TC3001

Series

EUROTHERM

Three phase
Thyristor Units

User
Manual

European Directives and CE Marking
(see overleaf)

EUROPEAN DIRECTIVES

COMPONENT

TC3001 thyristor unit is a component according to the **Directive 89/336/EEC** designed to be fitted in systems submitted to CE Marking according to the same Directive.
It is the responsibility of the installer to **affix** the CE Mark and **to establish** the CE declaration of conformity of its overall system in relation to the applicable European Directives.

In order to facilitate the integration of our components in the systems concerned by the CE Mark, Eurotherm has taken the following measures :

SAFETY

For **safety,** the **TC3001** products **installed and used in compliance with this manual** meet the essential requirements of the **Low Voltage Directive 73/23/EEC** of 19/02/73 (amended by the Directive 93/68/EEC of 22/07/93) according to their design.

ELECTROMAGNETIC COMPATIBILITY

For **Electromagnetic Compatibility,** a distinction is made between immunity and conducted and radiated emissions.

Immunity

For immunity, the **TC3001** products **installed and used in compliance with this manual meet** the essential requirements of the **Electromagnetic Compatibility Directive 89/336/EEC** of 03/05/89 (amended by the Directives 92/31/EEC of 12/05/92 and 93/68/EEC of 22/07/93) according to their design.

Radiated emission

For radiated emission, the **TC3001** products **installed and used in compliance with this manual meet** the essential requirements of the above mentionned **Electromagnetic Compatibility Directive** according to their design.

Conducted emission

To reduce the noise due to the utilization of its thyristor units, Eurotherm can supply specific filters. The purpose of these filters is to help you to filter your system and to make it compliant with the essential requirements of the **Electromagnetic Compatibility Directive.**

A declaration attesting the above mentionned statements is available on request.

CE MARKED APPARATUS

Eurotherm can supply equipment made of a thyristor unit and an external filter (referenced hereunder) that both form a **CE Marked apparatus** and is intended to be used in an installation.

Please, also refer to the installation guide of the filters.

In order to guarantee the best service, Eurotherm **have validated the compliance** of the TC3001 with the essential European Directive requirements **through product design and laboratory tests** described in a technical file for attention of official authorities.

A declaration of compliance with the European Directives is available on request.

EXTERNAL FILTERS

Nominal current of TC3001 product	Series filter EUROTHERM Part No.
25 A	LA 174937U063
40 A	LA 174937U063
60 A	LA 174937U063
75 A	LA 174937U100
100 A	LA 174937U100
150 A	LA 174937U160

For 250 to 500 A current consult your Eurotherm office

The electromagnetic compatibility of the TC3001 has been specially developed for the **industrial environment** and must not be used in residential type environments.

For further details, contact your Eurotherm office.

Printed in France 01/96 Part No. HA 174834 Issue A

This **TC3001 User Manual- Part No HA 174834** intends for the TC3001 series power thyristor units manufactured from **December 1995.**

This TC3001 User Manual (HA 174530) is valid for products manufactured before this date.

In order to help you reduce risks related to the effects of electromagnetic interference depending on the installation of the product, Eurotherm can supply you with the **"EMC Installation Guide"** (Part No. HA 025464).

This guide gives the rules generally applicable for Electromagnetic compatibility.

Manufactured by Eurotherm Automation S.A.
ISO 9001 - EN 29001 certified

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Thyristor power units

TC3001 series

Three-phase load control

User Manual

Printed in France 0296 HA 174834 Issue 2

The installation, configuration, commissioning and maintenance of the power unit must only be performed by a person **qualified and authorised to perform work in an industrial low voltage electrical environment.**

Important precautions and special information are indicated in the manual by two symbols:

DANGER

This symbol means that failure to take note of the information may have serious consequences for the safety of personnel and may even result in the risk of electrocution.

ATTENTION

This symbol means that failure to take note of the information may

- **have serious consequences for the installation**
- **result in the incorrect functioning of the power unit.**

These marks must indicate specific points.
The entire manual remains applicable.

It is the responsibility of the user and it is highly recommended, given the value of the equipment controlled using TC3001, to install **independent safety** devices.

This alarm must be tested regularly.

Eurotherm can supply suitable equipment.

As a result of the constant improvement of its products, Eurotherm may modify these specifications without warning.
For any further information and if in doubt, please contact your EUROTHERM office where technicians are at your disposal should you require advice or assistance with the commissioning of your installation.

Printed in France 02/96 HA 174834 Issue 2

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Chapter 1

IDENTIFYING THE THYRISTOR UNITS

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Chapter 1 IDENTIFYING THE THYRISTOR UNITS

GENERAL INTRODUCTION TO THE TC3001 SERIES

The **TC3001** series thyristor units are designed to **control the electrical power** on **all** types of **industrial three-phase** loads.

The **TC3001** series is designed to control the following loads:

- inductive (inductors or primary transformer coils),
- resistive (with low or high temperature coefficient),
- composed of short wave infrared elements.

The three-phase loads can be connected

- in star with neutral
- in star without neutral
- in closed delta
- in open delta.

The **TC3001** thyristor units control currents between **25 A** and **500 A**.

The nominal line-to-line voltage can be between **100 V and 480 V**.

The thyristor configuration is **indifferent** to the order of the supply phase rotation.

A TC3001 series thyristor unit is composed of **3 channels** containing a pair of thyristors mounted in anti-parallel.

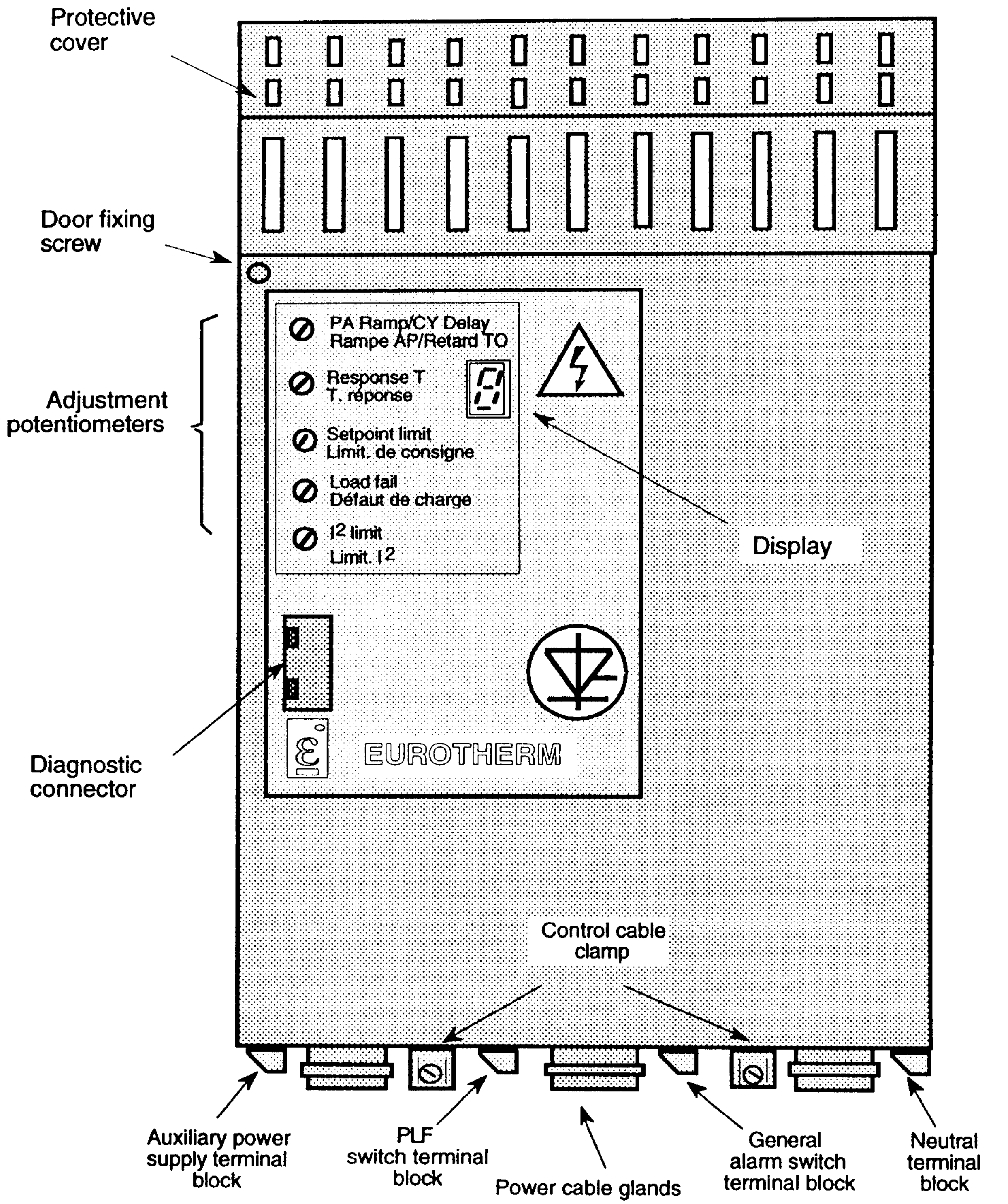

Figure 1-1 Overall view of the TC3001 thyristor unit

The **TC3001** thyristor units have the following **functions**:

- four types of **feedback**:
  - **V^2** or **I^2**
  - **V x I**
  - external measurement signal
- several thyristor **firing** modes:
  - logic (ON/OFF),
  - thyristor firing angle variation (Phase angle),
  - cycle time modulation (Burst firing mode and Phase angle burst),
  - soft operation: adjustable soft start and/or stop to eliminate over-currents on load with low resistance when cold or for other applications
- **permanent monitoring** of the load, the currents, the supply voltage and the frequency.

The thyristor unit is controlled with **analogue signals.**
For the input analogue signals, there are four possible voltage levels:
0-5 V ; 1-5 V ; 0-10 V ; 2-10 V
and two current levels:
0-20 mA and **4-20 mA.**

The instantaneous state of the thyristor unit, its operating mode, a load failure or the enabled alarms are indicated by message on a 7 segment **display** located on the front panel.

The front panel also includes:

- 5 **adjustment potentiometers** for the main operating parameters
- a **diagnostic** connector.

An **alarm** system detects failures in the loads and abnormal variations in the voltage and current.

Failure detection **is signalled** by the switches of two alarm relays and by the display.

If the current threshold pre-adjusted by the user or in the factory is exceeded, **the current monitoring system**

- stops the thyristor unit in Burst firing or Logic operation
- limits the current by thyristor angle variation in Phase angle, Phase angle burst and Burst firing operation with soft operation.

The **TC3001** thyristor unit is equipped with:

- a thyristor firing board ('**power board**') which generates thyristor firing pulses and measures the currents and voltages,
- a '**driver board**' for the auxiliary and control circuit power supply,
- a '**potentiometer board**' for the calibration of the thyristor unit current and voltage and for the adjustment of the main operating parameters,
- a '**filter board**' to protect the thyristor unit operation against transient interference.

The user terminal blocks below the thyristor unit are used for the following connections without having to open the front door:

- the auxiliary power supply,
- the reference neutral,
- two alarm relay switches.

The **filters** providing immunity against electromagnetic interference are fitted:

- at the reference neutral connection input,
- between the supply phases ('LINE') and the safety earth connector,
- between the load connections ('LOAD') and the safety earth connector,
- between the power phases (for 500 A nominal units).

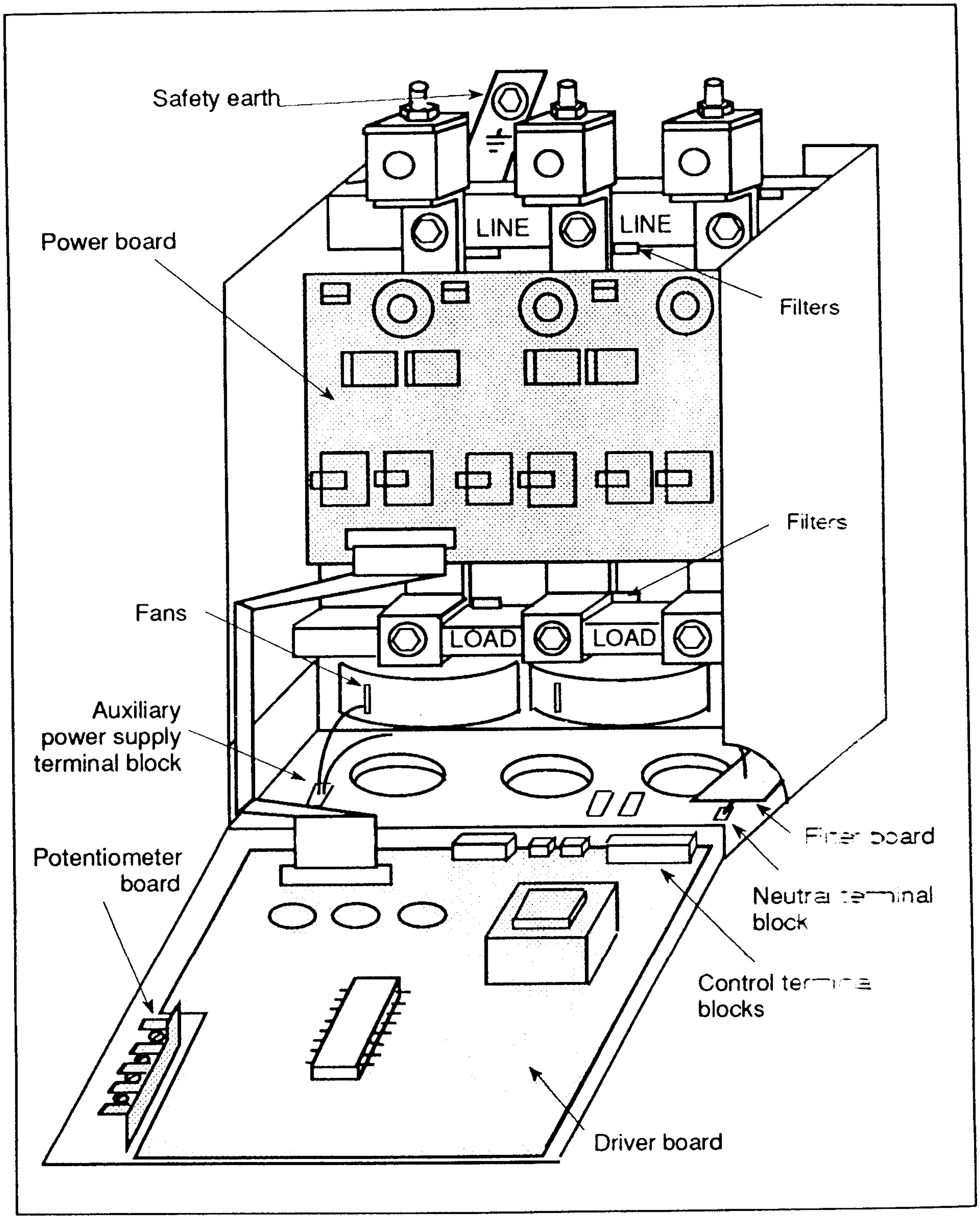

Figure 1-2 TC3001 thyristor unit electronic boards

TECHNICAL DATA

The TC3001 series is a series of power thyristor units designed for the control and feedback of 3 phases of industrial three-phase loads using thyristors.

Attention !

⚠ It is the user's responsibility to ensure that the nominal values of the thyristor unit are compatible with the conditions of installation and operation before commissioning the thyristor unit.

Power

Nominal current (per phase)	**25 A** to **500 A**
Nominal line-to-line voltage	**240 V** to **480 V** (+10%,-15%)
Operating voltage (calibration)	**100 V** to **480 V** Inhibition below 70% of calibrated voltage
Supply frequency	**42 Hz** to **68 Hz** Automatic adaptation Inhibition outside 40 to 70 Hz
Dissipated power	**1.3 W** (approximately) per ampere and per phase
Cooling	**Natural** convection (25 A to 75 A) **Permanent** fan cooling from **100 A**
Fans	2 for **100 A** to **250 A**, 3 for **300 A** to **500 A** Consumption **25 VA** per fan Supply voltage **115 V** or **230 V**
Load	**All types of industrial three-phase** load: resistive, short wave infrared, inductive, tungsten, primary transformer coil, etc.
Load connection	**Independent** of the phase rotation order
Load configuration	Closed (3 wires) and open (6 wires) delta Star without Neutral (3 wires) and with Neutral (4 wires) Load type and assembly configuration using jumpers

Environment

Operating temperature	**0°C** to **+50°C** (40°C for 500 A; at 50°C redesign to 450 A) maximum altitude **2000 m**
Storage temperature	**-10°C** to **+70°C**
Thyristor protection	Internal high speed **fuses** **Varistor** and RC snubber
Protection	**IP20** on front panel (according to **IEC 592**)
External cabling	To be performed according to the Standards **IEC 364**
Operating environment	Non-explosive, non-corrosive and non-conductive
Humidity	RH from **5%** to **95%** without condensation
Pollution	Degree **2** admissible, defined by **IEC 664**
Dimensions (25 A to 250 A)	**480 mm** (H) x **248 mm** (W) x **268 mm** (D) Weight **16 kg**, (250 A : **18 kg**)
(300 A to 500 A)	**570 mm** (H) x **373 mm** (W) x **268 mm** (D). Weight **21 kg**

Control

Power supply	**100 V** to **240 V** (+10%; -15%); consumption: **20 VA**
Signal type	**Analogue**
Control signal	**Voltage:** **0-5 V**; **1-5 V**; **0-10 V** or **2-10 V** Input impedance ≥100 kΩ **Current:** **0-20 mA**; **4-20 mA** Input impedance 100 Ω
Thyristor firing mode	• **ON/OFF** (Logic) • **Burst firing** (number of firing periods adjustable between **1** and **255** periods). • **Phase angle burst** (number of firing periods adjustable between **1** and **255** periods). For **these three** modes: - start at **zero voltage** for resistive loads with elimination of the DC component - start at **zero current** on each phase for inductive loads with **elimination** of transient currents (adjustment using potentiometer on front panel) - possibility of adjustable **soft** start and (or) end between **1 and 255** periods for the start and end of each firing cycle (thyristor firing angle variation) • **Phase angle** Possibility of **soft** start and (or) end with a **linear ramp** on a setpoint change (increase/decrease), the duration of the ramp from 0 to 100% firing is **0.1** s to **40 H** (adjustment using potentiometer on front panel).
Feedback type	• Power (**V x I**) • Mean of the squares of the three currents $I_{AVE}^2 = (I_1^2 + I_2^2 + I_3^2) / 3$ or the squared load voltage V^2 • External measurement
Feedback quality	**Linearity** : **±1%** in Phase angle; **±2%** in Burst firing **Stability** : **±1%** in Phase angle; **±2%** in Burst firing with variations: - of the load impedance ±30%; - of the supply voltage +10%, -15%; - of the temperature 0 to 50 °C Adjustable **response time**. To change from **10%** to **90%** power: - in Phase angle - **120 ms** to **1.5 s** - in Burst firing - **0.3** s to **150 s**
Retransmissions	Outputs (**0** to **10 V**) - three squared **currents** and squared **voltage** (filtered signal) - **feedback parameter** (DC signal).

Alarms

- **Voltage**:
  - absence of supply voltage on each phase
  - under-voltage (thyristor firing stopped below **70%** of the nominal thyristor unit voltage)
  - over-voltage (alarm for a voltage greater than the nominal thyristor unit voltage by **20%**)
  - a frequency above **70 Hz** or below **40 Hz** stops the operation of the thyristor unit
- **Currents** :
  - thyristor short-circuit and over-current detection
- **Load**:
  - **partial load failure** (PLF) detection, adjustment **using potentiometer** on front panel or using an external signal and potentiometer; the PLF detects the failure of **1** element out of **4** to **8** identical elements (depending on the three-phase configuration) mounted in parallel
  - load **unbalance** detection (for resistive loads or for short wave infrared elements), detection of an unbalance $\Delta I < 0.25\ I_{MAX}$

Current limit

The current limit sets the maximum value of I^2.
Adjustment of the current limit setpoint using a potentiometer on the front panel, with or without an external signal.

- For the thyristor firing modes
  - Phase angle
  - Phase angle burst
  - Burst firing with ramp or soft start / end:

thyristor firing angle variation.

- for the thyristor firing modes:
  - Logic
  - Burst firing

thyristor unit operation stop.

Monitoring

Permanent data on the alarm type and its degree of severity with a **display** and with **two relays**

Diagnostics

Connector for diagnostic unit used to adjust, control and calibrate the thyristor unit **locally** using **20 test signals**

Attention !

Due to the continual improvement of products, Eurotherm may be required to modify specifications without prior notice. For any further information and in the event of doubt, contact your Eurotherm Office.

CODING

TC3001 /	Nominal current /	Line voltage /	Auxiliary power supply /	Operating voltage (calibration) /	Input signal /	Thyristor firing mode /	Ramp, soft start, end /

Nominal current	Code
25 amperes	**25A**
40 amperes	**40A**
60 amperes	**60A**
75 amperes	**75A**
100 amperes	**100A**
150 amperes	**150A**
250 amperes	**250A**
300 amperes	**300A**
400 amperes	**400A**
500 amperes	**500A**

Line voltage	Code
240 volts	**240V**
440 volts	**440V**
480 volts	**480V**

For other voltages, contact your Eurotherm Office

Auxiliary power supply	Code
110 volts	**100V**
110 to 120 volts	**110V120**
200 volts	**200V**
220 to 240 volts	**220V240**

Operating voltage	Code
100 volts	**100**
110 volts	**110**
115 volts	**115**
120 volts	**120**
200 volts	**200**
220 volts	**220**
230 volts	**230**
240 volts	**240**
277 volts	**277**
380 volts	**380**
415 volts	**415**
400 volts	**400**
440 volts	**440**
480 volts	**480**

Input signal	Code
0 - 5 volts	**0V5**
1 - 5 volts	**1V5**
0 - 10 volts	**0V10**
2 - 10 volts	**2V10**
0 - 20 mA	**0mA20**
4 - 20 mA	**4mA20**

Thyristor firing mode	Code
Logic (ON/OFF)	**LGC**
Phase angle	**PA**
Burst firing:	
1 period	**FC1**
2 periods	**FC2**
4 periods	**FC4**
8 periods	**FC8**
16 periods	**C16**
32 periods	**C32**
64 periods	**C64**
128 periods	**128**
255 periods	**255**
Phase angle burst:	
1 period	**HC1**
2 periods	**HC2**
4 periods	**HC4**
8 periods	**HC8**
16 periods	**H16**
32 periods	**H32**
64 periods	**H64**
128 periods	**H28**
255 periods	**H55**

Ramp, soft start/end	Code
Without ramp and without soft start/end	**NRP**
Positive ramp or soft start	**URP**
Positive and negative ramps or soft start/end	**UDR**

Load connection /	Load type /	PLF detection /	Controlled parameter /	Current limit mode /	Auxiliary input-output /	Load unbalance detection /	Option /	End

Load connection	Code
Delta (3 wires)	3D
Star without neutral (3 wires)	3S
Star with neutral (4 wires)	4S
Open delta (6 wiress)	6D

Load type	Code
Inductive	IND
Other loads	RES

Partial load failure detection (PLF)	Code
According to standard curve	SD

Controlled parameter	Code
External (See Auxiliary input)	EX
Squared load current	I2
Squared load voltage	V2
Power	W

Current limit mode	Code
Reduction in the firing angle	
For the firing modes:	
• Phase angle	
• Phase angle burst	
• Burst firing with codes URP or UDR	
Adjust. using potent. on front panel	LINT
Adjust. using external signal 0-5 V	L0V5
1-5 V	L1V5
0-10 V	L0V10
2-10 V	L2V10
0-20 mA	L0mA20
4-20 mA	L4mA20
Firing stop	
For the firing modes:	
• Logic	
• Burst firing	
Adjust. using potent. on front panel	CINT
Adjust. using external signal 0-5 V	C0V5
1-5 V	C1V5
0-10 V	C0V10
2-10 V	C2V10
0-20 mA	C0mA20
4-20 mA	C4mA20

Auxiliary input/output		Code
Controlled parameter retransmission		RTR
External feedback (if controled parameter EX)	0-5 V	E0V5
	1-5 V	E1V5
	0-10 V	E0V10
	2-10 V	E2V10
	0-20 mA	E0mA20
	4-20 mA	E4mA20
Second setpoint	0-5 V	W0V5
	1-5 V	W1V5
	0-10 V	W0V10
	2-10 V	W2V10
	0-20 mA	W0mA20
	4-20 mA	W4mA20

Load unbalance detection	Code
Detection circuit disabled	000
Detection circuit enabled, relay switch open in alarm state	PLU
Detection circuit enabled, relay switch closed in alarm state	IPU

Options	Code
PLF alarm relay switch closed in alarm state	IPF
Fuse blown indication micro-switch	FUMS
Without internal fuses	NOFUSE

Simplified or complete coding

Coding can be performed with a **complete code** (all fields) or with a **simplified code** in which **only** the following are specified:

- the nominal current,
- the line voltage,
- the auxiliary power supply,
- the calibration voltage (tension d'utilisation),
- the options.

With a **simplified code,** the **TC3001** thyristor unit is supplied **configured** as shown below:

• Input signal	4 - 20 mA
• Thyristor firing mode	Phase angle
• Ramp, soft start / end	Without ramp or soft start / end
• Load connection	Star without neutral (3 wires)
• Load type	Inductive
• Partial load failure detection	According to standard curve Alarm relay switch open in alarm state
• Controlled parameter	Squared load voltage
• Current limit mode	Reduction in the thyristor firing angle, current limit adjustment using potentiometer on front panel
• Retransmission	Controlled parameter
• Load unbalance detection	Detection circuit enabled, alarm relay switch open in alarm state.

Coding example

Thyristor unit and installation parameters

Nominal load current	**120 amperes**
Nominal supply voltage	**440 volts (line-to-line)**
Auxiliary power supply	**220** to **240 volts**
Calibration voltage	Installation at **380 volts**
Input signal	**0 - 10 volts**
Firing mode	**8 period** burst firing with soft **start**
Connected loads	**Resistive**
Connection type	**Star without neutral**
Controlled parameter	Power
Current limit	Adjustment using potentiometer on front panel
Auxiliary retransmission output	**Controlled parameter**
Load unbalance detection	Detection circuit **enabled** relay switch open in alarm state
Option	Fuse blown indication **micro-switch**

Coding:

TC3001/150A/440V/220V240/380/0V10/FC8/URP/3S/RES/SD/W/LINT/RTR/PLU/FUMS/00

Attention !

The TC3001 thyristor unit operating voltage must be as close as possible to the supply voltage to prevent problems of non-operation in the event of a voltage drop less than 70 % of the nominal voltage (after calibration).
The **calibration** voltage (the operating voltage) is considered as the **nominal voltage** of the thyristor unit.

SERIAL NUMBER LABELS

Two **identification** labels (specifying the **coding** of the thyristor unit) and a **configuration** label provide all the information relating to the factory settings of the thyristor unit.

An identification label is **externally** located on the right-hand side panel of the unit.

EI **EUROTHERM** 2.20
WORTHING, ENGLAND : 903-268500
MODEL: TC3001/150A/440V/220V240/380/0V10/FC8/URP/3S/RES/SD/W/
LINT/RTR/PLU/FUMS/00

SERIAL No.: LC1111/001/001/12/95

RANGE / 3-PHASE 150 A 440 V 40-70 Hz
AUXILIARY POWER SUPPLY : 220-240 V
CALIBRATION VOLTAGE : 380 V

Figure 1-3 Example of identification label for a TC3001 thyristor unit
The information corresponds to the coding example

The second identification label and a configuration label are located **inside** the thyristor unit.

SERIAL No.: LC1111/001/001/12/95 TC3001

FACTORY SETTINGS:

INPUT: 0-10 V FIRING: 8 PERIODS BURST FIRING
CONFIGURATION: STAR WITHOUT NEUTRAL / RESISTIVE LOAD / STD PLF
FEEDBACK PARAMETER: FEEDBACK V x I
CURRENT LIMIT: LIMIT I USING POTENTIOMETER
AUX. INPUT / OUTPUT: RETRANSMISSION V x I
UNDER-VOLTAGE DETECTION THRESHOLD: 70%
LOAD UNBALANCE DETECTION: ENABLED
ANY NON-SPECIFIED FUSE INVALIDATES GUARANTEE
(SEE USER MANUAL): FERRAZ X300055 : BUSSMANN 170M3465

Figure 1-4 Example of configuration label for a TC3001 thyristor unit

Attention !

Following any reconfiguration on the part of the user, there is no guarantee that the thyristor unit and this information correspond to the unit coding.

Chapter 2

INSTALLATION

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Chapter 2 INSTALLATION

SAFETY DURING INSTALLATION

Danger !

TC3001 units must be installed by a person qualified and authorised to work in an industrial low voltage electrical environment.

Units must be installed in correctly fan-cooled electric cabinets, guaranteeing the absence of condensation and pollution.
The cabinet must be closed and connected to the safety ground in accordance with the standard IEC 364 or the current national standards.

For installations in fan-cooled cabinets, it is recommended to place a fan failure detection device or a thermal safety control in the cabinet.

Bulkhead mountings are possible with **TC3001** series units.

The units must be mounted with the heatsink positioned vertically and with no obstructions either above or below which could block the passage of the ventilation air.

If multiple units are installed in the same cabinet, they should be arranged in such a way that the air expelled by one unit cannot be admitted into the unit located above it.

Attention !

The units are designed to be used at an ambient temperature less than or equal to **50°C** (40°C for 500 A nominal units).

Leave a minimum space of **5 cm** between two units placed beside each other.

Excessive overheating may cause incorrect operation of the unit, which in turn may cause damage in the components.

TC3001 series power units have **permanent** fan cooling from **100 A** nominal.

DIMENSIONS

The overall dimensions of TC3001 thyristor units are given in figure 2-1.

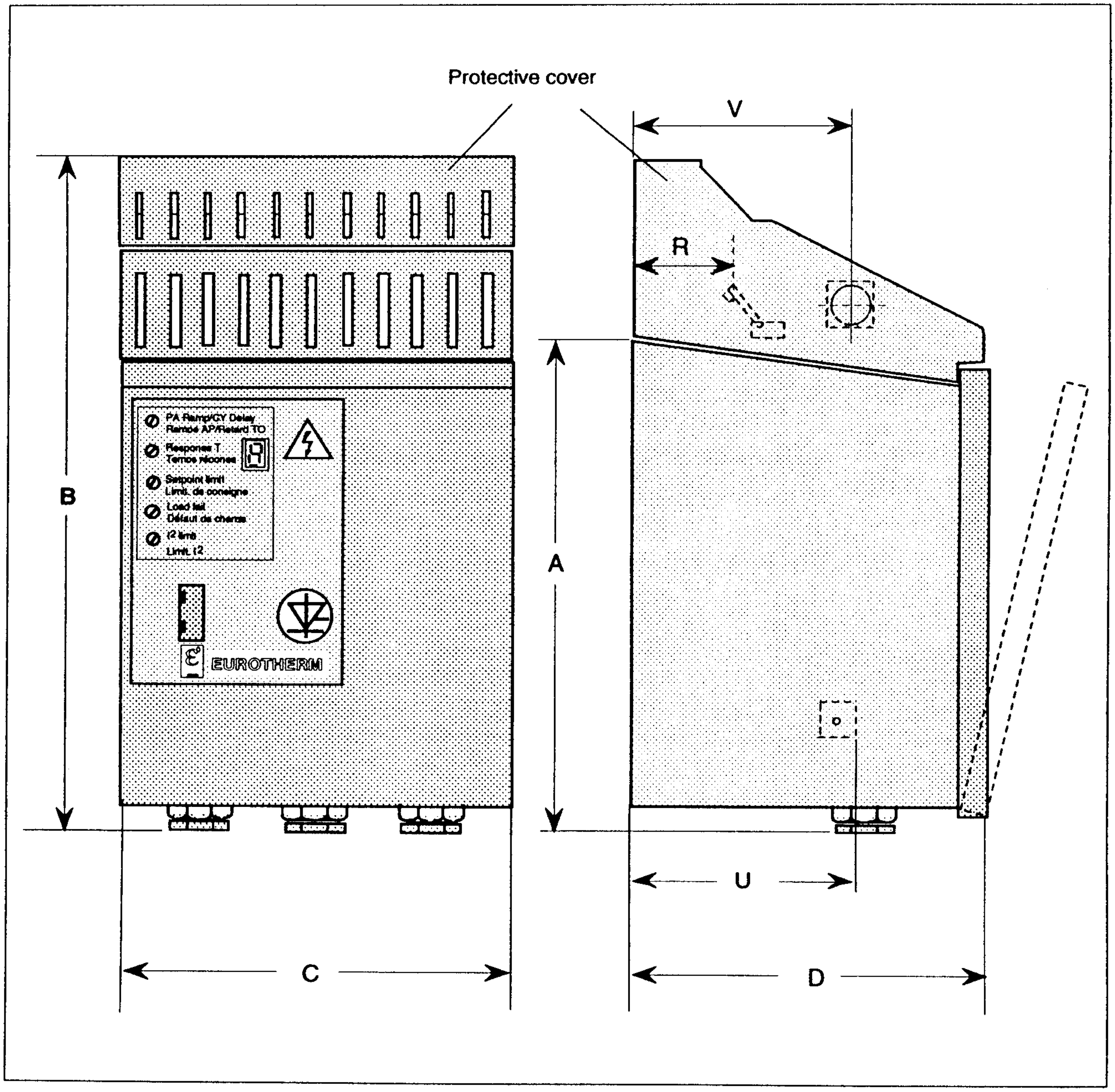

Figure 2-1 TC3001 thyristor unit values

The dimensions and weights of the TC3001 thyristor unit are given in tables 2-1 and 2-2.

Values (fig.2-1)	Dimensions (mm) Nominal thyristor unit current			Description
	25 to 150A	250A	300 to 500 A	
A	425	425	425	Height without protective cover
B	480	480	570	Height with protective cover
C	248	248	373	Width
D	268	268	268	Depth (with door open: 537 mm)
R	50	50	20	Distance between 'Earth' busbar and panel
U	150	125	150	Depth between 'LOAD' terminal and panel
V	145	145	170	Depth between 'LINE' terminal and panel

Table 2-1 TC3001 thyristor unit dimensions

Nominal thyristor unit current	25 to 150 A	250 A	300 to 500 A
Weight (kg)	16	18	21

Table 2-2 TC3001 thyristor unit weights

INSTALLATION DETAILS

TC 3001 series units are designed to be mounted directly on panels at the fixing points located on the rear of the unit.
TC 3001 thyristor units are equipped with two protective covers (upper and lower).

The thyristor units can be fixed with their protective covers in place.
However, for configurqtion, the upper protective cover must be removed.
In order to do this, open the door by unfastening the front screw located at the top left of the door. Then raise the door in order to release it from its notches and open it completely by pulling it towards you.

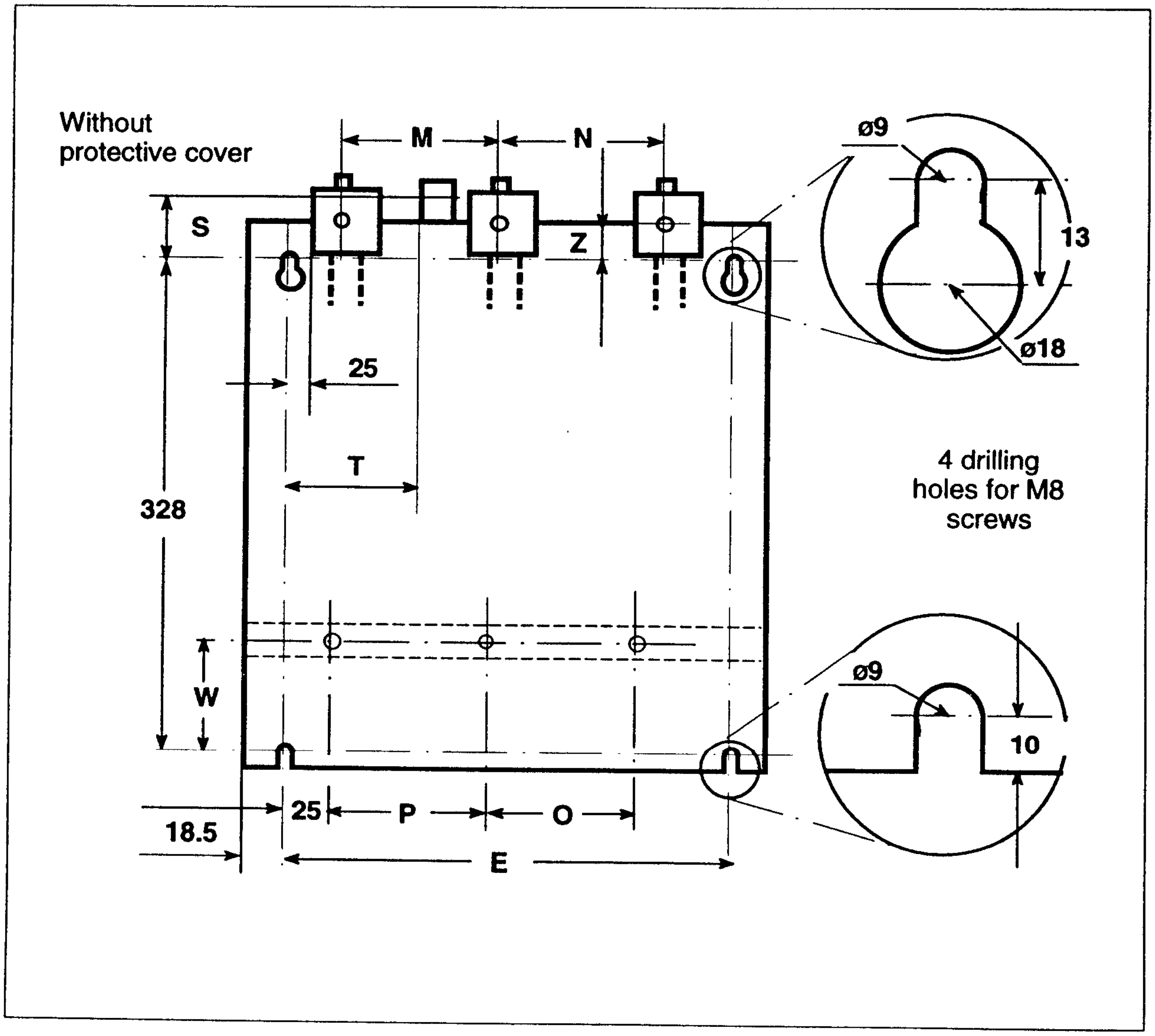

Figure 2-2 Fixing details

Values fig.2-2	Dimensions (mm) Nominal current 25A to 150A	250A	300A to 500A	Description
E	203	203	308	Width between the fixing holes
M and N	75	75	112	Distance between the 'LINE' terminals
O and P	75	75	112	Distance between the 'LOAD' terminals
S	60	60	30	'Earth" busbar and top fixing hole
T	65	65	220	'Earth' busbar and left fixing hole
W	70	85	70	'LOAD' terminal and bottom fixing hole
Z	40	50	30	'LINE' fuse and top fixing hole

Table 2-3 Fixing values

After drilling the support panel at the dimensions and values given above, insert the fixing screws half-way into the partition or mounting plate holes.

Position the **TC3001** unit by first of all inserting the upper screws in the respective holes of the upper section.

Lower the thyristor unit making sure that it is positioned correctly at the level of the lower screws.

Then lower the thyristor unit completely until it is in place.
Fasten the **4 screws** correctly.

Chapter 3

CABLING

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Chapter 3 CABLING

SAFETY DURING CABLING

Danger !

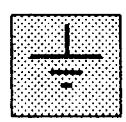
Cabling must be performed by personnel who are qualified to work with low voltage electrical equipment.
It is the user's responsibility to cable and protect the installation in accordance with current professional standards.
A suitable device guaranteeing electrical separation of the equipment and the supply must be installed upstream from the unit in order to perform the operation in complete safety.

TC3001 series units possess **two protective covers**: upper and lower.
The upper cover should be raised to facilitate cabling.
After connection and before power-up, put the upper protective cover back in place to ensure the specified **degree of protection**.

Danger !

Before any connection or disconnection, make sure that the power and control cables and wires are isolated from the voltage sources.
For safety reasons, the safety earth cable must be connected before any other connection during cabling and the last cable to be disconnected.

The **safety earth** is connected to the screw located on the strip provided for this purpose in the top part of the unit, behind the phase terminal and labelled as follows:



Attention !

To ensure the correct grounding of the TC3001 unit, make sure that the fixing is on the **reference ground surface** (panel or bulkhead).
Failing this, it is necessary to add a ground connection at **most 10 cm** long between the earth connection and the reference ground surface.

Danger !

This connection which is intended to ensure good **grond conductivity**, **can never** be used to **replace** the **safety earth** connection.

The power terminal capacities are given in table 3-1.

The **tightening torques** must observe the limit values in the same table.

Nominal current	**25 A to 150 A**	**250 A**	**300 A to 500 A**
Supply and load cables Safety earth cable	4 to 70 mm^2 14 to 35 mm^2	120 mm^2 64 mm^2	185 to 2x150 mm^2 95 to 185 mm^2
Fuse terminals Tightening torque	M8 12.5 N.m	M8 12.5 N.m	M10 25 N.m
Load screw Tightening torque	M10 25 N.m	M10 25 N.m	M12 28.8 N.m
Cable sheath passage diameter	20 mm	34 mm	38 mm

Table 3- 1 TC3001 thyristor unit power cabling details

The cross-section of the connection wires to be used must comply with the Standard **IEC 943**.

The power cables to the load should pass through **cable sheaths**.
These must be **tightened** as much as possible after the passage of the cables.

The cable sheath **passage** diameter is given in table 3-1.

Important !

For loads composed of 3 primary transformer coils, the coil **configuration direction** must be observed.

POWER WIRING DIAGRAMS

The TC3001 power wiring diagram depends on the load configuration.

Four **power** and **safety earth** wiring diagrams are given below for the different types of load configuration.

Star without neutral configuration

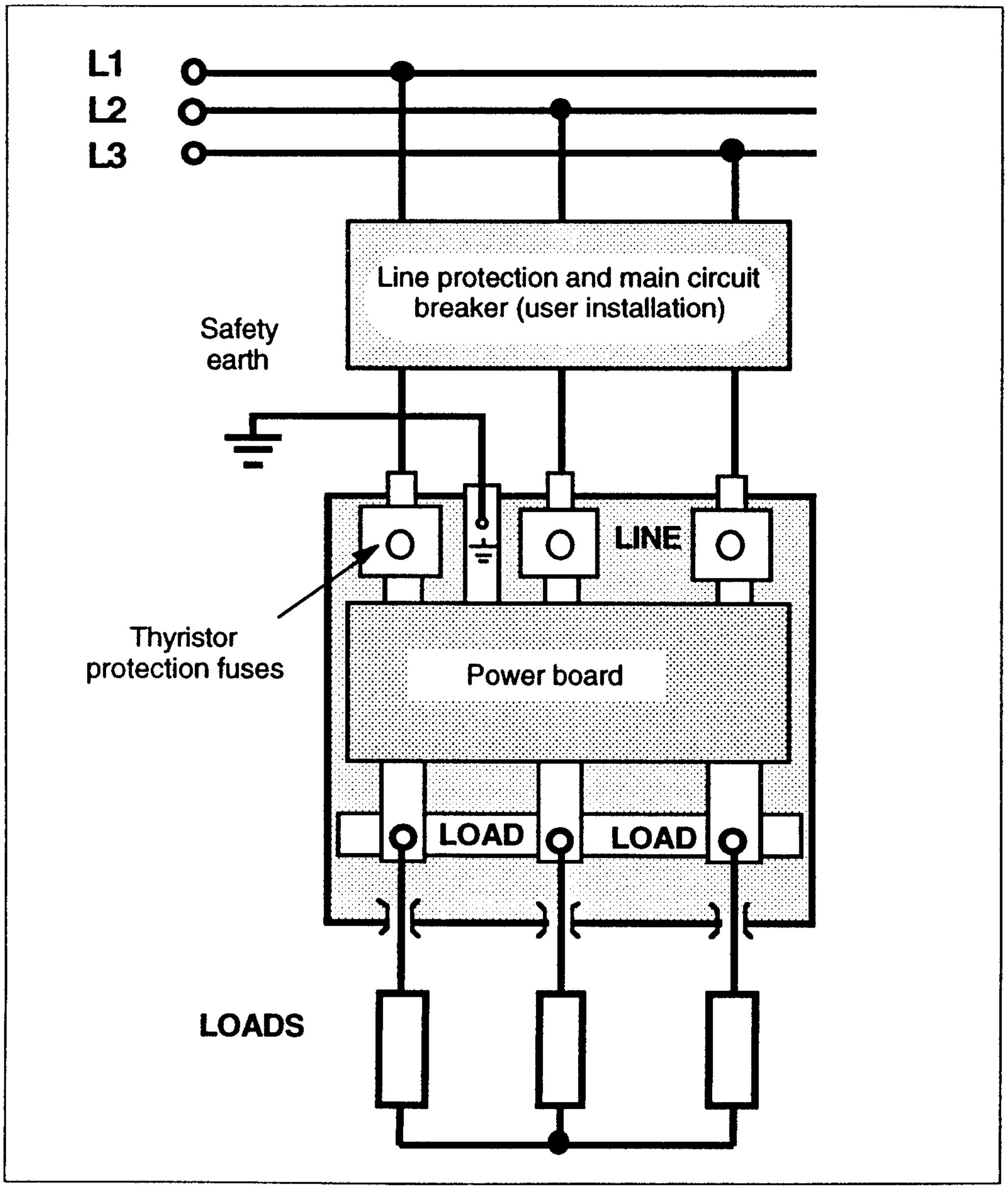


Figure 3-1 Power and safety earth wiring diagram for a load connected in 'Star without neutral' (3 wires)

Star with neutral configuration

If the load is wired in 'Star with Neutral' (4 wires), **the neutral must also be connected** to the neutral terminal block (terminal **71**) below the thyristor unit.

In the 'Phase angle' firing mode, the neutral current contains the sum of the 3rd harmonics of each phase. For small firing angles (less than 60°), the current passing in the neutral of the loads can be up to **2 times greater** than the line current.

Attention !

This current requires an adapted design of the neutral cable, especially for loads with a high current requirement at start-up.

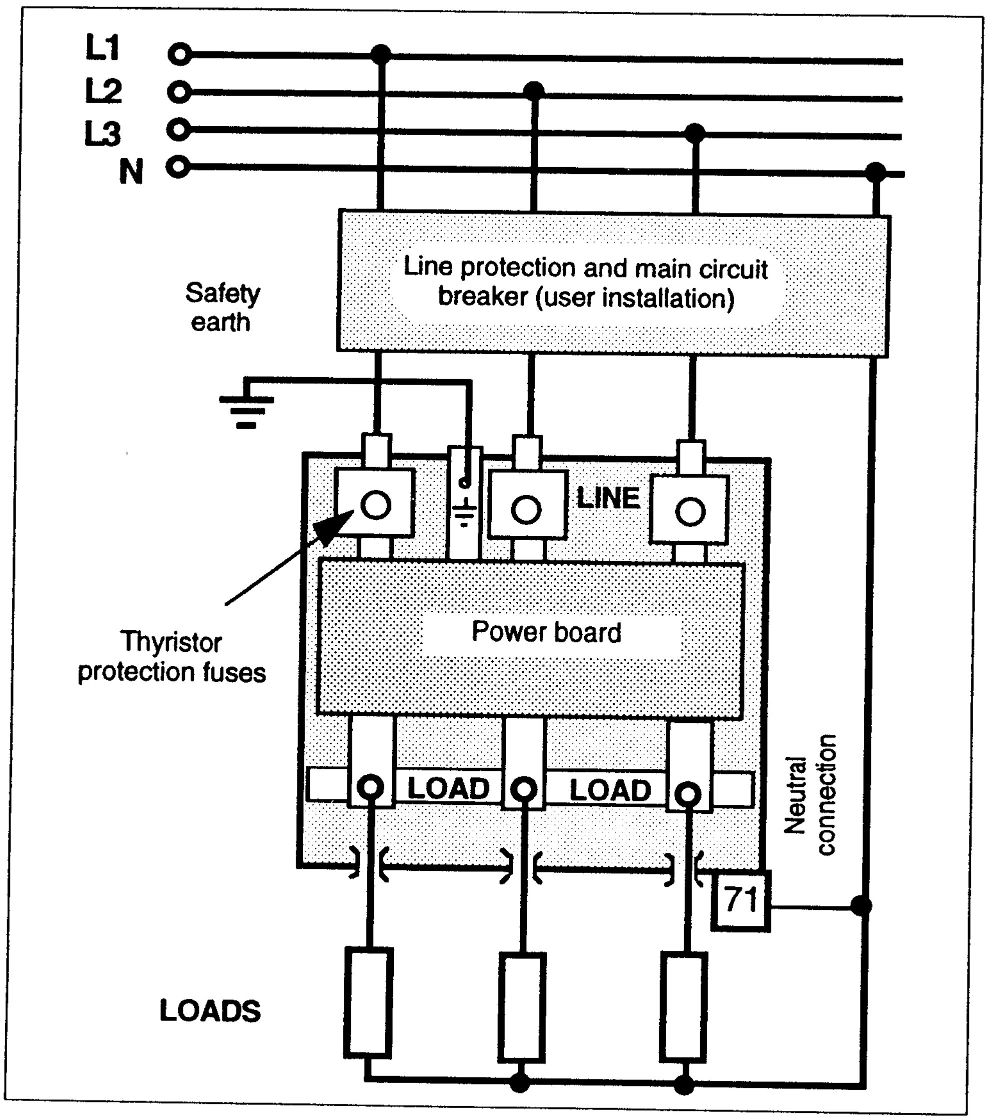


Figure 3-2 Power, safety earth and neutral wiring diagram for a load connected in 'Star with neutral' (4 wires)

Closed delta configuration

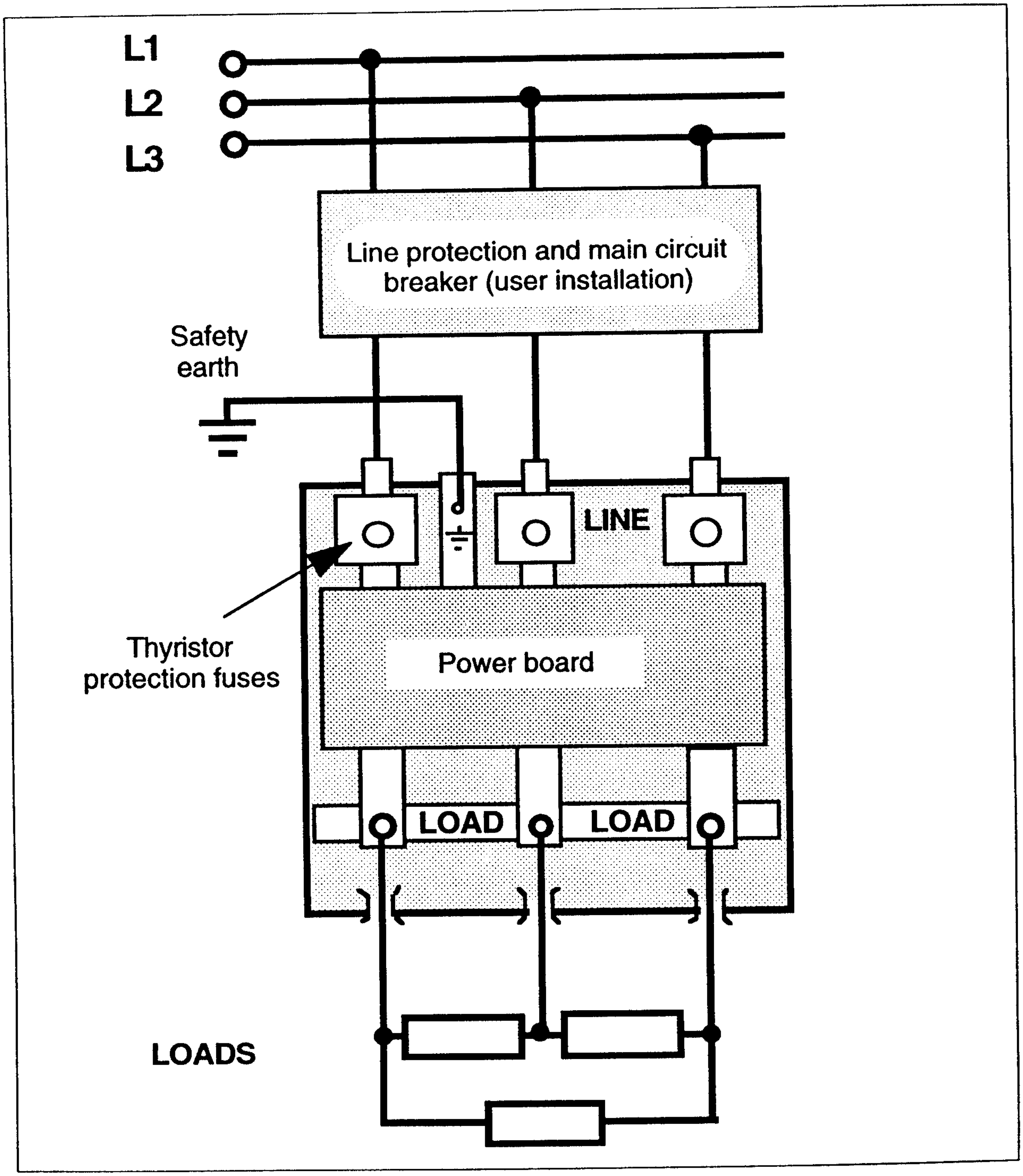


Figure 3-3 Power and safety earth wiring diagram for a load connected in 'Closed delta' (3 wires)

Open delta configuration

Important !
The load wiring diagram given below must be observed.

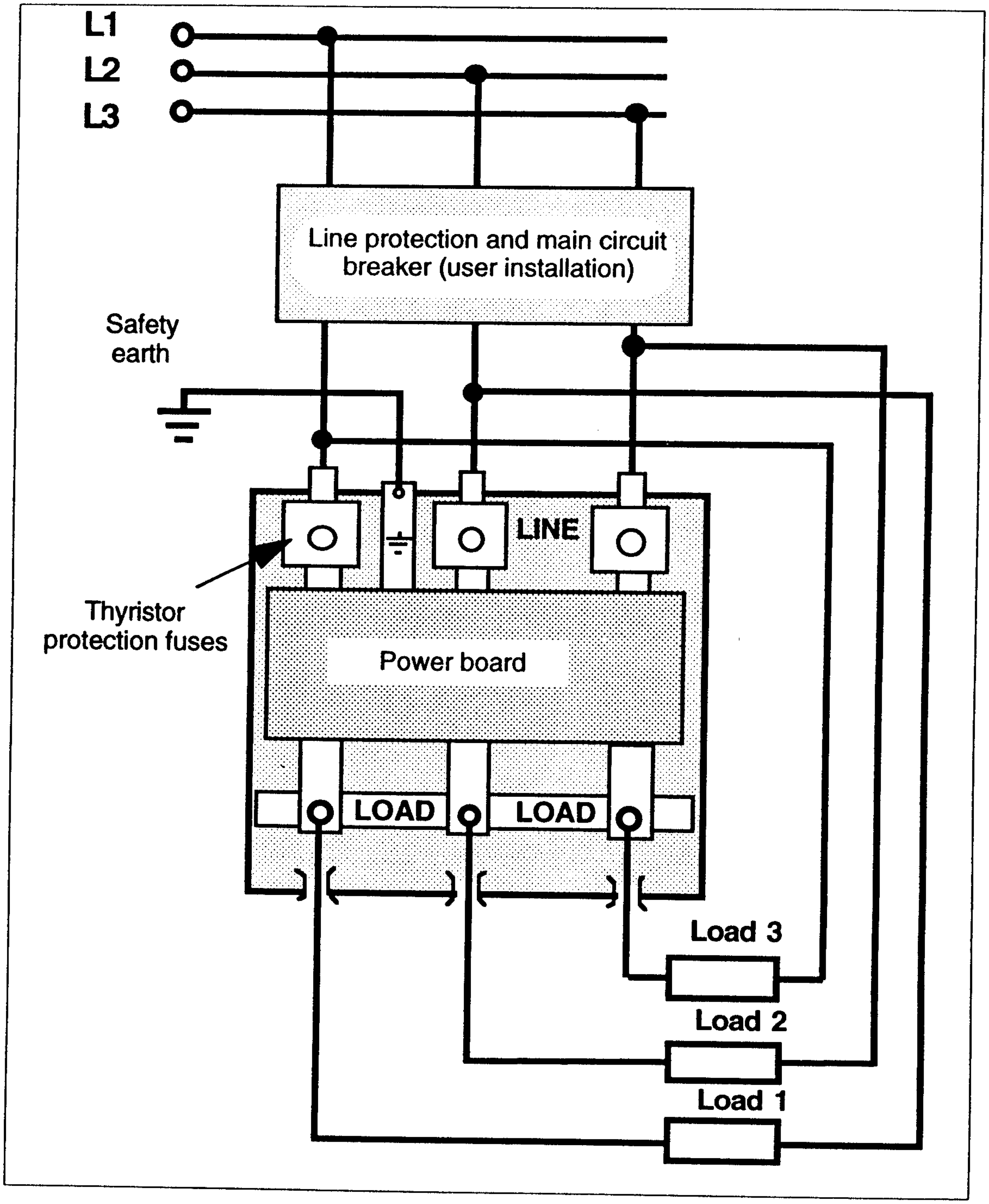


Figure 3-4 Power and safety earth wiring diagram for a load connected in 'Open delta' (6 wires)

USER TERMINAL BLOCKS

General introduction

The user terminal blocks, located below the TC3001 thyristor units, are intended for the following connections:

- the auxiliary power supply,
- the reference neutral (for Star with neutral configuration),
- the alarm relay switches.

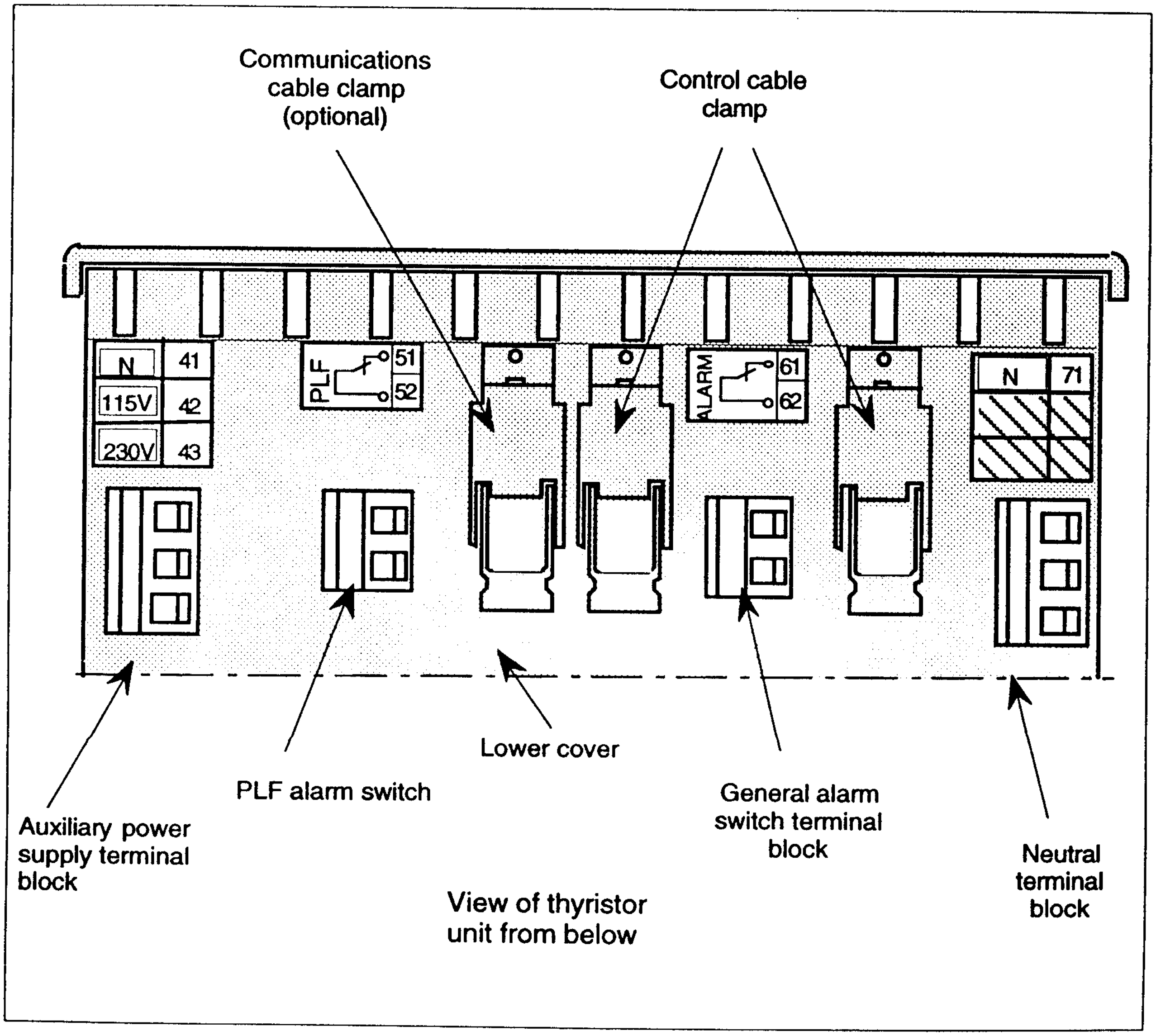


Figure 3-5 User terminal blocks

Terminal numbers	Destination
	Auxiliary power supply:
41	Neutral
42	115 V (single-phase supply)
43	230 V (single-phase or three-phase-line-to-line supplies)
	Partial load failure detection relay switch:
51	Switch open in alarm state (**standard**)
52	Switch closed in alarm state (**IPF option**)
	General alarm and partial load unbalance detection relay switch:
61	Switch open in alarm state (**PLU option**)
62	Switch closed in alarm state (**IPU option**)
71	Reference neutral (only in 'Star with neutral' load configuration).

Table 3-2 Destination of user terminal block terminals

The max. cross-section of the low level wires and cables is **1.5 mm^2**.

Tightening: **0.5 N.m.**

Auxiliary power supply

The 'Auxiliary power supply' user terminal block supplies power to the electronics (for units from **100 A**) and the fans.
The terminal block is located to the left below the thyristor unit.
The electronics earth is connected (inside the thyristor unit) with the earth of the power section.

The auxiliary power supply neutral wire is connected to terminal **41**.

The auxiliary power supply must be connected to a **115V** single-phase supply or to a **230V** single-phase or three-phase supply (line-to-line).

Terminal **42** is used if the auxiliary power supply voltage is **115V** (auxiliary power supply codes **100V** to **120V**).

Terminal **43** of the user terminal block is used if the auxiliary power supply voltage is **230V** (auxiliary power supply codes **200V** to **240V**).

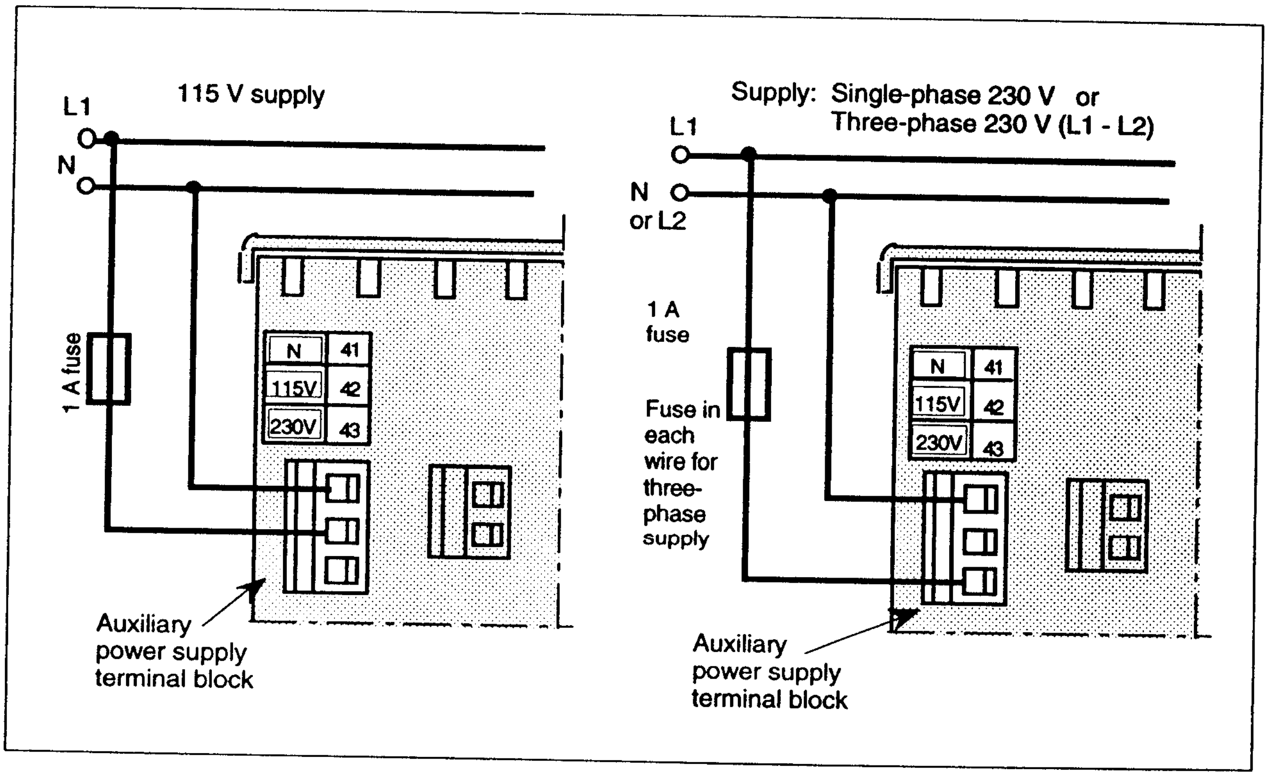


Figure 3-6 Auxiliary power supply configuration

Attention !

Each wire to a supply phase must be protected with a 1 A fuse.

Reference neutral

The reference neutral is connected to terminal **71** located on the neutral terminal block to the right below the thyristor unit (see figure 3-5).

Attention !

This connection is only made for the star with neutral load configuration.

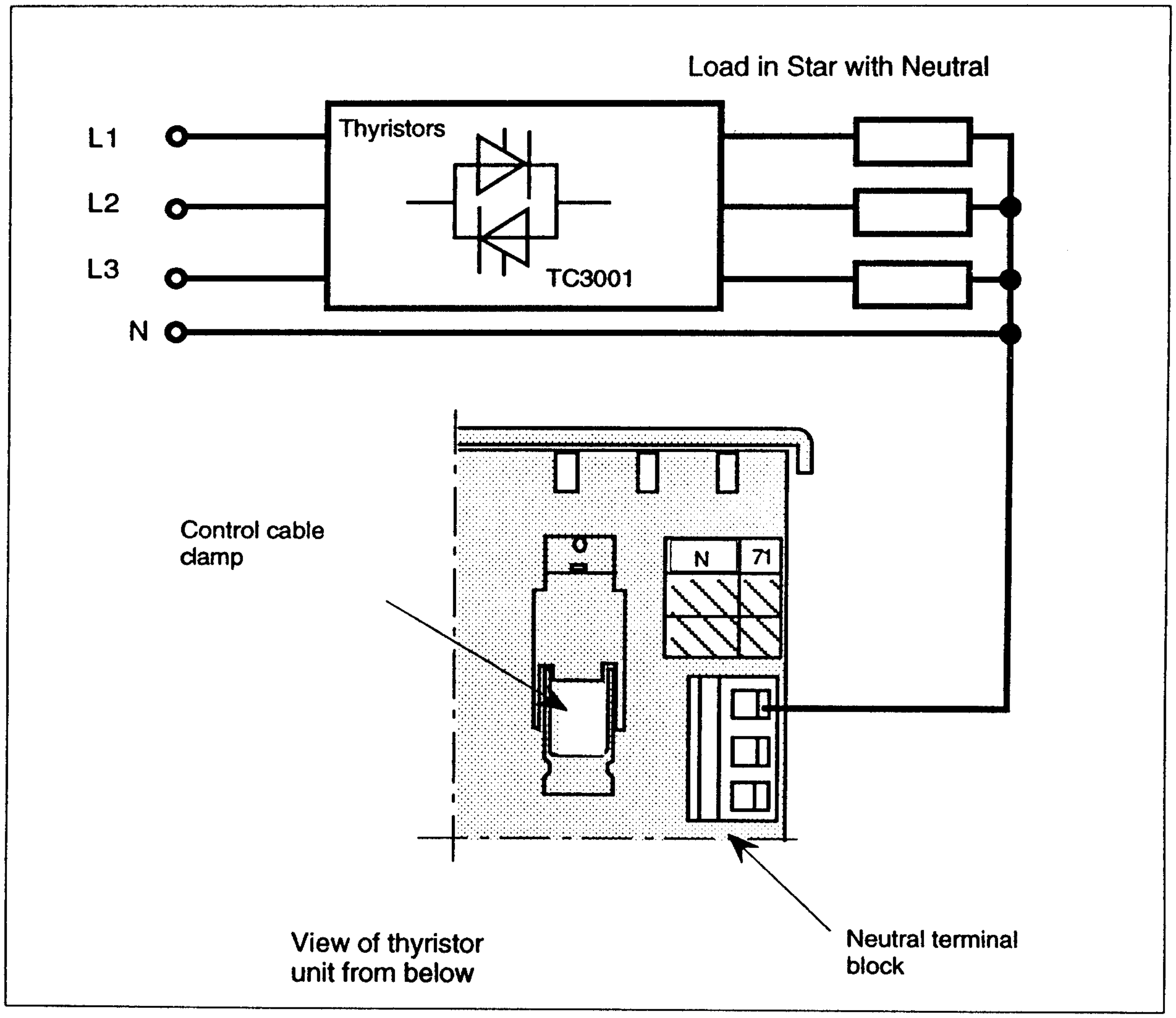


Figure 3-7 Neutral configuration

In the event of a neutral connection failure (incorrect electrical connection, blow-out of **F1** fuse on the power board, etc.), an **artificial power failure** is created in order to **stop** the thyristor unit operation, since the feedback system receives an incorrect feedback signal.

This failure is signalled with the message **'F' 'P'** on the front panel display.

Alarm switches

The TC3001 thyristor units are equipped with 2 alarm relays:

- general alarm detection (see 'Alarms' chapter) and partial load unbalance alarm,
- partial load failure detection (**PLF** alarm).

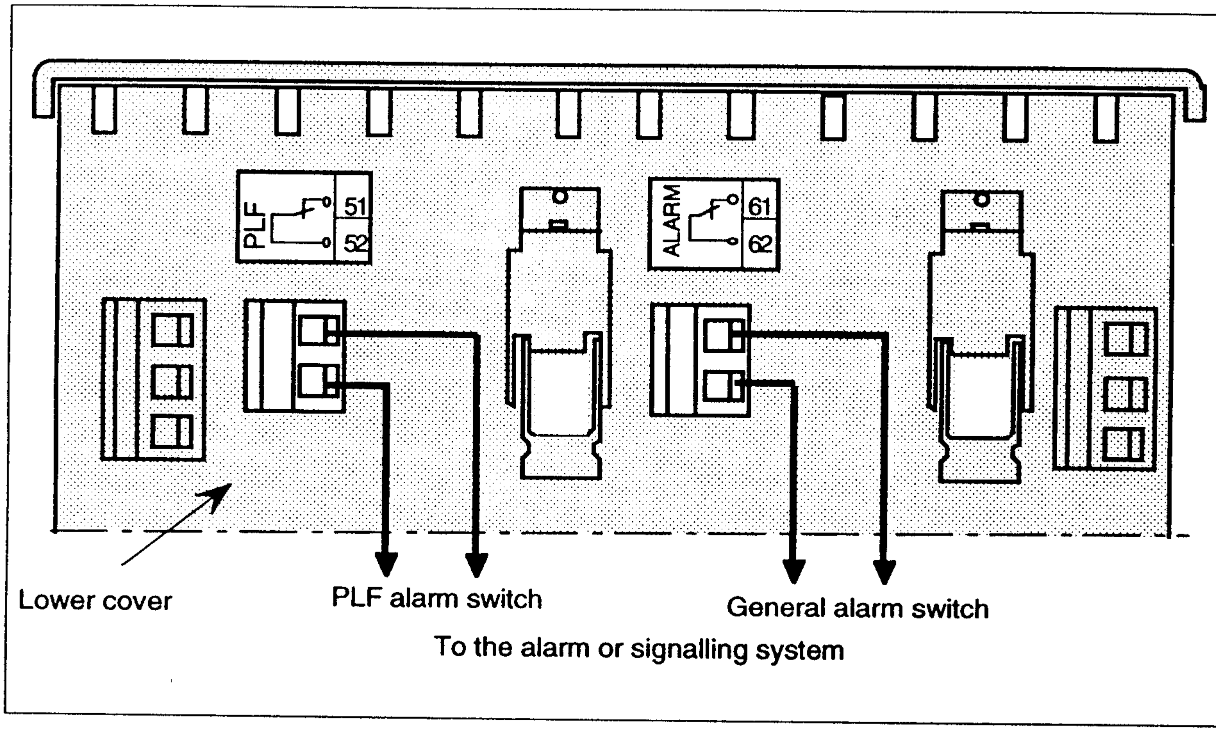


Figure 3-8 General alarm and PLF switch connection (view from below)

The alarm relay switch outputs are provided on the user terminal blocks below the thyristor unit and are available without opening the front door.

Important

The relay switches are protected against interference by internal RC snubbers.

The type of switches specifying the alarm state is determined by the thyristor unit coding.

Alarm type	Terminals	Switch type	Coding
PLF alarm	51, 52	N/O open in alarm state	Standard
		N/C closed in alarm state	IPF
General alarms	61, 62	N/O open in alarm state	PLU
		N/C closed in alarm state	IPU

Table 3-3 Destination of alarm switch terminals

CONTROL CABLES

Attention !

The control connections must be made with **shielded cables connected to the earth at both ends** in order to ensure satisfactory immunity against interference.

Separate the control cables from the power cables in the cable routes.

Fixing

The control wires must be grouped together in a shielded cable passing through the **cable clamp** under the unit.

To facilitate the safety earthing of the cable shield and to ensure maximum immunity to electromagnetic interference, the metal cable clamps are fixed directly to the ground of the TC3001 thyristor unit.

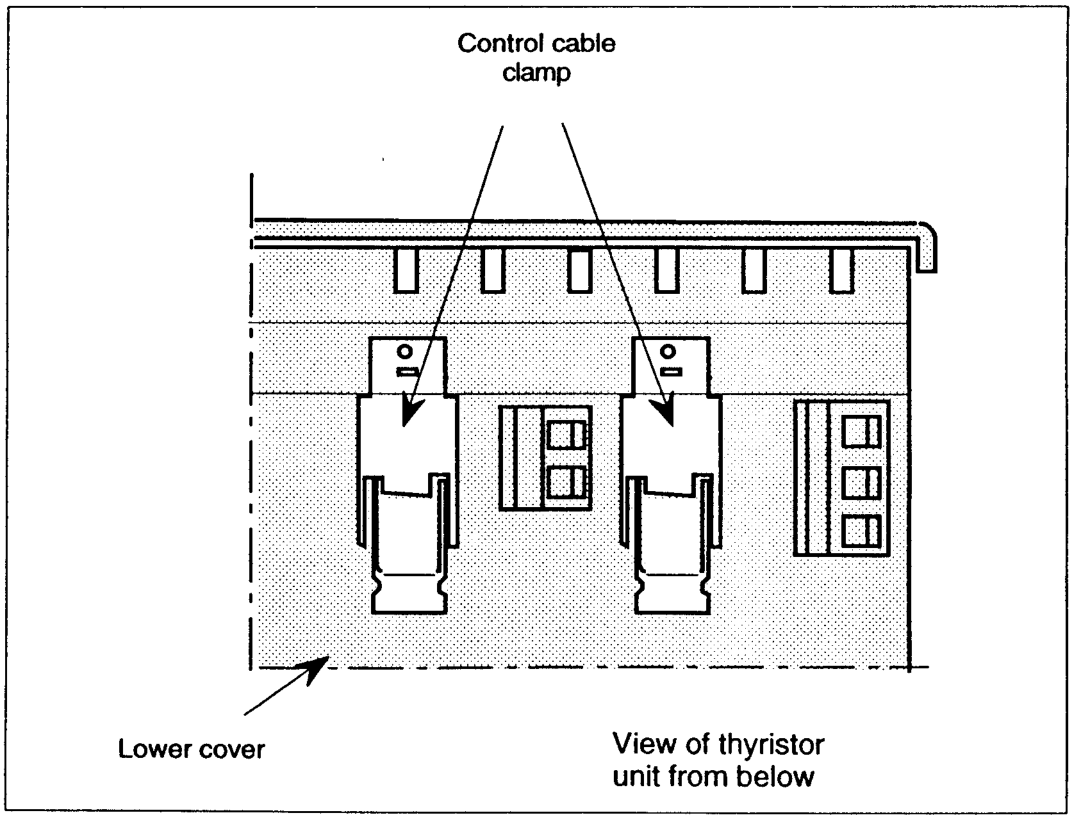


Figure 3-9 Control cable fixing

Connection of the shield to the ground

- **Strip** the shielded cable as shown in figure 3-10,a.

The control wires must be long enough for the connection between the metal cable clamp and the driver board user terminal blocks, with the door open.
The cabling inside the unit must be as short as possible.

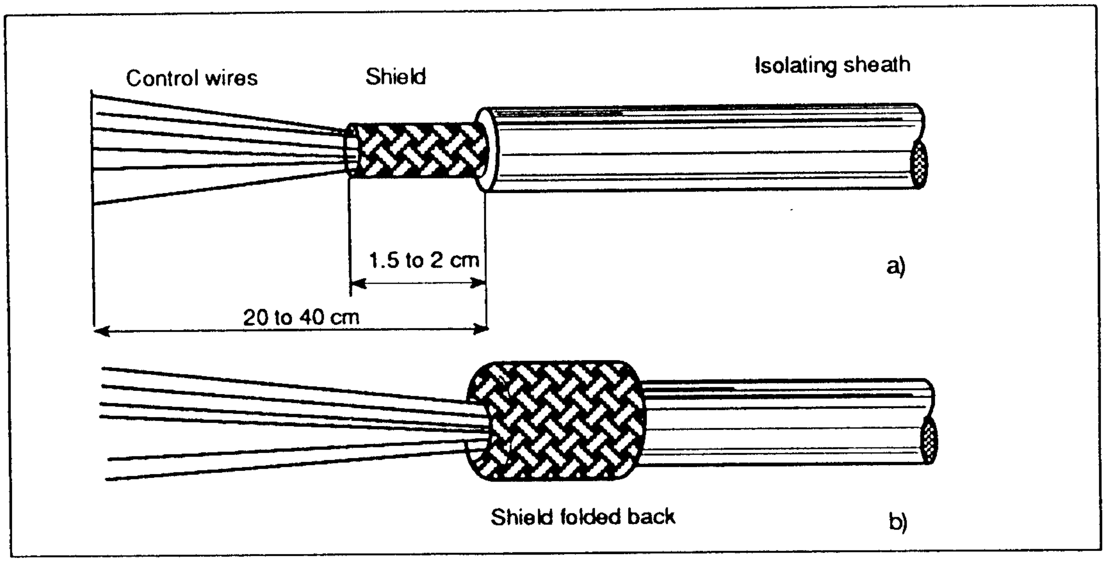


Figure 3-10 Control cable stripping

- **Fold back** the shield on the isolating sheath (figure 3-10,b)
- **Insert** the cable in the metal cable clamp so that the shield is located in the stirrup and does not enter the unit (it must not pass the lower cover).
- **Tighten** the stirrup (**4 x 1** flat screwdriver; tightening: **0.7 N.m.**).

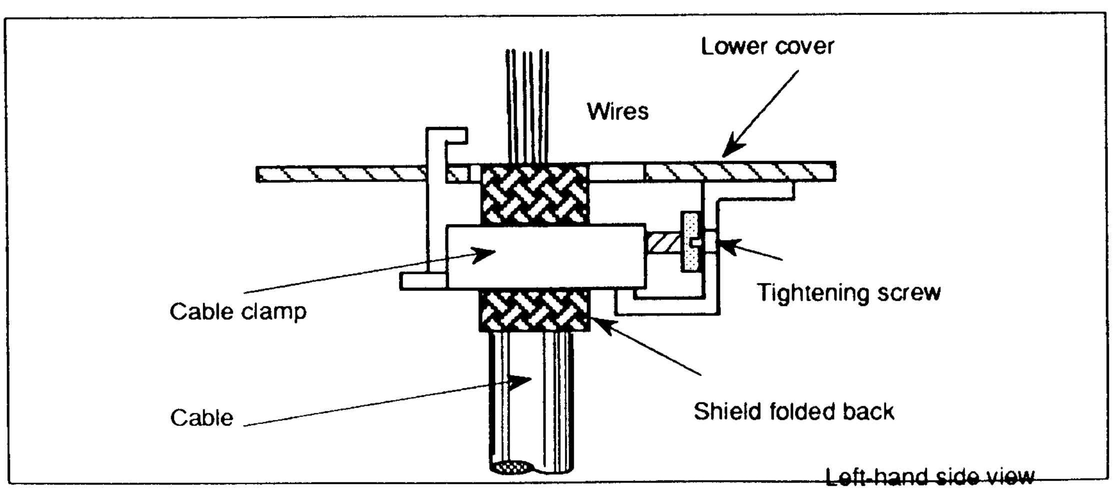


Figure 3-11 Cable tightening and shield grounding

The possible cable **diameters** with the shield folded back are **5 to 10 mm** per cable clamp.

CONTROL TERMINAL BLOCKS

The control wires are configured on the **driver board** for:

- the control setpoint connection
- the retransmissions of the following indications
  - voltage,
  - currents,
  - controlled parameter,
  - alarms.

Attention !

For electromagnetic compatibility reasons, the configuration must be made with cables and wires which are shielded and earthed (or grounded) at both ends.

Control terminal tightening: **0.5 N.m.**

The driver board terminal blocks can be accessed with **the front door open.**
To open the door, unfasten the front **screw**, release the door from its notches by raising it and pull it towards you.

Danger !

With the door open, dangerous live parts may be accessible if the TC3001 thyristor unit is switched on.

General introduction

Two user terminal blocks are located in the top right corner of the driver board.

The '**Retransmission**' terminal block labelled **H13** on the board contains **5** terminals labelled **01 to 05**.
The '**Control**' terminal block (**H12**) contains **7** terminals labelled **11 to 17**.

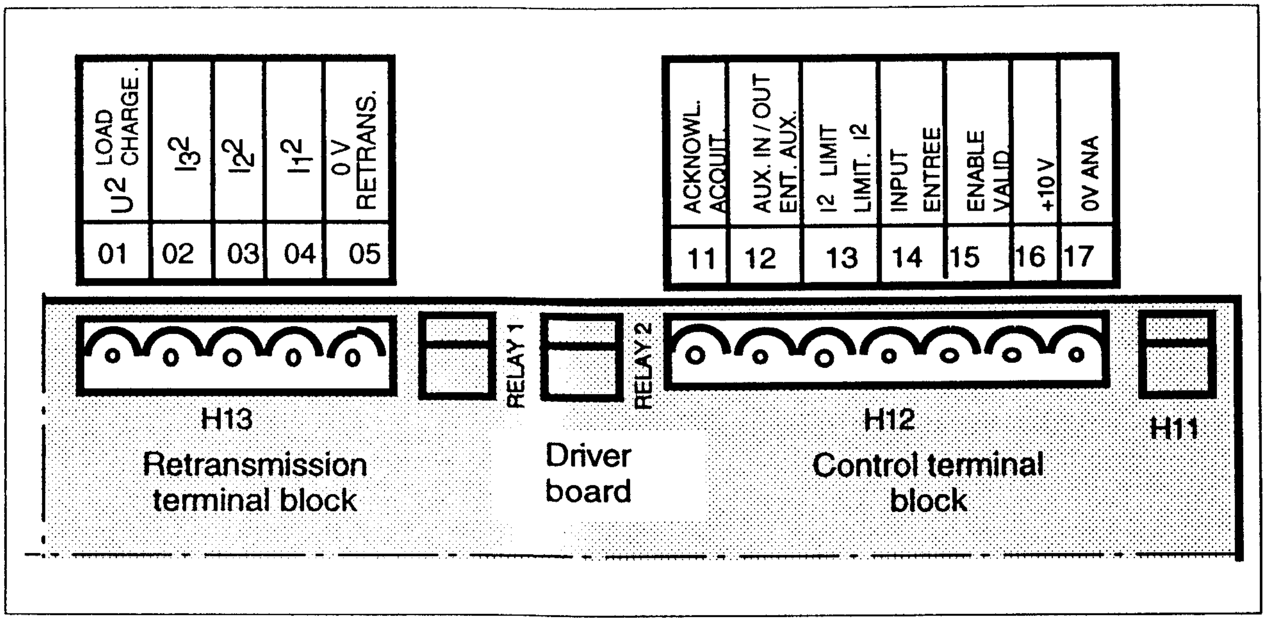


Figure 3-12 Driver board terminal blocks

Terminal	Designation on label	Destination
11	ACKNOWL. / ACQUIT.	Alarm acknowledge
12	AUX. IN/OUT ENT. AUX.	External feedback or retransmission of controlled parameter
13	I^2 LIMIT / LIMIT. I^2	External current limit
14	INPUT / ENTREE	Control input
15	ENABLE / VALID.	Enables thyristor unit operation
16	+10 V	+10 V
17	0 V ANA	0 V of analogue signals

Table 3-4 Control terminal block description

For the correct operation of the thyristor unit, terminal **15** ('**ENABLE**') must be connected to '**+10 V**' available on the same terminal block (terminal **16**).
This connection can be permanent or made via a switch opening under the effect of a safety device used to inhibit the thyristor unit (during the next half-period).

External control

The external control signal (external analogue setpoint) is connected to the control terminal block on the driver board, between terminal **14** ('**INPUT**') and terminal **17** ('**0 V ANA**' - 0 volt of analogue input signals).

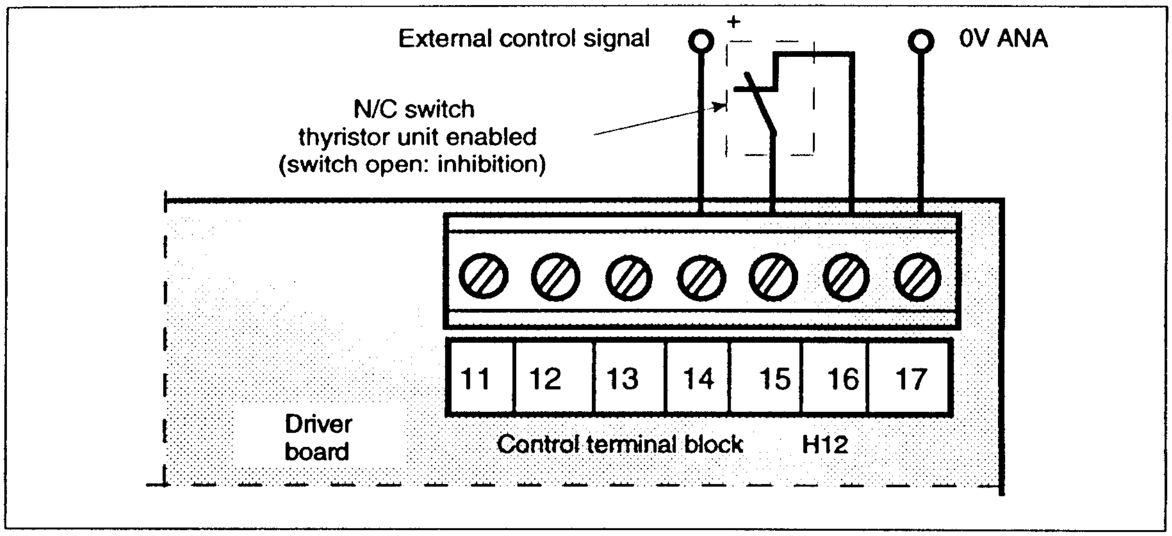


Figure 3-13 External control configuration

Manual control

The thyristor unit can be driven using the manual control.

For operation with the manual control, a **4.7 kΩ** to **10 kΩ** external potentiometer connected between terminals **17** ('**0 V ANA**') and **16** ('**+10 V**') must be used.
The potentiometer wiper is connected to the control terminal block analogue input (terminal **14**).

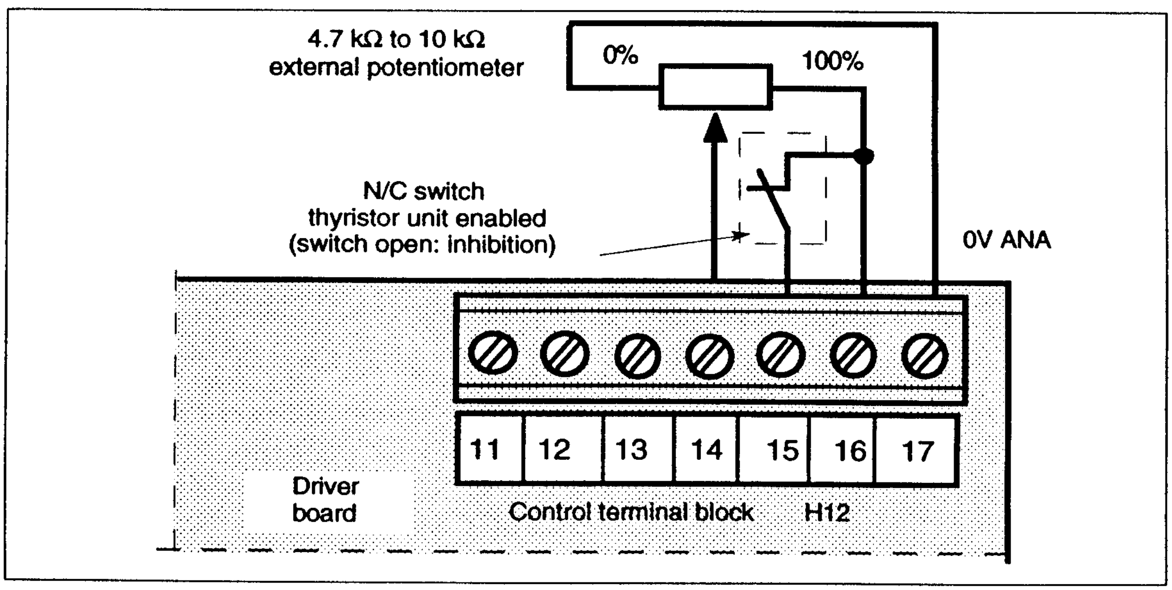


Figure 3-14 Manual control configuration using an external potentiometer

Auxiliary input / output

The auxiliary input / output (terminal **12** - '**AUX. IN/OUT**' on the Control terminal block) is used to send, depending on the configuration:

- the controlled parameter (output)
- the external feedback (input)
- the second analogue setpoint (input).

If retransmission of the controlled parameter has been configured, the internal feedback signal is available between terminals **17** ('**0 V ANA**') and **12** in the form of a DC signal with a scale **0-10V**. This retransmission represents:

- the mean of the squares of the three RMS currents,
- or the RMS voltage of the squared load,
- or the apparent power ($\mathbf{I_{ave.rms}}$ x $\mathbf{V_{rms\ load}}$).

If a feedback on an external measurement is selected, the external feedback signal must be connected between terminals **17** and **12**.
If a low selector type feedback is selected, the **2nd control signal** (second setpoint) must be connected between terminals **12** and **17**.
The TC3001 thyristor unit then controls **the lower** of the 2 control signals.
Terminals **15** and **16** of the control terminal block are connected to enable the thyristor unit.

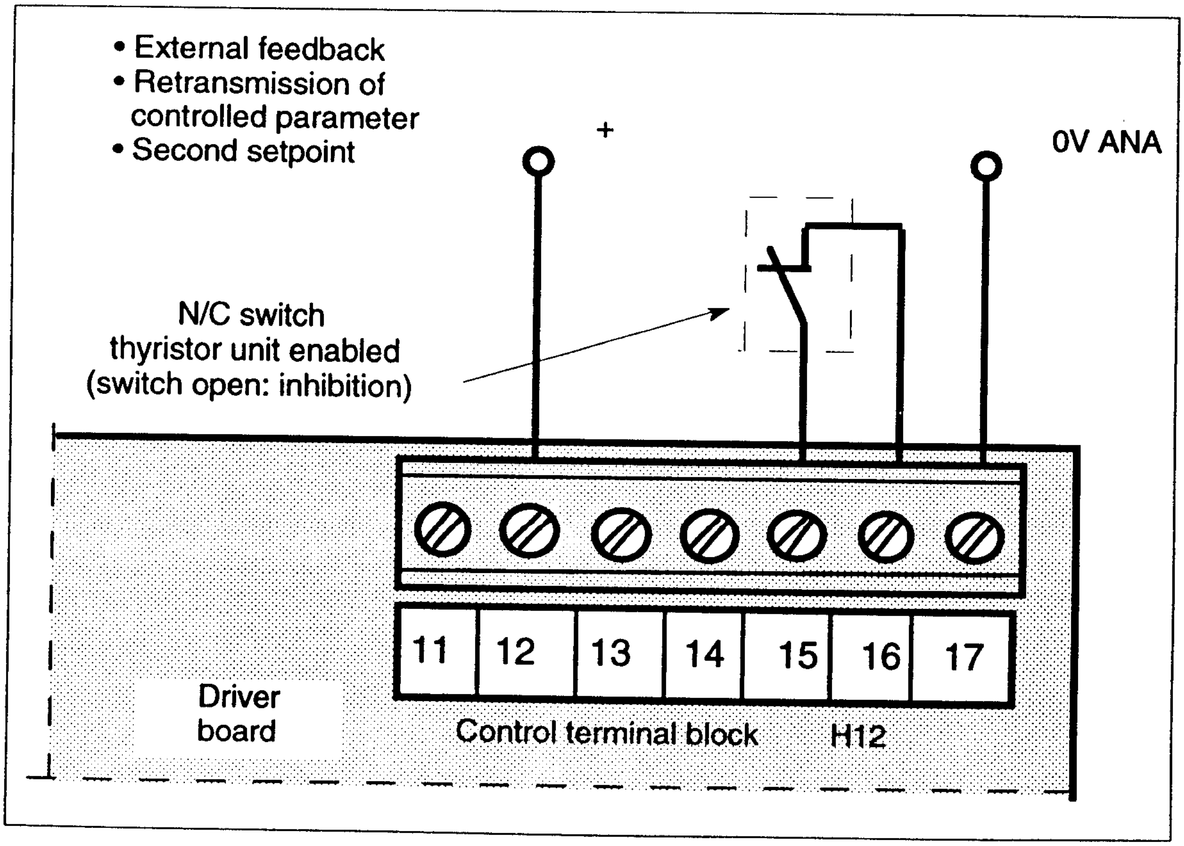


Figure 3-15 Auxiliary signal (input or output) configuration

I² limit

When the **external** signal current limit is configured (see 'Configuration' chapter), this signal must be connected between terminal **17** (**'0 V ANA'**) and terminal **13** (**'I² LIMIT'**) on the control terminal block. In this case, the current limit **potentiometer** on the front panel of the thyristor unit is **in cascade** with the external current limit signal.

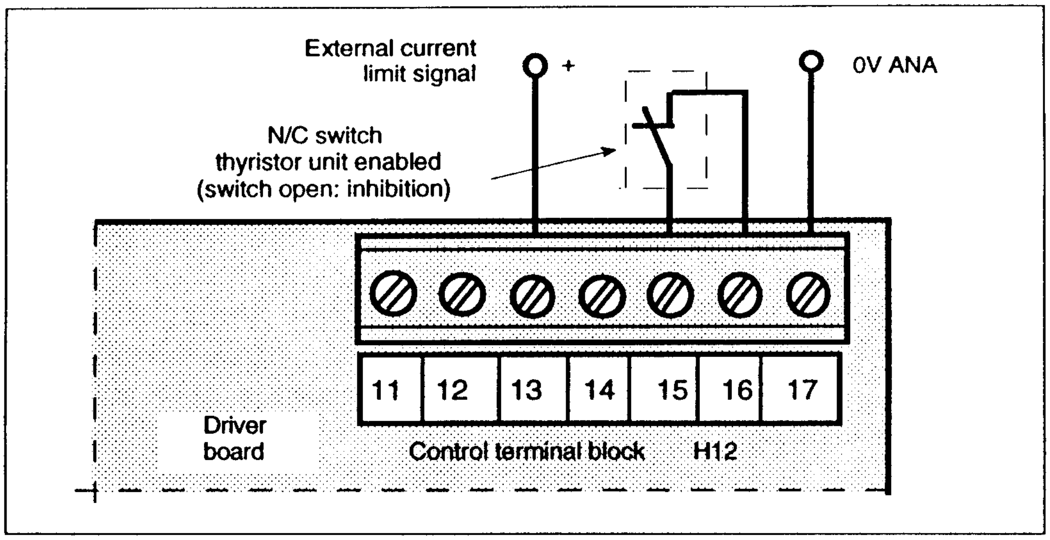


Figure 3-16 External current limit configuration

Alarm acknowledge

After the cause of certain alarms has disappeared (see 'Alarms' chapter), it is necessary to acknowledge the memorised alarm to return to normal thyristor unit operation.

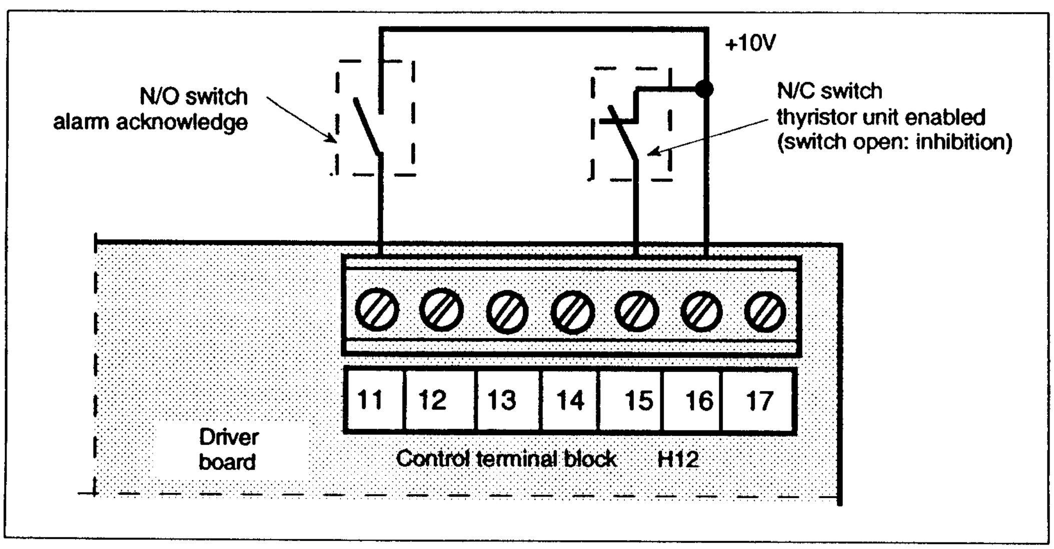


Figure 3-17 Alarm acknowledge

The alarm is acknowledged by connecting terminal **11** (**'ACKNOWL.'**) on the control terminal block to **'+ 10 V'** (terminal **16**) or to the external +10 volts with common 0 V.

RETRANSMISSION SIGNALS

The **TC3001** thyristor unit uses current measurement and load voltage analogue retransmissions and retransmissions of the parameter controlled by the fedback system.

The current and voltage retransmissions represent the **squared measurements** of the **RMS** currents and the **squared measurement** of the **RMS** load voltage.

The retransmissions of the measurements of $\mathbf{I_1^2}$, $\mathbf{I_2^2}$, $\mathbf{I_3^2}$ and $\mathbf{V^2}$ in the form of filtered DC signals (**0 - 10 V**) are output on terminals **01 to 05** of the retransmission terminal block of the driver board (see figure 3-12).

Term.	**Designation on label**	**Destination**
01	V^2 LOAD/CHARGE	Squared RMS load voltage retransmission
02	I_3^2	Phase 3 squared RMS current retransmission
03	I_2^2	Phase 2 squared RMS current retransmission
04	I_1^2	Phase 1 squared RMS current retransmission
05	0 V RETRANS.	Retransmission signal common 0 V

Table 3-5 Retransmission terminal block description (driver board)

Since the filtering time constant of these signals is **270 ms**, these signals follow the thyristor power modulation as soon as the firing time selected in 'Burst firing' mode is greater than **20 ms**.

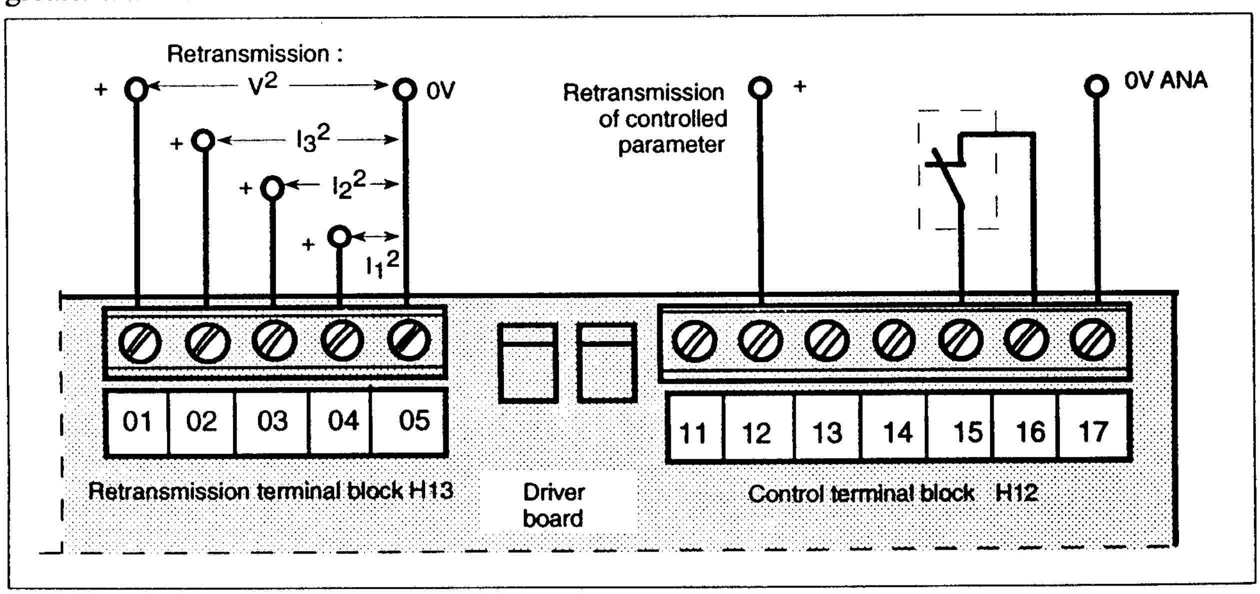


Figure 3-18 Retransmission signal configuration

If the retransmission **of the controlled parameter** is selected with the jumpers (see 'Configuration'), the '**AUX. IN/OUT**' output (terminal **12** of the control terminal block) is available to display the RMS values in the form of a DC signal.

Chapter 4

CONFIGURATION

Contents page

Chapter 4 CONFIGURATION

SAFETY DURING CONFIGURATION

The thyristor unit is configured in the factory using moveable **jumpers** and soldered **links**. The thyristor unit is **reconfigured** on site using **jumpers**.

Important !

The thyristor unit is supplied fully configured in accordance with the code on the identification label.

This chapter is included in order to

- **check** that the configuration is compatible with the application
- **modify,** if necessary, certain characteristics of the thyristor unit on-site.

The microprocessor takes the configuration into account when the thyristor unit electronic power supply is switched on.

Danger !

For safety reasons, the reconfiguration of the thyristor unit using jumpers must be performed with the unit **switched off** and by qualified personnel authorised to work in an industrial low voltage electrical environment.

Before starting the reconfiguration procedure, check that the thyristor unit is isolated and that an occasional power-up is impossible.

After the reconfiguration of the unit, correct the codes on the identification label to prevent any maintenance problems later.

POWER BOARD

The power board jumpers are used to configure:

- the three-phase voltage selection for synchronisation and measurement
- the adaptation to the load configuration type.

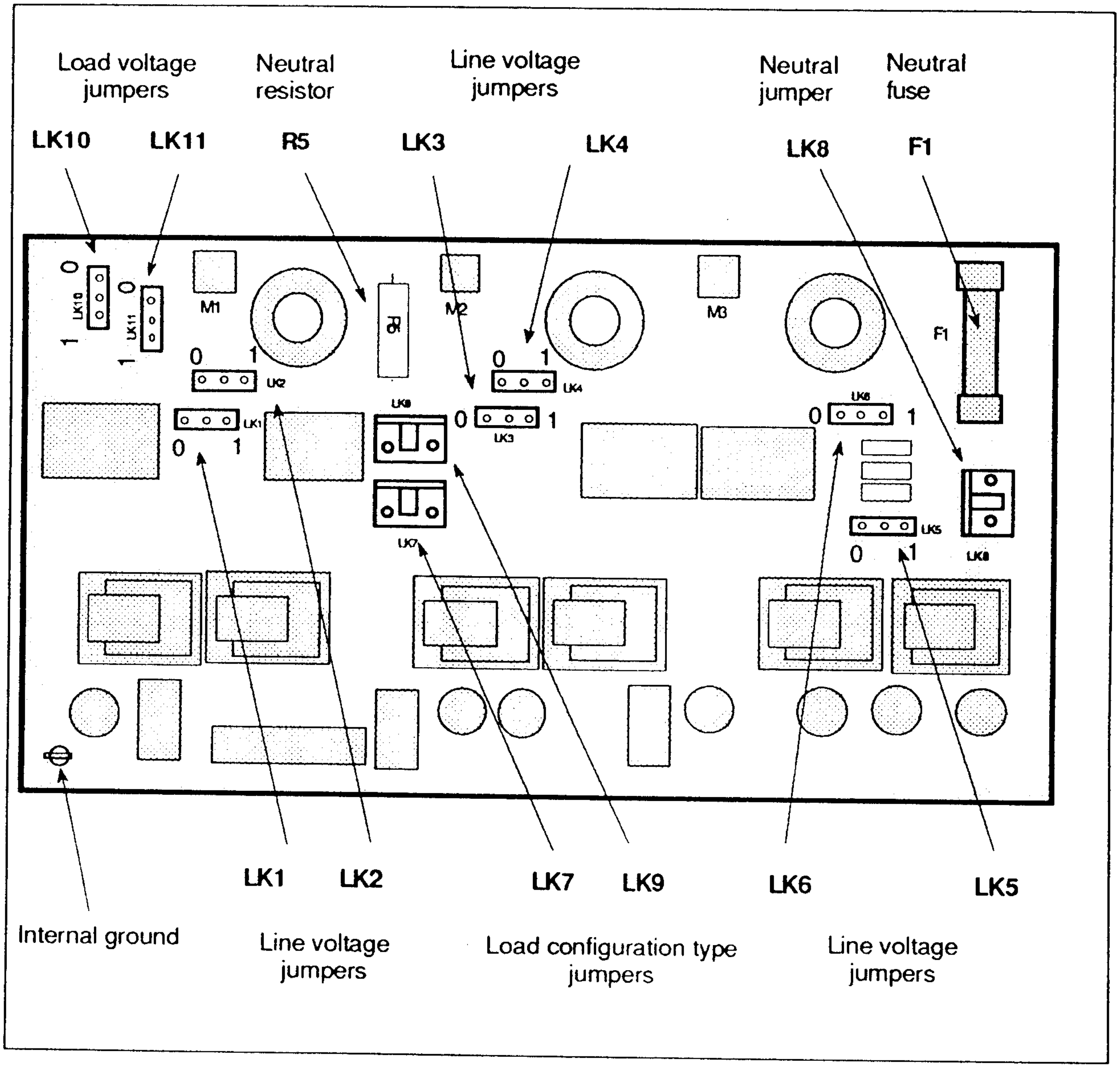


Figure 4-1 Location of jumpers on the power board

Voltage selection

For the synchronisation of operation of the electronics and for measurement, the line voltage and the load voltage must be configured according to the supply used.

The three-phase line voltage and load voltage of the default **TC3001** thyristor unit are configured according to the operating voltage code.

Operation of a **TC3001** thyristor unit on a supply voltage **different** to that specified on the order, may require the repositioning of jumpers **LK1** to **LK6** (three-phase line voltage) and **LK10** and **LK11** (load voltage) on the power board.

Line voltage less than or equal to	Position of jumpers	
	LK1, LK3, LK5 and LK10	LK2, LK4, LK6 and LK11
100, 110, 115 V, 120 V	1	1
200, 220, 230, 240 V	1	0
380, 400, 440 V	0	1
480 V	0	0

Table 4-1 Line voltage and load voltage configuration

Attention !

Do not use a thyristor unit on a supply voltage higher than the supply voltage specified for the thyristor unit.

Adaptation to the load configuration type

A thyristor unit is configured according to the load configuration type using jumpers **LK7** to **LK9** on the power board and using jumpers **K5** and **K6** on the driver board (see page 4-13).

⚠ **Attention !**

It is necessary to check that the position of jumpers LK7 to LK9 (table 4-2) corresponds to the position of jumpers K5 and K6 (table 4-12).

Load configuration	**Position of jumpers on power board**		
	LK7	**LK8**	**LK9**
Star without neutral (3 wires)	Jumper	Open	Open
Star with neutral (4 wires) Connection of the neutral wire to the user terminal block below the thyristor unit	Open	Jumper	Jumper
Closed delta (3 wires)	Jumper	Open	Open
Open delta (6 wires)	Open	Jumper	Open

Table 4-2 Load configuration type configuration

DRIVER BOARD

The driver board jumpers are used to configure:

- the auxiliary power supply,
- the control signals,
- the current limit type,
- the thyristor firing mode,
- the load configuration type,
- the operation type,
- the alarm relay switch type.

The functions of the driver board jumpers are summarised in the table below.

Function	Jumpers	Configuration see page
Auxiliary power supply	Soldered links LK1 and LK2	4-8
Main setpoint signals	J11 to J15	4-9
Auxiliary input or output	J36 and SW1	4-10
Auxiliary input/output type	J31 to J35	4-10
Current limit adjustment type	S1	4-11
External current limit signal	J21 to J25	4-11
Thyristor firing mode	K1 and K2	4-12
Setpoint change ramp action or soft start/end	K3 and K4	4-12
Load configuration type	K5 and K6	4-13
Load type	K7	4-13
Load unbalance detection	K12	4-13
Feedback parameter (value)	K8 and K9	4-9
Second setpoint action	K10	4-10
Relay switch type	VX1 and VX2	4-13
Calibration / Operation	M1 to M4	4-14

Table 4-3 Driver board jumper functions

The position of the jumpers **K11, K13** and **S2** is not important in this version of the thyristor unit.

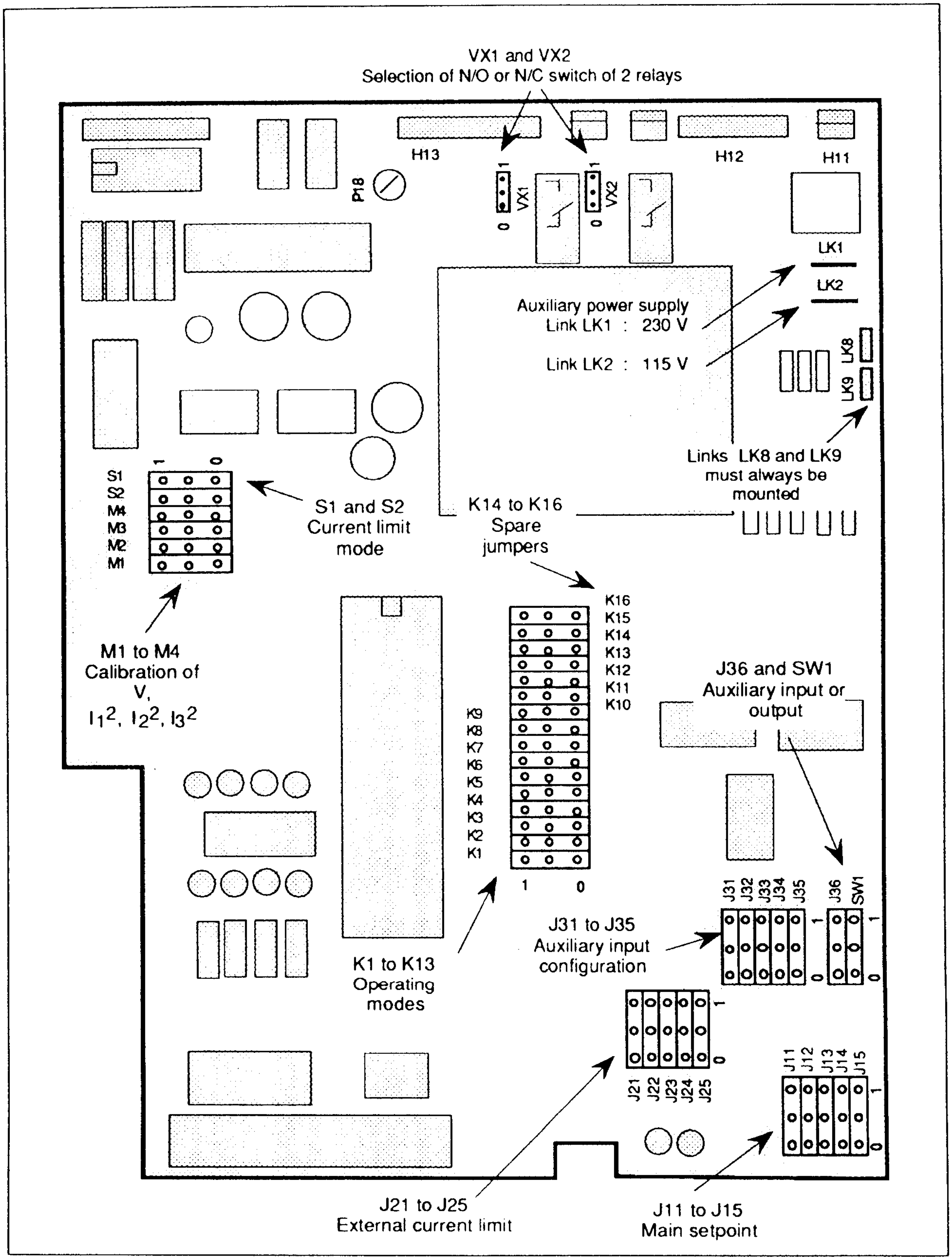


Figure 4-2 Location of configuration and calibration jumpers on the driver board

Auxiliary power supply

Two soldered links **LK1** and **LK2** on the driver board are used to configure the auxiliary voltage (the electronic and fan power supply) as **100 V to 120 V** or as **200 V to 240 V**.

Note: The power board also contains jumpers which are labelled **LK.**

Auxiliary voltage	Link soldered on the driver board in the factory
100/110/115/120 V	LK2
200/220/230/240 V	LK1

Table 4-5 Auxiliary power supply configuration

Attention !

The fans for fan-cooled units are **single-voltages.**

They cannot be powered with a voltage other than that indicated on the fan.

Consequently, the auxiliary power supply voltage **configuration** must **correspond** to the nominal voltage of the fan.

Main setpoint configuration

The five jumpers **J11** to **J15** are used to configure the analogue control main setpoint signal type (voltage or current) and the signal scale from the six available scales.

Main setpoint signal type and scale		Position of jumpers				
		J11	J12	J13	J14	J15
Voltage	0 - 5 V	1	1	0	0	0
	1 - 5 V	0	1	0	0	0
	0 - 10 V	1	0	1	0	0
	2 - 10 V	0	0	1	0	0
Current	0 - 20 mA	1	0	0	1	1
	4 - 20 mA	0	0	0	1	1

Table 4-5 Main setpoint signal configuration

Feedback value configuration

The **feedback value** (feedback, controlled parameter) is selected using the position of jumpers **K8** and **K9.**

Feedback value	Position of jumpers	
	K8	K9
Power (V x I)	1	1
Mean of the squared currents of the three phases (I^2)	0	1
Squared load voltage (V^2)	1	0
External measurement *)	0	0

Table 4-6 Feedback value configuration

*) When the feedback is performed on the external measurement, the position of jumpers **K10**, **J36** and **SW1** is **0**.

Auxiliary input/output configuration

The position of jumpers **J36** and **SW1** defines the destination of the auxiliary input/output (terminal **12** on the control terminal block):

- **the input** (used for the second setpoint and for the external measurement signal)
- **or the output** (used for the retransmission of the controlled parameter).

The scale of the retransmission output is: **0 - 10 V**.

The position of the jumper **K10** determines:

- the external measurement input or
- the second setpoint input (low selector feedback).

Auxiliary input/output type	Position of jumpers		
	K10	J36	SW1
Second setpoint	1	0	0
Feedback value retransmission	0	1	1
External measurement *)	0	0	0

Table 4-7 Auxiliary input / output type configuration
*) See feedback value configuration, table 4-6

When operation on the external measurement or with the second setpoint is selected, the type (voltage or current) and one of the six signal scales are configured using jumpers **J31** to **J35**.

Destination of auxiliary input/output	Signal type and scale		Position of jumpers				
			J31	J32	J33	J34	J35
Externa measurement or Second setpoint	Voltage	0 - 5 V	1	1	0	0	0
		1 - 5 V	0	1	0	0	0
		0 - 10 V	1	0	1	0	0
		2 - 10 V	0	0	1	0	0
	Current	0 - 20 mA	1	0	0	1	1
		4 - 20 mA	0	0	0	1	1
Feedback value retransmission	Voltage	0 - 10 V	1	0	0	0	0

Table 4-8 Auxiliary input/output scale configuration

Current limit setpoint

The '**Current limit**' corresponds to the value of the current **threshold** allowed by the load. This value is set by the user.

The current limit setpoint can come from :

- the **potentiometer** on the thyristor unit front panel
- or an **external** analogue **signal** in cascade with the front panel potentiometer.

The action of the TC3001 thyristor unit (thyristor firing angle variation or firing stop) if the current threshold set by the current limit setpoint is exceeded depends on the thyristor firing mode (see Coding and 'Current limit operation', page 5-28).

The jumper **S1** selects between the current limit using an external signal in cascade with the front panel potentiometer or only with the potentiometer (see table 4-9).

When the current limit threshold adjustment mode using the external signal is selected, the five jumpers **J21** to **J25** determine the type and scale of the external analogue signal.

Current threshold adjustment mode	**External current limit signal type and scale**		**Position of jumpers**					
			J21	**J22**	**J23**	**J24**	**J25**	**S1**
Using potentio-meter and external signal	Voltage	0 - 5 V	1	1	0	0	0	1
		1 - 5 V	0	1	0	0	0	
		0 - 10 V	1	0	1	0	0	
		2 - 10 V	0	0	1	0	0	
	Current	0 - 20 mA	1	0	0	1	1	
		4 - 20 mA	0	0	0	1	1	
Using potentiometer on front panel only								0

Table 4-9 Current limit setpoint configuration

Note: Jumper **S2** must always set to **0**.

Thyristor firing mode configuration

The thyristor **firing** mode and the presence of the setpoint change ramp or soft start/end are determined by the position of jumpers **K1** to **K4**.

Thyristor firing mode	**Position of jumpers**	
	K1	**K2**
Logic (ON/OFF)	0	0
Thyristor firing angle variation (Phase angle)	0	1
Burst firing	1	0
Phase angle burst	1	1

Table 4-10 Thyristor firing mode configuration

Soft start/end ramp	**Position of jumpers**	
	K3	**K4**
Without ramp and without soft start/end	0	0
Positive rampe in Phase angle or Soft start in Burst firing Phase angle burst and in ON/OFF	1	0
Positiive and negative ramps in Phase angle or Soft start/end in Burst firing Phase angle burst and in ON/OFF	1	1

Table 4-11 Presence of the ramp in soft start/end

The **number of periods** of the Burst firing and Phase angle burst cycle, the duration of the ramp on the setpoint changes or the soft start/end **time** can be adjusted using the potentiometers on the front panel (see 'Operation' chapter).

Configuration type and load type

The three-phase load configuration is determined by the position of the jumpers **K5** and **K6** on the driver board and **LK7, LK8** and **LK9** on the power board.

Attention !

It is necessary to check that the position of the jumpers **LK7** to **LK9** (table 4-2) corresponds to the position of the jumpers **K5** and **K6** (table 4-12).

Three-phase load configuration type or load type	Position of jumpers		
	K5	K6	K7
Star without neutral (3 wires)	0	0	
Star with neutral (4 wires)	1	0	
Closed delta (3 wires)	0	1	
Open delta (6 wires)	1	1	
Resistive load			0
Inductive load or transformer			1

Table 4-12 Load configuration type and load type configuration

The ON state of the partial load unbalance (**PLU**) detection circuit is determined by the jumper **K12** (the detection is enabled when **K12** = **1**).

The jumpers **K11** and **K13** must always be set to **0**.

Alarm relay switch type

The **general** and partial load failure (**PLF**) relays are **deactivated** at the time of the alarm or when the electronic power supply is switched off.
The jumpers **VX1** and **VX2** are used to select the type of N/O and N/C switches available on the user terminal block below the thyristor unit (see figure 3-5).

Important !

The relay switches are protected by RC snubbers against interference.

Relay switch type	Position of jumpers	
	VX1	VX2
	General alarm relay	PLF alarm relay
Normally open (N/O)	1	1
Normally closed (N/C)	0	0

Table 4-13 Relay switch type configuration

Calibration / Operation

The jumpers **M1** to **M4** are used to configure the thyristor unit either in the **calibration position**, or in the normal **operation position**, excluding the calibration procedure.

The thyristor unit can be calibrated easily using the potentiometers **P6** to **P9** on the potentiometer board (see 'Commissioning' chapter).

The analogue calibration signals (or RMS current and load voltage images) can be read using the **EUROTHERM** type **260** diagnostic unit (see page 6-6).
A diagnostic connector is provided for this purpose on the front panel of the thyristor unit.

Danger !
For safety reasons, the reconfiguration of the thyristor unit using jumpers must be performed by a qualified person with the unit switched off.

Calibrated parameter or image of an operating parameter		**Corresponding jumper**	**Position of jumpers**	
			Thyristor unit calibration	**Thyristor unit operation**
Squared load voltage	V^2	M1	0	1
Squared RMS current of a phase	I_1^2	M2	0	1
	I_2^2	M3	0	1
	I_3^2	M4	0	1

Table 4-14 Thyristor unit operating mode configuration (calibration or normal operation)

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Chapter 5 OPERATION

BLOCK DIAGRAM

The interaction between the main parts of the thyristor unit is shown in figure 5-1.

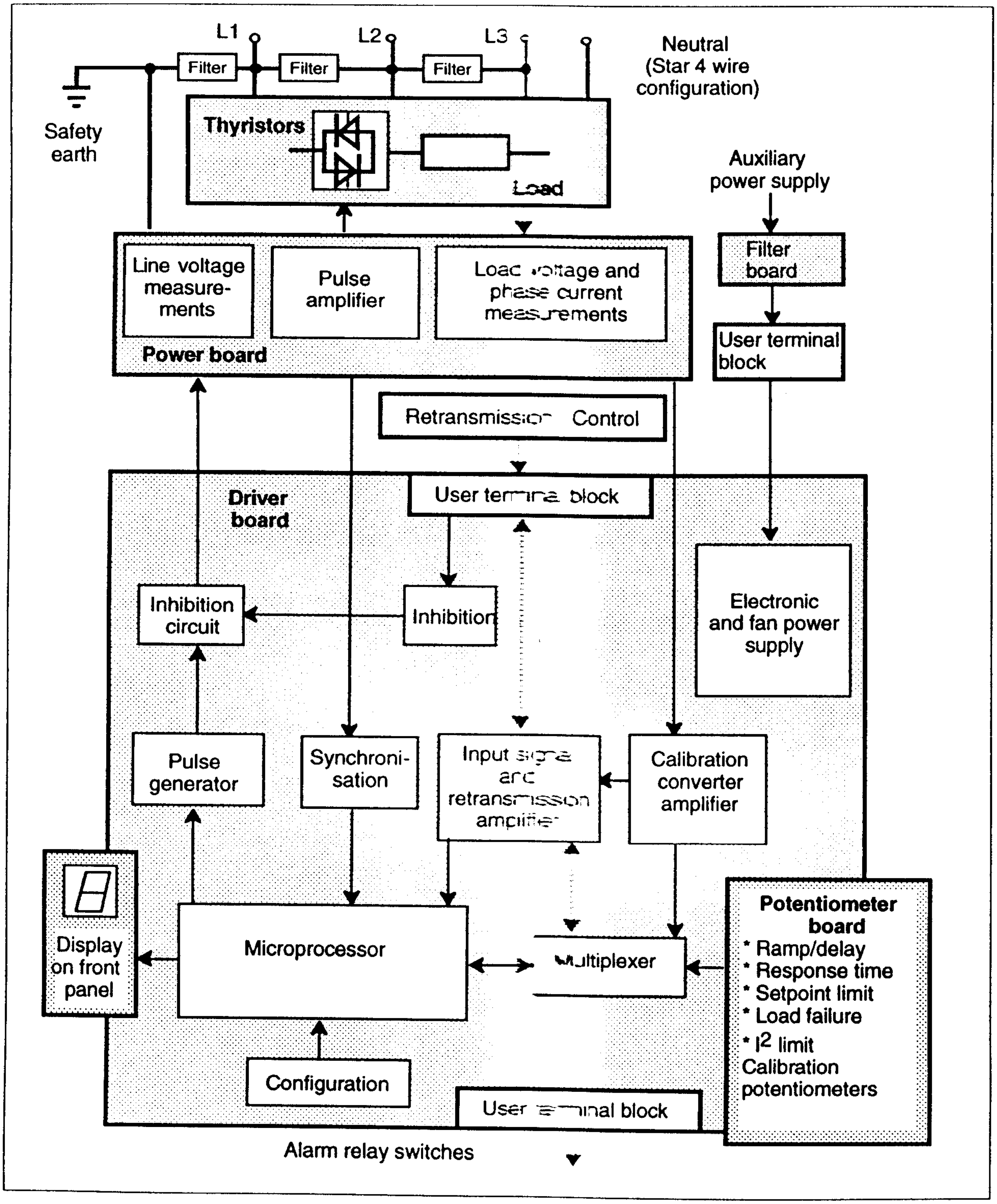


Figure 5-1 TC3001 thyristor unit block diagram

Thyristors

The 3 pairs of thyristors modulate the supply voltage which is applied to the three-phase load.

Danger !

Thyristors up to **250 A** nominal current are mounted in a module **isolated** from the heatsink. The **300 A** to **500 A** unit heatsinks are **not isolated** from the thyristors.

Power board

The thyristor firing pulses, generated by the driver board, are amplified and transmitted to the thyristors via pulse **transformers** which provide isolation.

Three current transformers are used to **measure the phase currents** and a voltage transformer is used to **measure the load voltage**.

Three voltage transformers are used for **synchronisation** on the supply voltage.

Potentiometer board

Five operation potentiometers located on the **potentiometer board** (which is mounted perpendicular to the driver board) can be accessed on the front panel. They are used to adjust the main thyristor unit operating parameters without having to open the front door.
Four calibration potentiometers can be accessed when the front door is open.

The functions of the operation potentiometers are indicated on the front panel of the thyristor unit and are explained in the relevant paragraph (page 5-15).

If the thyristor unit is replaced, the potentiometer board can be transferred to the new thyristor unit and thus retain all the adjustments specific to the application concerned.

Display

The 7 segment display is used for steady and flashing messages indicating the current operating mode of the thyristor unit, the alarm state and the error or fault type.

Diagnostic connector

The values from the feedback and the operation of the thyristor unit are available on the diagnostic connector located on the front panel. It is used to measure the voltages of 20 points on the electronic circuit with a EUROTHERM type 260 diagnostic unit.

Driver board

The analogue control signals and parameter retransmissions are applied to the driver board **user terminal blocks**.

The **pulse generator** emits the firing pulses for the thyristor gate at the request of the microprocessor.

An inhibition line blocks the oscillations if the thyristor unit is disabled (by disconnecting the 'Enable' input from the '+10V' terminal on the user terminal block or via the external input).

The **synchronisation** circuit supplies the microprocessor with three signals corresponding to the sign of the line voltages measured and a signal corresponding to the zero voltage crossing.

A square raising circuit supplies four signals corresponding to the squares of the measured signals: I_1^2, I_2^2, I_3^2 and V^2.

An '**OR**' circuit selects the highest value from the squares of the three currents which is compared to an adjustable threshold of the current limit setpoint.

The **multiplexer** selects the signal applied to the analogue/digital converter inside the microprocessor from the measurements, front panel potentiometer voltages and the control signals, according to the program procedure.

The driver board **microprocessor** controls the entire operation of the thyristor unit and the message display.

The amplification of the input signals converts the low level signals and amplifies the retransmissions.

Two **relays** are used for the external detection of the active alarm state.

Important !

Each external link, each control or retransmission signal and the auxiliary power supply are protected against interference by an LC filter.

A **diagnostic connector** located on the front panel of the thyristor unit is used, with the **EUROTHERM type 260** diagnostic connector, to control or measure the main thyristor unit operating parameters.

The **watchdog** monitors the correct functioning of the software; in the event of a fault, it sends a '**Reset**' signal to the microprocessor.

THYRISTOR FIRING MODES

'Phase angle' mode

In '**Phase angle**' mode, the power transmitted to the load is controlled by firing the thyristors on a part of the supply voltage alternation.

For the three-phase load configuration in star **with neutral**, the load voltage is composed of portions of supply '**phase-neutral**' voltage alternations.

For the three-phase load configuration in **open** delta, the load voltage is composed of portions of **line-to-line** voltage alternations.

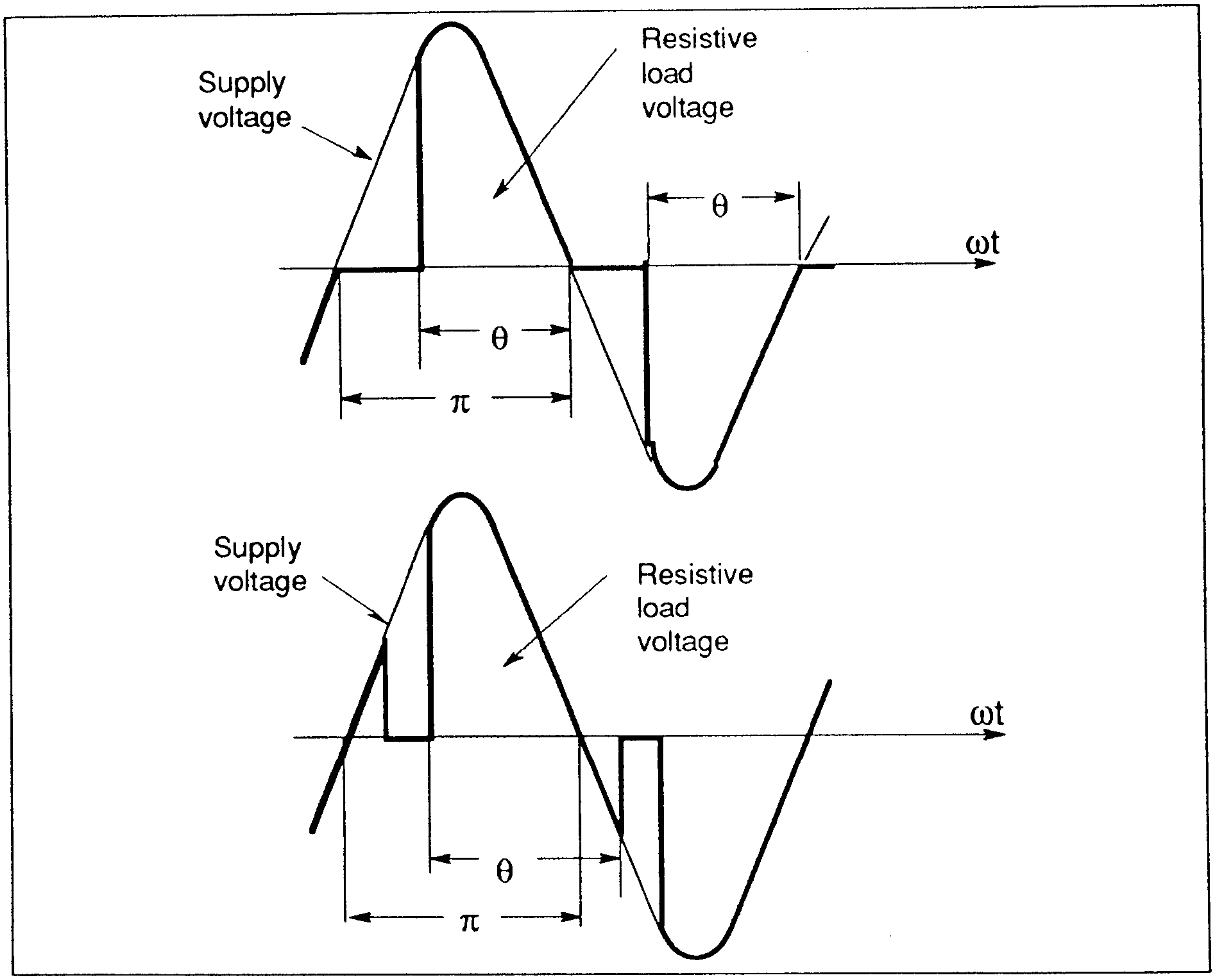


Figure 5-2 Load voltage in 'Phase angle' (star with neutral or open delta)

The firing angle (θ) varies in the same way as the control system signal.

The output power is not a linear function of the firing angle.

The three-phase load voltage, configured in star **without neutral** or in **closed** delta (3 wire configuration), is composed of portions of **two-** or **three-phase** waves according to the thyristor firing angle value.

In **two-phase** operation, the thyristor output voltage (between 'LOAD' terminals) is the voltage between two **firing** phases.
In the star without neutral configuration, this voltage is applied to the 2 arms of the load in series. In the closed delta configuration, this voltage is applied to one load arm, connected between 2 firing phases and on the other 2 load arms in series.

In **three-phase** operation, the voltage of each load arm is the **phase** voltage for the star without neutral configuration or the **line-to-line** voltage for the closed delta configuration.

The figure below shows two examples of **three-phase resistive** voltages configured in star without neutral.

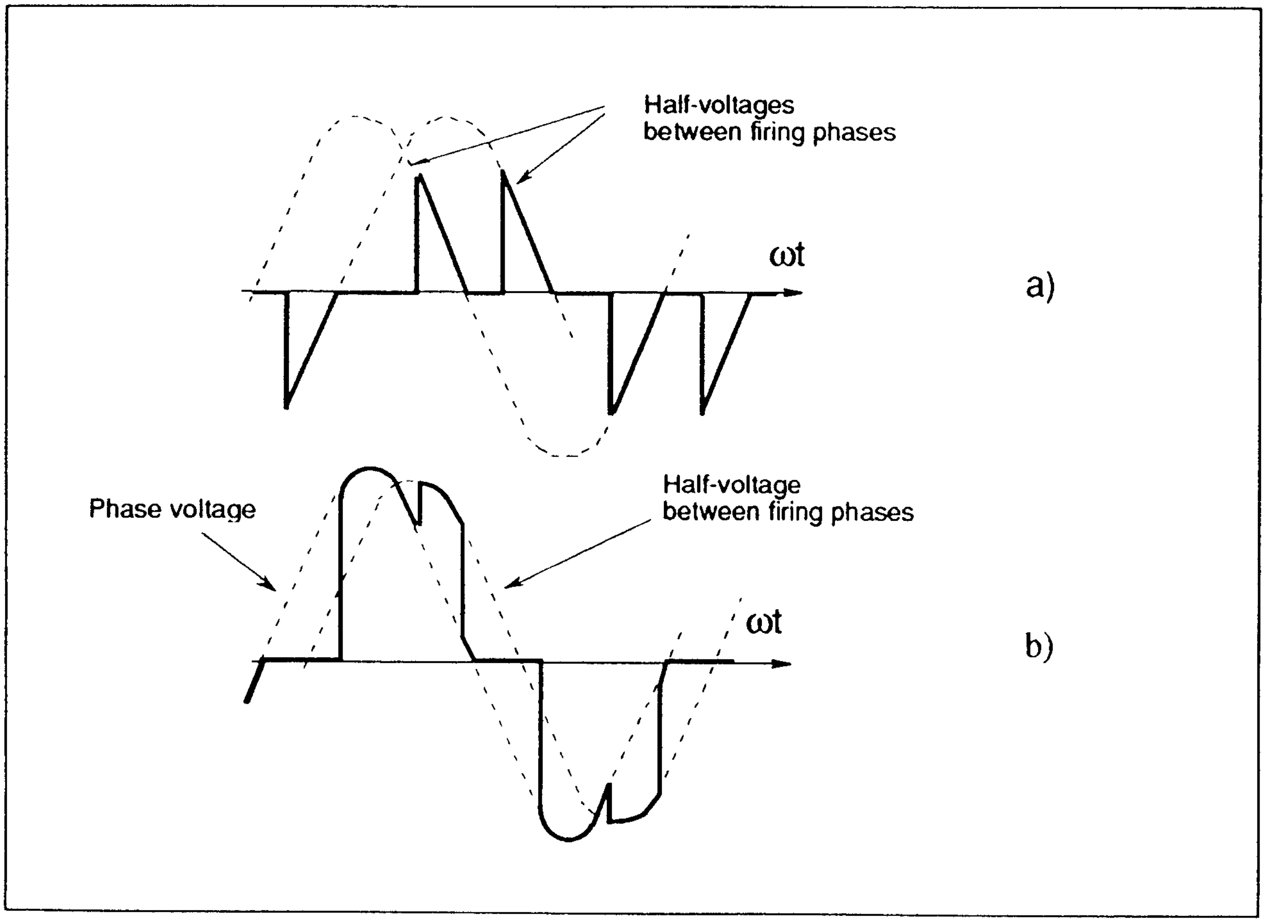


Figure 5-3 Resistive load voltage (star without neutral) in 'Phase angle'

For a small firing angle ($\theta<60°$), the load voltage is composed of portions of half-voltages between phases (figure 5-3,a).
For a large firing angle ($\theta>60°$), the load voltage is composed of portions of voltage of one phase and portions of half-voltages between phases (figure 5-3,b).

In **Phase angle** mode, the **current limit** is easy to use.
The current limit acts through the thyristor firing angle variation in order to maintain the squared value of the RMS current less than the threshold set by the 'Current limit' setpoint.

The **Phase angle** is used to start with small thyristor firing angles (to prevent over-currents when switching on cold low resistance loans or transformer primary coils).

The gradual increase in the firing angle depends on the operation selected by the user (**ramp** on the setpoint change) or is under the control of the current limit.

The ramp on the setpoint change can be **positive** (gradual increase in the firing angle during the power increase request) or **positive and negative** (gradual increase and decrease in the thyristor firing angle).

The table below gives the possible types of operation in '**Phase angle**' firing mode (code **PA**).

Mode	**Code**	**Corresponding operation**	**Action and Current Limit code**	
			Firing stop	**Firing angle variation**
Standard	NRP	Thyristor firing angle dependent on the control signal	—	LINT or L***
Ramp	URP	Positive ramp with adjustable slope on the setpoint change.	—	LINT or L***
	UDR	Positive and negative ramps with adjustable slopes on the setpoint change.		

Table 5-1 Possible types of operation in 'Phase angle' mode

'Logic' mode

The '**Logic**' thyristor firing mode ('**ON/OFF**') controls a power in the load proportionally to the firing time set by the **logic** control signal.
This firing mode is activated from an input signal greater than **50%** of the full scale and as long as the input signal is not less than **25%** of the full scale.

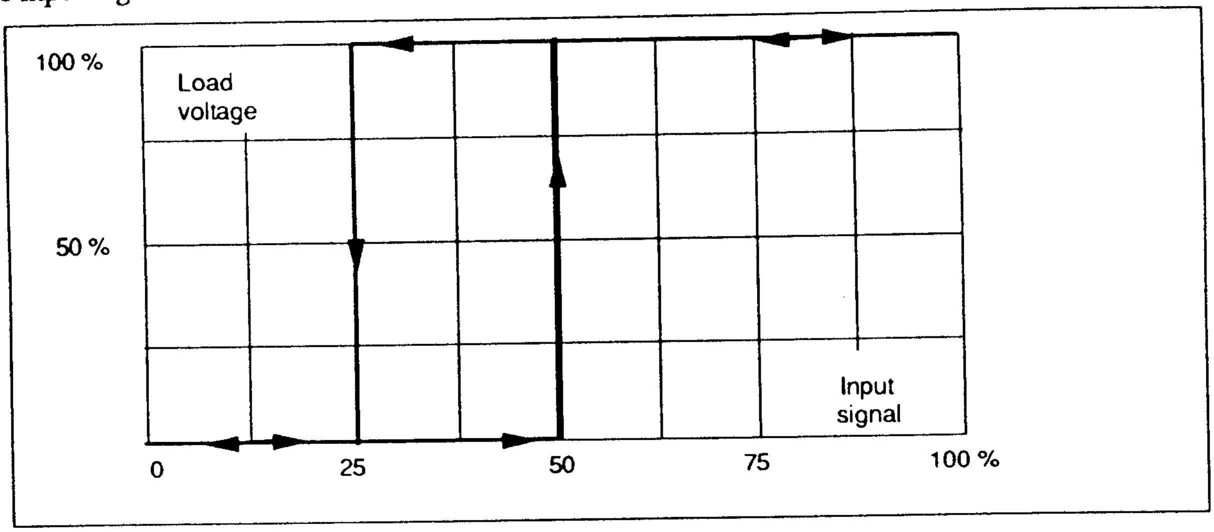


Figure 5-4 'Voltage - Logic signal' diagram

Important !

To reduce an emission of electrical interference and electromagnetic radiation, the thyristors are switched at zero voltage for the resistive loads on the 3 phases.

This produces a slight **unbalance** of the power in the three arms of the load. In order to eliminate the DC component generated on each phase, **firing rotation** is performed (patented by Eurotherm Automation).

This mode cannot be used in transformer primary coils.

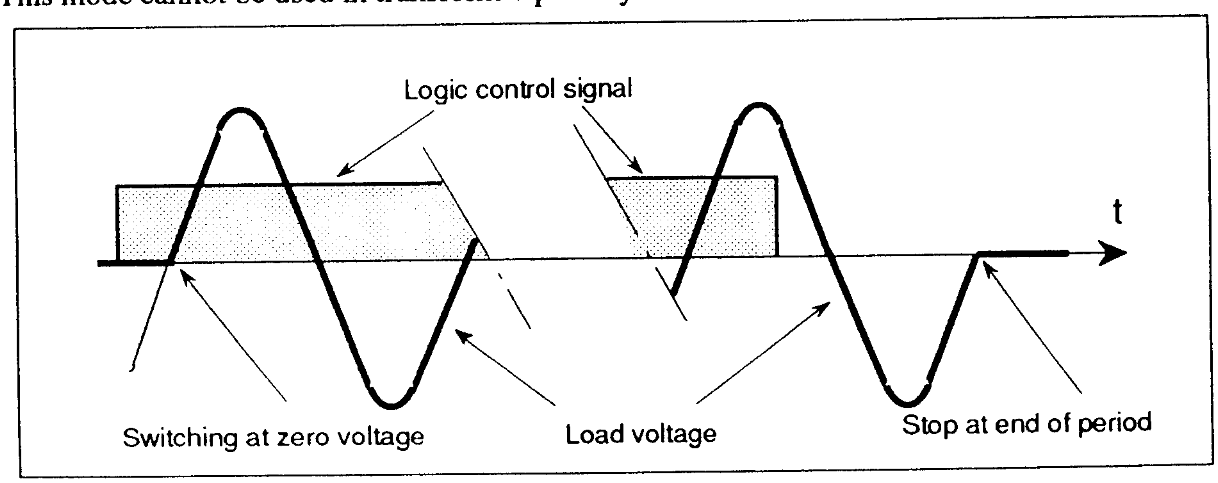


Figure 5-5 'Logic' firing mode

The **Logic** can also be configured with a **soft** (or start and end) in thyristor firing angle variation. There are two possibilities:

- **start** in **Phase angle** with the firing angle increased gradually and **immediate stop** at the first **zero crossing** (as soon as the control signal is less than **25%**)
- **soft** start **and** non-firing in **Phase angle**.

For inductive loads, firing at zero voltage generates transient operation which may, in certain cases, induce a saturation of the magnetic circuit (see fig.5-6,a) and a high speed fuse blow-out (thyristor protection).

To prevent this saturation, the firing on each phase can be **delayed** with reference to the corresponding zero voltage (see figure 5-6,b).

The optimum **delay angle** (ϕ) must be adjusted with the front panel potentiometer '**PA Ramp/ CY Delay**', as a function of the load (max. delay 90°).

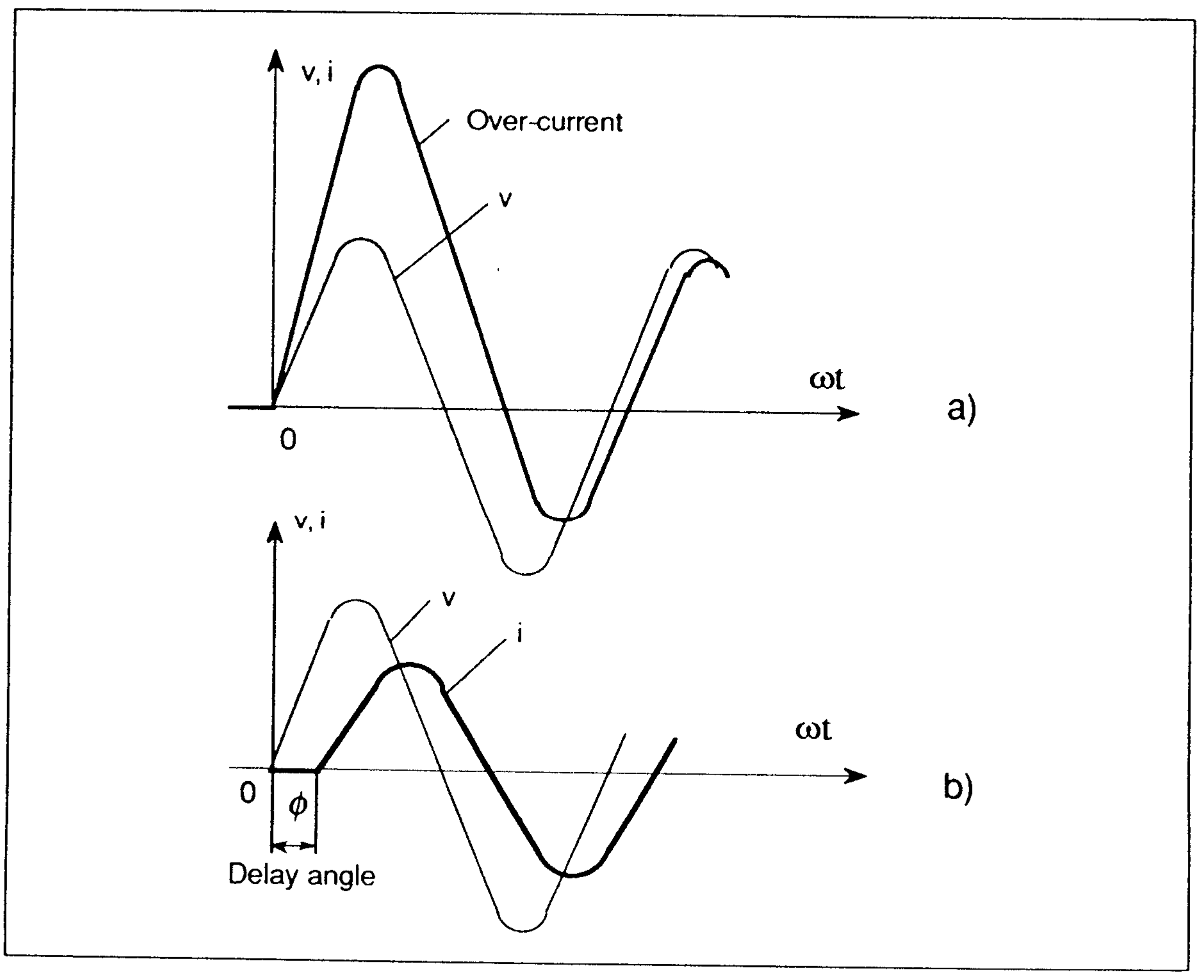


Figure 5-6 Inductive load switching at zero voltage (a) and with a delay angle (b)

The table below gives the possible types of operation in '**Logic**' mode (code **LGC**).

Mode	**Code**	**Corresponding operation without current limit**	**Action and Current Limit code**	
			Firing stop	**Firing angle variation**
Standard	NRP	ON time corresponds to the time that the control signal is present. Code **RES**: Firing start and stop of thyristors at zero voltage on each phase (each new firing starts at the different zero voltage). Code **IND**: On each phase, the first firing is delayed by an adjustable angle.	CINT or C***	—
Soft Adjustable time	URP	Soft start with thyristor firing angle variation from zero to full firing. Stop at end of supply cycle. (Default code **RES**)		
	UDR	Soft start and end with thyristor firing angle variation from zero to full firing and from full firing to zero. (Default code **RES**)		

Table 5-2 Possible types of operation in 'Logic' (ON/OFF) mode

'Burst firing' mode

The '**Burst firing**' mode is a **proportional cycle** which consists of supplying a series of **complete** supply voltage **periods to the load**. (see figure 5-7).

Thyristor firing and non-firing are synchronised with the supply and are performed **at zero voltage** for a resistive load. Each new firing starts at the zero voltage of a different phase in order to rebalance the power consumption of the 3 phases and to eliminate the DC component (firing **signal rotation** is covered by a Eurotherm patent).

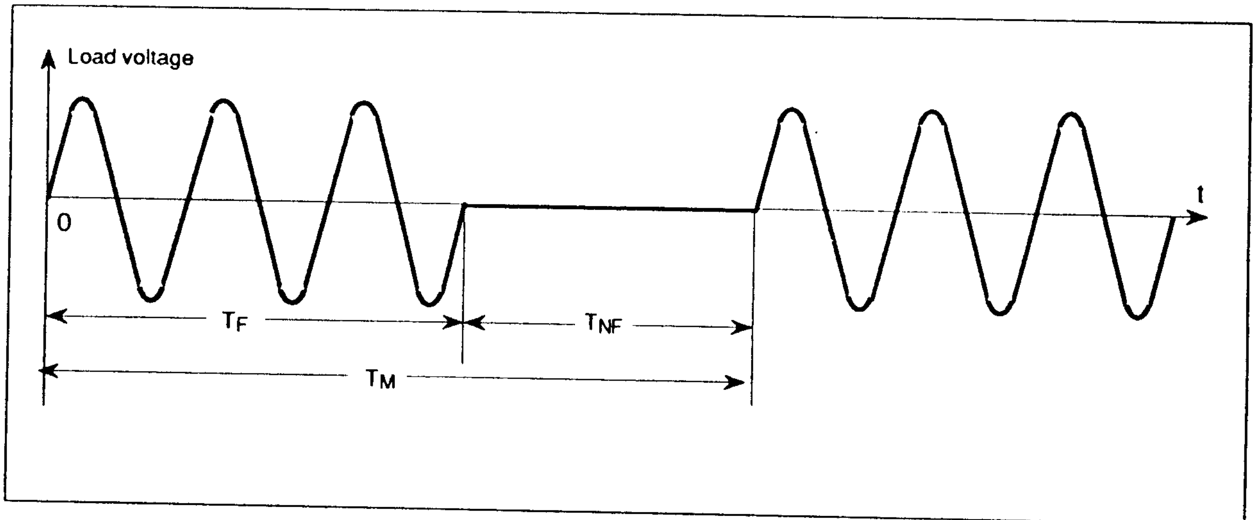


Figure 5-7 'Burst firing' mode (T_F - firing time; T_M - modulation period)

In Burst firing mode, feedback is performed with a **constant** firing time T_F (or non-firing time T_{NF}) and a **variable** modulation time T_M.
The firing time T_F is selected by the user on the thyristor unit order.

The 'Burst firing' mode with **a single** firing or non-firing period is called the "**Single cycle**" mode.

Important !

For **less than 50%** power, the **firing** time is **set.**
For **more than 50%** power, the **non-firing** time is **set.**
For 50% power, the firing time is **equal** to the non-firing time.

The Burst firing modulation period time (T_M) is determined by the feedback as a function of the set firing (or non-firing) time, the setpoint, the feedback and the feedback algorithm.

The feedback system **adjusts** the **basic** burst firing modulation periods (T_M) in order to retain optimum accuracy irrespective of the output power.

The **'Burst firing'** mode (codes **FC1 to 255**) can be configured **with:**

- soft start (or start and end) in thyristor firing angle **variation** during the required time (limited by the firing time)
- the firing **delay** of the first firing thyristor, at each cycle
- the current **limit,** the action of which depends on the use of soft operation.

The table below indicates possible operation in Burst firing mode.

<table>
<tr><th rowspan="2">Mode</th><th rowspan="2">Code</th><th rowspan="2">Corresponding operation without current limit</th><th colspan="2">Action and Current Limit code</th></tr>
<tr><th>Firing stop</th><th>Firing angle variation</th></tr>
<tr><td>Standard

Number of firing (or non-firing) cycles selected by the user.</td><td>NRP</td><td>Proportional cycle with a modulation period determined by the feedback system.

Code RES: Thyristor firing and non-firing at the zero voltage of each phase.
Firing rotation of the 6 thyristors at each Burst.
Code IND: On each phase, the first firing is delayed by an adjustable angle. Same firing sequence of the 6 thyristors at each Burst.</td><td>CINT
or
C***</td><td>—</td></tr>
<tr><td rowspan="2">Soft

Adjustable ramp time. Limited by the basic cycle time (firing time).</td><td>URP</td><td>Soft start with thyristor firing angle variation from zero to full firing.
Stop at end of supply cycle.
(Default code RES)</td><td rowspan="2">—</td><td rowspan="2">LINT
or
L***</td></tr>
<tr><td>UDR</td><td>Soft start and stop with thyristor firing angle variation from zero to full firing and from full firing to zero.
(Default code RES).</td></tr>
</table>

Table 5-3 Possible types of operation in 'Burst firing' mode

'Phase angle burst' mode

The operation of the thyristor unit in 'Phase angle burst' firing mode **depends** on the **state** of the **current limit**.

- Current limit **disabled** (the RMS current is below the current threshold): thyristor firing in '**Burst firing**'
- Current limit **enabled** (current threshold exceeded): thyristor **firing angle variation** during each basic burst ('**Phase angle burst**' operation).

When the current limit is no longer enabled, switching to full firing in Burst firing must be performed with a soft start over 8 periods (at the first burst only).
Feedback in **Phase angle burst** mode is performed as in **Burst firing**.
The table below indicates the possible types of operation in 'Phase angle burst' mode (codes **HC1 to H55**).

Mode	Code	Corresponding operation without current limit	Action and Current Limit code	
			Firing stop	Firing angle variation
Standard Number of firing (or non-firing) cycles selected by the user.	NRP	Proportional cycle with a modulation period determined by the feedback system. Code **RES**: Thyristor firing and non-firing at the zero voltage of each phase. Code **IND**: First firing delayed on each phase.	—	LINT or L***
Soft Adjustable ramp time. Limited by the basic cycle time.	URP	Soft start with thyristor firing angle variation from zero to full firing. Stop at end of supply cycle. (Default code **RES**)	—	LINT or L***
	UDR	Soft start and stop with thyristor firing angle variation from zero to full firing and from full firing to zero. (Default code **RES**).		

Table 5-4 Possible types of operation in 'Phase angle burst' mode

ADJUSTMENT POTENTIOMETER FUNCTIONS

Five potentiometers are provided to enable the user to adjust the operation of the **TC3001** thyristor unit without opening the front door.

They are available on the top left section of the thyristor unit front panel.

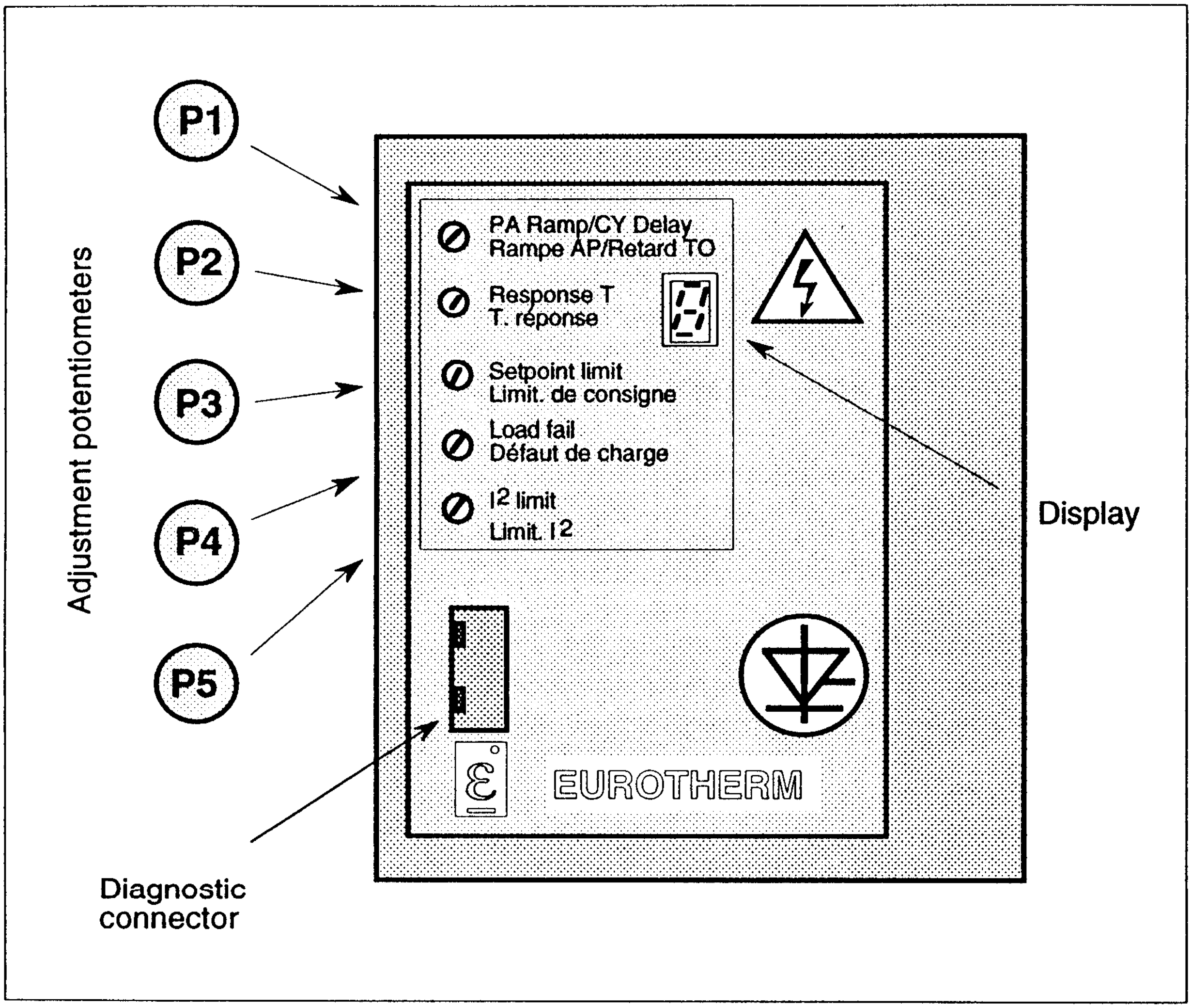


Figure 5-8 Front panel potentiometers

The adjustment potentiometers have **10** turns and are labelled **P1** to **P5** from top to bottom.

The potentiometer functions are summarised in the table below.

The functions of the potentiometers **P1, P2** and **P3** depend on the selected firing mode and the thyristor unit configuration (load type, selected ramp, soft start or start and end).

Potentio-meter	Designation on front panel	Firing modes	Function
P1	PA Ramp/ CY Delay	Phase angle	Ramp setpoint adjustment
		Logic Burst firing Phase angle burst	Soft start or start and end adjustment
			First alternation delay angle adjustment (for inductive loads only).
P2	Response time	Phase angle	Feedback loop response time adjustment.
		Burst firing Phase angle burst	Basic burst firing time adjustment.
P3	Setpoint limit	All except Logic mode	Input signal limit adjustment.
P4	Load fail	All firing modes	Partial load failure detection adjustment.
P5	I^2 limit	All firing modes	Limited current threshold adjustment.

Table 5-5 Summary of the front panel potentiometer functions

'PA Ramp / CY Delay' potentiometer

The potentiometer **P1** labelled '**PA Ramp / CY Delay**' on the front panel is used to adjust the following:

- **the ramp on the setpoint changes** (Phase angle firing mode);
- **the soft start/end** (Burst firing, Logic and Phase angle burst firing modes);
- **the delay angle** (Burst firing, Logic and Phase angle burst firing modes).

Conditions and positions of jumpers			**Functions of potentiometer P1 'PA Ramp / CY Delay'**
Firing mode	**Operation**		
Phase angle K1 = 0 K2 = 1	No ramp	K3 = 0	**No** action
	Positive ramp	K3 = 1 K4 = 0	Ramp **duration** adjustment (number of periods) for setpoint **changes**. The ramp is enabled for power **increase** requests
	Positive and negative ramp	K3 = 1 K4 = 1	Ramp **duration** adjustment (number of periods) for **both** power **increase** and **decrease** requests
Logic K1 = 0 K2 = 0 Burst firing K1 = 1 K2 = 0 Phase angle burst K1 = 1 K2 = 1	Resistive load. No soft start	K7 = 0 K3 = 0 K4 = 0	**No** action
	Inductive load. No soft start	K7 = 1 K3 = 0	Adjustment of **first** alternation firing **delay** from **0°** to **90°**
	All loads. Soft start	K3 = 1 K4 = 0	**Start duration** adjustment (number of periods) in thyristor firing angle variation. **Immediate stop** after first 0 crossing.
	All loads. Soft start and end	K3 = 1 K4 = 1	Adjustment of **both start** and **end** duration in thyristor firing angle variation

Table 5-6 Functions of the potentiometer P1 for the various firing modes

Note: For the Burst firing and Phase angle burst modes, the soft operation time is limited by the basic cycle.

Setpoint change ramp

The ramp duration (T_r) is the number of supply cycles (therefore, the time taken) for the thyristor unit firing to **change** from **0%** to **100% (positive** ramp) or from **100%** to **0%** **(negative** ramp).

The **Setpoint change ramp** function is only available in the 'Phase angle' firing mode.

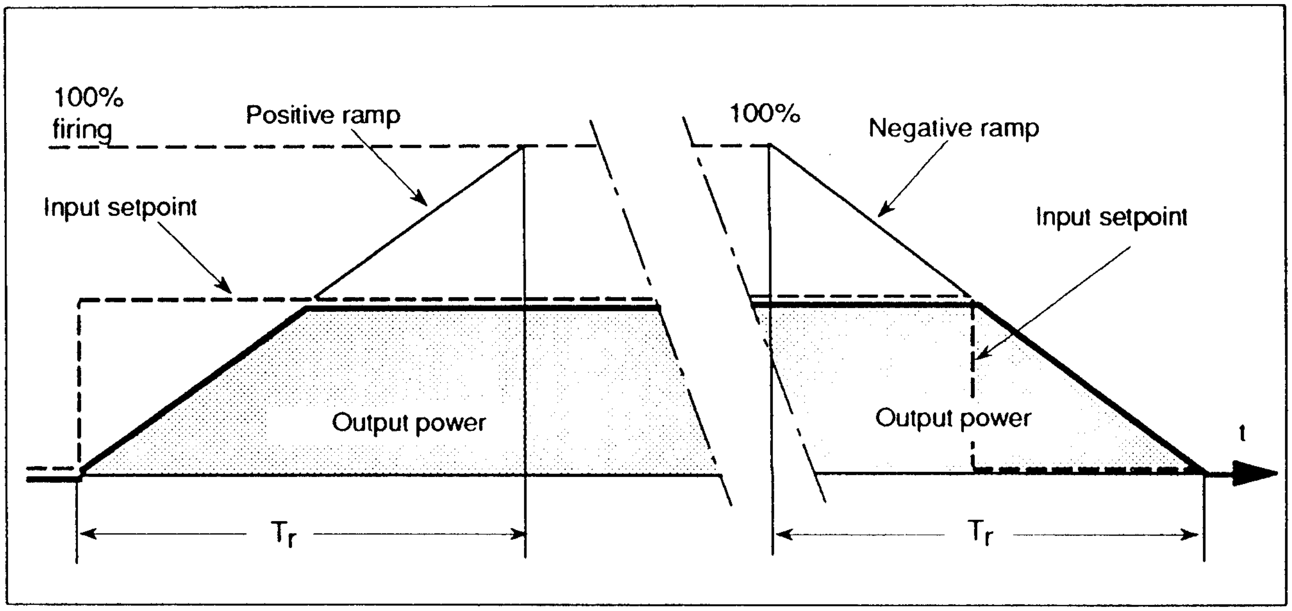


Figure 5-9 Positive and negative ramps during setpoint change in Phase angle mode

Note: After the electronics is switched on, the setpoint ramp is reset to zero. If the setpoint has not changed, the setpoint ramp is not enabled when the thyristor unit is re-enabled after inhibition.

Important !

- The ramp duration is set for **both** the positive and negative ramps.
- For the same T_r adjustment, the **slope** of the ramp is **constant** irrespective of the setpoint change amplitude.

The adjustment made using the potentiometer **P1** can be read using the Eurotherm type 260 diagnostic unit (in the form of an adjustment voltage in position **11**).

The T_r values (in number of periods elapsed in ramp and in time) and the corresponding adjustment voltages are given in the table below.

P1 Adjustment voltage (read in position 11 of the diagnostic unit)	**Ramp duration (Tr)**		
	Number of periods	**50 Hz supply**	**60 Hz supply**
0.10 V	4	0.08 s	0.066 s
0.25 V	8	0.16 s	0.133 s
0.40 V	16	0.32 s	0.266 s
0.55 V	32	0.64 s	0.53 s
0.72 V	64	1.28 s	1.06 s
0.85 V	128	2.56 s	2.12 s
1.00 V	256	5.12 s	4.24 s
1.20 V	512	10 s	8.5 s
1.30 V	1,024	20 s	17 s
1.50 V	2,048	41 s	34 s
1.65 V	4,096	1 min 22 s	1 min 8 s
1.80 V	8 192	2 min 44 s	2 min 16 s
1.95 V	16 384	5 min 28 s	4 min 32 s
2.10 V	32 764	11 min	9 min
2.30 V	65 528	22 min	18 min
2.40 V	131,000	44 min	36 min
2.60 V	262,000	1 hour 27 min	1 hour 12 min
2.75 V	534,000	3 hours	2 hours 30 min
2.90 V	1,050,000	6 hours	5 hours
3.10 V	2,100,000	12 hours	10 hours
3.25 V	4,190,000	24 hours	20 hours
4.00 V	8,390,000	48 hours	40 hours

Table 5-7 Ramp adjustment during setpoint change in 'Phase angle'

The duration T_r, adjusted by the user, is given in table 5-7 for a change of the input signal from **0** to **100%**.

Important !

The positive ramp is completed as soon as the firing angle corresponding to the current setpoint has been reached (see figure 5-9).

Soft start / end

Soft operation (start or start and end) can be configured in the following firing modes:

- Logic,
- Burst firing and
- Phase angle burst.

The soft start duration (T_{SS}) is the time taken for the output power to **change** from **0%** to **100%** with thyristor firing angle variation from **0** to **full firing**.

The soft end duration (T_{se}) is the time taken for the output power to **change** from **100%** to **0%** with thyristor firing angle variation from **full firing** to **0**.

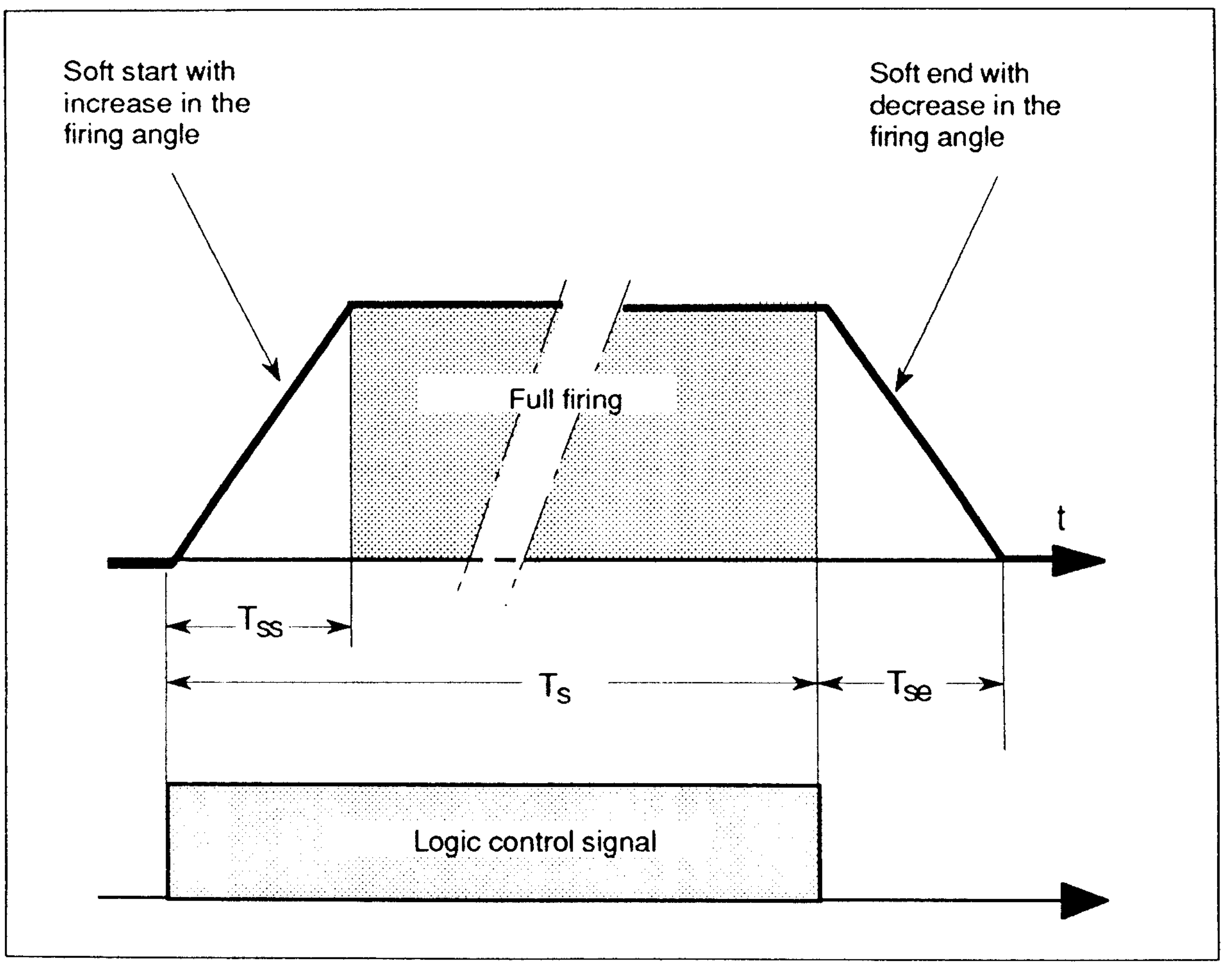


Figure 5-10 Soft start and end in Logic mode

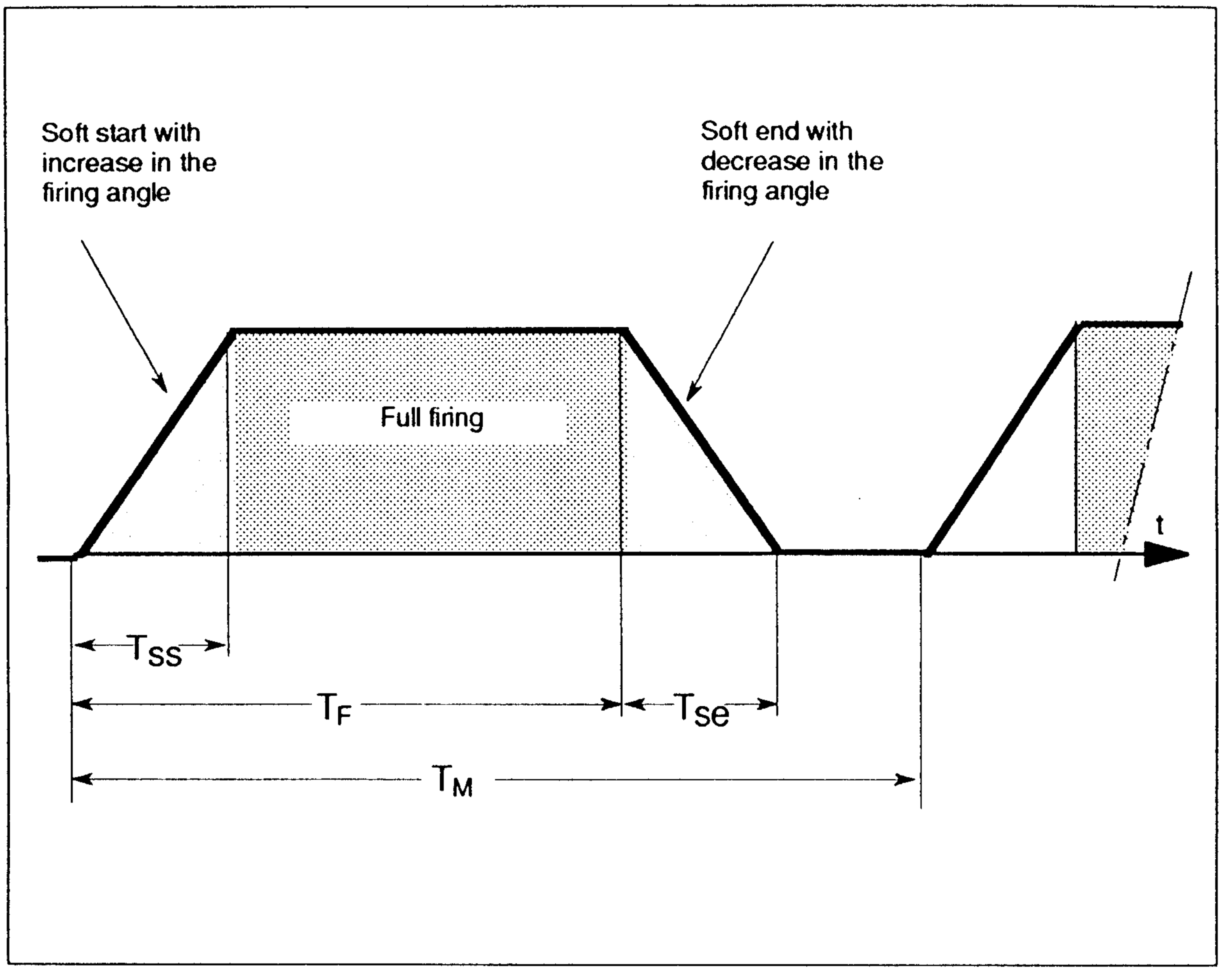


Figure 5-11 Soft start and end in Burst firing mode

In the Burst firing and Phase angle burst modes, the number of soft start or end periods is limited to the number of cycles in the selected firing time.

The soft start time ($\mathbf{T_{SS}}$) is not included in the firing cycle ($\mathbf{T_F}$), but all the power sent in the load is taken into account in the feedback.

After the soft start with thyristor firing angle variation, the thyristor unit remains in **full firing**:

- during the time the input signal is present $\mathbf{T_S}$ (in Logic mode)
- during the firing time of one modulation period $\mathbf{T_M}$ (in Burst firing mode).

The duration of the thyristor firing angle change is adjusted using the potentiometer P1 for **both** the start and the end (**T_{ss}** always **equal** to **T_{se}**).

The soft start and end duration can be adjusted using the potentiometer **P1** from **0** to the number of modulation periods.

The maximum soft start/end duration corresponds to the number of periods in the basic cycle (selected modulation period).

The adjustment position of the potentiometer **P1** can be read using a EUROTHERM type 260 diagnostic unit in the form of an adjustment voltage in position **11**.

P1 Adjustment voltage (read in position 11 of the diagnostic unit)	**Soft start/end duration (T_{ss} = T_{se})**		
	Number of periods	**50 Hz supply**	**60 Hz supply**
0.05 V	0	0	0
0.10 V	1	20 ms	16.6 ms
0.15 V	2	40 ms	33.3 ms
0.25 V	3	60 ms	50.0 ms
0.35 V	5	100 ms	83.3 ms
0.40 V	8	160 ms	133 ms
0.50 V	16	320 ms	266 ms
0.55 V	32	640 ms	533 ms
0.70 V	37	740 ms	616 ms
1.30 V	43	860 ms	716 ms
2.00 V	51	1.02 s	0.85 s
2.50 V	64	1.28 s	1.07 s
3.50 V	85	1.70 s	1.42 s
4.00 V	128	2.56 s	2.13 s
5.00 V	255	5.10 s	4.25 s

Table 5-8 Soft start/end duration

Delay angle

The potentiometer **P1** adjusts the firing angle delay of the first alternation for the control of **inductive** loads in the following firing modes:

- Logic,
- Burst firing and
- Phase angle burst

without soft start/end.

A **90°** delay angle is obtained with **P1** turned completely **clockwise**.
A **0°** delay angle is obtained with **P1** turned completely **anti-clockwise**.

The scale in figure 5-12 gives the equivalence between the adjustment voltage V_{11} (read in position **11** of the diagnostic unit) and the delay angle.

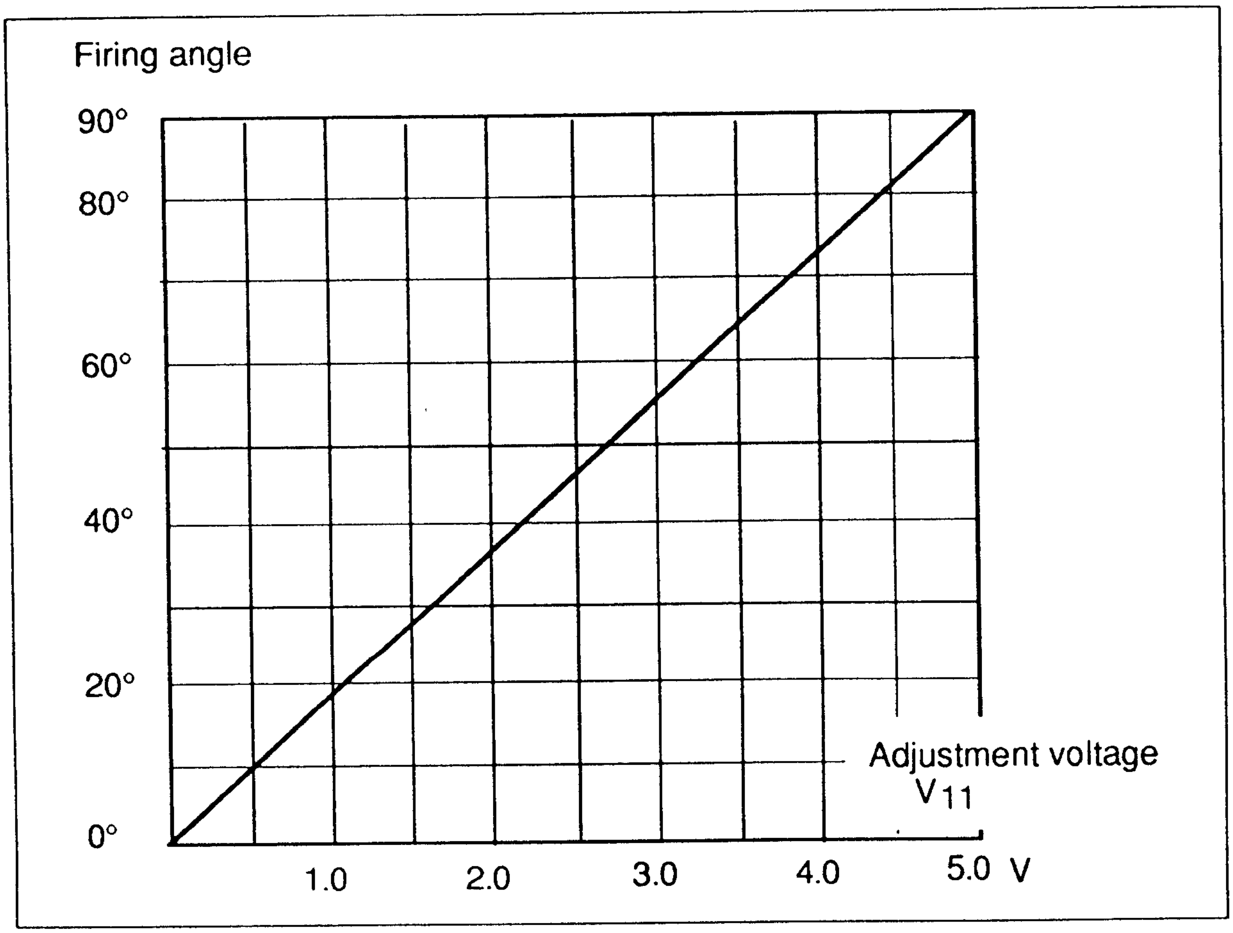


Figure 5-12 Delay angle adjustment scale

In the factory, the potentiometer **P1** is preadjusted to **5 V** (**90°** delay angle) if the coding indicates the use of the inductive load.

'Response time' potentiometer

The potentiometer **P2** labelled '**Response T**' on the front panel is used to adjust the **feedback loop response time** (in 'Phase angle' firing mode) or the **number of firing periods** in the basic cycle (in 'Burst firing' and 'Phase angle burst' firing modes).

Firing mode	**Positions of jumpers**	**'Response time' potentiometer functions**
Phase angle	K1 = 0; K2 = 1	Feedback loop **reponse time** adjustment. The response time depends on the feedback loop gain
Logic	K1 = 0; K2 = 0	No action
Burst firing	K1 = 1; K2 = 0	Adjustment of the **number of** firing (or non-firing) periods in the basic cycle.
Phase angle burst	K1 = 1; K2 = 1	

Table 5-9 Functions of the potentiometer P2

Standard response time in 'Phase angle'

The feedback loop response time can be adjusted from **13** to **52** periods using the potentiometer **P2**. When **P2** is turned **clockwise**, the response time **is increased** (since the gain is decreased).

An increase in the gain can cause the setpoint to be exceeded transiently.
Stability can be increased, but by decreasing the feedback loop gain.

A satisfactory **'stability / gain'** compromise is obtained with a response time of approx. **0.68 s.** This **standard** response time (default setting) corresponds to an adjustment voltage of **4.3 V** (read in position **10** of the EUROTHERM type 260 diagnostic unit).

Number of firing periods in the basic cycle

The firing (or non-firing) time in the 'Burst firing' and 'Phase angle burst' modes is set using the potentiometer **P2**.

Important !

The potentiometer **P2** adjusts:

- the duration of the basic cycle **firing** time for **less than 50%** power
- the duration of the basic cycle **non-firing** time for a power **greater than or equal to 50%**

The adjustment varies between **a single** period ('**Single cycle**' firing mode) and **255** periods.

The adjustment made can be **read** using the Eurotherm type 260 diagnostic unit in position **10** (in the form of an **adjustment voltage**).

P2 Adjustment voltage (read in position 10 of the diagnostic unit)	Basic firing (or non-firing) time		
	Number of periods	**50 Hz supply**	**60 Hz supply**
0 V	1	20 ms	16.6 ms
0.5 V	2	40 ms	33.3 ms
1.0 V	4	100 ms	83.3 ms
2.0 V	8	160 ms	133.3 ms
2.5 V	16	320 ms	266.6 ms
3.0 V	32	640 ms	533.3 ms
3.5 V	64	1.28 s	1.07 s
4.5 V	128	2.56 s	2.13 s
5.0 V	255	5.10 s	4.25 s

Table 5-10 Basic cycle firing (or non-firing) time

'Setpoint limit' potentiometer

The potentiometer **P3** labelled '**Setpoint limit**' on the front panel can be used to **limit the input signal setpoint**.

The input signal limit function is **enabled** in the Phase angle, Burst firing and Phase angle burst firing modes, but **does not act** when the TC3001 thyristor unit is configured in **Logic** firing mode.

The setpoint limit adjustment made using the potentiometer **P3** can be **read** using the Eurotherm type 260 diagnostic box in position **9** (in the form of an adjustment voltage-V_9).

The adjustment voltage value V_9 of the limit input signal E_{LIM} (in % of the selected **scale**) can be obtained according to the equation:

$$V_9 = 5\ V \times \frac{E_{LIM}\ \%}{100\%}$$

where E_{LIM} represents the value of the limited input value.

E.g.: Required setpoint limit $E_{LIM} = 65\%$
Adjustment voltage (read in position **9**)

$$V_9 = 5\ V \times \frac{65\%}{100\%} = 3.25\ V$$

This adjustment obtained signifies that when the input signal is **100%**, the output power reaches **65%** of its nominal value (or calibration value).

When the input signal is **20%**, the output power is only **13%** of its nominal value:

$$\frac{20\ \% \times 65\%}{100\%} = 13\%$$

This limit affects the voltage, current or power supplied by the thyristor unit.

E.g.: 400 V / 100 A thyristor unit, feedback type: power
Nominal unit power $P_{UN} = 69.2$ kW
Nominal power of load used $P_{LN} = 40$ kW
Adjustment voltage (read in position **9**)

$$V_9 = 5\ V \times \frac{40}{69.2} = 2.9\ V$$

'Load fail' potentiometer

The potentiometer **P4** labelled '**Load fail**' on the front panel is used to adjust the **maximum sensitivity** of the partial load failure (**PLF**) detection circuit for the real load.

The adjustment of the potentiometer **P4** is used to **memorise** the nominal operating conditions of the load (e.g. over at operating temperature).

The PLF detection circuit continuously measures the RMS line-to-line voltage and the three RMS line currents. This is used to calculate the 3 load impedances (detected by the thyristor unit) and compare them with the impedance value memorised during the PLF detection adjustment (see 'Commissioning' chapter, page 6-14).

A PLF alarm is triggered when 1 (or more) of the 3 impedances has increased in relation to the greatest of the 3 impedances measured during the adjustment.

Since the PLF detection is performed **with reference to the highest impedance**, if the three-phase load is **unbalanced** then the detection sensitivity on the 3 phases is **different.**

The sensitivity is best on the phase with the highest impedance.
The PLF detection sensitivity on the other two phases is low if the system is unbalanced.

Using the potentiometer **P4** it is possible to correct the PLF detection sensitivity with reference to the adjusted sensitivity (see PLF detection adjustment).

To reduce the PLF detection sensitivity in the event of **untimely alarms** (if the detection threshold is **adjusted at the limit**), turn the potentiometer **P4** slightly anti-clockwise.

'I^2 limit' potentiometer

The 'I^2 **limit**' potentiometer **(P5)** is used to **adjust the maximum intensity threshold** allowed by the load.
If this threshold is **exceeded**, the current **limit** action is triggered, depending on the firing mode:

- with thyristor firing angle **variation** or
- with the thyristor unit operation **stop**.

Depending on the configuration, the current threshold can be set using the potentiometer P5 or using an external signal. **The potentiometer P5 remains enabled irrespective of the selected limit mode.** The potentiometer on the front panel **realigns** the limit range according to the maximum level set either by the external input or by the internal voltage.

The current threshold adjustment sets the value of the **squared** current and can be read by the diagnostic unit in position **19** in the form of an adjustment voltage - $\mathbf{V_{19}}$.

With the values of the nominal load current $\mathbf{I_{LN}}$ after the calibration and the current threshold $\mathbf{I_{LIM}}$, the value of the adjustment voltage can be obtained according to the equation:

$$V_{19} = 5\,V \times \frac{I_{LIM}^2}{I_{LN}^2}$$

E.g.	**:**	Nominal load current	**100 A**
		Limited current (current threshold)	**80 A**

Adjustment voltage using the potentiometer P5:

$$V_{19} = 5\,V \times \frac{80^2}{100^2} = 3.2\,V$$

When the user has selected the **external signal** to adjust the current limit setpoint remotely, **all** the limit signals used must be taken into account. The value of the voltage $\mathbf{V_{19}}$ (adjustment using the potentiometer **P5**) must be calculated using the same equation.

CURRENT LIMIT OPERATION

The current limit acts as a **safety device** when the current threshold (set by the user) has been exceeded. The current limit affects **the highest** of the three thyristor unit currents.

The current limit circuit uses the **squared current** limit in order to react more effectively on the increase in the thyristor unit currents.
The current limit sets the value of I^2 **maximum**.

The detection of a **current greater than** or **equal** to the threshold set

- using the potentiometer **P5** on the front panel or
- using the external signal and using the potentiometer **P5**

leads to **the ON state** of the current limit.

The **action** of the current limit is **determined by the firing mode.**

Phase angle:

- **reduction** of thyristor firing required,
  the internal feedback algorithm changes from current limit
  operation to normal operation.
- If another over-current is detected during the change to normal operation,
  the current limit with firing angle variation is continued.

Logic: thyristor unit operation **stopped** at first detection.

Burst firing without soft operation:

- **alarm** and **reduction** of the firing angle the first time the threshold is exceeded;
- **soft start** on the number of periods **selected**
  (with a **minimum** of **8** periods) for the next cycle;
- thyristor unit operation **stopped** if a **second** over-current is detected before the
  previous alarm is acknowledged (during start on the 8 periods).

Burst firing with soft operation and **Phase angle burst:**

- **reduction** of the thyristor firing **angle** in order to keep the RMS current less than or
  equal to the current threshold (in firing cycle);
- **soft start** on the number of periods **selected**
  (with a **minimum** of **8** periods) for the next cycle;
- operation in **Burst firing** mode with a **reduced** firing angle
  (adjusted in order to keep RMS current less than the limit threshold)
  if an over-current is detected.

In the **Burst firing** with soft start/end and **Phase angle burst** firing modes, the feedback system incorporates the power actually dissipated in the load and calculates the new cyclic ratio so that the total power **corresponds** to the **setpoint** applied excluding the current limit.

FEEDBACK OPERATION

The internal feedback loop algorithm of the **TC3001** series thyristor unit takes into account the feedback value selected by the user using the configuration jumpers (see page 4-9).

The feedback parameters are as follows:

- load power - **P**
- mean of squared currents - **I^2**
- squared load voltage - **V^2**
- external (feedback) measurement - **External measurement**

For the control signal applied on the **analogue** input, the response curve is **linear** between **0%** and **100%** with 'dead bands' between 0 and 2% and between 98% and 100%.

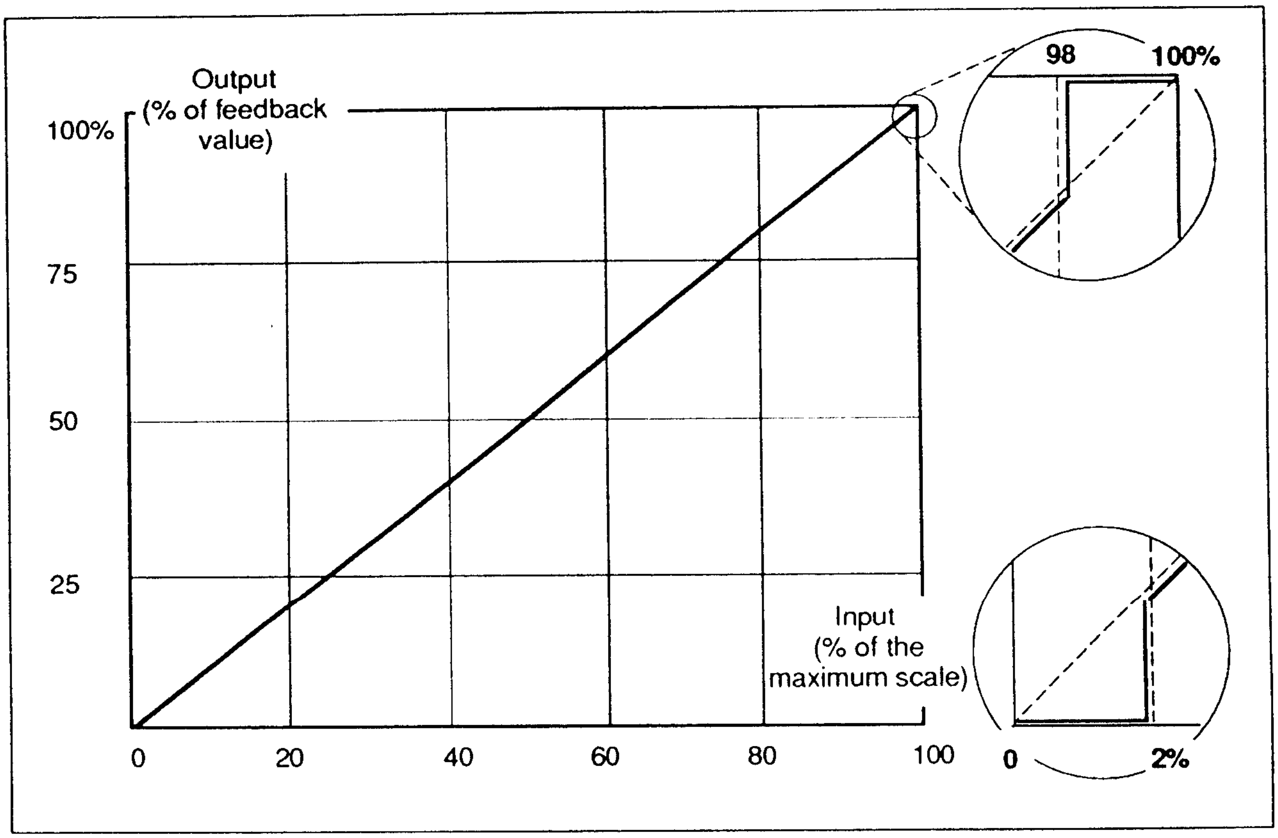


Figure 5-13 'Input/Output' response curve

The output power of the thyristor unit is calibrated according to the **selected feedback** value and the thyristor unit calibration (see 'Calibration', page 6-8).

Squared current

This parameter represents the value of **the mean** of the square of the three RMS line currents

$$I_{AVE}^2 = \frac{I_1^2 + I_2^2 + I_3^2}{3}$$

This value can only reach **100%** if the three-phase loads are balanced (or almost balanced) since the current limit, when it is adjusted to its maximum value, limits the highest of the three currents to **110%** I_{NOM}^2 (or **105%** I_{NOM}).

Squared load voltage

The V^2 feedback parameter is the square of the **RMS load** voltage:

- voltage between phases **1** and **2** of the load for closed or open delta and star without neutral configurations;
- voltage between phase **1** of the load and the **neutral** for a star with neutral configuration.

Power

The '**Power**' feedback parameter represents the mean apparent power supplied in the load

$P = V_{LOAD} \times I_{AVE}$

I_{AVE} represents the **mean** of the RMS current

$$I_{AVE} = \frac{I_1 + I_2 + I_3}{3}$$

V_{LOAD} represents the RMS **line-to-line** voltage of the load.
The nominal power is

$$P_{NOM} = (V_{NOM} \times I_{AVE.NOM})$$

As described for the current value, the current limit acts with a maximum threshold of **105%** of the nominal thyristor unit current. This means that **maximum** power can only be obtained if the three-phase loads are **balanced**.

External measurement

The **external feedback** signal has four voltage scales and two current scales.

Voltage: 0 - 5 V; 1 - 5 V; 0 - 10 V; 2 - 10 V (input impedance ≥ 100 kΩ)
Current: 0 - 20 mA; 4 - 20 mA (input impedance 100 Ω).

Chapter 6

COMMISSIONING PROCEDURE

Contents Page

Chapter 6 COMMISSIONING PROCEDURE

Read this chapter carefully before commissioning the thyristor unit

COMMISSIONING PROCEDURE SAFETY

Important !

Eurotherm cannot be held responsible for any damage to persons or property or for any financial loss or costs resulting from the incorrect use of the product or the failure to observe the instructions contained in this manual.

It is therefore the user's responsibility to ensure that all the nominal values of the power unit are compatible with the conditions of use and installation before commissioning the unit.

Danger !

Dangerous live parts may be accessible when the front door is open.

Only personnel qualified and authorised to work in industrial low voltage electrical environments can access inside the unit.

Access to internal components of the thyristor unit is prohibited to users who are not authorised to work in industrial low voltage electrical environments.

The temperature of the heatsink may exceed 100°C.
Avoid all contact, even occasional, with the heatsink when the unit is in operation. The heatsink remains hot approximately 15 min after the unit has been switched off.

CHECKING THE CHARACTERISTICS

Attention !

⚠ Before connecting the unit to an electrical supply, make sure that the **identification code** of the thyristor unit corresponds to the coding specified in the **order** and that the characteristics of the thyristor unit are **compatible with the installation**.

Load current

The maximum load current (line current or arm current in Open delta) must be less than or equal to the value of the nominal current of the thyristor unit taking the load and supply variations into account.

If the three identical loads are configured in **closed delta**, the current of each phase of the thyristor unit is **√3 times as high** as the current of each **arm** of the load.

For the given power (**P**) of the three-phase load and for the line voltage V_L (line-to-line voltage), the current to be compared with the nominal thyristor unit current is:

$$I = \frac{P}{\sqrt{3} \times V_L}$$

For the open delta, the current to be compared with the nominal thyristor unit current is:

$$I = \frac{P}{3 \times V_L}$$

Load configuration type

Make sure that the configuration type used is correctly configured using the jupers

- **K5** and **K6** on the driver board (see page 4-13)
- **LK7**, **LK8** and **LK9** on the power board (see page 4-5).

Supply voltage

The **voltage applied** to thyristors in the OFF state, **depends on the load configuration type**.

For the **star without neutral, closed** or **open delta** configurations, the nominal value of the thyristor unit voltage must be greater than or equal to the **line-to-line** voltage of the supply used.

For the **star with neutral** configuration, the nominal thyristor unit voltage can be greater than or equal to the voltage between the **phase and neutral** of the supply used.

A thyristor unit can be used on a three-phase supply of a voltage **less** than the voltage specified for the thyristor unit, by **reconfiguring** it (see table 4-1, page 4-4).

If the supply voltage is less than **70%** of the nominal thyristor unit voltage, after 5 s of integration, the thyristor unit changes to inhibition (thyristor control withdrawn).

The thyristor unit is re-enabled automatically if the voltage returns to a value greater than or equal to 70 % of the nominal value of the thyristor unit.

Attention !

Given the inhibition at 70 % of the nominal voltage, the operating (calibration) voltage must be as close as possible to the nominal supply voltage used.

Auxiliary power supply voltage

The auxiliary power supply voltage must correspond to the power supply available.

The voltage is selected in the factory, according to the order code, using soldered links on the driver board (see page 4-8).

Input signals

The jumper configurations on the driver board must be compatible with the selected levels of the analogue signals used for:

- control (see page 4-9)
- the external current limit (see page 4-11)
- the external measurement (see pages 4-9 and 4-10).

DIAGNOSTIC UNIT

For easier commissioning and adjustment operations and for the thyristor unit state diagnostics, it is advisable to use the **EUROTHERM type 260** diagnostic unit.

The diagnostic unit possesses a flat cable which is plugged into the 20-pin connector (diagnostic connector) provided on the front panel of the thyristor unit.

The **20-way switch** of the diagnostic unit is used to view the values of the thyristor unit and feedback parameters on its digital display. The unit displays two decimal places for the precise indication of the selected values.

The signals from the diagnostic connector may also be viewed using an oscilloscope.

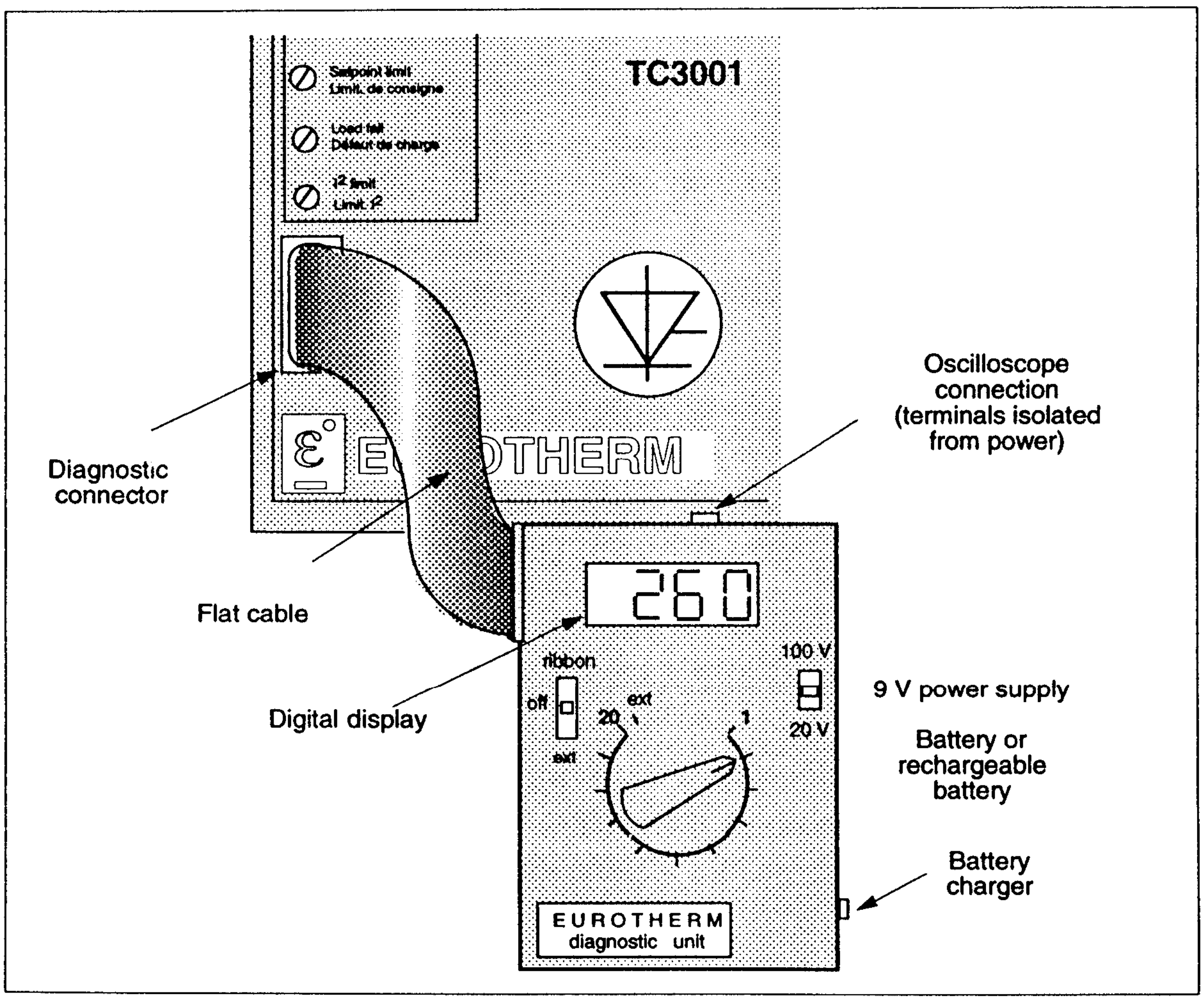


Figure 6-1 Connection of the EUROTHERM type 260 diagnostic unit and the TC3001 thyristor unit

The following table gives the description of each position of the **EUROTHERM type 260** diagnostic unit and the typical values of the signals measured.
These signals are **DC** values.

Position	Designation	Typical value	Remarks
1	Power supply	+5.6 V	
2	Reference	+5 V	
3	Power supply	+15 V	
4	User voltage	+10 V	Control term. block
5	Power supply	-15 V	-14.45 to -15.55 V
6		+21 V	Rectified, filtered
7	Input control signal (at converter output)	0 to 5 V	
8	PLF detection adjustment threshold	0 to 5 V	Potentiometer **P4**
9	Setpoint limit	0 to 5 V	Potentiometer **P3**
10	Burst firing cycle time	0 to 5 V	Potentiometer **P2**
11	Ramp, soft start/end or delayed firing duration	0 to 5 V	Potentiometer **P1**
12	Calibration of I_1 (M_2=0) or Image of I_1 in operation (M_2=1)	1 to 10 V in calibration,	Jumper M2 = 0 Potentiometer **P7**
13	Calibration of I_2 (M_3=0) or Image of I_2 in operation (M_3=1)	0 to 1.67 V	Jumper M3 = 0 Potentiometer **P8**
14	Calibration of I_3 (M_4=0) or Image of I_3 in operation (M_4=1)	in operation	Jumper M4 = 0 Potentiometer **P9**
15	Synchronisation	5 V pulses	Zero crossing
16	Microprocessor reset	5 V pulses	Normal operation : 0V
17	Enable	5 V logic	Inhibition : 0 V
18	Power supply	Common 0 V	
19	Current limit setpoint (current threshold I^2)	0 to 5 V	Potentiometer **P5**
20	Calibration of voltage (M_1=0) or Image of V in operation (M_1=1)	1 to 10 V in calibration; 0 to 1.67 V in operation	Jumper M1 = 0 Potentiometer **P6**

Table 6-1 Destination of the positions of the EUROTHERM type 260 diagnostic unit

THYRISTOR UNIT CALIBRATION

The thyristor unit is calibrated so that the **maximum value** of the selected input signal **scale corresponds** to the **nominal values** of the **currents** and **voltage** allowed by the load used.

The calibration performed also acts on the power retransmission signals and on the feedback signal selected for the feedback algorithm.

The four potentiometers (labelled **P6** to **P9**) used to calibrate the thyristor unit in terms of voltage and current. They are located on the **potentiometer board**, placed perpendicular to the driver board (see figure 1-2). The calibration potentiometers can be accessed with the front door open. Each potentiometer can be adjusted by **10 turns**.

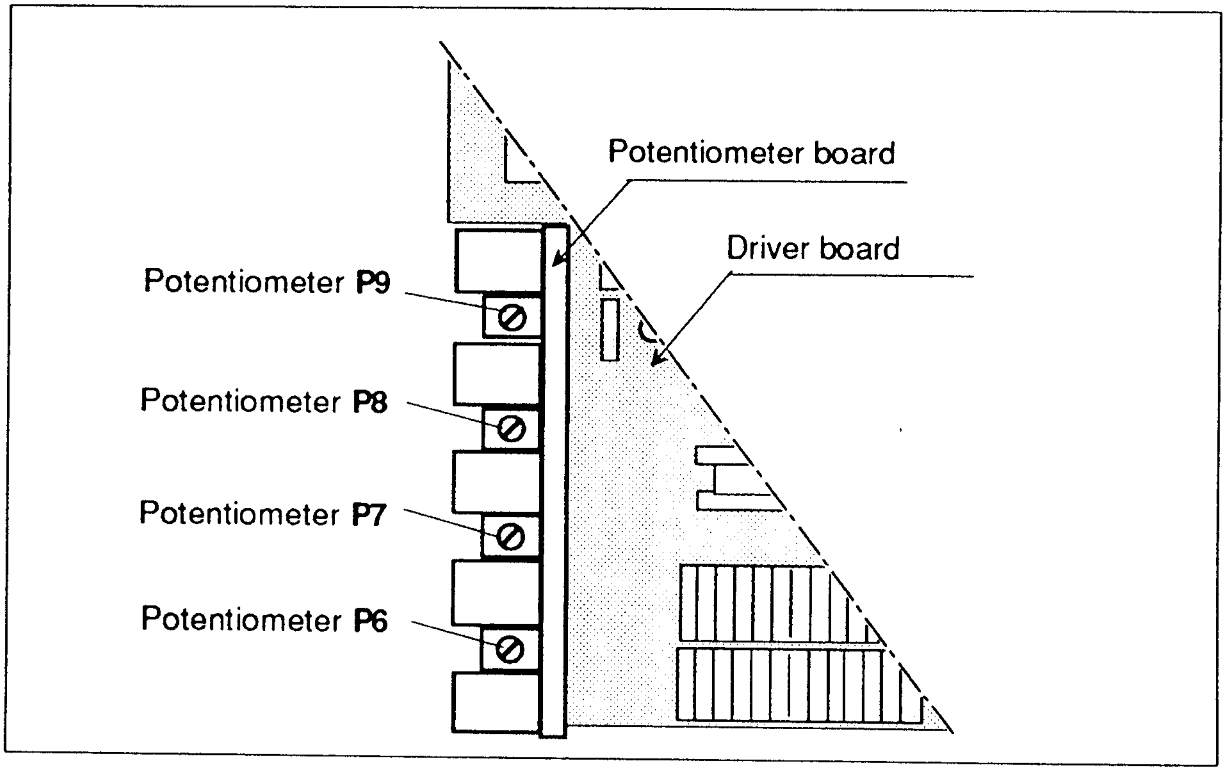


Figure 6-2 Location of calibration potentiometers

The calibration procedure must be performed using the **EUROTHERM type 260** diagnostic unit enabling accurate readings of the calibrated values.

Note: Calibration is not essential if:
- the retransmissions **are not used**
- the load current and voltage are **close** to those of the TC3001 thyristor unit

There are two possible types of calibration depending on the position of calibration jumpers **M1** to **M4** :

- **non-firing** calibration or
- **full firing** calibration.

Normally, calibration must be performed during **non-firing** (the jumpers **M1** to **M4** on the driver board are set to **position 0**).

The calibration of the thyristor unit during non-firing does not require the operation of the installation under nominal conditions and can be performed **without the presence** of the three-phase voltage.

Once the non-firing calibrations have been **performed**, the calibration jumpers must be reset to the **operating** position (**1**).

Full firing calibration is performed if it is necessary to **fine-tune** or **readjust** the calibration **during thyristor unit operation.**
In this case, the calibration jumpers must be left in the **operating position.**

In the factory, the calibration signals are adjusted for the **nominal voltage** and **nominal currents** specified in the thyristor unit order. The following calibration procedure is optional and is only to be performed for conditions when the nominal load voltage and currents can be changed.

Important

If the value is calibrated at its **nominal** value, the corresponding reading on the diagnostic unit in positions **12, 13, 14** and **20** is **1 V** (jumpers M1 to M4 in **calibration** position).

For the firing calibration, it should be taken into account that in **full firing** (sinusoidal current operation), the DC values (rectified sinusoidal signals, double alternations) read in positions **12, 13, 14** and **20** of the EUROTHERM type 260 diagnostic unit are **1.67 V (855 V** RMS or **2.61 V** peak to peak on the oscilloscope) in nominal current and voltage conditions.

Attention

⚠ Calibration **cannot be performed** at a value less than **10%** of the nominal currents

Phase current calibration

To calibrated the currents of the thyristor unit, calculate the calibration voltage V_{CA} for each phase according to the following ratio:

$$V_{CA}\,(V) = 1\,V \times \frac{I_{UN}}{I_{LN}}$$

where I_{UN} - nominal thyristor unit current (see identification label)
I_{LN} - nominal load current.

Non-firing calibration (M2 to M4 in position 0)

- Check the **0** of the jumper (**M2** to **M4**) corresponding to the phase to be calibrated
- By turning the potentiometer of the phase to be calibrated (**P7** to **P9**), display the value V_{CA} calculated on the diagnostic unit display in positions **12**, **13** and **14** (phase **1, 2 and 3** respectively)
- Reset the jumpers **M2** to **M4** in the operating position.

Example:

Balanced three-phase load power	P	= **150 kW**
Line voltage	V_L	= **380 V**
Nominal thyristor unit current	I_{UN}	= **300 A**

The nominal load current $$I_{LN} = \frac{P}{\sqrt{3} \times V_L} = \frac{150 \times 10^3\ W}{\sqrt{3} \times 380\ V} = 228\ A$$

The calibration voltage: $$V_{CA} = 1\ V \times \frac{I_{UN}}{I_{LN}} = 1\ V \times \frac{300\ A}{228\ A} = 1.32\ V$$

Each potentiometer must therefore be turned consecutively (**P7** to **P9**) to obtain **1.32 V** on the diagnostic unit display in each of the positions **12, 13** and **14.**

Firing calibration (M2 to M4 in position 1)

If it is necessary to **fine-tune** or **readjust** the calibration during thyristor unit operation, the adjustment can be made with the calibration jumpers **in the operating position.**

For this procedure, the signals read by the diagnostic unit are rectified values, corresponding to currents actually measured.

The **full firing** phase current calibration is therefore obtained by adjusting the voltage V_{CA} to the value **1.67 V**.

Load voltage calibration

To calibrate the voltage of the **TC3001** thyristor unit, calculate the calibration voltage (V_{CA}) according to the following ratio:

$$V_{CA}(V) = 1\ V \times \frac{V_{UN}}{V_{LN}}$$

where V_{UN} - nominal thyristor unit voltage (see identification label)
V_{LN} - nominal load voltage (line-to-line voltage of the supply used).

Important !

For a **star with neutral** configuration, V_{CA} must be multiplied by $\sqrt{3}$.

Note: For the the Star with neutral configuration, the default calibration is **1.73 V.**

Non-firing calibration (M1 in position 0)

By turning the potentiometer **P6**, display the value V_{CA} calculated on the diagnostic unit display in position **20.** Reset the jumper **M1** in the operating position (1).

Example 1: Nominal **TC3001** thyristor unit voltage $V_{UN} = 380\ V$
Line voltage, 3 wire configuration $V_{LN} = 350\ V$

Calibration voltage: $V_{CA} = 1\ V \times \frac{V_{UN}}{V_{LN}} = 1\ V \times \frac{380\ V}{350\ V} = 1.09\ V$

The potentiometer **P6** must be turned to obtain **1.09 V** in position **20** on the display.

Example 2: Same conditions as in example 1, but in **star with neutral** configuration.

Calibration voltage: $V_{CA} = 1.09\ V \times \sqrt{3} = 1.89\ V$

The potentiometer **P6** must be turned to obtain **1.89 V** in position **20** on the display.

Firing calibration (M1 in position 1)

The signal read by the diagnostic unit is the **rectified** value, corresponding to the **voltage actually** measured. In **full** firing (sinusoidal load voltage operation), the DC value read on position **20** must be **1.67 V.**

Line voltage calibration

The line voltage read by the microprocessor can be adjusted using the potentiometer (labelled **P18**) located on the driver board (see figure 4-2, page 4-7).

Attention !

This adjustment is made in the factory and **must not be modified.**

COMMISSIONING

Preliminary adjustments

- After checking the cabling, make sure that the '**Enable**' input (terminal **15** on the driver board) is connected directly or via a closed switch to '**+10 V**' (terminal **16** on the same terminal block) or to an external voltage between +5 V and + 10 V referenced in relation to terminal **17** ('**0 V**').

- After calibration, check that the Calibration/Operation jumpers **M1 to M4** are in the operating position (**1**).

- The initial position of the potentiometer **P1** depends on the **thyristor firing mode.**

  - 'Phase angle' operation: potentiometer **P1** set to **zero** - completely **anti-clockwise** - (except if the ramp is used) - which gives **0** in position **11** of the diagnostic unit.

  - 'Burst firing' operation on the inductive load or on a transformer primary coil: potentiometer **P1** completely **clockwise**, which corresponds to a **90°** delay in the first thyristor firing.

- Set the potentiometer **P3** ('Setpoint limit') to zero, i.e. completely **anti-clockwise**.

- Set the potentiometer **P5** ('I^2 limit') to the calculated position for the required current limit.

Attention !

If the potentiometer **P5** is set completely **to zero** by mistake (turned completely **anti-clockwise**), the thyristor operation in the Logic and Burst firing modes is **stopped** by the '**Over-current**' alarm.

In this case, after setting P5 to a value other than zero, the **alarm** must be **acknowledged.**

Power-up

During power-up, **automatic recognition of the phase rotation order** is performed.

- Switch on the thyristor unit (power supply and auxiliary power supply).

Attention !

If the control power is supplied **before** the power-up, the '**Under-voltage**' alarm is displayed.

- Check that the load current is equal to **0** in the **absence** of the control signal.
- Apply a control signal to the input (terminal 14 of the driver board).
- Turn the potentiometer **P3** slightly clockwise and check that the current increases in the load and that it varies as a function of the level of **P5**.

Important !

The thyristor unit always starts with a **safety ramp** of **32** periods in firing angle variation **irrespective of the** selected thyristor firing **mode.**

This safety ramp is applied at the start:

- at the control electronics **power-up**,
- after an **inhibition**
- after a microprocessor **reset,**
- from a zero setpoint in 'Phase angle burst' mode (8 periods only).

- Make sure that the RMS current does not exceed the nominal thyristor unit current when **the setpoint is 100%** and the potentiometer **P3** is turned completely clockwise.

If the currents do not correspond to the applied control signal while the signals of the potentiometers **P5** and **P3** are at **100%**, readjust the current **calibration.**

The control signal can be read in position **7** of the diagnostic unit (**5V** corresponds to **100%**of the input signal).

The data on the load currents is available in positions **12, 13** and **14** of the diagnostic unit.

Delayed firing adjustment on inductive load
'Burst firing' and 'Logic' modes

To eliminate the transient operation over-current during the power-up of inductive loads, the first firing on each phase in the 'Burst firing' and 'Logic' modes must be delayed with reference to the corresponding zero voltage (see page 5-9).

The optimum delay angle depends on the load used and can be adjusted with potentiometer **P1** ('**CY Delay**') on the front panel.

In the factory, the delay angle is adjusted to **90°** (potentiometer **P1** completely clockwise).

To fine-tune the delay angle during commissioning, follow the procedure below:

- Check that the position of the jumper **K7** on the driver board is **1** (inductive load) and that the potentiometer **P1** is at the **maximum** value, i.e. turned completely **clockwise.**
- Connect an oscilloscope to display the transient current.
- **After** the power-up, turn the potentiometer **P1** slowly **anti-clockwise** until the **transient current** at firing, displayed on the oscilloscope, has a **minimum amplitude.**

Data on the delayed firing angle is available in voltage form in position **11** of the diagnostic unit (**5 V** corresponds to **90°**; the delay angle adjustment scale is given on page 5-22).

PARTIAL LOAD FAILURE DETECTION ADJUSTMENT

The partial load failure detection (**PLF** detection) is adjusted to obtain the **maximum sensitivity** of the **PLF** detection circuit in nominal thyristor unit and load operating conditions. This adjustment consists of **memorising** the **nominal** operating **conditions** using the potentiometer **P4**.

The PLF adjustment (or non-adjustment) is displayed on the front panel **display** (see chapter 7).

Note: The PLF adjustment only applies to **low** temperature coefficient loads.
To **inhibit** the PLF detection, the potentiometer **P4** must be turned **anti-clockwise**.

For the **PLF** adjustment:

- **Calibrate** the thyristor unit currents and voltage
- Set to the **nominal conditions** for use and installation so that the partial load failure detection has the best sensitivity.
- Turn the potentiometer **P4** gradually clockwise until the flashing message '**P**', followed by a line **number** with the highest impedance, is displayed on the front panel display.
This message flashes for **5** s during which the nominal load impedance is **recorded.**

Attention !

The PLF detection adjustment is only possible if the current of each of the phases is greater than **25%** of the nominal load current.

Important !

It is advisable to adjust the PLF detection to 100% firing (load at highest temperature).

In **Slow cycle** mode, during the PLF adjustment, turn the potentiometer P5 very **carefully** since the PLF detection is only enabled during the firing cycle.

If the thyristor unit current or voltage **calibration** is **modified**, a PLF detection **adjustment** must then be **repeated**.

Chapter 7

DISPLAY MESSAGES

Contents page

Chapter 7 DISPLAY MESSAGES

GENERAL

During the thyristor unit commissioning procedure and during its operation, messages are displayed on the front panel display. These messages inform the user on:

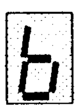
- the type of thyristor unit operation
- the enabled alarms
- the errors and the faults.

Two types of message are shown on the display.

- **Steady** messages indicating the current thyristor unit operating mode. The thyristor unit operates **normally, or in** current limit, in Phase angle mode, or is inhibited.
- **Flashing** messages indicating **abnormal** operation (an error or a failure).

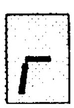
STEADY MESSAGES

Normal operation in **Phase angle** mode

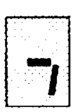


Normal operation in the following modes:
- **Burst firing**
- **Phase angle burst**

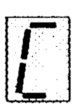
Normal operation in **Logic** mode.



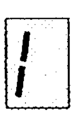
Ramp on a setpoint **increase** with thyristor firing angle variation.



Ramp on a setpoint **decrease** with thyristor firing angle variation.



Current limit with thyristor firing angle variation.



Inhibition of thyristor unit (terminal 15 '**Enable**' on the driver board is at **0 V** or is not connected to **+10V**).

FLASHING MESSAGES

A flashing message is composed of **three consecutive displays** for **1.25** s each (the second and third displays can be **empty**).

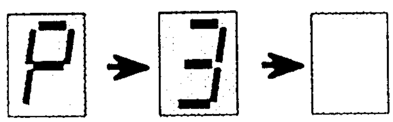
The display indicates three types of flashing messages:

- Message **'P'** - a partial load failure detection. The next message indicates the phase number (or disappearance of detection).
- Message **'E'** - an **error**. The **next** message indicates the alarm **type**.
- Message **'F'** - a **failure** (thyristor unit inhibition). The **next** message indicates the alarm **type**.

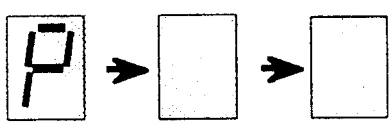
During these messages, **the decimal point** on the display indicates **the alarm ON state.** The flashing messages are used to **identify** certain alarms. For the alarm display conditions and their detailed state see '**Alarms**' chapter.

P L F detection

The thyristor unit **continues** to operate.



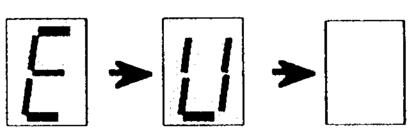
A partial load failure. The failure is still **present.** The second message indicates the phase **No.** concerned (phase **3** in the example). If several phases are at fault, only the lowest **No.** is displayed.
When the alarm disappears, the message **'P'** remains memorised (but not the phase No.).



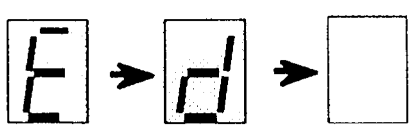
A partial load failure **has been detected** but it no longer exists. **Waiting** for an acknowledgement.

Error

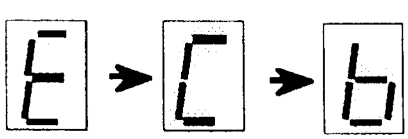
The thyristor unit **continues** to operate.



Supply **over-voltage**.
This message disappears at the same time as the over-voltage.



Load **unbalance** (appears after **5 s**) if **PLU** detection is configured.
This message disappears at the same time as the unbalance.

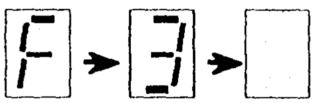


The **first** detection of over-current in **Burst firing** mode. The thyristor unit is in current limit in angle variation. This alarm is memorised and must be acknowledged.
(If a second detection occurs before the alarm is acknowledged, the thyristor unit operation is inhibited with the failure message indication).

Failures

The detection of the following failures causes the **inhibition** of operation.
The thyristor unit returns automatically to normal operation as soon as **the cause** of the failure **disappears** (phase missing, frequency, under-voltage) or after an **acknowledgement** (thyristor short-circuit, over-current, external signal failure).

The messages below appear **5 s after** the failure has appeared (except for over-current).

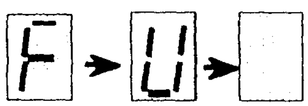


- **One** or **more supply phases** are **missing**.

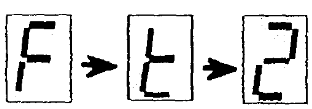
The **second** message indicates the **No.** of the missing phase (e.g.phase **3**). If several phases are concerned **only the lowest No.** is displayed).

- **Thermal** switch in alarm state (display '**F**' '**1**').

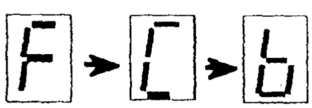
- Supply **frequency outside** normal operating limits **(40 to 70 Hz)**
- **Failure** of **neutral circuit** in Star with neutral configuration (fuse blow-out on the power board, etc..)



Under-voltage of supply **V < 70 %** of the **nominal** voltage.



Short-circuit of thyristors in at least **1** phase.
The **third** message indicates the **No.** of the phase concerned (e.g. phase **2**).

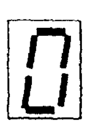


Current threshold **exceeded** in **Logic** mode or **Second** over-current in **Burst firing** mode (without acknowledgement after the first over-current).

External signal return **failure** for a feedback on an external measurement (except in Logic mode).

MICROPROCESSOR FAILURE

The display does not indicate **any** message or indicates **incoherent** messages.
The thyristor unit operation is **inhibited** (by the 'Watchdog') and the driver board must be replaced.



- Microprocessor reset to zero ('**Reset**')
- Thyristor unit initialisation (temporary message).

Chapter 8 ALARMS

Contents page

Chapter 8 ALARMS

The alarms used by the TC3001 thyristor unit protect the thyristors and the installation against **abnormal operation** and give the user **information** on the type of failures that have occurred.

Danger !

Alarms cannot be used to replace personnel protection.

It is the user's responsibility and it is highly recommended, given the value of the lequipment controlled by the TC3001, to install **independent safety devices which should be checked regularly.**
For this purpose, Eurotherm can supply several types of alarm detectors.

ALARM STRATEGY

The **TC3001** thyristor unit alarms are entirely **managed by the microprocessor** of the driver board which retransmits its data (alarms enabled or not) **using the display** on the thyristor unit front panel and **two alarm relays.**

The alarms are **given levels** (see figure 8-[illegible]). The detection of a high level alarm **inhibits** the processing of lower level alarms.

The enabled state of all the alarms is indicated by the front panel **display** (see pages 7-1 to 7-4) and two **alarm relays** (see page 8-[illegible]).

The **highest** level alarms detect the following failures:

- absence of one or more supply phases
- over-current in Logic and Burst firing modes
- under-voltage
- abnormal supply frequency
- thyristor short-circuit
- external measurement signal failure.
- neutral failure (fuse blow-out on the power board).

The detection of one of these failures causes the thyristor unit **operation to be inhibited** (display '**F**' '...').

The low level alarms (display '**E**' '...') monitor:

- the over-voltage
- the current unbalance
- the partial load failure
- the first over-current in Burst firing mode.

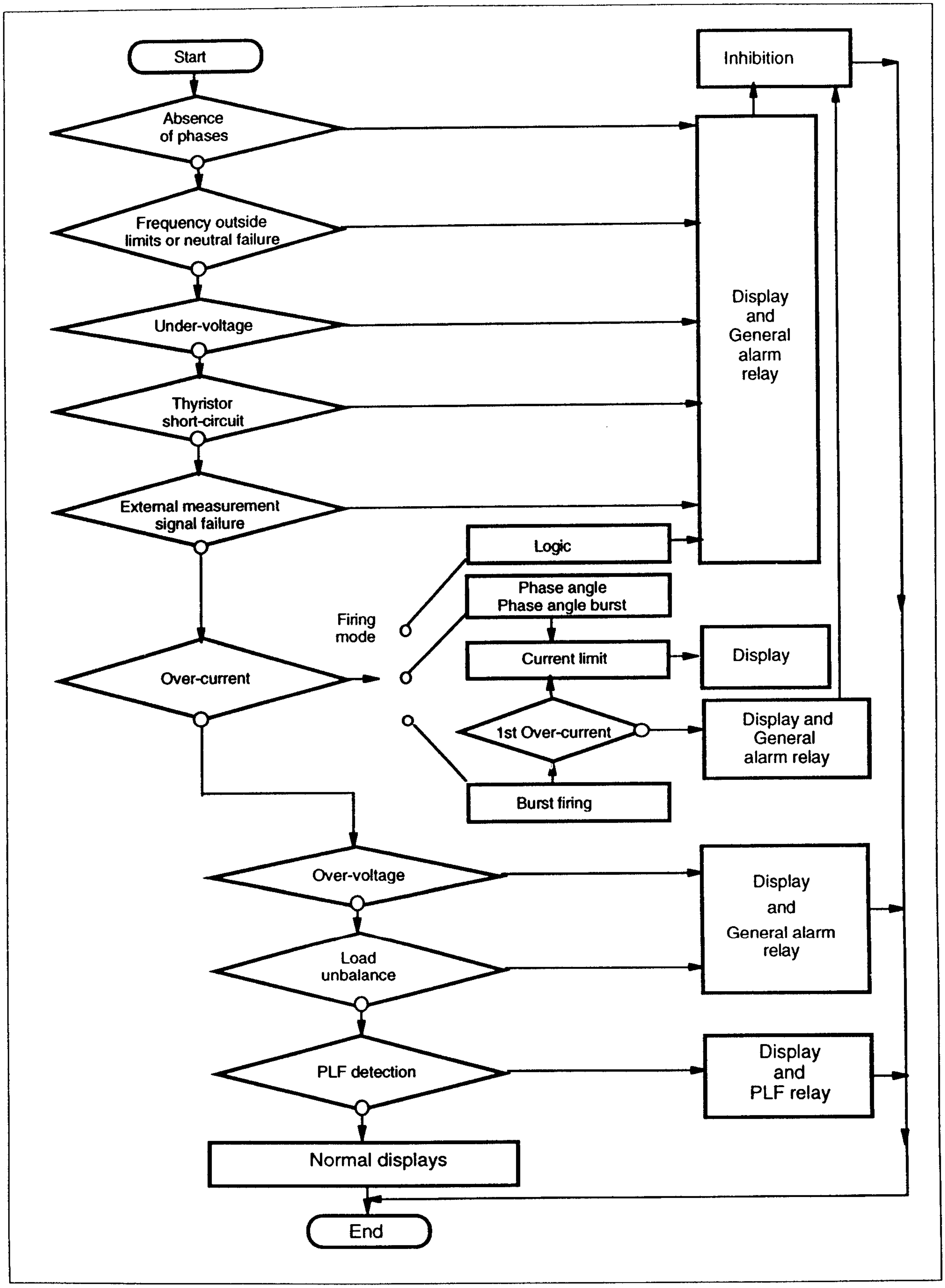


Figure 8-1 Alarm levels and strategy

ALARM RELAYS

Two alarm relays are located on the driver board:

- the partial load failure relay (**PLF** relay)
- the relay for all the other alarms (**general alarm relays**).

The partial load failure detection changes the state of the **PLF relay**.
The detection of any other alarm changes the state of the **general alarm relay**.

The switches (**N/O** or **N/C** depending on the configuration) can be used to indicate the alarm state. The switches are available on the user terminal block below the thyristor unit (terminals **51-52** and **61-62**).

The relay switches can be connected without opening the front door of the thyristor unit.

The alarm relay switch connections are given on page 3-12.

The switch cut-off capacity is **0.25 A (250 Vac** or **30 Vdc).**

The switch operating voltage must never be greater than **250 Vac**.

The Alarm relays are **deactivated** in the **alarm** state or when the thyristor unit is **switched off**.

SERIOUS ALARMS

Serious alarms detect the absence of or a significant drop in the supply voltage, over-currents (in Logic and Burst firing modes), whether the frequency limits have been exceeded, neutral failure in the power board in the star with neutral configuration, thyristor short-circuits and external measurement signal failure.

These alarms are integrated for **5 s before being handled** (except for Over-current).

Serious alarms **stop** the operation of the thyristor unit by **inhibiting** thyristor gate pulses and **activate** the general alarm relay.
Thyristor firing is stopped at the first zero current crossing.

The state of the serious alarms is indicated by **flashing messages** on the front panel display and by the general alarm relay **switch** (N/O or N/C depending on the configuration).

Absence of supply phases

This alarm appears when one or more supply phases are absent.
The phase absence alarm can be activated by **supply** failures, by **fuse** blow-out, by the opening of the **circuit breakers** or line **contactors**, and also by the opening of a thyristor unit safety **thermal switch** with permanent cooling (in this case display '**F**' '**1**').

The active alarm state can be seen on the display (messages '**F**' '**1**', '**F**' '**2**' or '**F**' '**3**' depending on the absent phase) and is signalled by the general alarm relay switch.

If several phases are cut off, **a single** message is displayed with the lowest phase number of the absent phase numbers (phase **1** on the left, **2** in the centre and **3** on the right).

The supply phase absence alarm is not memorised and disappears as soon as the **three phases** are **present**. The thyristor returns to normal operation automatically.

Under-voltage

The Under-voltage alarm uses the voltage between phases **1** and **2** as a reference.
If the line voltage drops by over **30%** in relation to the nominal value, the under-voltage alarm is detected, which:

- **inhibits** the thyristor unit,
- **activates** the general alarm relay
- displays the flashing message '**F**' '**U**' on the front panel display.

This alarm is not memorised and disappears as soon as the supply voltage is greater than the set threshold. The thyristor unit is started up again automatically, if the voltage returns to over **70%** of the nominal voltage.

Over-current

In **Logic** mode and in **Burst firing** mode (on the **second** over-current only), the current limit acts with a thyristor firing **stop** ('**Over-current**' alarm).

If the RMS value of the **maximum current** of one of the load phases **in these two modes exceeds** the current threshold allowed in the load (current threshold I_{LIM}) by **10%**, the thyristor unit operation **is stopped** and the thyristor gate pulses are **inhibited.** Thyristor firing is stopped at the first zero current crossing.
The active state of the Over-current alarm in these firing modes is displayed with the flashing message '**F**' '**C**' '**b**' and with the change of state of the general alarm relay.

If the current limit is exceeded in the Phase angle, Phase angle burst and Burst firing modes with soft start/end (or the first Over-current in Burst firing), the current limit in thyristor firing angle variation is activated and the thyristor unit operation is not inhibited (see'Current limit'). The active state of the Over-current alarm in these firing modes is displayed with the steady message 'C'.

The current threshold (I_{LIM}) is set using the '**I^2 limit**' potentiometer (**P5**) on the front panel of the thyristor unit. The potentiometer **P5** can operate in cascade with an external current limit signal or with the internal voltage.

For increased efficiency, the Over-current detection circuit uses the **squared** of the RMS load current I^2_L to compare with the squared value of the **resulting** current limit setpoint. This setpoint is set by the position of the potentiometer **P5** by taking into account the possible presence of the **external** current limit signal.

Thyristor unit operation after inhibition is only possible after an alarm **acknowledgement** (see page 8-16).

Frequency error

If the supply frequency is **outside** the normal operating limits (**40** to **70 Hz**), the frequency error alarm:

- **activates** the general alarm relay
- **inhibits** the thyristor unit
- displays the flashing **message** '**F**' '**P**' on the front panel display.

This alarm is not memorised and disappears as soon as the supply frequency returns to the normal operating limits.

Neutral failure

For the correct operation of the thyristor unit is the **star with neutral** configuration (4 wires), the neutral must be connected to the power board. The **Neutral** user terminal block below the thyristor unit, the neutral **fuse**, the resistor **R5** and the jumper **LK9** on the power board are used for the connection.

In the event of a failure of this circuit or a neutral fuse blow-out only in 4 wire Star load configurations, the Neutral failure alarm:

- activates the general alarm relay
- inhibits the thyristor unit
- displays the flashing **message 'F' 'P'** on the front panel display.

This alarm is not memorised and disappears as soon as the connection of the neutral to the power board is restored.

Thyristor short-circuit

The short-circuit detection is active if the measured current is greater than **10%** of the calibration current (nominal load current I_{LN}), **when** the thyristor firing request is zero (main setpoint at zero).

In the event of a **thyristor short-circuit** detection in two or three phases:

- the thyristor unit is **inhibited,**
- the alarm relay is **activated,**
- the flashing message **'F' 't'** is displayed
  (the third character indicates the **number** of the phase concerned).

The thyristor short-circuit in **a single phase** (3 wire configuration) is considered as a load **unbalance** and activates the corresponding alarm.

The Thyristor short-circuit alarm is memorised. To **deactivate** this alarm and restart the thyristor unit, the alarm must be **acknowledged** or the power switched off.

External measurement signal failure

This alarm appears when the **absence** of the external measurement signal is detected if a feedback on an external measurement is selected (coding '**EX**' and '**E*****') and the output power **is not zero** (alarm **deactivated** in Logic mode).

The detection of an external signal failure:

- **inhibits** the thyristor unit,
- **activates** the general alarm relay,
- displays the message **'F' 'E'**.

The unit can be restarted after the alarm **acknowledgement**.

LOW LEVEL ALARMS

The low level alarms **do not inhibit** the thyristor unit.
The anomalies detected are displayed with a change in the **relay** switches and with messages on the **display**.

The low level alarms (except for the First over-current in Burst firing) are only active **5 s after** the corresponding failure has appeared.

Over-voltage

If the line voltage is greater than the nominal thyristor unit voltage by more than **20%**, the over-voltage alarm is detected:

- the **general** alarm relay is **activated,**
- the flashing message '**E**' '**U**' appears on the front panel display.

In the event of over-voltage, the thyristor unit **is not inhibited,** the feedback **keeps** the value of the feedback parameter for the given operating point **constant**.

If the unit returns to a voltage less than **110%** of the nominal thyristor unit voltage, the relay returns to the non-alarm state.

First over-current in Burst firing

In **Burst firing** mode configured **without** soft start/end, the **first** detection of a current greater than or equal to the threshold set using the potentiometer **P5** (taking into account he possible existence of the external limit signal) activates the current **limit**.

The current limit has the following effect:

- the thyristor firing angle is **decreased** in order keep the current less than the current threshold
- the message '**E**' '**C**' '**b**' is displayed on the front panel display.
- the **soft** start over **8** periods when the next cycle starts.

If no over-current is detected after these 8 periods, normal thyristor unit operation in Burst firing mode is resumed.
The error message is memorised and must be **acknowledged** (see page 8-16).

If a new over-current is detected during the start over 8 periods, the operation is stopped with a **failure** message (see 'Over-current').

Load unbalance

If phase unbalance detection is selected (code **PLU** or **IPU**), the **TC3001** thyristor unit load is continually controlled by the thyristor-controlled current unbalance detection system.

The following failures can be detected on **one** or **two phases**:

- failure of part or all of a load arm;
- short-circuit of the thyristors of one phase;
- open circuit of one or more thyristors;
- supply unbalance.

If the impedance of the **three** loads varies **in a uniform manner** (e.g. the ageing of silicon carbide components), this **cannot be detected** by the unbalance detection.

To detect the load unbalance, the driver board microprocessor calculates the **difference** between the **highest** and **lowest RMS current** of the three controlled currents

$$\Delta I = I_{RMS.MAX} - I_{RMS.MIN}$$

A load unbalance alarm is activated (if it is selected with the jumper **K12**), on the following condition:

$$\Delta I > 0.25\ I_{RMS.MAX}$$

Attention !

The unbalance detection is disabled if the highest of the three RMS current values is not at least equal to **10%** of the nominal load current.

When the alarm is activated:

- the general alarm relay is **deactivated**
- the front panel display indicates the message '**E**' '**d**'.

The load unbalance alarm is not memorised and **disappears** automatically, **5 s** after obtaining rebalanced currents.

Partial load failure (PLF)

The partial load failure detection circuit continuously measures

- the RMS line-to-line load voltage $\mathbf{V_{RMS}}$ and
- three RMS line currents $\mathbf{I_{1RMS}}$, $\mathbf{I_{2RMS}}$, $\mathbf{I_{3RMS}}$.

The values measured are used to calculate the three line-to-line impedances Z_{12}, Z_{23}, Z_{31} and to compare them with the **impedance memorised** during the **PLF** adjustment.

This makes it possible to detect, on one of the phases, a **partial failure** or an **increase** in the impedance of the load (provided that the thyristor unit current is at least equal to **10%** of the nominal load current).

The partial load failure detection **adjustment** consists of **memorising**, using the '**Load fail**' potentiometer on the front panel (**P4**), the nominal operating conditions (**calibrated** voltage and currents).

The partial load failure detection **cannot** function if the **adjustment** has not been **made.**

In the vent of partial load failure detection in the one of the load phases:

- the flashing message '**P**' '**1**', or '**P**' '**2**', or '**P**' '**3**' is displayed on the front panel display
  (if the alarm disappears, it remains in memory except for the phase No. concerned);
- the '**PLF Alarm**' is **deactivated.**

The alarm is acknowledged if:

- the failure **disappears**
- another PLF **adjustment** is made.

The PLF alarm can be acknowledged when the thyristor unit is inhibited.
However, the PLF alarm cannot be acknowledged if the power supply is not available (display '**F**' '**1**').

The alarm detection is **adapted** for a resistive load with constant temperature coefficient.

The **partial** load failure detection system (also called the load impedance sensor) also monitors **total** load failure when one of the RMS line currents is equal to **zero.**

PLF detection sensitivity

The partial load failure detection is carried out using the measurements of the **thyristor** currents and the **load** voltage, which gives the **PLF** a **different** detection level depending on the load configuration.

The sensitivity of the **PLF** detection can be described by the maximum number of the elements (N) mounted in parallel. The failure of one of these elements activates the **PLF detection** circuit.

Table 8-1 **gives** the information used to define the sensitivity of the **PLF** for the different three-phase configurations, when the controlled load is composed of N identical elements in parallel.

Configuration			**Number N of elements in parallel**
Star	Without Neutral	The centres of all the load stars are not interconnected (figure 8-2)	8
		The centres of all the load stars are interconnected (figure 8-3)	4
	With Neutral	The centres of all the load stars are interconnected (figure 8-4)	8
Delta		Closed (figure 8-5)	5
		Open (figure 8-6)	6

Table 8-1 PLF detection sensitivity in the different configurations
(detection of failure of an element out of **N** identical elements mounted in parallel)

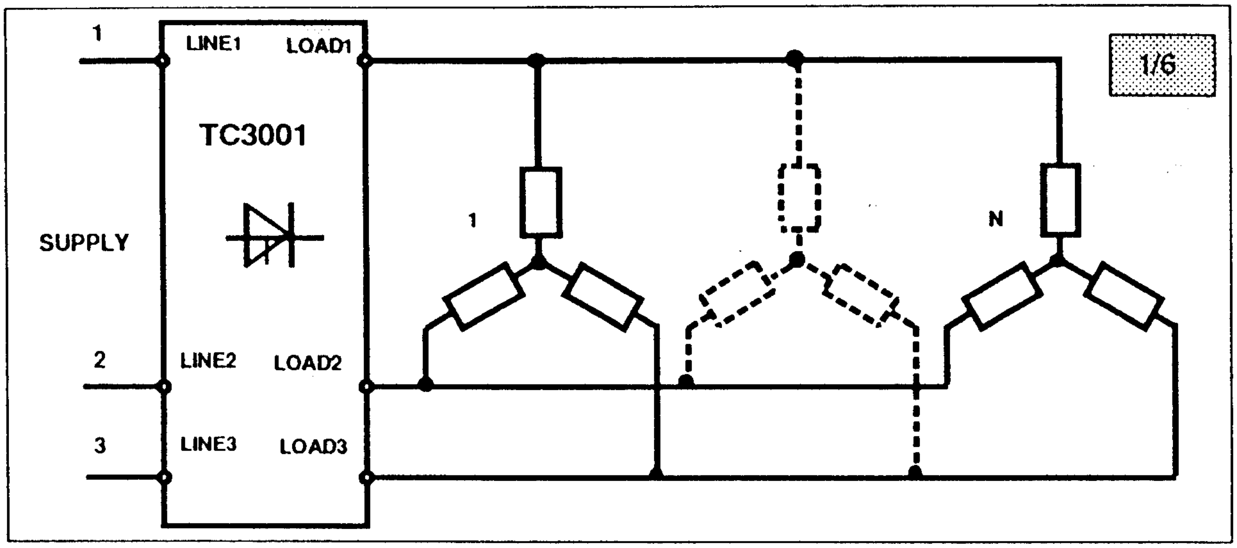


Figure 8-2 Star without neutral configuration. Central points of stars not interconnected
N identical stars in parallel in each phase

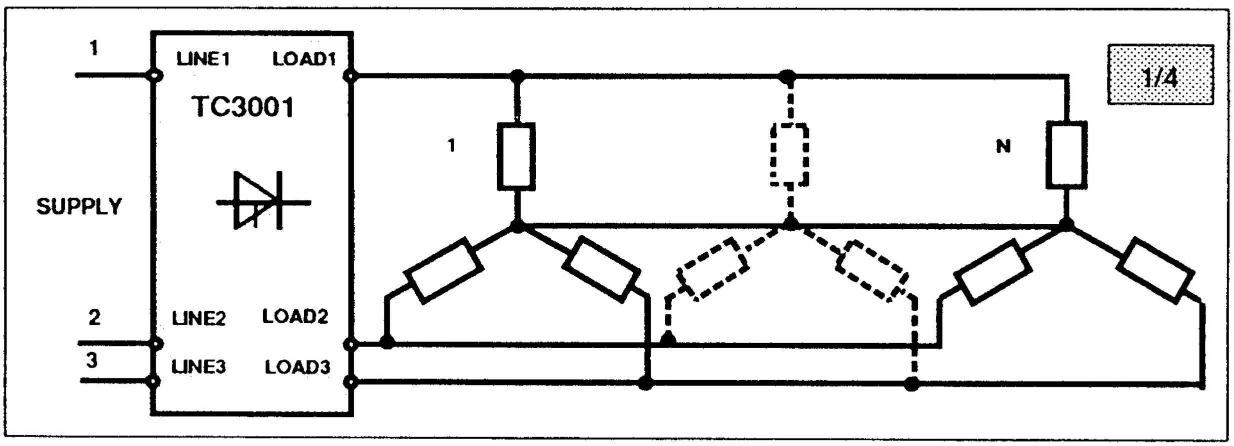


Figure 8-3 Star without neutral configuration. Central points of stars interconnected

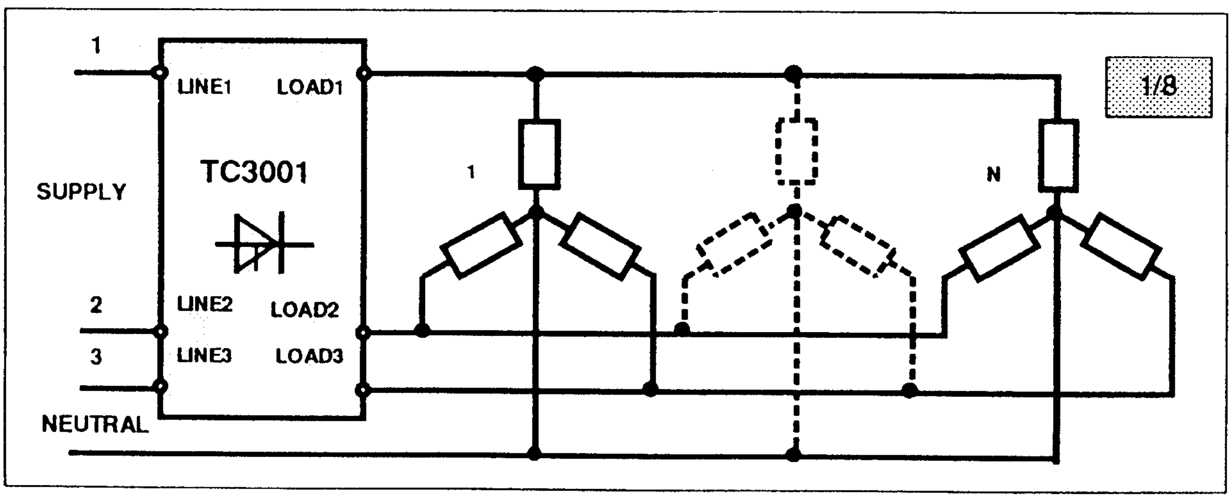


Figure 8-4 Star with neutral configuration. Central points of stars interconnected

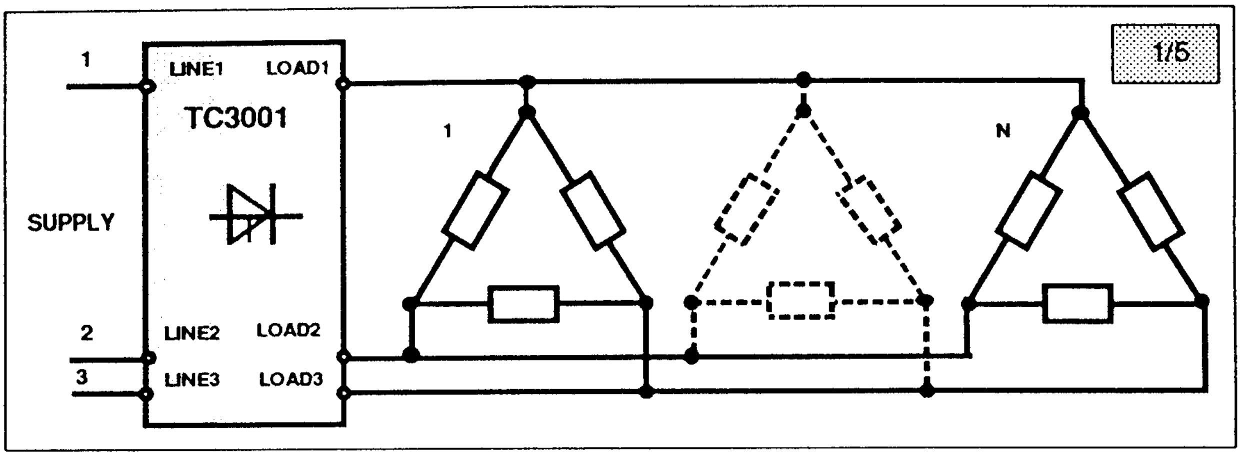


Figure 8-5 Closed delta configuration

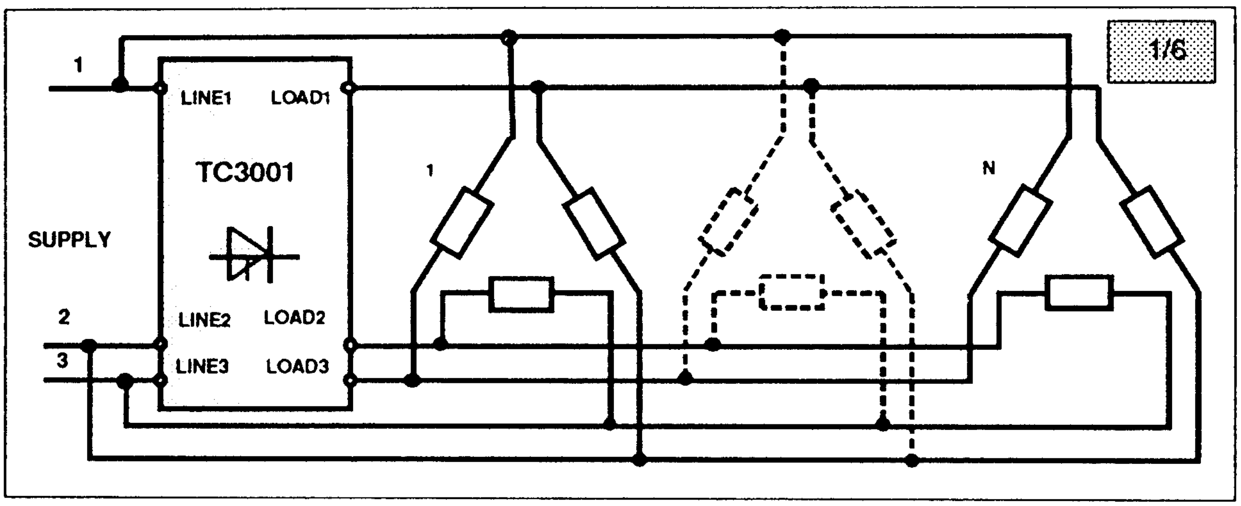


Figure 8-6 Open delta configuration

If the user requires **maximum sensitivity** of the PLF detection, it is advisable to choose one of the following configurations:

- Star with central points of stars not interconnected and not connected to the supply neutral
- star with central points of stars interconnected and connected to the supply neutral.

ALARM MANAGEMENT

The main characteristics of all the **TC3001** thyristor unit alarm types and the states of the alarm relays and the thyristors are given in table 8-2.

In this table:

V_{LINE} - RMS line-to-line voltage (line voltage)
V_N - nominal line voltage
V_L - RMS load voltage
V_{LN} - nominal load voltage

I_L - RMS load current
I_{LN} - nominal load current
I_{LIM} - limited current (limit setpoint set with the front panel potentiometer with or without external signal)
I_{MAX} - the highest of the three real load RMS currents

Z_{ij} - load impedance between phases **i** and **j**
Z_{LN} - nominal load impedance (calculated using the calibrated voltage and currents)

V_{EXT} - external measurement signal
OP - output power signal (inside thyristor unit)

f - supply frequency.

Alarm	Conditions: Alarm ON	Conditions: Alarm OFF	Inhibition	Display	Acknowl-edge
Partial load failure	$Z_{ij} > K \cdot Z_{LN}$ (K depends on configuration, page8-8) ($V_L \geq 30\%\ V_{LN}$ and $I_L \geq 30\%\ I_{LN}$)	After ack-nowledgement. disappearance or new adjustment	No	P 1 P 2 P 3	Yes
Over-current in Logic or Burst firing	$I_L > 110\%\ I_{LIM}$	After ack-nowledgement	Yes	F C b	Yes
First over-current in Burst firing	$I_L > 110\%\ I_{LIM}$	Next cycle without over-current	No	E C b	Yes
Over-voltage	$V_{LINE} > 120\%\ V_N$	$V_{LINE} \leq 110\%\ V_N$	No	E U	No
Load unbalance	$\Delta I > 0.25\ I_{MAX}$ ($I_L \geq 10\%\ I_{LN}$)	$\Delta I \leq 0.25\ I_{MAX}$	No	E d	No
Absence of supply phases	Absence of synchronisation pulses	After appearance	Yes	F 1 F 2 F 3	No
Under-voltage	$V_{LINE} < 70\%\ V_N$	$V_{LINE} \geq 70\%\ V_N$	Yes	F U	No
Frequency error	40 Hz > f > 70 Hz	40 Hz ≤ f ≤ 70 Hz	Yes	F P	No
Thyristor short-circuit	$I_L > 10\%\ I_{LN}$ (OP = 0)	After ack-knowledgement	Yes	F t 1 F t 2 F t 3	Yes
External meas. signal failure	$V_{EXT} = 0$ $OP \neq 0$	After disappearance	Yes	FE	Yes
Thermal switch (permanent cooling only)	Fan cooling failure	After acknow-ledgement and cooling	Yes	F 1	No
Neutral failure	Neutral fuse blown on neutral not connected	Appearance of neutral circuit	Yes	FP	No

Table 8-2 Alarm characteristics

ALARM ACKNOWLEDGEMENT

The thyristor unit can only be started up again after inhibition due to memorised alarms:

- thyristor short-circuit
- over-current in Logic and in Burst firing
- external measurement failure

after an acknowledgement.

The information of all the alarms which require acknowledgement is given in table 8-2 (page 8-15).

To acknowledge the alarms, it is possible to:

- switch **off** the electronic power supply of the driver board,
- connect terminal **11** ('**Acknowledge**') on the driver board to terminal **16** ('**+10 V**')
- apply a **+10 V** external signal to terminal **11** ('**Acknowledge**').

Alarms can only be acknowledged using terminal **11** when the voltage between phases 1 and 2 is not available (display '**F**' '**1**').

The **PLF** alarm can be acknowledged with a **new adjustment** (see page 6-16).

Chapter 9

MAINTENANCE

Contents page

Chapter 9 MAINTENANCE

Danger !

The thyristor unit must be maintained by qualified personnel only

THYRISTOR PROTECTION

The thyristors of the TC3001 series thyristor units are protected as follows:

- the internal high speed fuse against significant over-currents (e.g. short-circuit)
- the RC snubber and the varistor against too fast voltage variations and transient over-voltages when the thyristors are not firing.
- the thermal switch (in the event of accidental overheating of the cooler the thermal switch opens, which causes the thyristor firing to be stopped).

THYRISTOR PROTECTION FUSES

The standard version of TC3001 series power thyristor units is supplied with high speed fuses mounted on the line busbar.

Attention !

High speed fuses are only used for the internal protection **of thyristors** against wide amplitude over-loads.

These high speed fuses may under no circumstances be used to **protect the installation.**

Danger !

The user's installation **must be protected upstream** (non-high speed fuses, thermal or electromagnetic circuit breaker, suitable fuse-isolator) and comply with current standards.

Table 9-1 contains all the part numbers of the original internal fuses (when the thyristor unit leaves the factory) and the fuses which can be used for replacements during maintenance.

Maximum line-to-line voltage: **480 V.**

Nominal current		Part No.		
Th. unit	**Fuses**	**EUROTHERM**	**FERRAZ**	**BUSSMANN**
25 A	50 A	LA172468U050	S300373	170M3459
40 A	80 A	LA172468U080	S300051	170M3461
60 A	80 A	LA172468U080	S300051	170M3461
75 A	100 A	LA172468U100	T300052	170M3462
100 A	125 A	LA172468U125	V300053	170M3463
150 A	200 A	LA172468U200	X300055	170M3465
250 A	315 A	LA172468U315	Q300003	170M4460
300 A	400 A	LA172468U400	H300065	170M5458
400 A	500 A	LA172468U500	K300067	170M5460
500 A	630 A	LA172468U630	M300069	170M5462

Table 9-1 Recommended high speed fuses for thyristor protection

Attention !

The use of any fuses **other** than those recommended for thyristor protection **invalidates the thyristor unit guarantee.**

FUSE BLOWN INDICATION MICRO-SWITCH

As an option, high speed fuses may be equipped with a fuse blown indication micro-switch (FUMS option) with the part No.:

for BUSSMANN fuses:
EUROTHERM DC172267 or FERRAZ P96015 or BUSSMANN 170H0069
for FERRAZ fuses:
EUROTHERM DC172997 or FERRAZ G310 000

To ensure improved isolation between the cabling of the micro-switch terminals and the power and the cover, TC3001 power thyristor units are supplied with three "flag" type lugs and isolating sleeves.

Each external terminal of the fuse blown indication micro-switch must be cabled with a "flag" lug and an isolating sleeve in compliance with figure 9-1.

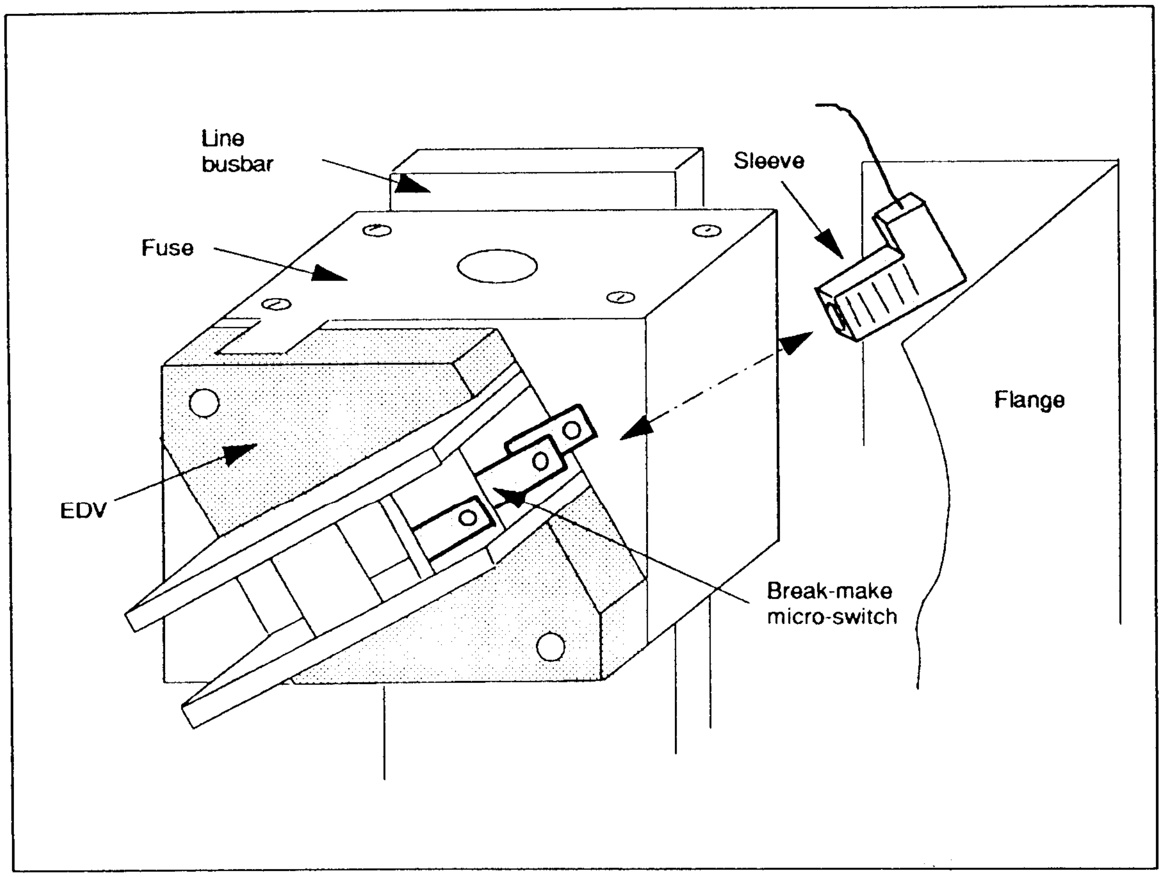


Figure 9-1 Use of "flag" lugs and isolating sleeves to observe isolating distances.

AUXILIARY VOLTAGE CONNECTION PROTECTION FUSES

These fuses must protect the auxiliary voltage connection (see 'Cabling' chapter).

Auxiliary voltage (max)	1 A fuse 6.3 x 32 mm	Fuse-isolator support	Overall 'Fuse-Isolator' dimensions (mm)
480 V	CS174289U1A0	CP174293	63 x 15 x 52

Table 9-2 Recommended fuse for auxiliary voltage connection protection

NEUTRAL PROTECTION FUSE

A neutral protection fuse is mounted on the power board in the Star with neutral configuration (**F1** on figure 4-1, page 4-3).

Operating voltage (max)	Rating	Dimensions	Eurotherm Part No.
480 V	1.6 A	6.3 x 32 mm	CS173676

Table 9-3 Recommended fuse for neutral protection

SERVICING

TC3001 thyristor units must be mounted with the heatsink positioned vertically and with no obstructions either above or below which could block the passage of the ventilation air.

Attention !

If multiple units are installed in the same cabinet, they should be arranged in such a way that the air expelled by one unit **cannot be admitted** into the unit located above it.

In order to ensure correct cooling of the unit, users are advised to **clean the heatsink and the protective grill** of the fans regularly according to the degree of environmental pollution.

Danger !

Every **six months**, check that the screws of the power cables and safety earth are **tightened** correctly (see "Cabling", page 3-3).

TOOLS

Operation	Flat screw-driver (mm)	Wrench	Electrical equipment
Fixing		Depending on M8 screw heads selected by the customer	
Opening (closing) of front door		CHc No. 4 for M5 screw	
Safety earth connection		HEX17 (M10) HEX19 (M12)	
Power connection (supply side) and fuse change		HEX13 (M8) (25 to 250 A) HEX17 (M10) (300 to 500 A)	
Load connection		HEX17 (M10) (25 to 250 A) HEX19 (M12) (250 to 500 A)	
Cable clamp tightening	0.5 x 3.5		
Control and auxiliary power supply voltage connection	0.5 x 3.5		
Board fixing	0.8 x 5.5	For M4 nut	
Commissioning and calibration	0.4 x 2.5		Ammeter or RMS clip. Oscilloscope (recommended) EUROTHERM type 260 diagnostic unit (recommended)

Table 9-4 Tools