and the device is in *LOCAL* mode *(see LOCAL mode and REMOTE mode)*, the reference value is modified from the keyboard of the display board. The procedure to change the reference value is as follows:

1. Start the device and wait for it to enter into *RUNNING* status *(see Operating statuses).*
2. Select the working point display by pressing the *INC* or the *CURSOR* key.
3. Press the INTRO key. The display will show, blinking:

E		1	0	0.	0

Where 100.0 is the current reference value.

4. Each short push of the *INC* key increases the reference value by 0.1%. If you press and hold the *INC* key for more than two seconds the reference value is increased more rapidly. Each short push of the *CURSOR* key decreases the reference value by 0.1%. If you press and hold the *CURSOR* key for more than two seconds the reference value decreases more rapidly.

5. When the desired reference value has been obtained, press *INTRO* to validate the change and return to the working point display.

MODIFICATION THROUGH COMMUNICATIONS

If the *POT_KEY* input is at high level and the device is in *REMOTE* mode *(see LOCAL mode and REMOTE mode)*, the reference value is modified through Communications *(see Communications)*. If the *POT_KEY* input is at low level, modifications to the reference value done in this way are to no effect.

MODIFICATION IN STOPPED STATUS

If the *POT_KEY* input is at high level and the device is in *LOCAL* mode *(see LOCAL mode and REMOTE mode)*, the reference value may be modified like any other parameter provided that the device is in *STOPPED* status *(see Parameters)*. If the *POT_KEY* input is at low level, modifications to the reference value done in this way are to no effect.

Linearization

When the device operates in *B6C* or *W3C* mode, it is possible to instruct the device to linearize the output. To linearize the output means that the output percentage does not indicate the conduction angle but the efficient voltage applied to the load through the converter (*B6C*) or the regulator (*W3C*) that is being governed. To activate this option the *LINEAR* parameter must be set to a *YES* value. When the linearization is deactivated, the device applies a firing angle equal to the one shown by the regulation output. When linearization is activated, the device applies a firing angle which produces an efficient voltage percentage in the load as shown by the regulation output.

PID

For *VOLTAGE*, *INTENSITY* or *SERIES* regulations, the device features two internal PID's. One PID regulates VOLTAGE and another one regulates *INTENSITY*. In *SERIES* regulation, both are used. The PID parameters for VOLTAGE are as follows *(see Parameters)*:

KP_VOLTAGE: Proportional constant.
TI_VOLTAGE: Integral time.
TD_VOLTAGE: Derivative time.

And the PID for intensity is the following:

KP_VOLTAGE: Proportional constant.
TI_VOLTAGE: Integral time.
TD_VOLTAGE: Derivative time.

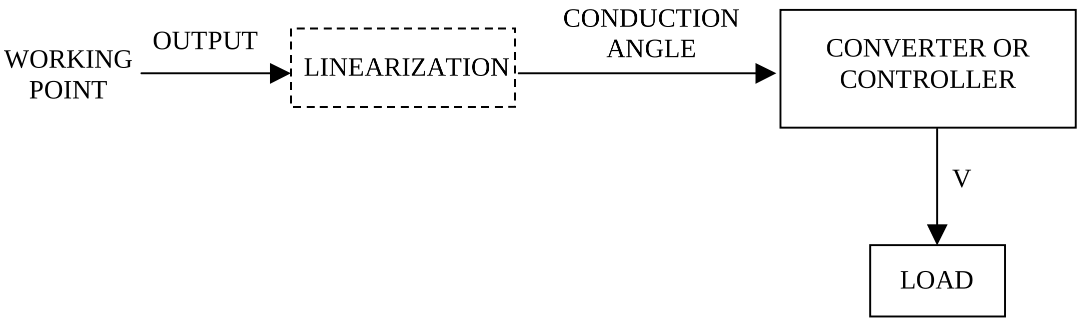
The integral and derivative parts can be made null by setting a value of 0 to their respective constants.

The variable used by the voltage PID is the *VOLT* input. The variable used by the intensity PID may be either *INT1+/INT1-* or *L1/L2/COM*. The cycling or sampling time of the variable is equal to the period of the network voltage that is applied to the converter or controller. Thus, for a network frequency of 50Hz the sampling time is 20 msec., and for a network frequency of 400 Hz it is 2.5 msec.

The PID outputs are limited to 0.0% at the bottom and 100.0% at the top, blocking integration in case the calculation falls outside this interval.

DIRECT mode regulation

In this regulation mode, the working point is set directly at output. If linearization is activated *(see Linearization),* the percentage of efficient voltage in the load is equal to the percentage shown in the working point. If linearization is deactivated, a conduction angle is applied which is equal to the percentage shown by the working point.



VOLTAGE LIMITATION

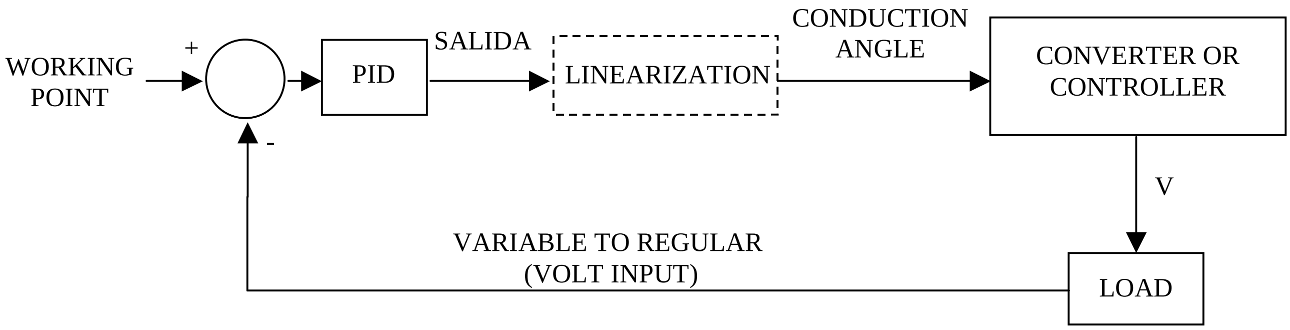
If the voltage limitation is activated through the *LIM_VOLTAGE* parameter *(see Parameters),* the device attempts to prevent its *VOLT* input value from being higher than the value of the *MAX_VOLTAGE* parameter, giving priority to this condition rather than to the working point value. To that effect it uses the internal voltage PID and its constants must be adjusted.

INTENSITY LIMITATION

If the intensity limitation is activated through the *LIM_INTENSITY* parameter *(see Parameters),* the device attempts to prevent its input *INT1+/INT1-* or *L1/L2/COM* value from being higher than the value of the *MAX_INTENSITY* parameter, giving priority to this condition rather than to the working point value. To that effect it uses the internal intensity PID and its constants must be adjusted.

VOLTAGE mode regulation

When regulated in *VOLTAGE* mode, the device uses the voltage PID to regulate the output and to cause the value in % of its *VOLT* input to be equal to the value in % of the working point. If linearization is activated *(see Linearization)*, the efficient voltage percentage in the load is equal to the percentage shown in the output. If linearization is deactivated, a conduction angle equal to the percentage shown by the output is applied.



VOLTAGE LIMITATION

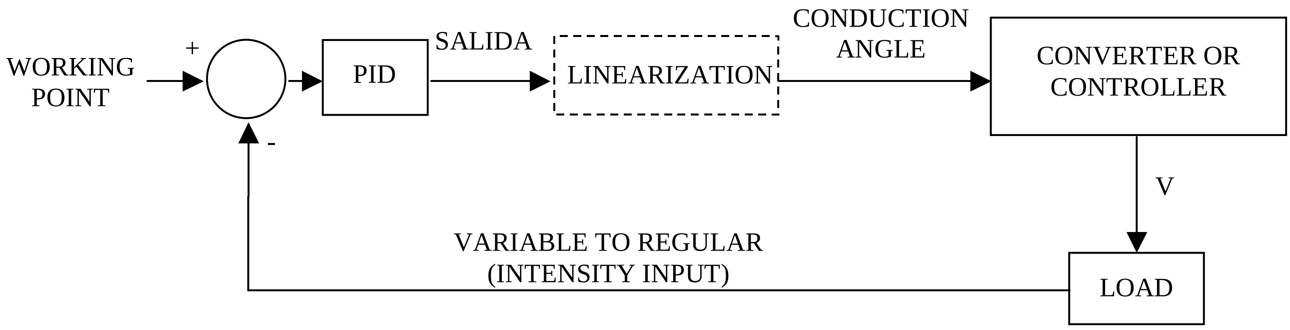
If voltage limitation is activated through the *LIM_VOLTAGE* parameter *(see Parameters)*, the device prevents inputs of reference values that are higher than the value of the *MAX_VOLTAGE* parameter.

INTENSITY LIMITATION

If intensity limitation is activated through the *LIM_INTENSITY* parameter *(see Parameters)*, the device attempts to prevent the value of its *INT1+/INT1-* or *L1/L2/COM* input from being higher than the value of the *MAX_INTENSITY* parameter, giving priority to this condition rather than to regulating the value of the *VOLT* input. To that effect it uses the internal intensity PID and its constants must be adjusted.

INTENSITY mode regulation

When regulated in *INTENSITY* mode, the device uses the intensity PID to regulate the output and to cause the value in % of its intensity input to be equal to the value in % of the working point. If linearization is activated *(see Linearization)*, the percentage of efficient voltage in the load is equal to the percentage shown by the output. If linearization is deactivated, a conduction angle equal to the percentage shown by the output is applied.



VOLTAGE LIMITATION

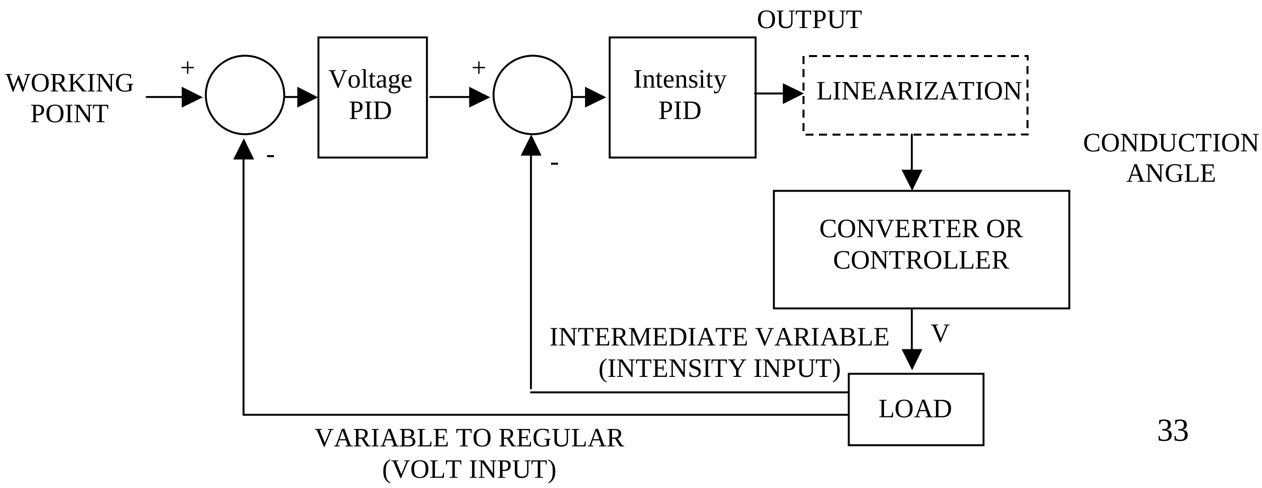
If the voltage limitation is activated through the *LIM_VOLTAGE* parameter *(see Parameters),* the device attempts to prevent the value in its *VOLT* input from being higher than the value of the *MAX_VOLTAGE* parameter, giving priority to this condition rather than to the regulation of the value of the *INT1+/INT1-* or *L1/L2/COM* input. To that effect it uses the internal voltage PID and its constants must be adjusted.

INTENSITY LIMITATION

If the intensity limitation is activated through the *LIM_INTENSITY* parameter *(see Parameters),* the device prevents inputs of reference values that are higher than the value of the *MAX_INTENSITY* parameter.

SERIES mode regulation

When regulating in *SERIES* mode, the device uses the voltage PID and the intensity PID to regulate the output and to cause the value in % of its *VOLT* input to be equal to the value in % of the working point. The output of the voltage PID is applied as the reference value for the intensity PID and the output of the intensity PID is the applied output. If linearization is activated *(see Linearization),* the percentage of efficient voltage in the load is equal to the percentage shown by the output. If linearization is deactivated a conduction angle is applied which is equal to the percentage shown by the output.



VOLTAGE LIMITATION

If the voltage limitation is activated through the *LIM_VOLTAGE* parameter *(see Parameters),* the device prevents inputs of reference values that are higher than the value of the *MAX_VOLTAGE* parameter.

INTENSITY LIMITATION

If the intensity limitation is activated through the *LIM_INTENSITY* parameter *(see Parameters),* the device limits the output of the voltage PID (working point of the intensity PID) to values that are lower than the value of the *MAX_INTENSITY* parameter.

Alarms

The MP410 has a total of six potential alarms. All of them are described below in order of priority. In case more than one alarm is activated at the same time, the device will perform based on the alarm with the highest priority.

SCR FAILURE

This alarm is activated when the device detects that some of the thyristors cannot be burst triggered. In order for the device to be able to detect this failure, it requires a minimum of applied output, which depends on the configuration of the bridge *(see Supported configurations and frequency)* and the network frequency. In order to deactivate the alarm a reset must be applied *(see Start and Reset)*. The device comes to a total stop when this alarm is activated, that is, it does not go through the RAMP DOWN status. This alarm can be prohibited through the AL_FAILURE_THYRISTORS parameter. If the value is set to YES, the alarm is permitted. If the value is set to NO, the alarm is prohibited. Every time a thyristor must be burst triggered because the device detects that it is disconnected and must switch to conduction, a burst is applied with the number of pulses indicated by the BURST parameter. Once the thyristor has been burst triggered, no further burst is applied unless the thyristor is current-free. This represents important energy savings in the burst firing of the thyristors. Depending on the application and the working frequency more or fewer burst pulses will be required. Further, the value of the BURST parameter also indicates how many pulses must be applied to a thyristor before signaling SCR FAILURE in case the thyristor is not successfully burst triggered.

INHIBIT INPUT

Alarm number 1. This alarm is activated when the *INHI_IN* input is activated. To deactivate this alarm, this input must be deactivated. The device comes to a full stop when this alarm is activated, that is, it does not go through *RAMP DOWN* status. This alarm is always permitted.

THERMOSTAT

Alarm number 2. This alarm is activated when the THERMO input is activated. To deactivate this alarm this input must be deactivated. The device comes to a full stop when this alarm is activated, that is, it does not go through *RAMP DOWN* status. This alarm is always permitted.

PHASE FAILURE

Alarm number 3. This alarm is activated when the device detects that more than one phase is failing. To deactivate the alarm you must recover the phases. This alarm is not always displayed. The device comes to a full stop when this alarm is activated if the

AL_FAILURE_PHASE parameter is set to a *YES* value. If the parameter is set to a *NO* value, the alarm is only displayed but the device does not stop.

OVER HOT

This alarm is activated when the temperature measured in the *CON_IN_TEMPE* input exceeds the value of the *CON_TEMPERATURE* parameter. To deactivate this alarm the measured temperature must be lower than the value of the *CON_TEMPERATURE* parameter less a hysteresis of 10 ºC. The device normally stops when this alarm is activated, that is, it goes through the *RAMP DOWN* status. This alarm may be prohibited through the *AL_TEMPERATURE* parameter. If you set the value to *YES*, the alarm is permitted. If you set the value to *NO,* it is prohibited.

OVER CURRENT

Alarm number 5. It only works when the device is configured as a STARTER *(see Supported configurations and frequency)*. This alarm is activated when the measured current exceeds the value of the *MAX_INTENSITY* parameter for 25 continuous seconds. To deactivate the alarm you must apply a *reset (see Start and Reset)*. The device normally stops when this alarm is activated, that is, it goes through the *RAMP DOWN* status. This alarm may be prohibited through the *LIM_INTENSITY* parameter. If you set the value to *YES*, the alarm is permitted. If you set the value to *NO*, it is prohibited.

Parameters

NUMBER	NAME	VALUES	UNIT	DISPLAY MESSAGE	DEFAULT VALUE
0	LOCAL_REMOTE	0:LOCAL 1:REMOTE		LR	LOCAL
1	ADDRESS	01-31		Ad	01
2	CONFIGURATION	0:USER_DELAY 1:B6C 2:W3C 3:STARTER		CF	W3C
3	PHASE DIFFERENCE	00-90	DEGREES	DY	00
4	AUTO_MANUAL	0:AUTO 1:MANUAL		Am	MANUAL
5	PEAK	000.0/066.0-100.0	%	P	66.0
6	TIME_PEAK	0.0-9.9	SECONDS	PS	0
7	PEDESTAL	000.0/066.0-100.0	%	D	66.0
8	RAMP_UP	00.0-99.9	SECONDS	RU	0
9	RAMP_DOWN	00.0-99.9	SECONDS	Rd	0
10	LIM_INTENSITY	0:NO 1:YES		CL	NO
11	MAX_INTENSITY	00.0-99.9	%	Cm	00.0
12	AL_TEMPERATURE	0:NO 1:YES		HL	NO
13	CON_TEMPERATURE	000-150	ºC	Hm	000
14	AL_FAILURE_PHASE	0:NO 1:YES		PA	NO
15	AL_FAILURE_THYRIST ORS	0:NO 1:YES		SA	NO
16	ENERGY_SAVING	0:NO 1:YES		ES	NO
17	REGULATING_MODE	0:DIRECT 1:VOLTAGE 2:INTENSITY 3:SERIES		Rm	DIRECT
18	LINEAR	0:NO 1:YES		LI	NO
19	REFERENCE VALUE	000.0-100.0	%	E	000.0
20	KP_INTENSITY	0.00-9.99		PC	0.05
21	TI_INTENSITY	0.00-9.99	SECONDS	IC	1.00
22	TD_INTENSITY	0.00-1.00	SECONDS	DC	0.20
23	LIM_VOLTAGE	0:NO 1:YES		VL	NO
24	MAX_VOLTAGE	00.0-99.9	%	Vm	00.0
25	KP_VOLTAGE	0.00-9.99		PV	0.05
26	TI_VOLTAGE	0.00-9.99	SECONDS	IV	1.00
27	TD_VOLTAGE	0.00-9.99	SECONDS	DV	0.20
28	INPUT_INTENSITY	0:INT1+/INT1- 1:L1/L2/COM		CI	INT1+/INT1-

29	BURST	00-50	PULSES	b	5
30	PASSWORD	0000-9999		A	

Parameter modification

Below is a description of the different procedures available to modify the device parameters:

MODIFICATION BY KEYBOARD

If the device is in *LOCAL* mode *(see LOCAL mode and REMOTE mode),* parameters are modified using the keyboard in the display board. Modification of parameters is password protected. The procedure to change the value of the parameters is as follows:

1. Stop the device and wait for it to enter into *STOPPED* status *(see Operating statuses).* Once in this status, press the *INTRO* key for three seconds.
2. The display will show, with the last digit blinking:

A0000

Where 0000 must be written with the password value: By pressing the *CURSOR* key you change the digit to be modified, indicated by blinking. Short pushes of the *INC* key increase the value of the blinking digit. If you press and hold the *INC* key for more than two seconds the value of the blinking digit is increased more quickly. When the digit reaches the value 9, if you press *INC* it returns to value 0.

3. Once you have keyed in the right password value, press *INTRO* to go on to step 4. If you press *INTRO* and the password value is wrong you return to step 2. The third time that you press *INTRO* with a wrong password value it leads to the blocking of the device showing the following in its display:

Error

4. The display shows, one by one, the parameters and their values. To switch back and forth from parameters you must press the *INTRO* key. Parameters that are not used based on the programming that has been done with the previous ones do not appear. When the last parameter is programmed, the device returns to *STOPPED* status. Modification of the value for each parameter is done by pressing the *CURSOR* key to select the digit to be changed and pressing the *INC* key until you get the desired digit value.

MODIFICATION THROUGH COMMUNICATIONS

If the device is in *REMOTE* mode (*see LOCAL mode and REMOTE mode*), the parameters can only be modified through Communications *(see Communications).*

Loading default parameters

If you press the B2 key (see ***Physical description****)* for 5 seconds, the device loads the default values into the parameters.

Communications

Features

Physical support: RS-485
Speed: 9600 bauds
Parity: No parity
Stop bits: 1
Byte order in words: Byte High first and Byte Low last
Synchronism: Slave device, all communications initiated by Host.
End of line connectable through jumper J1.

Read-only data

Read-only data, whether the device is in *REMOTE* or in *LOCAL* mode, can only be read. The data addresses are as follows:

ADDRESS	DESCRIPTION
0	Indicates the device status: 0:*STOPPED* 1:Measuring the cosine of φ for the energy saving of the *STARTER* configuration. 2:*RAMP_UP* 3:*RUNNING* 4:*RAMP_DOWN*
1	Working point in % x 10. From 0 to 1000
2	Active alarm: *0: No alarms* *1: INHIBIT INPUT* *2: THERMOSTAT* *3: PHASE FAILURE* *4: OVER HOT* *5: OVER CURRENT* *6: SCR 1 FAILURE* *7: SCR 2 FAILURE* *8: SCR 3 FAILURE* *9: SCR 4 FAILURE* *10: SCR 5 FAILURE* *11: SCR 6 FAILURE*
3	*POT_KEY* input status*:* *0: Low level* *1: High level*
4	Value of *CON_IN_TEMPE* input. From 0 to 150
5	Value of *IN_0_5 or IN_0_10* input in % x 10. From 0 to 1000
6	Value of *INT1+/INT1-* or *L1/L2/COM* input in % x 10. From 0 to 1000
7	Value of *VOLT* input in % x 10. From 0 to 1000

The size of the read-only data is 2 bytes (word).

Read and write data

Read and write data, as expressed by its name, can be read and written through communications if the device is in *REMOTE* mode. If the device is in *LOCAL* mode, they can only be read.

The set of read and write data is made up by the parameters, whose data address is equal to the parameter number, plus the *STOP_START* data, whose data address is 31.

By writing the *STOP_START* data you can command the starting or stopping of the device remotely. If the value of the data is 0, stop is commanded; if the value of the data is 1, start is commanded.

Parameters whose values have decimals are communicated as integers that are equal to the value multiplied by 10^n, where n is the number of decimals. The size of the read and write data is 2 bytes (word).

Protocol

All values are sent in hexadecimal format coded in ASCII. For instance: to send the value 956, first it is formatted into hexadecimal (0x03BC) and the characters '0' '3' 'B' and 'C' are sent. Thus, for 1 byte values 2 bytes need to be sent and for 1 word values 4 bytes need to be sent.

The communications address of each device is the *ADDRESS* parameter. Although the *ADDRESS* parameter is one word, the address field in the frame is 2 bytes, only codifying the byte under the parameter. No more than 31 devices can be in the bus and all devices present in the bus must have different communications addresses.

READING READ-ONLY DATA

From host to device:

'S'	DH	DL	'0'	CHKH	CHKL	'T'

DH: Device address high byte.
DL: Device address low byte.
CHKH: Checksum high byte.
CHKL: Checksum low byte.

From device to host:

'S'	DH	DL	'4'	VHH0	VLH0	VHL0	VLL0	....	VHH7	VLH7	VHL7	VLL7

CHKH	CHKL	'T'

DH: Device address high byte.
DL: Device address low byte.
VHHx: X read-only data high part high byte.
VLHx: X read-only data high part low byte.
VHLx: X read-only data lower part high byte.

VLLx: X read-only data lower part low byte.
CHKH: Checksum high byte.
CHKL: Checksum low byte.

READING READ AND WRITE DATA

From host to device:

‘S’	DH	DL	‘1’	CHKH	CHKL	‘T’

DH: Device address high byte.
DL: Device address low byte.
CHKH: Checksum high byte.
CHKL: Checksum low byte.

From device to host:

‘S’	DH	DL	‘5’	VHH0	VLH0	VHL0	VLL0	....	VHH7	VLH7	VHL7	VLL7

CHKH	CHKL	‘T’

DH: Device address high byte.
DL: Device address low byte.
VHHx: X read-only data high part high byte.
VLHx: X read-only data high part low byte.
VHLx: X read-only data low part high byte.
VLLx: X read-only data low part low byte.
CHKH: Checksum high byte.
CHKL: Checksum low byte.

WRITING READ AND WRITE DATA

From host to device:

‘S’	DH	DL	‘2’	VHH0	VLH0	VHL0	VLL0	....	VHH7	VLH7	VHL7	VLL7

CHKH	CHKL	‘T’

DH: Device address high byte.
DL: Device address low byte.
VHHx: X read-only data high part high byte.
VLHx: X read-only data high part low byte.
VHLx: X read-only data low part high byte.
VLLx: X read-only data low part low byte.
CHKH: Checksum high byte.
CHKL: Checksum low byte.

From device to host:

‘S’	DH	DL	‘6’	CHKH	CHKL	‘T’

DH: Device address high byte.
DL: Device address low byte.
CHKH: Checksum high byte.
CHKL: Checksum low byte.

WRITING STOP_START

From host to device:

‘S’	DH	DL	‘3’	VHH	VLH	VHL	VLL	CHKH	CHKL	‘T’

DH: Device address high byte.
DL: Device address low byte.
VHH: *STOP-START* data high part high byte.
VLH: *STOP-START* data high part low byte.
VHL: *STOP-START* data low part high byte.
VLL: *STOP-START* data low part low byte.
CHKH: Checksum high byte.
CHKL: Checksum low byte.

From device to host:

‘S’	DH	DL	‘7’	CHKH	CHKL	‘T’

DH: Device address high byte.
DL: Device address low byte.
CHKH: Checksum high byte.
CHKL: Checksum low byte.

WRITING THE REFERENCE VALUE PARAMETER

From host to device:

‘S’	DH	DL	‘8’	VHH	VLH	VHL	VLL	CHKH	CHKL	‘T’

DH: Device address high byte.
DL: Device address low byte.
VHH: *REFERENCE VALUE* parameter high part high byte.
VLH: *REFERENCE VALUE* parameter high part low byte.
VHL: *REFERENCE VALUE* parameter low part high byte.
VLL: *REFERENCE VALUE* parameter low part low byte.
CHKH: Checksum high byte.
CHKL: Checksum low byte.

From device to host:

‘S’	DH	DL	‘9’	CHKH	CHKL	‘T’

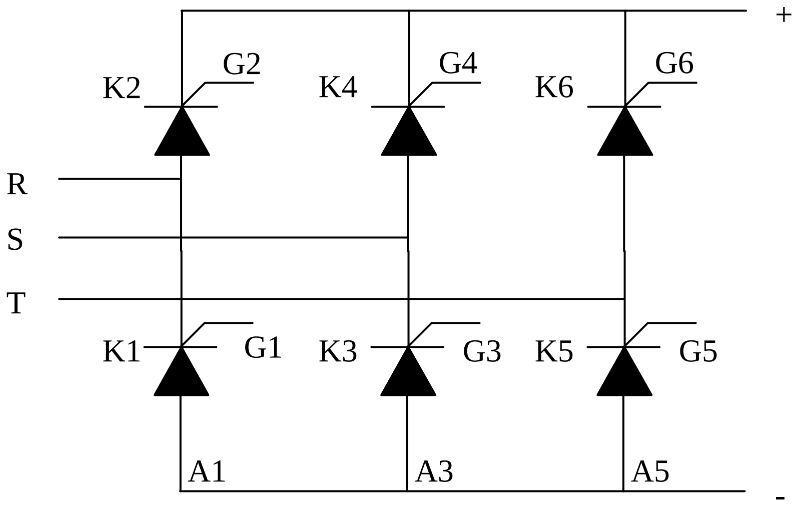
DH: Device address high byte.
DL: Device address low byte.
CHKH: Checksum high byte.

CHKL: Checksum low byte.

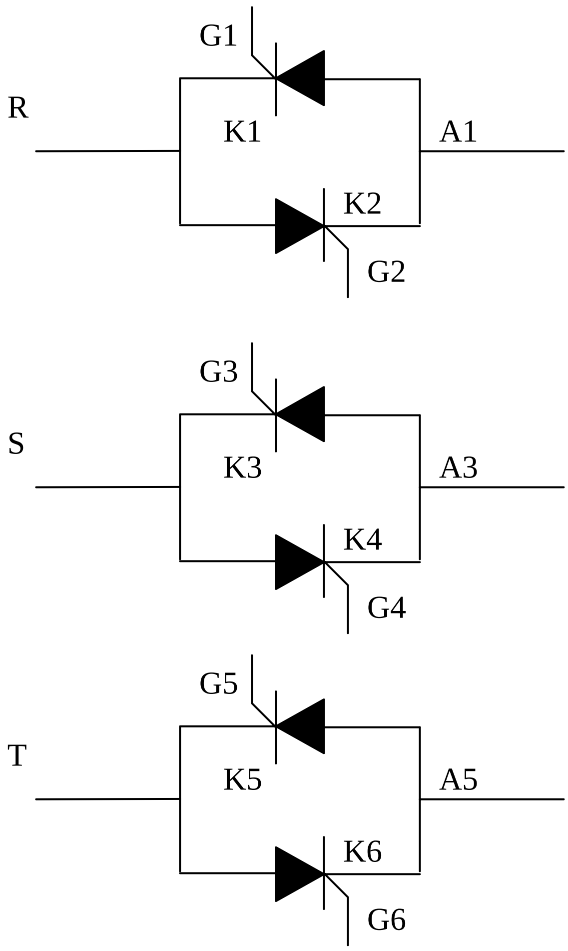
Checksum calculation

In order to calculate the checksum of the frame it is initiated with a value of 0xFF and an XOR operation is performed with each byte of the frame except for the byte of frame end ‘T’ and the byte at the beginning of frame ‘S’.

CONNECTION DIAGRAM



B6C



W3C