TU1451 and TU1471

thyristor units

Four single-phase channel control

Digital Communications

User
Manual

Part No HA 175120 ENG Issue 1.2 Printed in France 12/97

CE

EUROPEAN DIRECTIVES

CE MARK

The CE Mark of **TU1451** and **TU1471** products implies that the essential protection requirements of the European Low Voltage Directive are observed.

ELECTROMAGNETIC COMPATIBILITY (EMC)

For industrial environments, excluding residential environments

Eurotherm certifies that the **TU1451** and **TU1471** products, when installed and used in accordance with their User Manual, meets the following EMC test standards and enables the system or installation in which there are installed to comply with the EMC Directive in regards to the **TU1451** and **TU1471** products.

EMC STANDARDS

Immunity	Generic Standard	: EN 50082-2
	Test Standards	: EN 61000-4-2, EN 61000-4-4, ENV 50140, ENV 50141
Emissions	Generic Standard	: EN 50081-2 (see filter using)
	Test Standard	: EN 55011
	Product Standard	: IEC1800-3 (without filters)

EMC FILTER USING

To reduce the conducted emissions that occur when using thyristor units, according to the EN 50081-2 standard, the serial filters hereunder are used.
Eurotherm can supply the external serial filters.

Nominal current of thyristor unit (per channel)	Serial filter order code (per channel)
25 A	FILTER / MON / 25A /00
40 A and 60 A	FILTER / MON / 63A / 00
75 A and 100 A	FILTER / MON / 100A / 00
125 A	2 x FILTER / MON / 100A / 00 in parallel

SAFETY

The **TU1451** and **TU1471** products installed and used in accordance with this User Manual are designed to comply with the essential protection requirements of the European Low Voltage Directive 73/23/EEC dated 19/02/73 (amended by Directive 93/68/EEC dated 22/07/93).

VALIDATION BY COMPETENT BODY

Eurotherm has validated the compliance of the **TU1451** and **TU1471** products with EMC test standards through design and laboratory tests that have been validated with a Technical Construction File by a Competent and Notified Body, **LCIE** (Laboratoire Central des Industries Électriques).

CE DECLARATION OF CONFORMITY

A CE Declaration of Conformity is available on request.
For further information on CE Mark, please contact your nearest Eurotherm office.

EMC INSTALLATION GUIDE

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.

MANUALS IN USE

This **TU1451** and **TU1471 User Manual (Part No HA 175120 ENG)** intended for the TU1451 and TU1471 series power thyristor units manufactured beginning **October 1996.**

The TU1451 and TU1471 User Manual (Part No HA175121) is valid for products manufactured from June 1996 to October 1996.

The TU1451 and TU1471 User Manual (Part N° HA 173627) is valid for products manufactured before June 1996.

PRECAUTIONS

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

WARNING!

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.

CAUTION!

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.

PERSONNEL

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.**

INDEPENDENT SAFETY

It is the responsibility of the user and it is highly recommended, given the value of the equipment controlled using TU1451/71, to install **independent safety** devices. This alarm must be tested regularly.
Eurotherm can supply suitable equipment.

FURTHER INFORMATION

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.

TU1451 AND TU1471 USER MANUAL

The safety instructions for the installation and use of the TU1451 and TU1471 thyristor units are given on the following pages:

Contents

Page

Chapter 1 IDENTIFYING THE THYRISTOR UNITS

Chapter 2 INSTALLATION

Contents (Continued)

Page

Chapter 3 WIRING

Chapter 4 CONFIGURATION

Cont.2

Contents (Continued)

Page

Chapter 5 OPERATION

Chapter 6 COMMISSIONING PROCEDURE

Contents (Continued)

Page

Chapter 7 ALARMS

Chapter 8 MAINTENANCE

Chapter 1

IDENTIFYING THE THYRISTOR UNITS

Contents page

Chapter 1 IDENTIFYING THE THYRISTOR UNITS

GENERAL INTRODUCTION TO THE TU1451 AND TU1471 THYRISTOR UNITS

The **TU1451** and **TU1471** thyristor units are designed to control power in high or low temperature coefficient resistive loads or short wave infrared elements.

The **TU1451** or **TU1471** thyristor unit is composed of **4 independent** single-phase control thyristor **channels** mounted on a common heatsink. This layout reduces the cabinet volume required, particularly for installations comprising a high number of independently controlled loads.

The **TU1451** thyristor unit controls a maximum current of **40 A** per channel at a maximum nominal (line-to-line) voltage of **500 V.**

The **TU1471** thyristor unit controls a maximum current of **40 A** to **125 A** per channel, with a maximum nominal (line-to-line) voltage of **500 V.**

- In the **basic** version, the **TU1451** and **TU1471** thyristor units are controlled by **analogue** signals and only operate in 'Phase angle' thyristor firing mode.

  This thyristor unit version is not equipped with digital communications (the thyristor units are not equipped with a microprocessor board).

  Basic version thyristor units do not require any configuration.

- In the **'digital communications'** version, the **TU1451** and **TU1471** thyristor units are equipped with a **microprocessor** board which controls the thyristor unit operation. This board (called the control and communication board or **CCC** board) is installed in the **CCC** option.

  The thyristor units are controlled by digital or analogue signals.

In the **CCC** option, the **TU1451** and **TU 1471** digital communication thyristor units offer the following functions:

- two control modes: power or load voltage,
- different thyristor firing modes: Phase angle, Single cycle (1 supply cycle) and Burst firing (8 supply cycles) with or without soft start
- voltage, current and load monitoring
- digital communications.

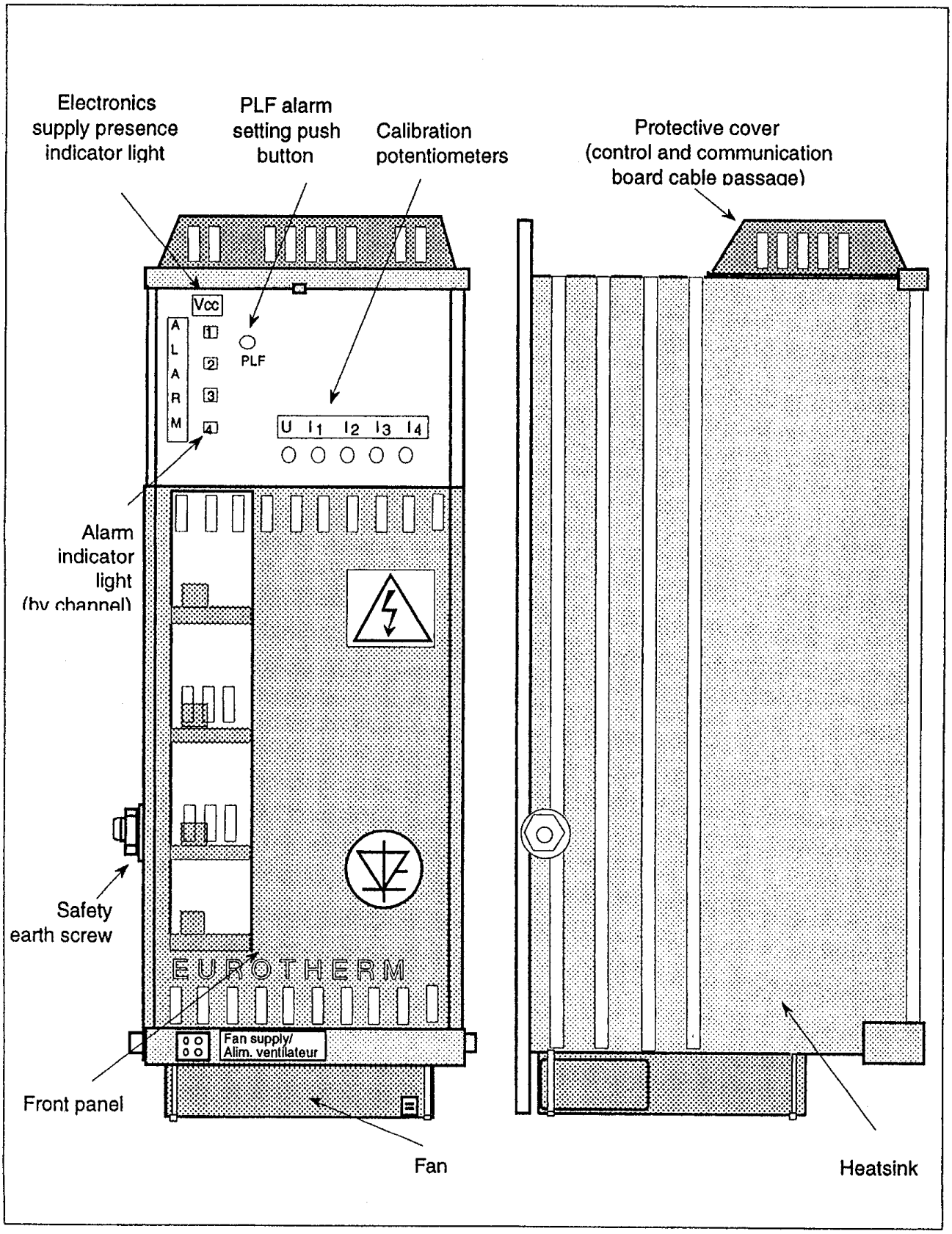


Figure 1-1 Overall view of the TU1451 thyristor unit

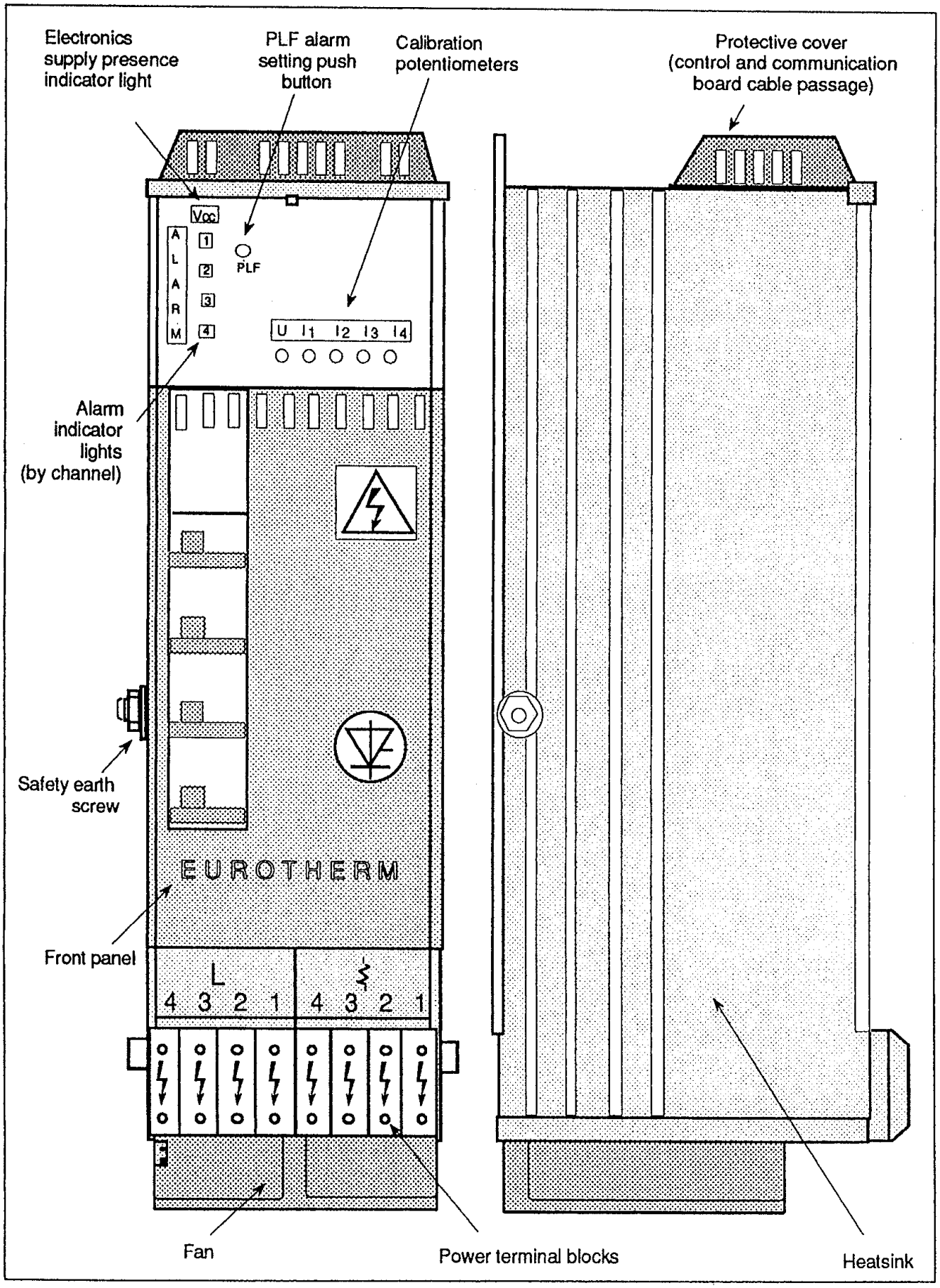


Figure 1-2 Overall view of the TU1471 thyristor unit

The **digital communications** are used for remote control and monitoring, while reducing the volume of low level wiring significantly.

The monitor control uses the integrated **RS422** or **RS485** digital link.

The data is exchanged either according to the **Eurotherm** protocol or according to the **JBUS ®** ou **MODBUS ®** protocol.

The cbaud rate is **9600** baud or **19200** baud.

For further details on the digital communications of the TU series thyristor unit digital communications, see the 'TU Range. Digital communications' User manual (Part No. HA 173688).

In the **CCC** option, the thyristor units can be controlled by **digital communications** with a digital setpoint or an analogue setpoint.

The analogue input signals have four choices of voltage level:

0-5 V ; 1-5 V ; 0-10 V ; 2-10 V

and two current levels:

0-20 mA and 4-20 mA.

In the event of digital communication failure (detected by an external system), fallback operation in manual control using analogue signals is provided.

A **green** light emitting diode (LED) on the front panel of the thyristor unit signals the presence of the control supply (**Vdc** indicator light).

An **alarm** system detects the failures in the loads and inadmissible variations in the voltage or current. A failure detection is signalled by the **digital communications** and by a **relay** contact.

Four **red** light emitting diodes (lebelled 'Alarm 1 to 4') visible on the front panel, signal the faulty channels due to total or partial load **failure**.

The current monitor stops the thyristor unit operation if the pre-set current limit is exceeded or in the event of an over-current.

The partial load failure detection can be set automatically using the '**PLF**' push button located on the front panel, simultaneously for all the channels, or using the digital communications.

The voltage calibration (labelled '**U**') and channel current (labelled '$\mathbf{I}_1$' to '$\mathbf{I}_4$') potentiometers are available on the thyristor unit front panel.

The **TU1451** and **TU1471** thyristor units are equipped with permanent fan cooling.

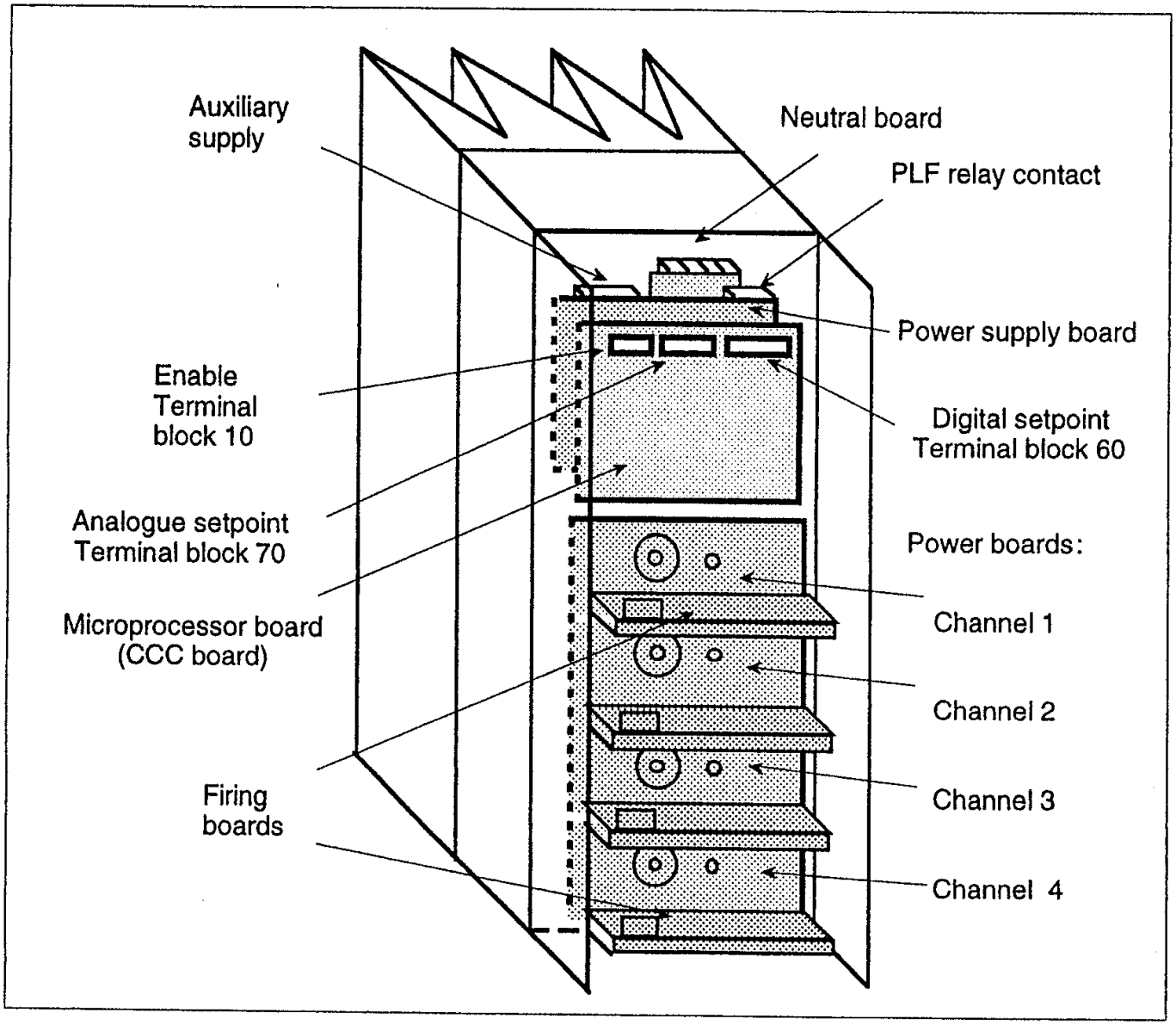


Figure 1-3 Location of the TU1451 and TU1471 thyristor unit electronic boards

The digital communications version **TU1451** and **TU1471** thyristor units are equipped with the following electronic boards (see figure 1-3):

- a '**microprocessor board**' (CCC board) per thyristor unit,
- 4 '**power boards**' (one for each channel),
- 4 '**firing boards**' (one for each channel)
- a '**power supply board**' per thyristor unit.
- a '**synchronisation voltage board**'.

Depending on the microprocessor board configuration, the **TU1451 and TU1471** units can be used with analogue signals or remote controlled using a communicating control system (CCS) such as Eurotherm **PC3000** or a PC with the Eurotherm software **IPSG** Eurotherm or any other suitable equipment.

The internal filters protect the **TU1451** and **TU1471** thyristor units against electromagnetic interference.

TECHNICAL DATA

The TU1451 and TU1471 units are power thyristor units designed to control 4 independent industrial single-phase loads using thyristors.

Caution !

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 channel)	**25 A** and **40 A** (TU1451) **40 A, 60 A, 75 A, 100 A** and **125 A** (TU1471)
Nominal line-to-line voltage	**100 Vac** to **500 Vac** (+10%,-15%) Inhibit below **85%** of the nominal voltage; response time <10 ms; automatic reset 2 s after return to 90 % of the nominal value
Residual current	In the OFF state, typically less than **30 mA**
Power supply frequency	**50** or **60 Hz** (±2 Hz)
Dissipated power	**1.3 W** (approx.) per ampere and per channel
Cooling	**Permanent** fan cooling
Fan	Consumption **23 VA** Supply voltage: **115 Vac** or **230 Vac**
Load	**Resistive** with high or low temperature coefficient or short wave infrared elements (or transformer primary in Phase angle firing mode)
Load control	Using thyristors in anti-parallel configuration

Connection

External wiring	To be performed according to the standards **IEC 364**
Power	Screw terminals for **10 mm^2** cable (max) - for TU1451 **35 mm^2** cable (max) - for TU1471
Auxiliary supply, control, alarm contact	Plug-in terminal block. **0.5 mm^2** to **1.5 mm^2** cable Shielded control cable, grounded at both ends.
Fan supply	Screw terminals for **0.5 mm^2** to **1.5 mm^2** cable (TU1451) Crimp-type lugs with sheaths (TU1471)

Control

Control	• Using **digital communications** with a digital or analogue setpoint • Using a purely **analogue** signal
Analogue signal	Can be selected using the configuration: **0-5 V ; 1-5 V ; 0-10 V ; 2-10 V** **0-20 mA ; 4-20 mA**
Input impedance	**10 kΩ** for **10 V** and **5 V** ; **255 Ω** for current input
Thyristor firing mode	• Firing angle variation (**Phase angle**) • **Single cycle** (**1** firing or non-firing time) • **Burst firing** (**8** supply cycles) • Burst firing with soft start
Control range	• **96%** in Phase angle (minimum firing angle **4** degrees at 50 Hz) • **92%** in Burst firing
Stability	For **+10%, -15%** voltage variations: • **2%** in Phase angle, Single cycle and Burst firing • **3%** in Soft start
Control mode	Common for all the channels: • squared load voltage • load power
Control linearity	**2 %** in Burst firing and Single cycle **1%** in Phase angle
Enable/Inhibit	With external contact on user terminal block (switches to TLF state and channel inhibit). Independent functions for each channel.

Digital communications

Communication bus	**RS485** (**RS422**) serial link
Communication speed	Configurable: **9600** or **19200** baud
Communication protocol	**Eurotherm** or **JBUS ®** or **MODBUS ®**.

Alarms

Detection	Inadmissible line voltage variations Following failures on each channel: • thyristor short-circuit • over-current • current limit exceeded • total load failure (TLF) of each channel • partial load failure (PLF) of each channel
Alarm signalling	Digital communications and alarm relays. A red indicator light for each channel identifies the channel on which the PLF or the TLF is detected
Partial load failure detection sensitivity	Failure of one out of 5 identical elements mounted in parallel

Environment

Operating temperature	**0°C** to **+50°C** in vertical position (See current allowed as a function of the ambient temperature, page 1-11)
Operating altitude	**2000 m** maximum
Storage temperature	**-10°C** to **+70°C**
Protection	**IP20** (according to **IEC 529**)
Thyristor protection	External high speed **fuse** per channel **Varistor** and **RC** snubber circuit
Operating atmosphere	Non-explosive, non-corrosive and non-conductive
Humidity	**RH** of **5%** to **95%** without condensation
Pollution	Degree **2** allowed, defined by **IEC 664**
Electromagnetic compatibility (unit installed and operated in compliance with this Manual, see European Directives chapter)	**Immunity**: according to standards **EN 61000-4-2, EN 61000-4-4, EN 61000-4-3** **Radiated emission**: according to **EN 55011** **Conducted emission** : according to **EN 50081-2** (with external filter) according to **EN 61800-3** (without external filter).
Electrical safety	According to **Low Voltage Directive 73/23/EEC**
CE Marking	TU1451/71 products bear the **CE Mark** (see European Directives chapter).

Caution !

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.

INFLUENCE OF THE AMBIENT TEMPERATURE

The nominal current of the thyristor unit is guaranteed for ambient temperatures from **0** to **50°C**.

Beyond this temperature, the use of the thyristors is defined by the derating curves (admissible current decrease or increase curves, as a function of the ambient temperature).

The **derating** curves are related to the thermal operating conditions.
They are based on the choice of thyristors and the cooling mode.

The derating curves take into account:

- the thyristor junction temperature,
- the thyristor current limit values,
- the temperature inside the thyristor units,
- the fuse operating limit values,
- the connection operating limit values,
- the electronic board component maximum operating temperatures.

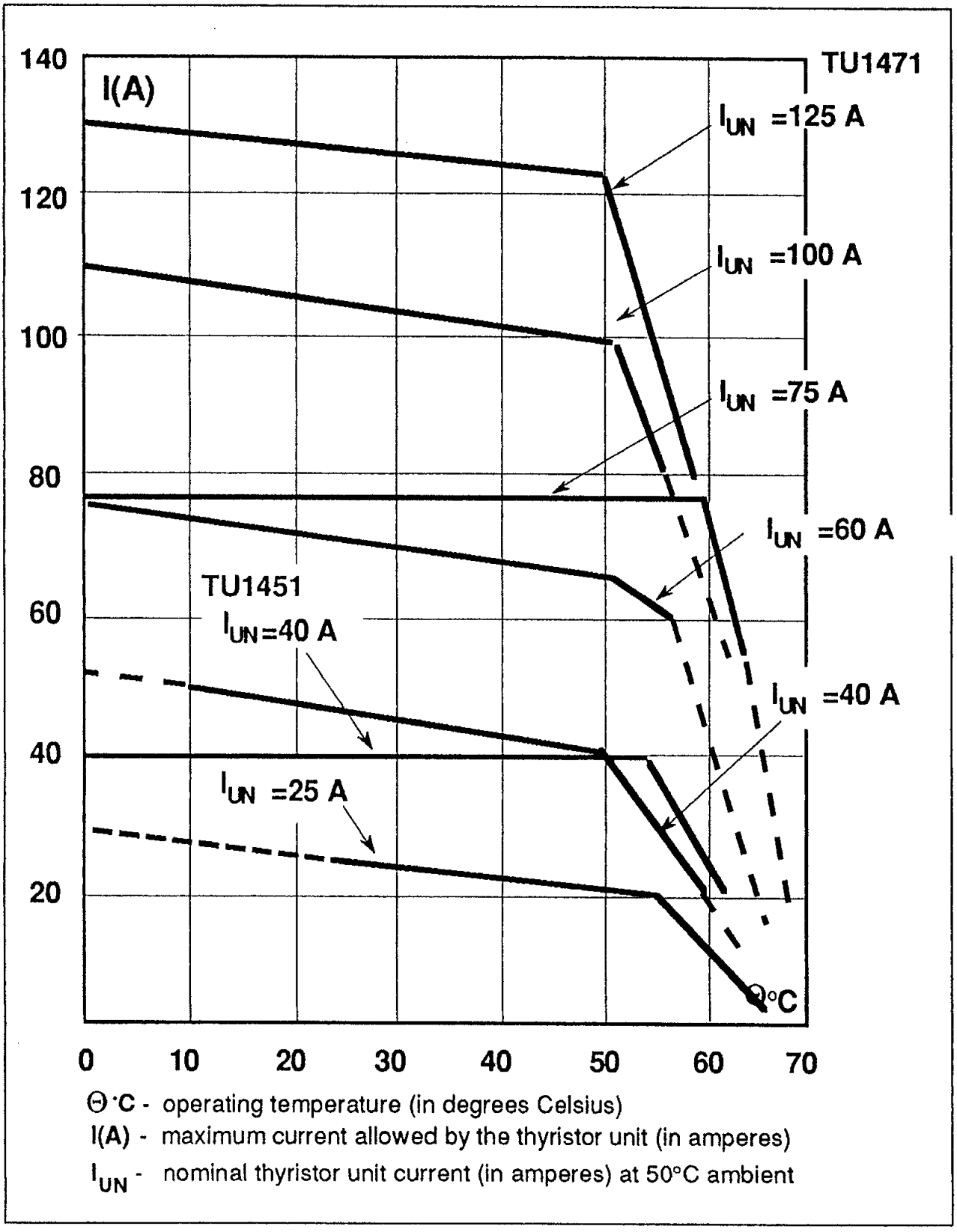


Figure 1-4 Derating curves for TU1451 and TU1471 thyristor units

CODING

Thyristor unit

Model	/	Nominal current	/	Nominal voltage	/	Fan supply	/	Analogue input	/	Firing mode

Model	Code
TU1451 nominal currents 25 A and 40 A	TU1451
TU1471 nominal currents 40A to 125 A	TU1471

Fan supply	Code
115 V	115V
230 V	230V

Nominal current		Code
TU1451	25 A	25A
	40 A	40A
TU1471	40 A	40A
	60 A	60A
	75 A	75A
	100 A	100A
	125 A	125A

Analogue input	Code
0 - 5 V	0V5
1 - 5 V	1V5
0 - 10 V	0V10
2 - 10 V	2V10
0 - 20 mA	0mA20
4 - 20 mA	4mA20

Nominal voltage	Code
100 V	100V
110 V	110V
115 V	115V
120 V	120V
200 V	200V
220 V	220V
230 V	230V
240 V	240V
380 V	380V
400 V	400V
415 V	415V
440 V	440V
480 V	480V
500 V	500V

Firing mode	Code
Phase angle	PA
Single cycle (1 cycle)	FC1
Burst firing (8 cycles)	FC8
Burst firing with soft start	SFC8

For other voltages, contact your EUROTHERM Office.

CCC option	/	Communication protocol	/	Control mode	/	Load type	/	Digital communications	/	Alarm contact type	/	End 00

CCC option	Code
Control and communication board	CCC

Load type	Code
Infrared	IR
Resistive	RES

Communication protocol	Code
EUROTHERM	EIP
MODBUS ®	MOP
JBUS ®	JBP

Digital communications	Code
No digital communications	CTRL
Digital communications at 9600 baud	96
at 19200 baud	192

Control mode	Code
Squared voltage	V2
Power	W

Alarm contact type	Code
Alarm relay contact closed in alarm state	NC
Alarm relay contact open in alarm state	NO

External fuse and fuse holder assembly

Each **TU1451** and **TU1471** thyristor unit channel must be protected by an external high speed fuse.

These fuses and fuse holders are to be ordered separately.

'External fuse and fuse holder' assembly code	/	Nominal current code	/	End 00

'External fuse and fuse holder' assembly code

Thyristor unit model	Nominal current	Code	Cylinder dimensions (mm)
TU1451	25 A 40 A	FU1038 FU1451	10 x 38 14 x 51
TU1471	40 A to 75 A 100 A and 125 A	FU2258 FU2760	22 x 58 27 x 60

Nominal thyristor unit current code

Nominal current	Code
25 A	**25A**
40 A	**40A**
60 A	**60A**
75 A	**75A**
100 A	**100A**
125 A	**125A**

The details of the thyristor protection high speed fuses and the fuse holders are given in chapter 8 ('Maintenance').

CODING EXAMPLE

Power thyristor unit model	**TU1451**
Nominal current	**40 A**
Nominal voltage	**380 V**
Fan supply	**230 V**
Analogue voltage signal	**0-10 V**
Thyristor firing mode	**Single cycle**
'Digital communications' version	
Communication protocol	**EUROTHERM**
Baud rate	**9600 baud**
Process value	**Power**
Load	**Resistive**
Alarm relay contact	**Open in alarm state**

Thyristor unit coding

TU1451 / 40A / 380V / 230V / 0V10 / FC1 / CCC / EIP / W / RES / 96 / NO / 00

Fuse and fuse holder assembly coding

FU1451 / 40A / 00

SERIAL NUMBER LABEL

The serial number label providing all the information relating to the factory settings of the thyristor unit is located on the upper outer left-hand side of the unit.

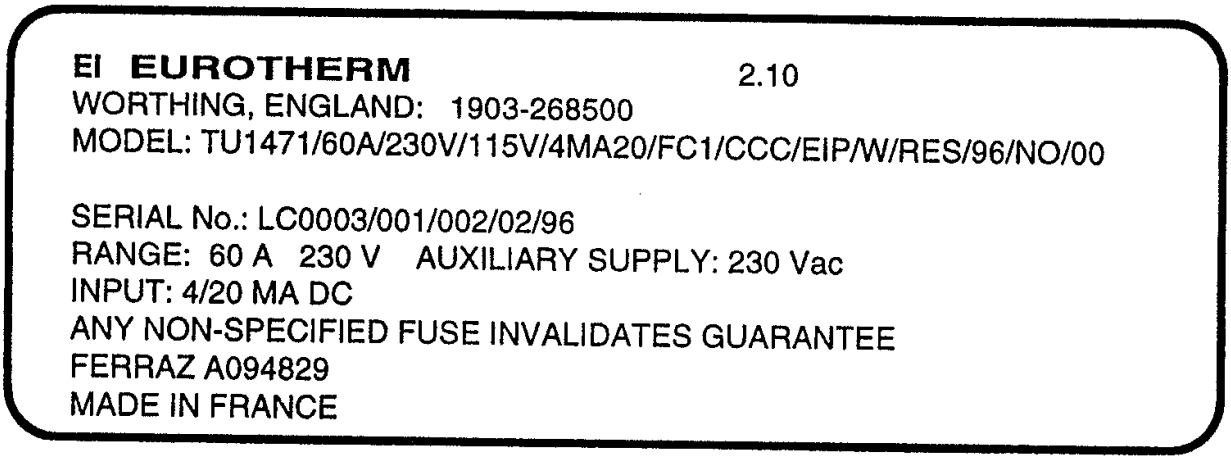


Figure 1-6 Example of a serial number label
The information corresponds to the TU1471 thyristor unit, nominal current 60 A, nominal voltage 230 V, fan supply 115 V, analogue input on the microprocessor board 4-20 mA dc

Codes: **FC1,CCC,EIP,W,RES,96,NO,00** - see pages 1-12 and 1-13.

Caution !

Any reconfiguration done by the user will render obsolete the original in-house configuration code shown on the label.

Chapter 2

INSTALLATION

Contents page

Chapter 2 INSTALLATION

SAFETY DURING INSTALLATION

Warning !

TU1451 and TU1471 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 earth 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.

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 from one unit cannot be admitted into the unit located above it.

Important !

Leave a vertical space of at least **30 cm** between two units.
Leave a minimum space of **5 cm** between two units placed beside each other.

Caution !

The units are designed to be used at an ambient temperature less than or equal to **50°C**.

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

TU1451 and **TU1471** thyristor units have **permanent** fan cooling using an internal fan.

DIMENSIONS

The dimensions of the TU1451 and TU1471 thyristor units are given in table 2-1.

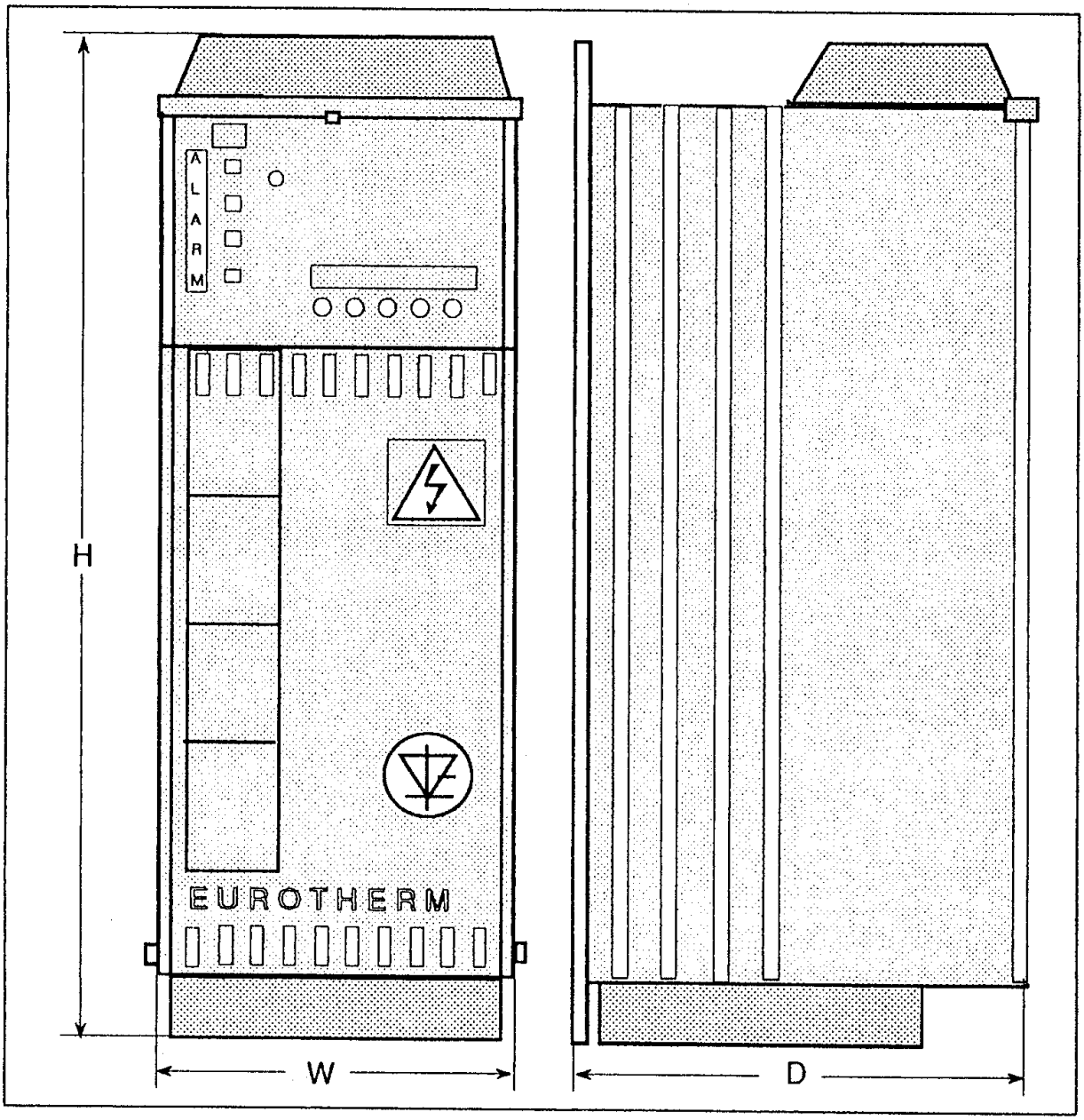


Figure 2-1 Overall dimensions

Model	Height (H) mm	Width (W) mm	Depth (D) mm	Weight kg
TU1451	470	144	193	11
TU1471	675	144	206	15.5

Table 2-1 Overall dimensions and weight

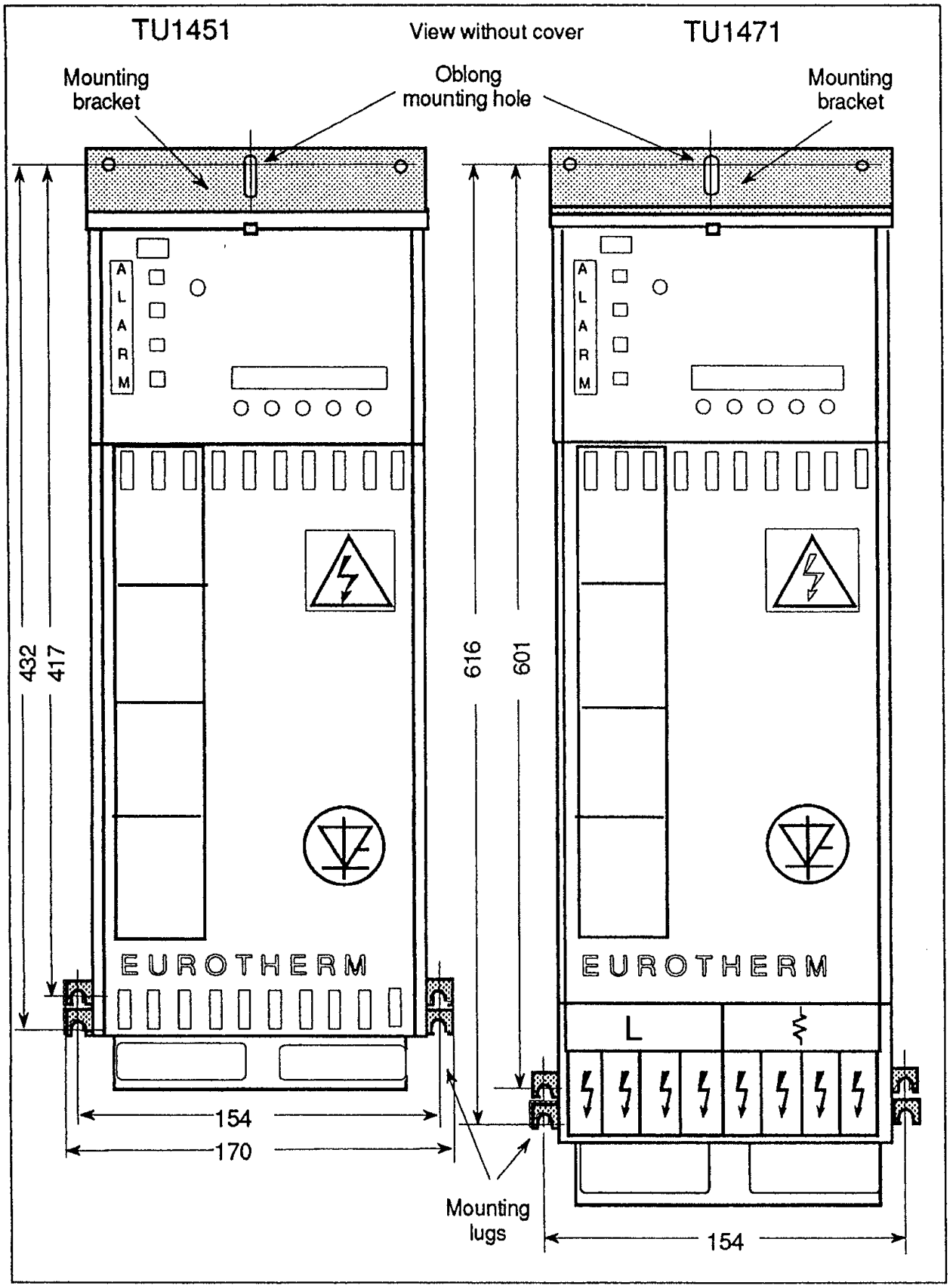


Figure 2-2 TU1451 and TU1471 thyristor unit mounting points.

MECHANICAL MOUNTING

General

The **TU1451** and **TU1471** thyristor units can be installed in two different ways:

- **bulkhead**
- **semi-embedded** on a panel.

The semi-embedded mounting makes it possible to evacuate **80** to **90 %** of the thermal energy dissipated by a thyristor unit outside the electrical cabinet.

The thyristor unit mounting depends on the installation mode and the fan cooling mode.

A mounting bracket and two mounting lugs are used for the mounting of non-fan-cooled **TU1451** and **TU1471** thyristor units.

Thyristor unit mounting

Bulkhead mounting

The following instructions apply for both thyristor unit models:

- Fix an upper bracket on the panel via the oblong hole at the top of the thyristor unit using an **M6** screw.
- Fit the two **M6** lower screws in the cabinet, observing the drilling values (figure 2-3).
- Lower the thyristor unit to the pre-mounted screws and mount the two mounting lugs located in the lower part of the heatsink.
- Unfasten the central screw of the bracket slightly in order to slide it upwards using the oblong hole and then downwards in the grooves of the heatsink.
- Once the bracket is mounted in the thyristor unit, fasten the screws.

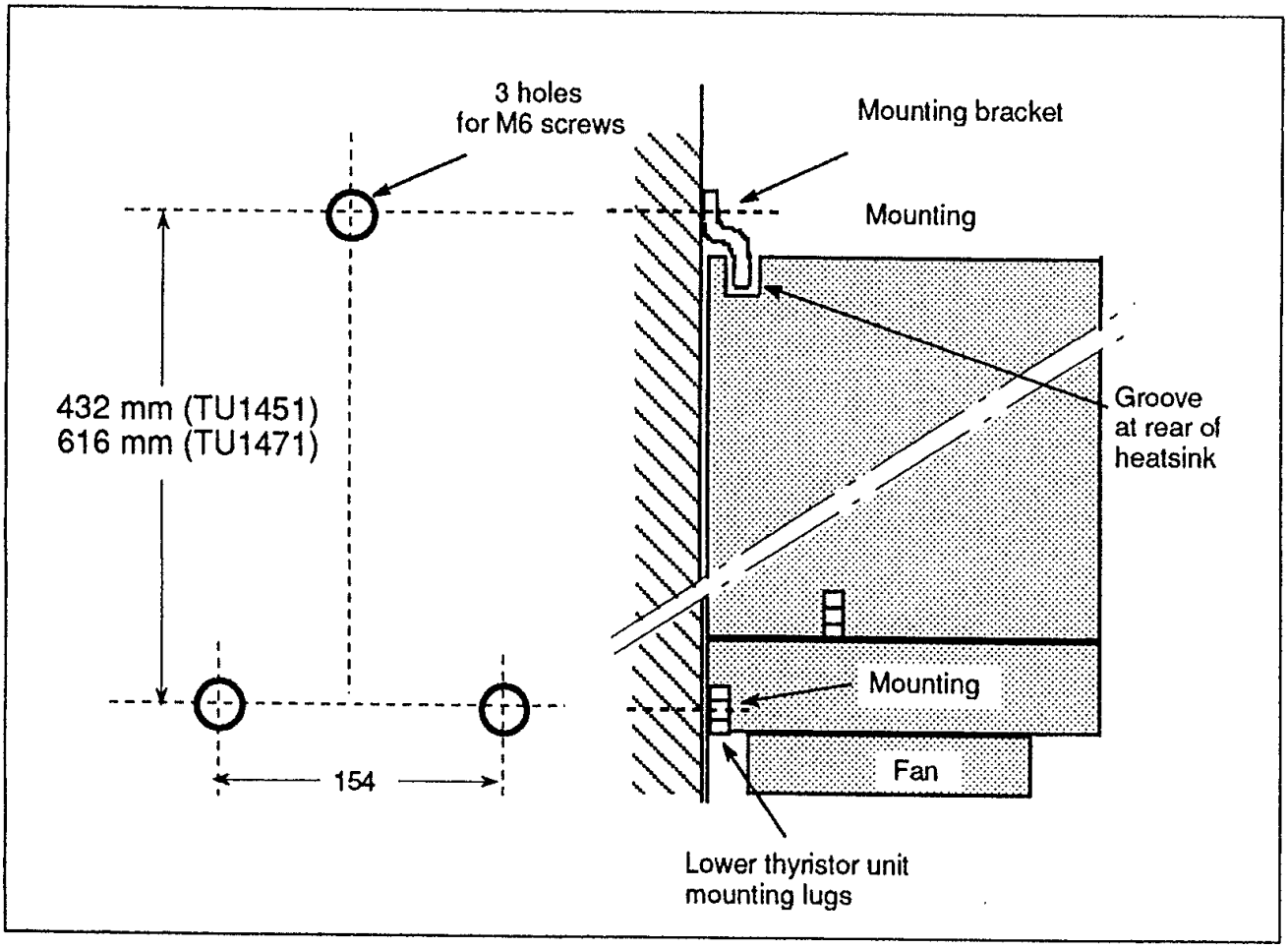


Figure 2-3 Thyristor unit drilling and mounting values (in mm). Bulkhead mounting

Semi-embedded mounting

The following instructions apply for both thyristor unit models:

- Fit the two **M6** screws in the cabinet, observing the drilling values given (figure 2-4).
- Move the thyristor unit in the cut-out, lowering to the pre-mounted screws and mount the two mounting lugs located in the bottom part in the middle of the heatsink.
- Insert the upper bracket in the groove in the middle of the heatsink.
- Fix the upper bracket through the oblong hole using an **M6** screw.

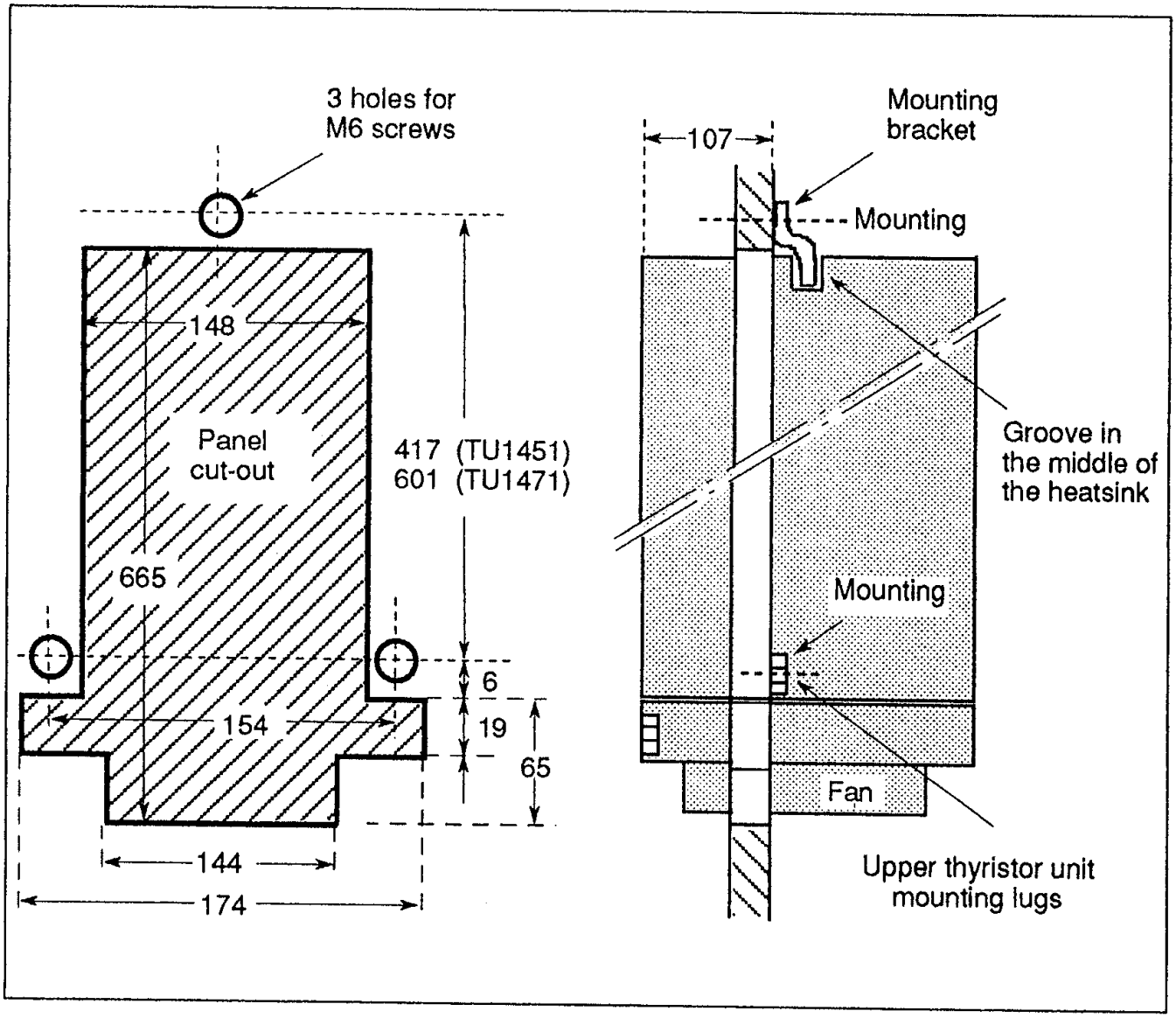


Figure 2-4 Thyristor unit drilling, cutting and mounting values (in mm)
Semi-embedded mounting on panel

Opening the front panel

- Insert a thin screwdriver (**3.5 mm**) and push the inner catch (see figure 2-5).
- Raise the plastic lock upwards until it clicks and pull the panel towards you using the lock.
- Lower the assembly and release the notches on the front panel (bottom notches for the TU1451 thyristor unit and middle and bottom notches for the TU1471 thyristor unit).

Closing the front panel

- Insert the notches of the front panel completely in the lateral grooves of the heatsink (see figure 2-5).
- Insert the upper part of the front panel in the grooves.
- Press on the lock until it clicks approximately **5 mm** lower.

The front panel is then locked.

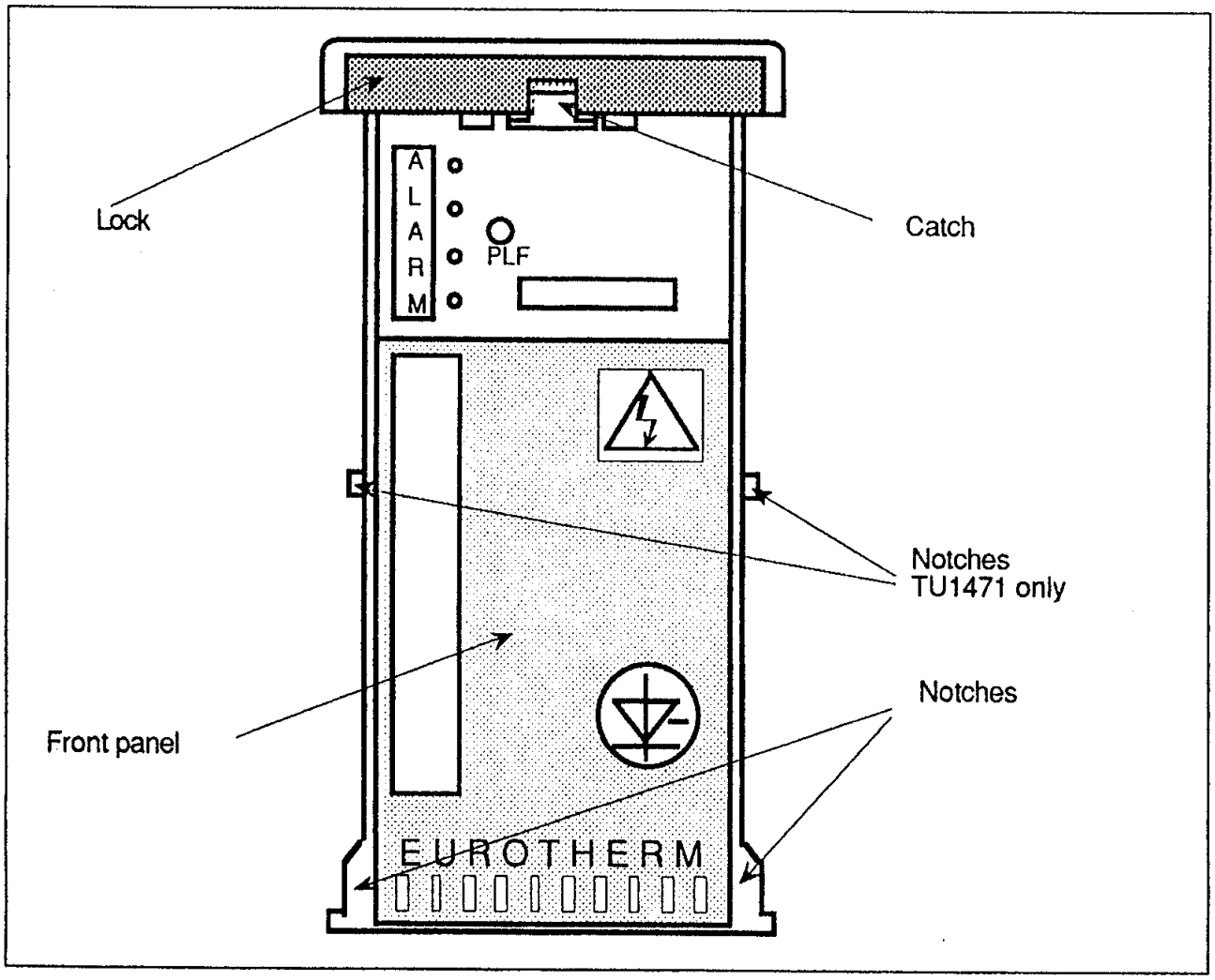


Figure 2-5 Front panel

Chapter 3

WIRING

Contents page

Chapter 3 WIRING

SAFETY DURING WIRING

Warning !

- Wiring must be performed by personnel who are qualified to work in a low voltage electrical environment.
- It is the user's responsibility to wire and protect the installation in accordance with current professional standards.
- A suitable device guaranteeing electrical separation of the equipment and the power supply must be installed upstream in order to perform the operation in complete safety.
- 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 wiring and the last cable to be disconnected.

Caution !

To ensure the correct grounding of the TU1451 and TU1471 units, make sure that the fixing is on the **reference ground surface** (panel or bulkhead).

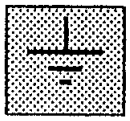
Failing this, it is necessary to add a ground connection at **most 10 cm** long between the earth connection and the reference ground surface.

Warning !

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

EARTH CONNECTION

The **safety earth** is connected to the **M8** screw mounted on the groove provided for this purpose on the rear side of the heatsink and labelled as follows:



The earth wire is connected to the earth screw using a round lug for **M8** screws and bolts. The screw slides in a groove of the heatsink and can be **moved** as required.

The cross-section of the earth cable must be:

- **4** to **10 mm²** (**TU1451**)
- **10** to **25 mm²** (**TU1471**).

The safety screw tightening torque must be **10.8 N.m.**

POWER CABLE FIXING

The external power supply and load wiring is **different** for the **TU1451** and **TU1471** thyristor units.

The **TU1451** thyristor unit is equipped with **8 internal terminals (small columns)** located on the power boards, which can be accessed with the front panel removed.

The **TU1471** thyristor unit is equipped with **8 single-pole terminal blocks** located at the bottom of the thyristor unit.

Warning !

Before any connection, make sure that the earth cable is connected..

Caution !

- Tighten the power connections according to the recommendations given for each type of thyristor unit.
- Incorrect tightening can cause incorrect thyristor unit operation and serious consequences for the installation.

TU1451 thyristor unit

Power terminals

The power terminals are labelled '**LINE**' and '**LOAD**' on the power boards.

The terminal capacity (allowed power cable cross-section) is **4 mm²** to **10 mm²**.
The **free** length of the cables must not be greater than **80 cm**.

To wire the lines and the loads:

- remove the front panel (see figure 2-5)
- remove the plastic caps protecting the LINE and LOAD terminals
- unfasten the set screw
- insert the corresponding cables from the lines or loads
- insert the screws without tightening them and put the protective caps in place before tightening
- fasten the connection (tightening **2.5 N.m**) and close the front panel.

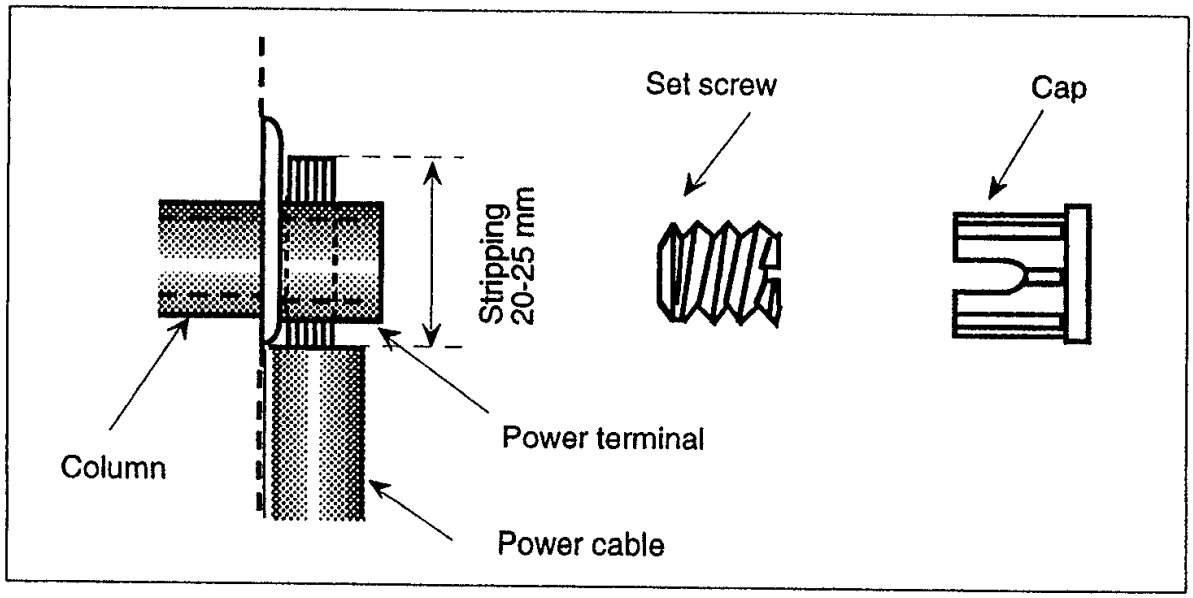


Figure 3-1 TU1451 thyristor unit power wiring

Fan supply

The **fan supply** must be connected to the two terminals of the terminal block fitted at the bottom of the thyristor unit (at the same level as the fan). Terminal tightening: **2.5 N.m.**
A label indicates the fan position.

To protect the fan supply, a **0.5 A** fuse is to be provided in the wire to a line.

TU1471 thyristor unit

Power terminals

The terminal capacity (allowed cross-section) of the power cable is **4 mm²** to **35 mm²**.

To wire the lines and the loads:

- remove the single-pole safety plates on the power terminal block at the bottom of the thyristor unit (see figure 3-2)
- unfasten the terminals and insert the corresponding cables from the line or loads
- tighten the cables (tightening **3.5 N.m**)
- put the safety plates back in place.

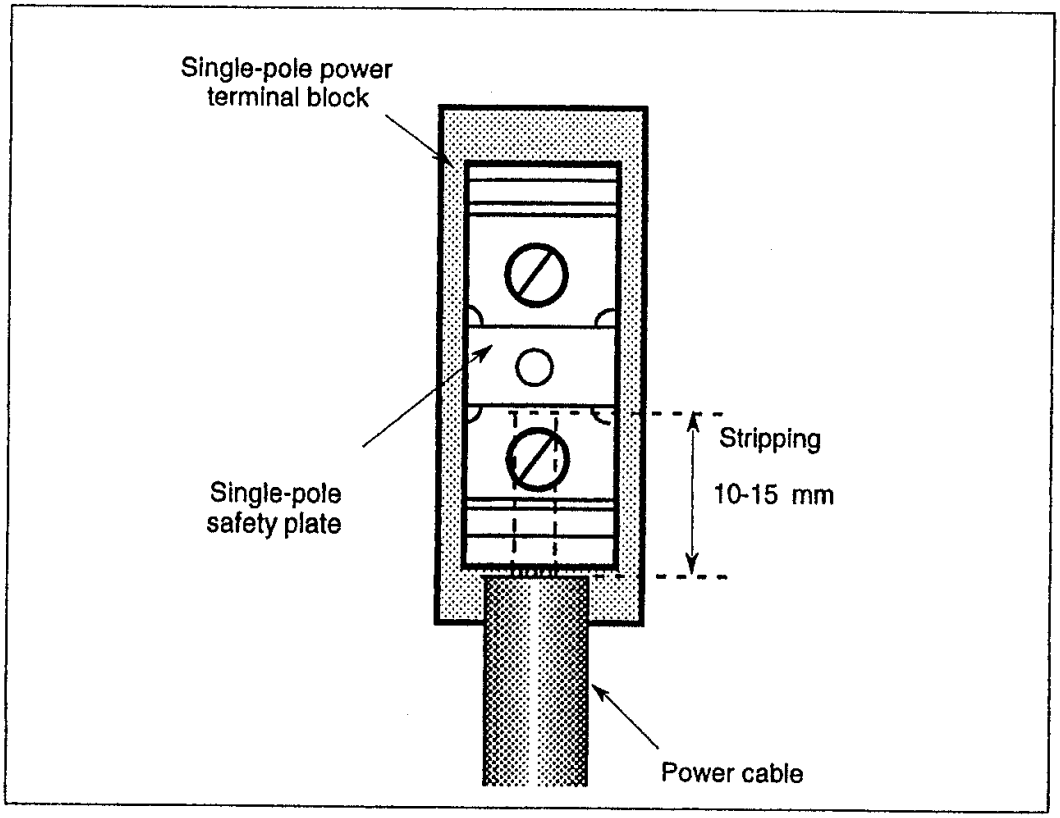


Figure 3-2 TU1471 thyristor unit power wiring

Fan supply

The fan supply must be connected **directly** to the two terminals fitted on the fan using two crimping **faston lugs**.
Sheath each lug with **2** heat-shrinkable sheaths (for double isolation) and heat. The sheaths should pass the lug by 0.5 mm.
4 lugs and 8 sheaths are supplied with the thyristor unit.

To protect the fan supply, a **0.5 A** fuse is to be provided in thr wire to a line.

USER TERMINAL BLOCKS

The terminal blocks are located in the top part of the thyristor unit electronic boards.

The connections are made on the **power supply** board for the electronics supply and for the alarm relay contact,

The connections are made on the **microprocessor** board for the digital communications, for the analogue control and for the thyristor unit enable.

The neutral or the reference phase is connected on the **synchronisation voltage** board.

In order to access the user terminal blocks, the front panel must be removed.

The connections are made on plug-in terminal blocks.
The max. wire cross-section is **2.5 mm²**; terminal tightening: **0.7 N.m.**

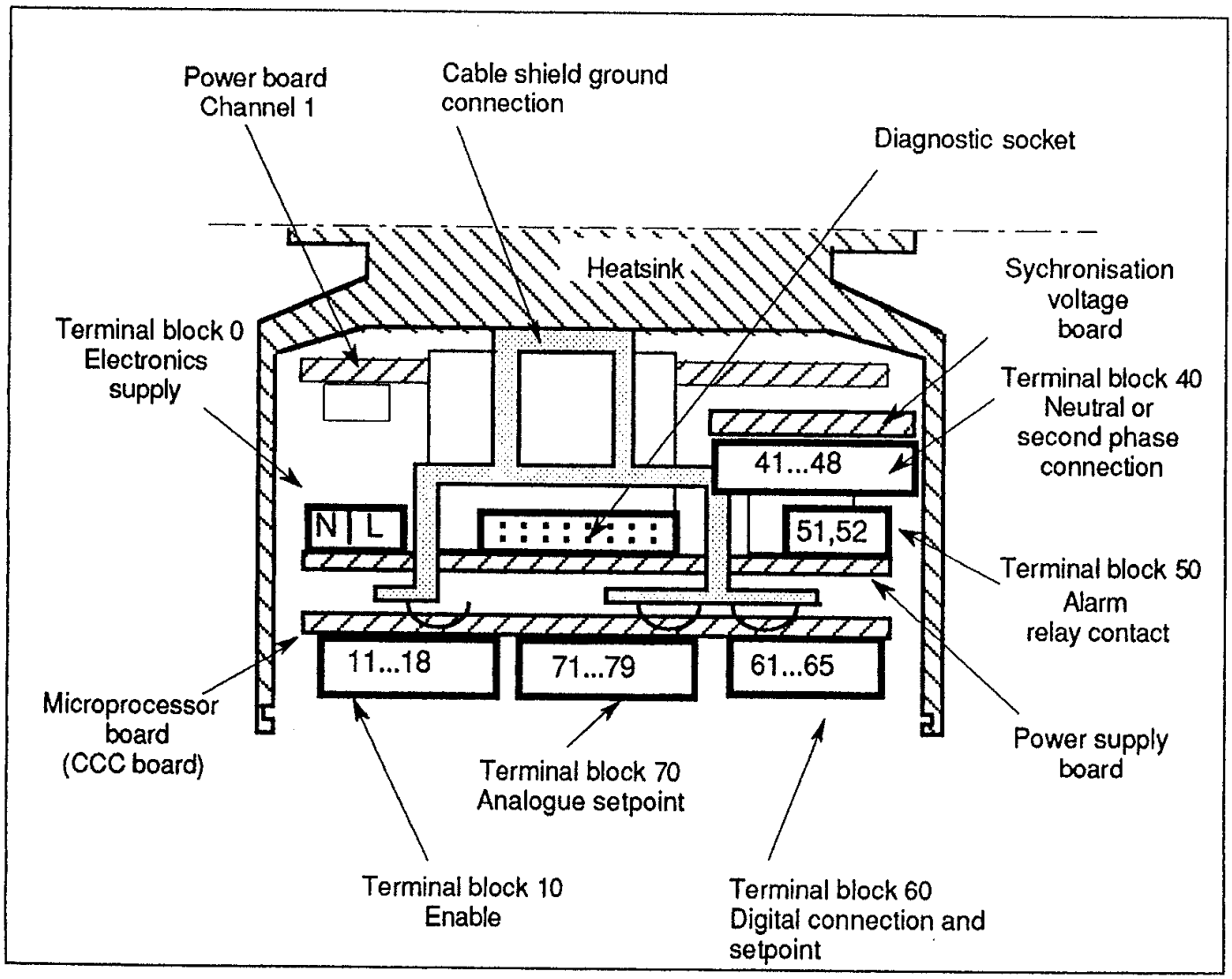


Figure 3-3 Location of terminal blocks on the electronic boards (seen from above)

POWER SUPPLY BOARD

Auxiliary supply

The auxiliary supply powers:

- the electronics control
- the partial load failure detection circuit.

The 'L' terminal is used for the supply phase connection.
The 'N' terminal is the neutral or the reference phase.

Caution !

For normal thyristor firing reasons, the auxiliary supply (terminals **L** and **N**) and the power supply of the 4 channels (the terminals labelled '**LINE**') must be connected **to the same phase.**

The auxiliary supply is protected with a **filter** against electrical interference from the power supply in common mode.

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

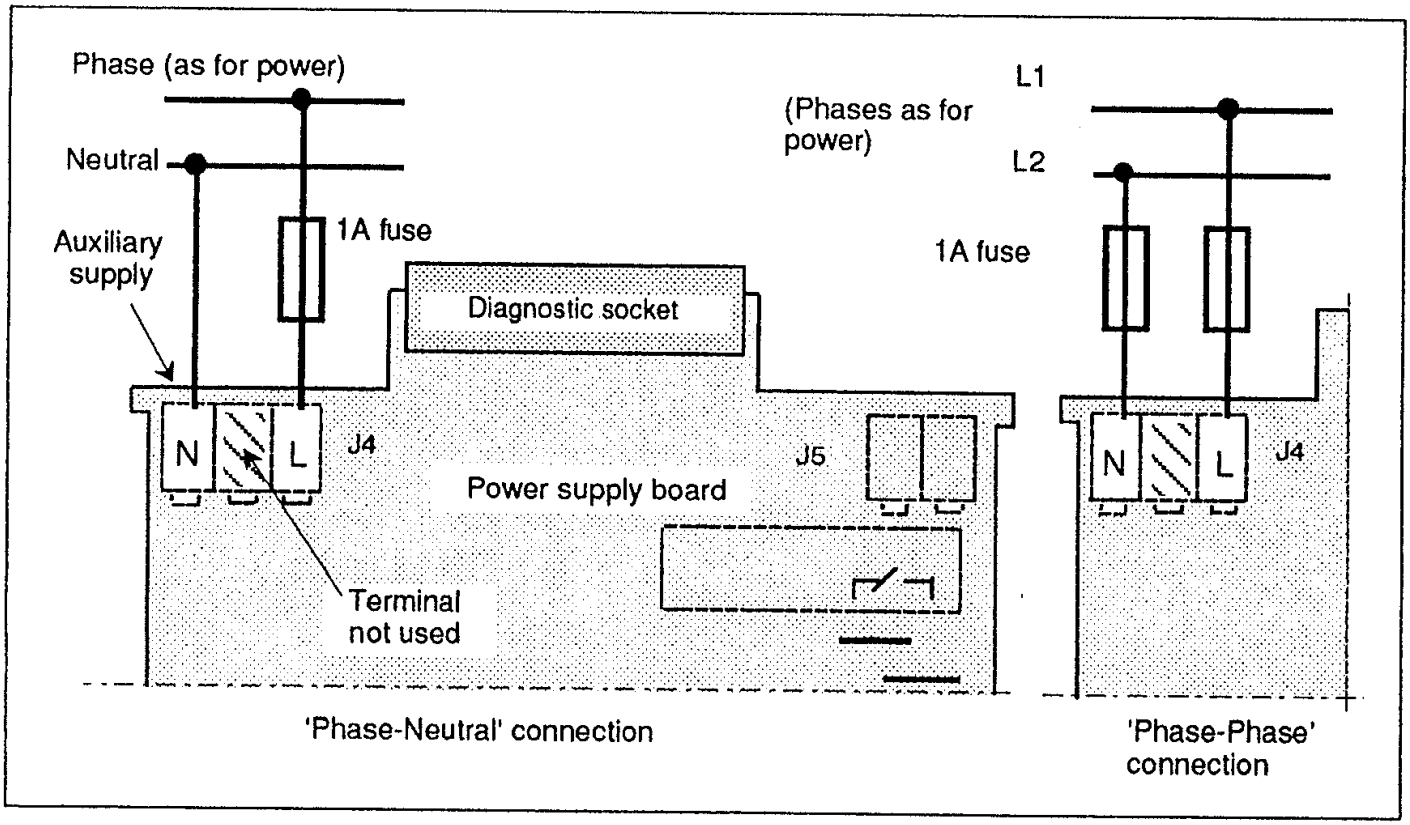


Figure 3-4 Auxiliary supply and alarm contact terminal blocks (seen on soldered side)

Alarm relay contact

The relay contact which signals the ON state of certain alarms is connected on the user terminal block at the top part of the power supply board (terminals **51** and **52**).

The contact type (normally open or closed) is configured according to the coding.

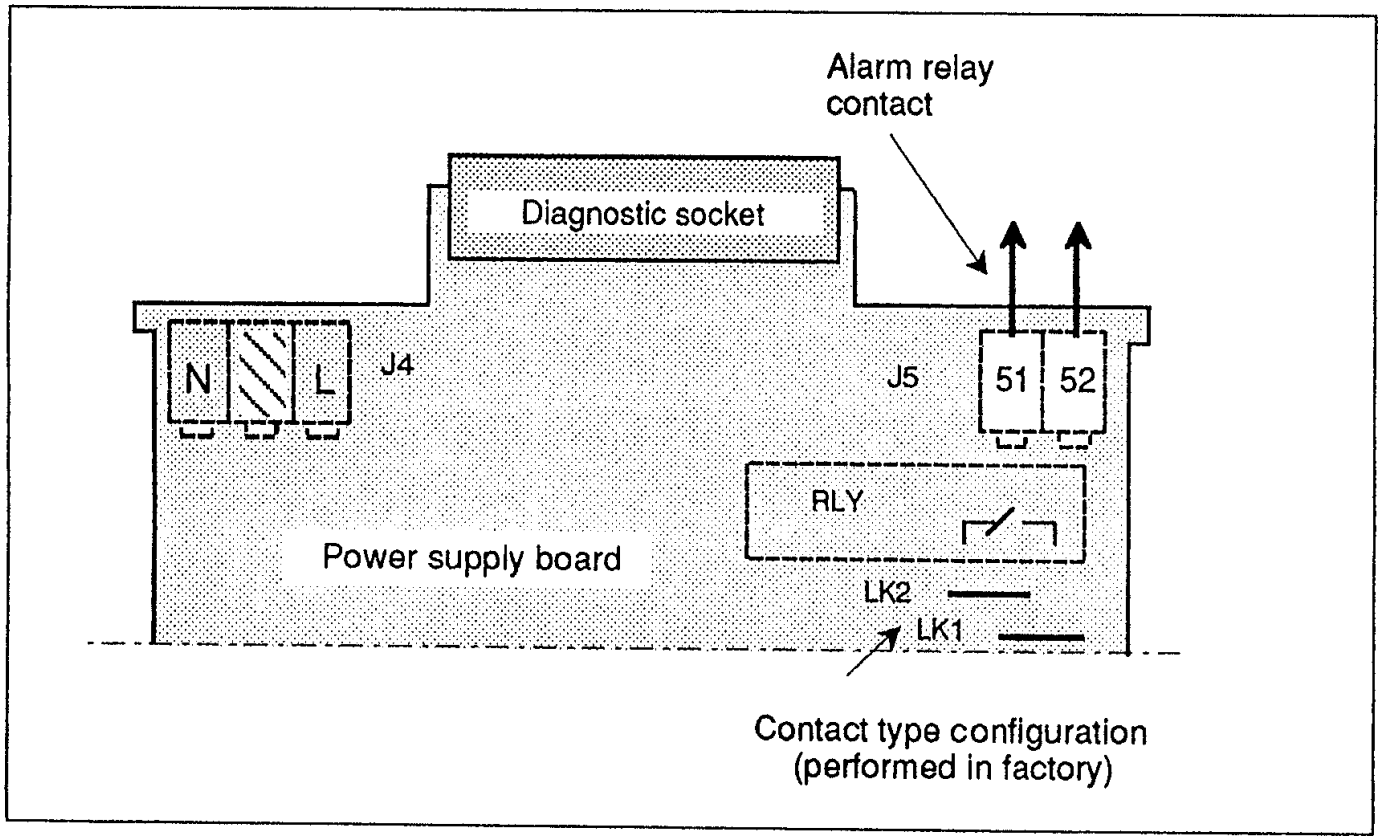


Figure 3-5 Alarm contact connection (seen on soldered side)

SYNCHRONISATION VOLTAGE BOARD

The neutral or the reference phase are connected on the **synchronisation voltage** board for the operation of the control electronics.

The neutral or reference phase (second supply phase) connection is determined the thyristor unit power connection.

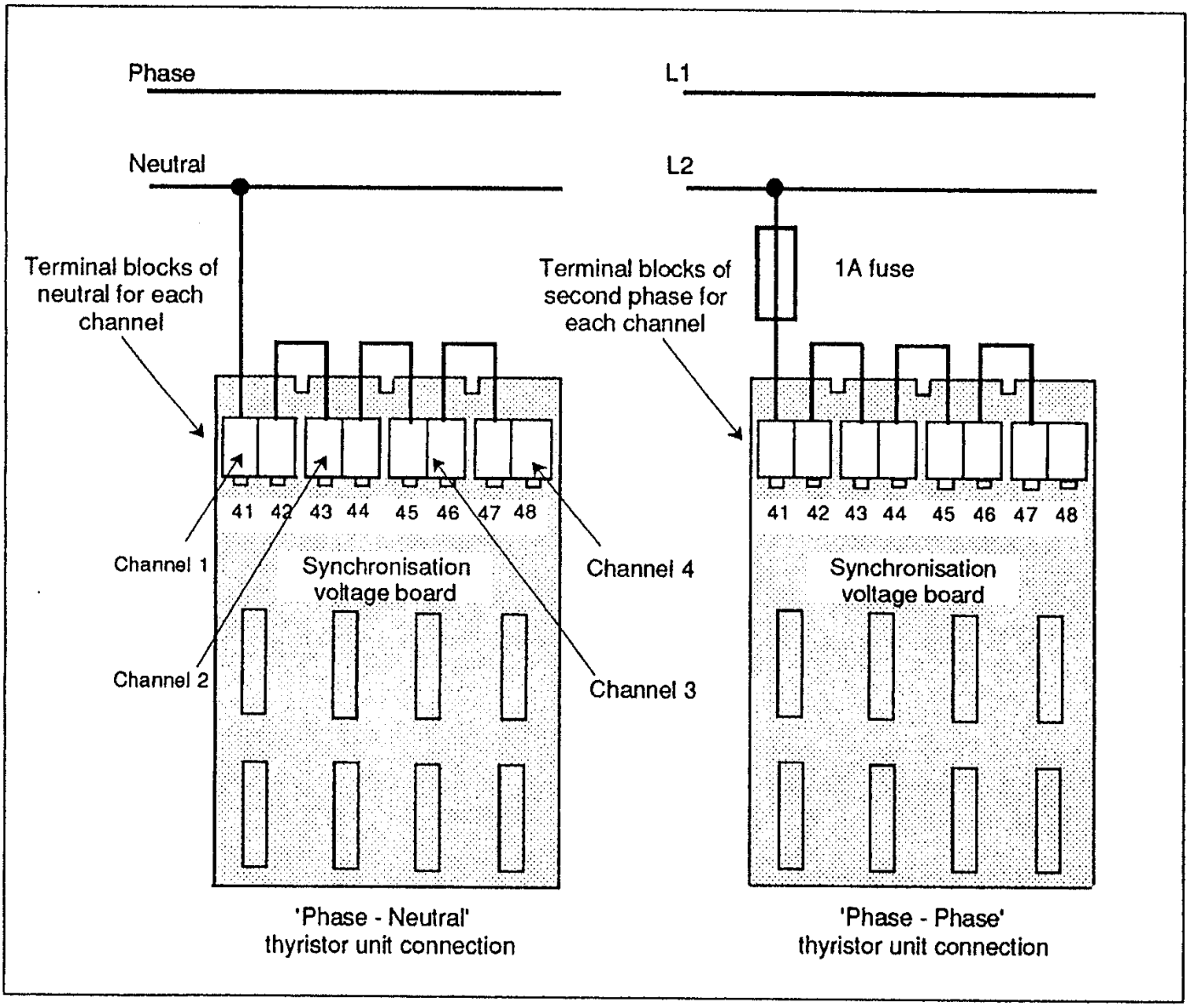


Figure 3-6 Synchronisation voltage board connection

CONTROL CABLE FIXING

The cables used to connect the control electronics must be **short** and **shielded.**

Caution !

The control must be connected using cables which are **shielded and earthed at both ends** in order to guarantee satisfactory immunity against interference.

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

Plug-in control terminal block connectors are provided for the following cables sizes:
0.5 to **1.5 mm²**.

Passage through the upper cover

The communication, control, auxiliary supply cables and the diagnostic socket are passed through the plastic upper cover.

To remove the protective cover:

- Insert the screwdriver between the two centring devices located at the rear and push it downwards as far as possible (see figure 3-7).
- Turn slightly without exertion to unlock the clip.
- Pull the cover upwards.

  Pass the wires and the low level and electronics supply plug-in connectors **through** the cable passage holes.
- Connect the plug-in connectors on the power supply, neutral and microprocessor board terminal blocks.

After the connection, put the protective cover back in place:

- Insert the edge of the upper cover in the first of the two heatsink grooves.
- Press on the rear of the cover to lock.

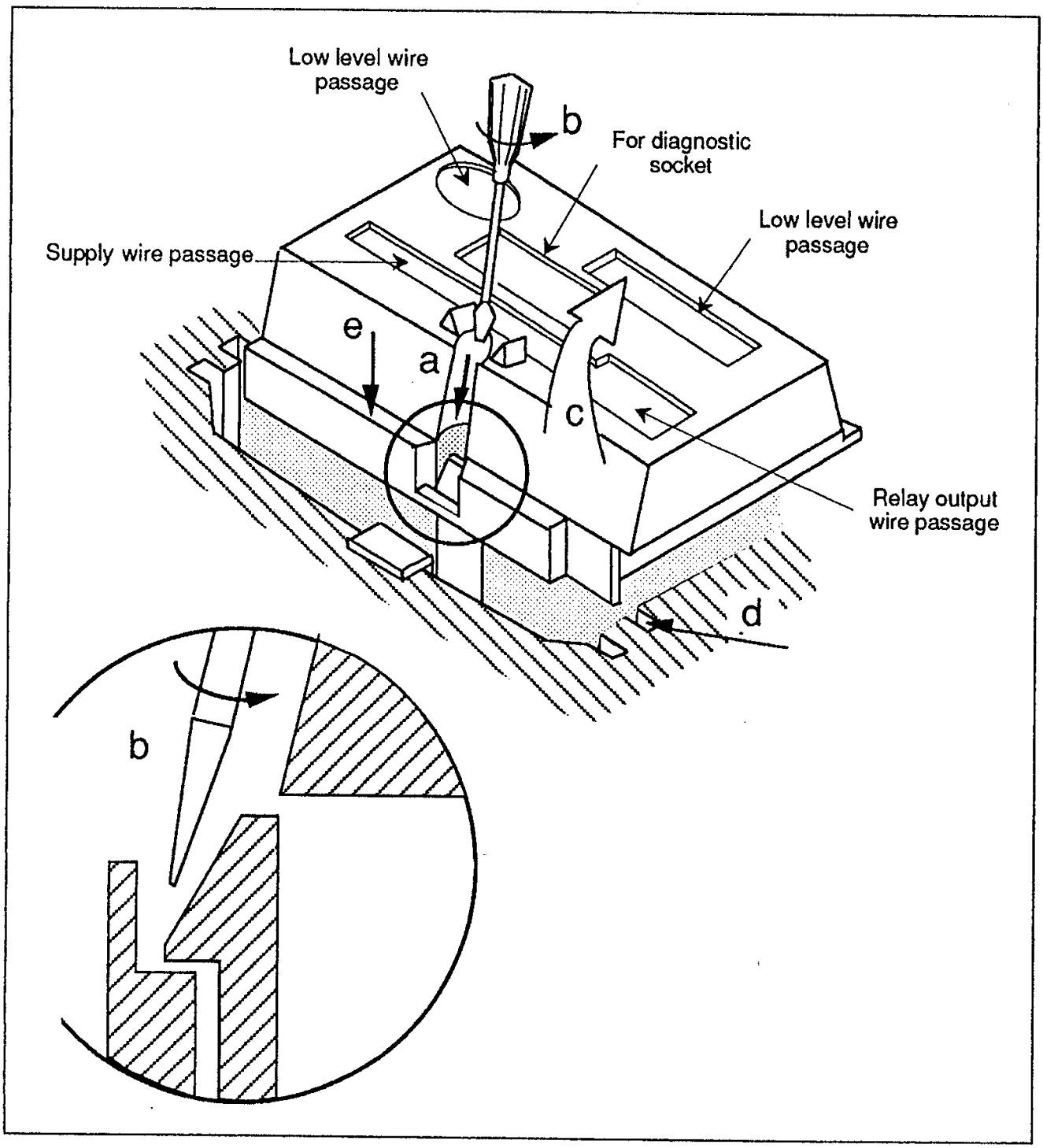


Figure 3-7 Removing the cover

Connection of the shield to the ground

The control wires must be grouped together in shielded cables passing through **cable clamps** mounted on the microprocessor board.

Important !

In order to connect the cable shield to the safety earth more easily and to guarantee maximum immunity to electromagnetic interference, the **metal** cable clamps are **mounted directly on the ground** of the unit (see figure 3-3, page 3-6).

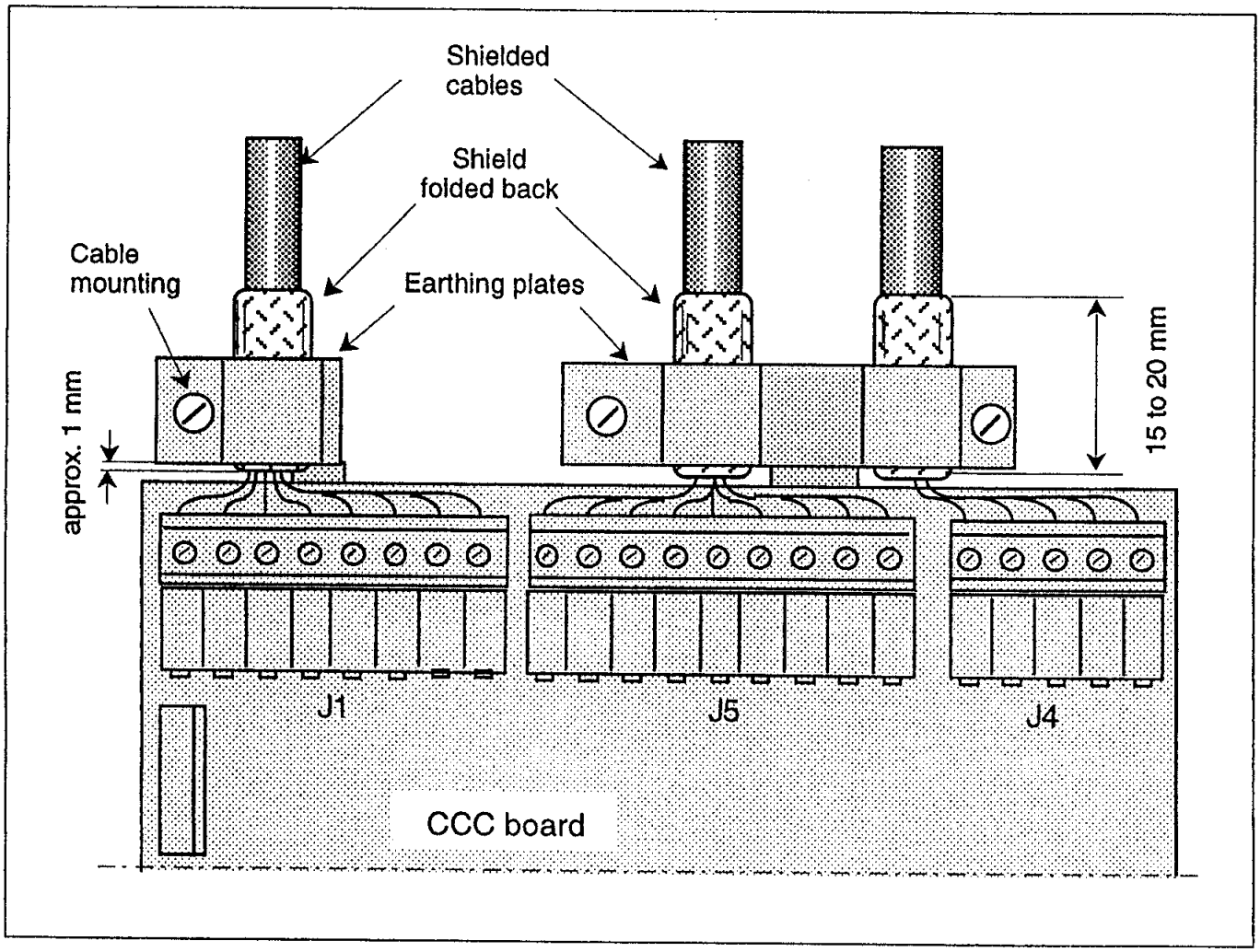


Figure 3-8 Location of the control cable clamps

The wiring inside the unit must be as short as possible.

The mounting screw tightening **is 0.7 N.m.**

Control signal connection

The control signals are connected using plug-in terminal block **60** (digital control) or **70** (digital control) which can be accessed when the front panel is removed.

Warning !

- Dangerous live parts may be accessible when the front panel is removed if the thyristor unit is switched on.
- Before removing the front panel, make sure that the heatsink is not hot.

Examples of analogue or digital signal connection are given below.

Analogue setpoint

The analogue setpoint is connected to terminal block **70**.

The analogue setpoint can be used with digital control (in order to download the information to a control station) or without digital communications. In order to use the analogue setpoint with digital control, terminal **74 ('A/N')** must be disconnected from **'+ 10 V'**.

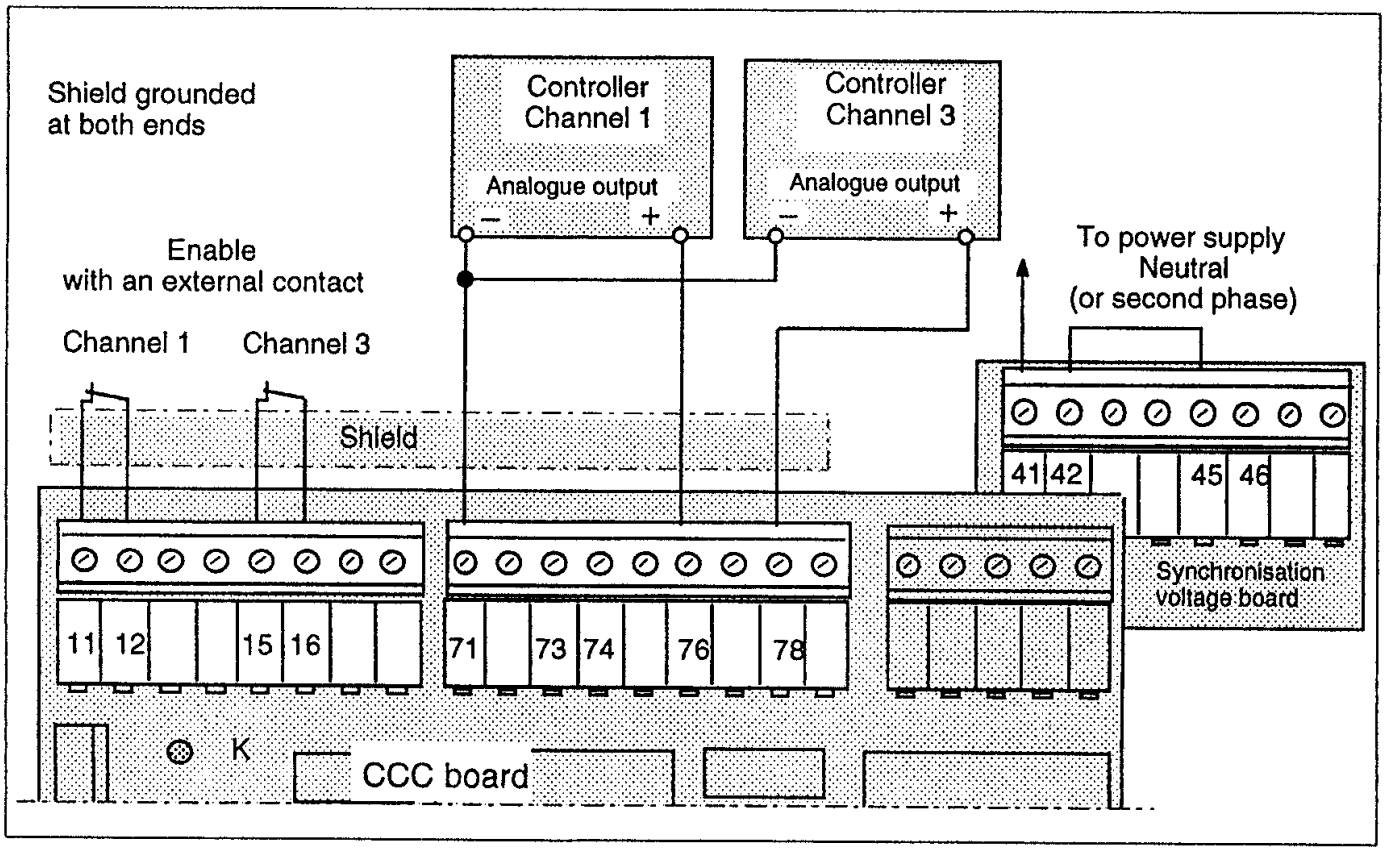


Figure 3-10 Example of channel 1 and 3 analogue signal connection without communications

The analogue setpoints are either the main setpoints from a controller, or the fallback setpoints in the event of a failure on the digital communications.

Manual control

In the event of digital communication failure, the fallback position consists of controlling the thyristor unit with a manual control.

For the manual control to be used, four **10 kΩ** potentiometers (one potentiometer per channel) are connected between terminals **73 (+10 V)** and **71 (0 V)** on the microprocessor board. The potentiometer wipers are connected to the channel analogue inputs.

The fallback position can use another **0-10 V** analogue signal.

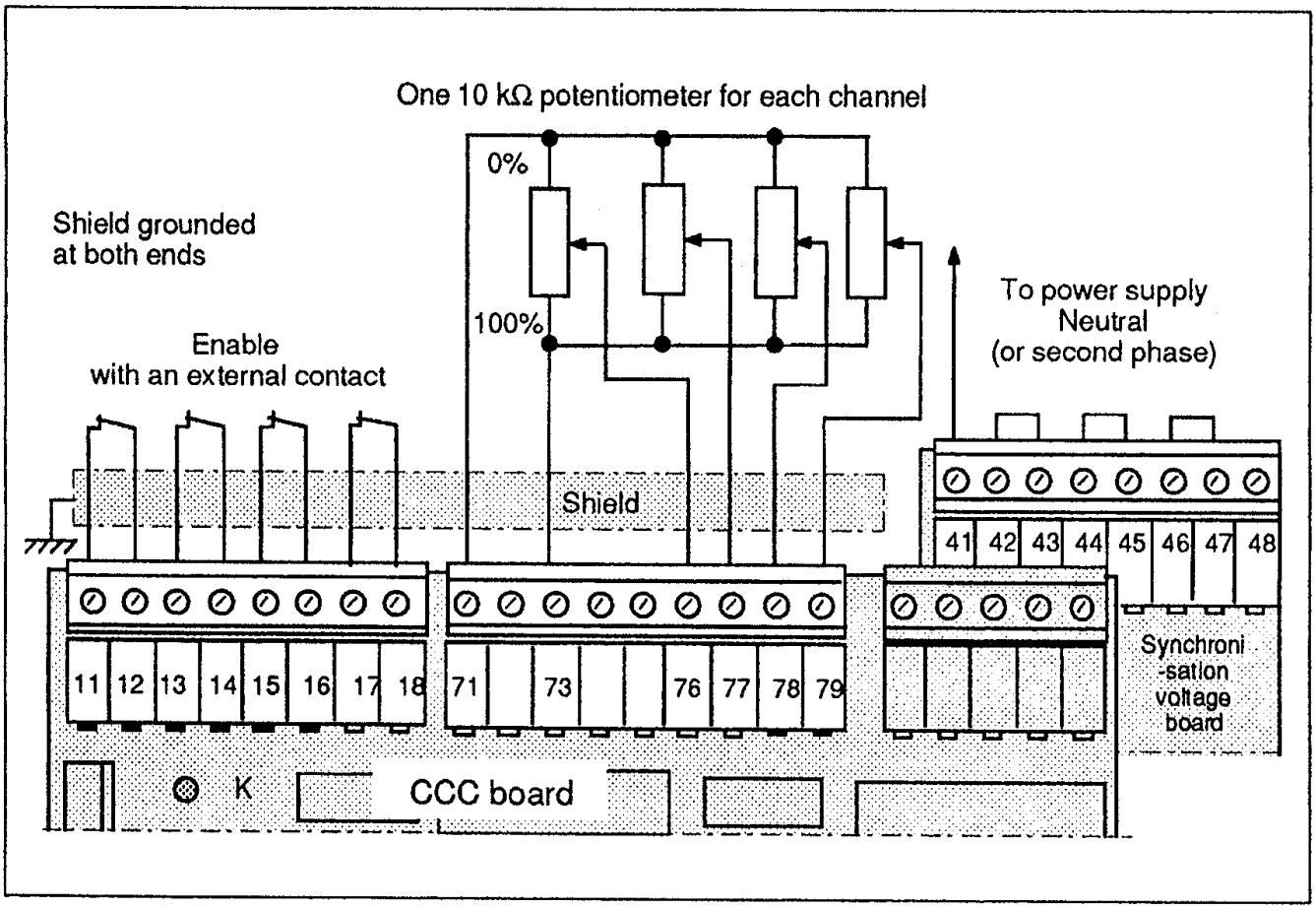


Figure 3-11 Example of manual control configuration in the event of failure of the digital communications

When using the manual control, terminal **74 ('A/N')** must be disconnected from terminal **73 ('+10 V')**.

Manual control

In the event of digital communication failure, the fallback position consists of controlling the thyristor unit with a manual control.

For the manual control to be used, four **10 kΩ** potentiometers (one potentiometer per channel) are connected between terminals **73 (+10 V)** and **71 (0 V)** on the microprocessor board. The potentiometer wipers are connected to the channel analogue inputs.

The fallback position can use another **0-10 V** analogue signal.

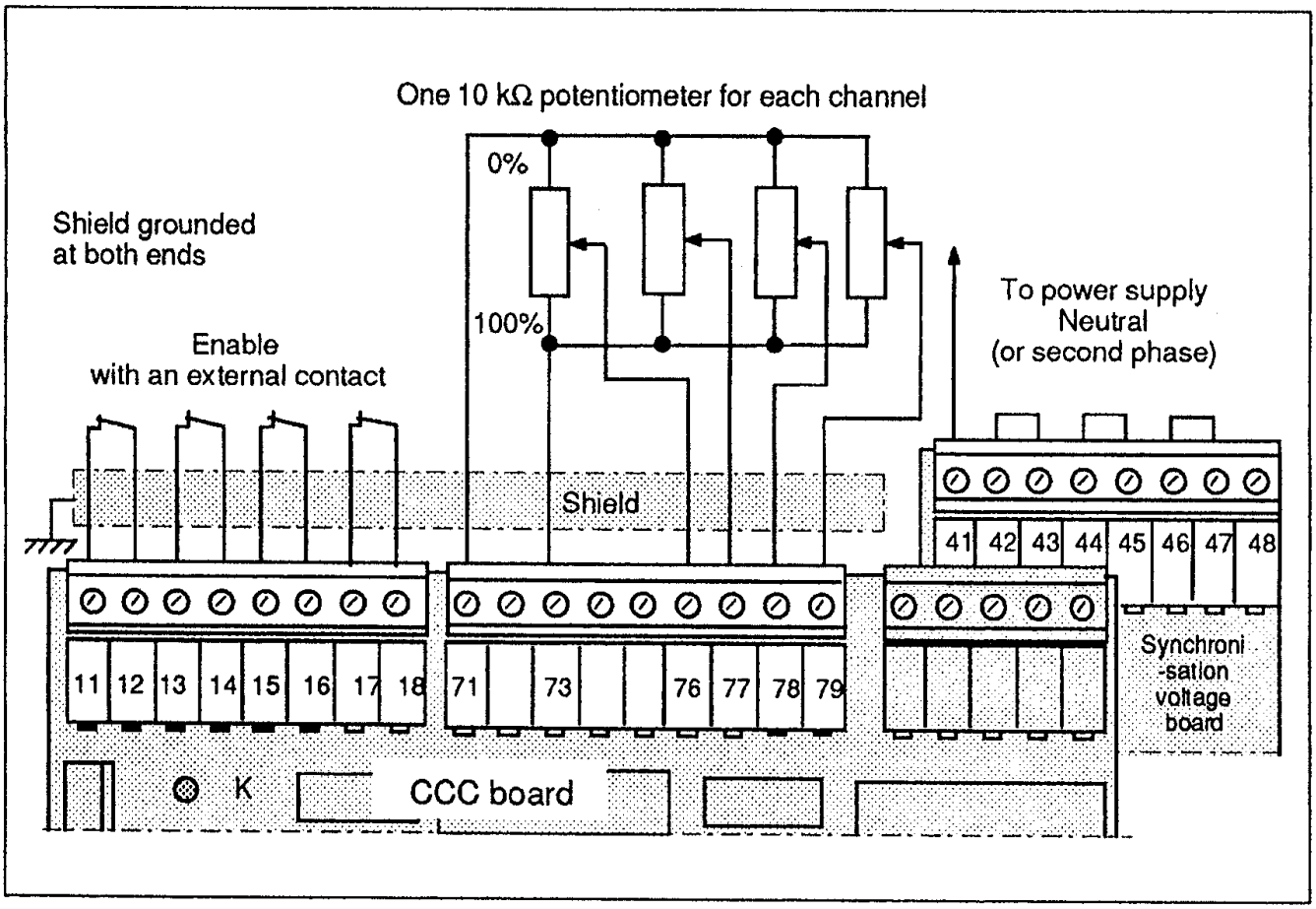


Figure 3-11 Example of manual control configuration in the event of failure of the digital communications

When using the manual control, terminal **74 ('A/N')** must be disconnected from terminal **73 ('+10 V')**.

Digital setpoint

The digital setpoint must be connected to terminal block **60**.

When using the digital setpoint, terminal **74** must be connected to terminal **73** ('+10V').

In order to use the digital setpoint to control the **TU1451** and **TU1471** thyristor units, the Eurotherm **261** interface is required.

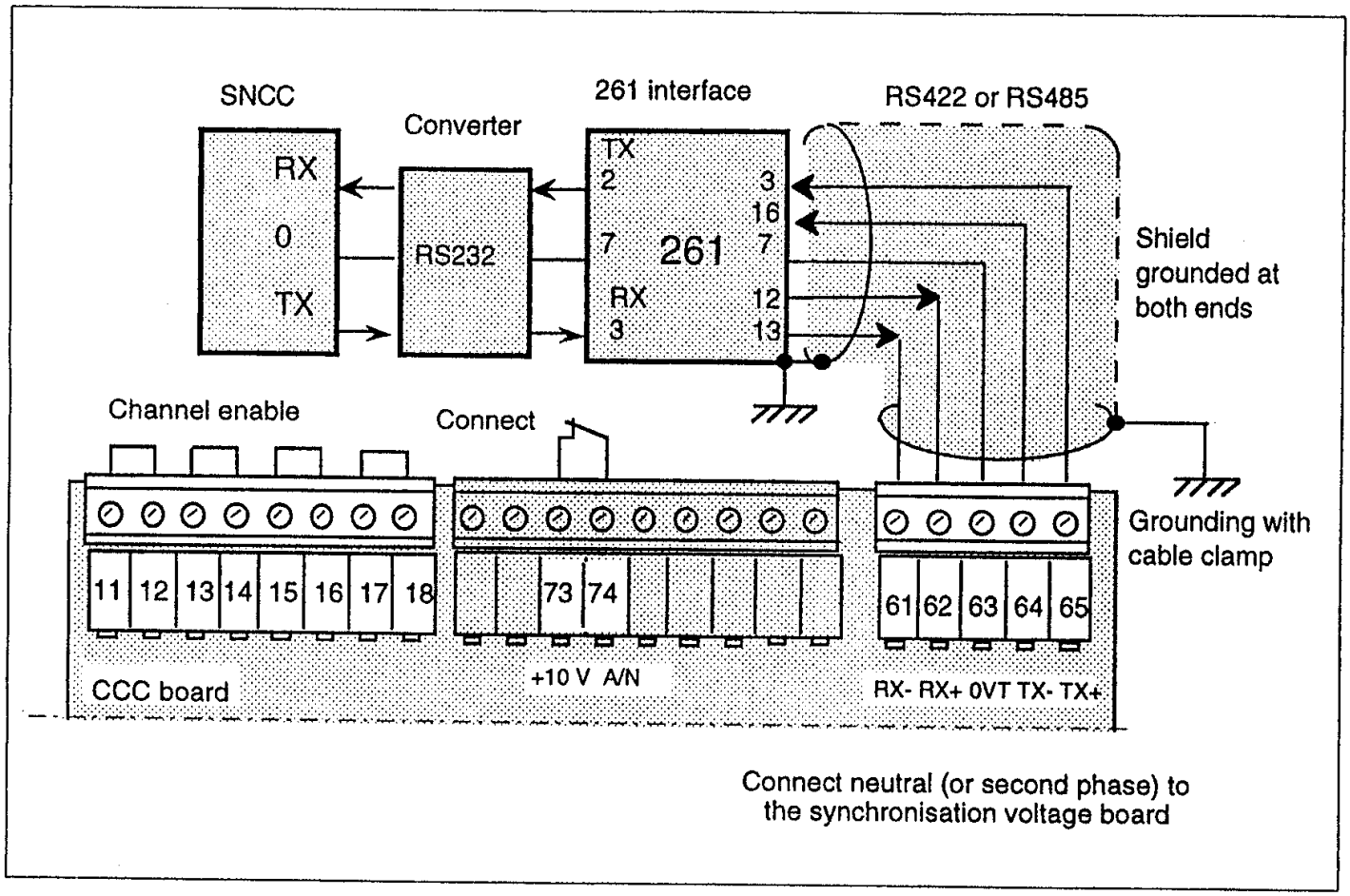


Figure 3-12 Connection with a Eurotherm 261 interface RS232/RS422 (RS485) converter

The digital setpoint is sent by a Communicating control system (SNCC) such as Eurotherm **PC3000**, a PC equipped with Eurotherm **IPSG** software or any other suitable equipment.

THYRISTOR UNIT CONNECTION

Power

The installation must be connected **by the user** to the power supply using a **line protection and main circuit breaker**.

Caution !

The external fuses are used to protect the thyristors and can never be used to replace the installation protection fuses.

They must be installed before power-up.

The external fuses are ordered separately (see pages 1-16 and 8-4).

It is recommended to mount the external fuses in line fuse-isolators.
As for all circuit breakers, the fuse-isolators cannot be opened when the thyristor unit is on-load.

Electronics supply

For correct thyristor firng, the auxiliary power supply on the power supply board must be connected to the **same** phases as the power (see figure 3-4).

Fan

The external fan supply must be connected.

For **TU1451** thyristor units, the connection is made on the **screw** terminal block of the bottom part of the thyristor unit.

For **TU1471** thyristor units, the connection is made directly to the two terminals fitted on the fan using two crimping **faston lugs** (supplied with the thyristor unit).
Sheath each lug with **2 sheaths**, allowing approximately **0.5 mm** to pass, and heat.
The sheaths should pass the lug by **0.5 mm** (2 heat-shrinkable sheaths supplied per lug).

The fan supply must be protected with a **0.5 A** fuse in each wire to a power supply phase. Fan consumption:

15 W at **230 V, 50 Hz** (14 W, 60 Hz),
15.5 W at **115 V, 50 Hz** (14.5 W, 60 Hz).

CONNECTION EXAMPLES

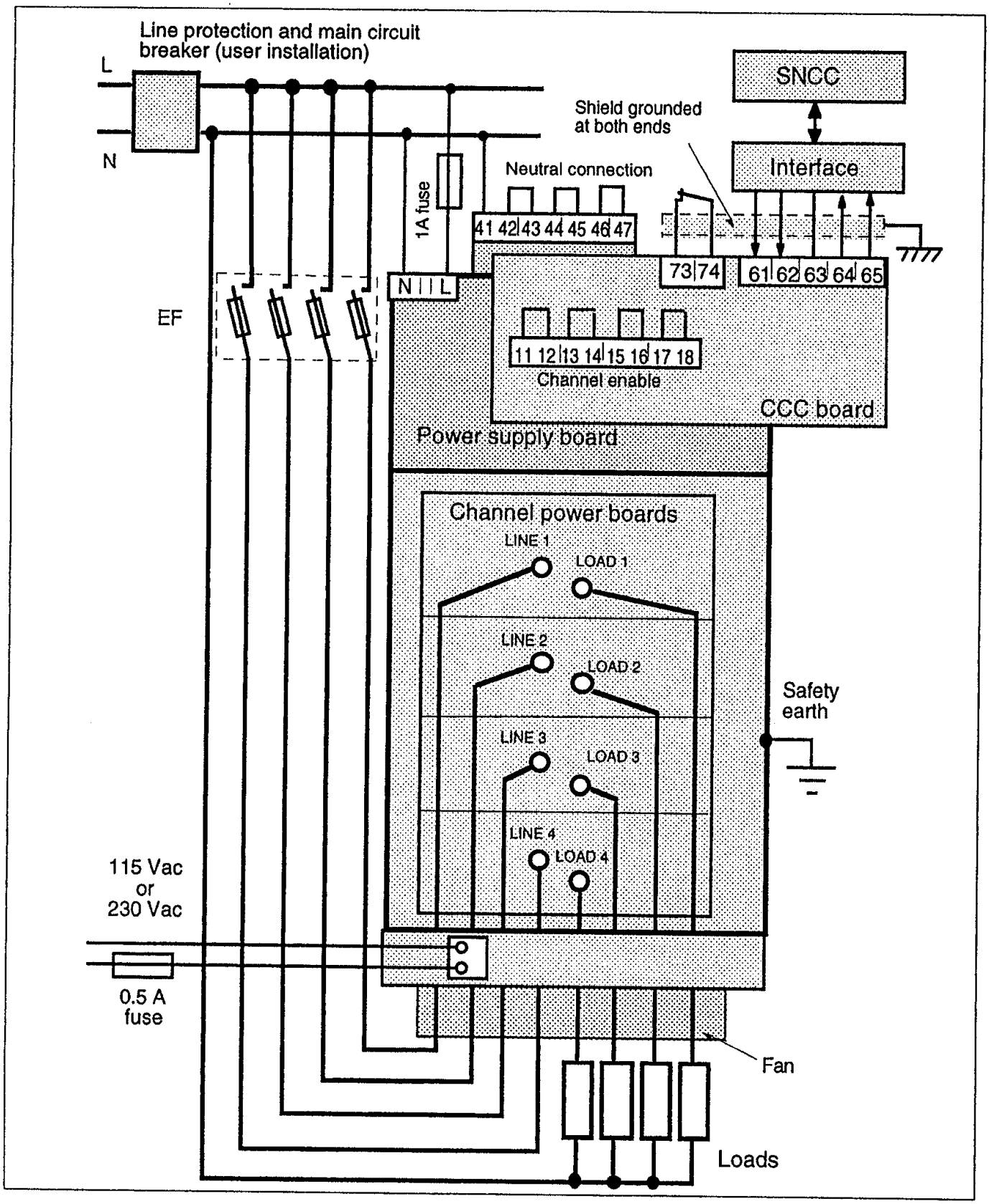


Figure 3-13 Example of TU1451 thyristor unit connection with a digital setpoint

The digital setpoint is sent by a EUROTHERM SNCC or equivalent.
A fuse is required to the neutral wire for the line-to-line connection.
For a TU1471, the control and auxiliary supply connection is the same.

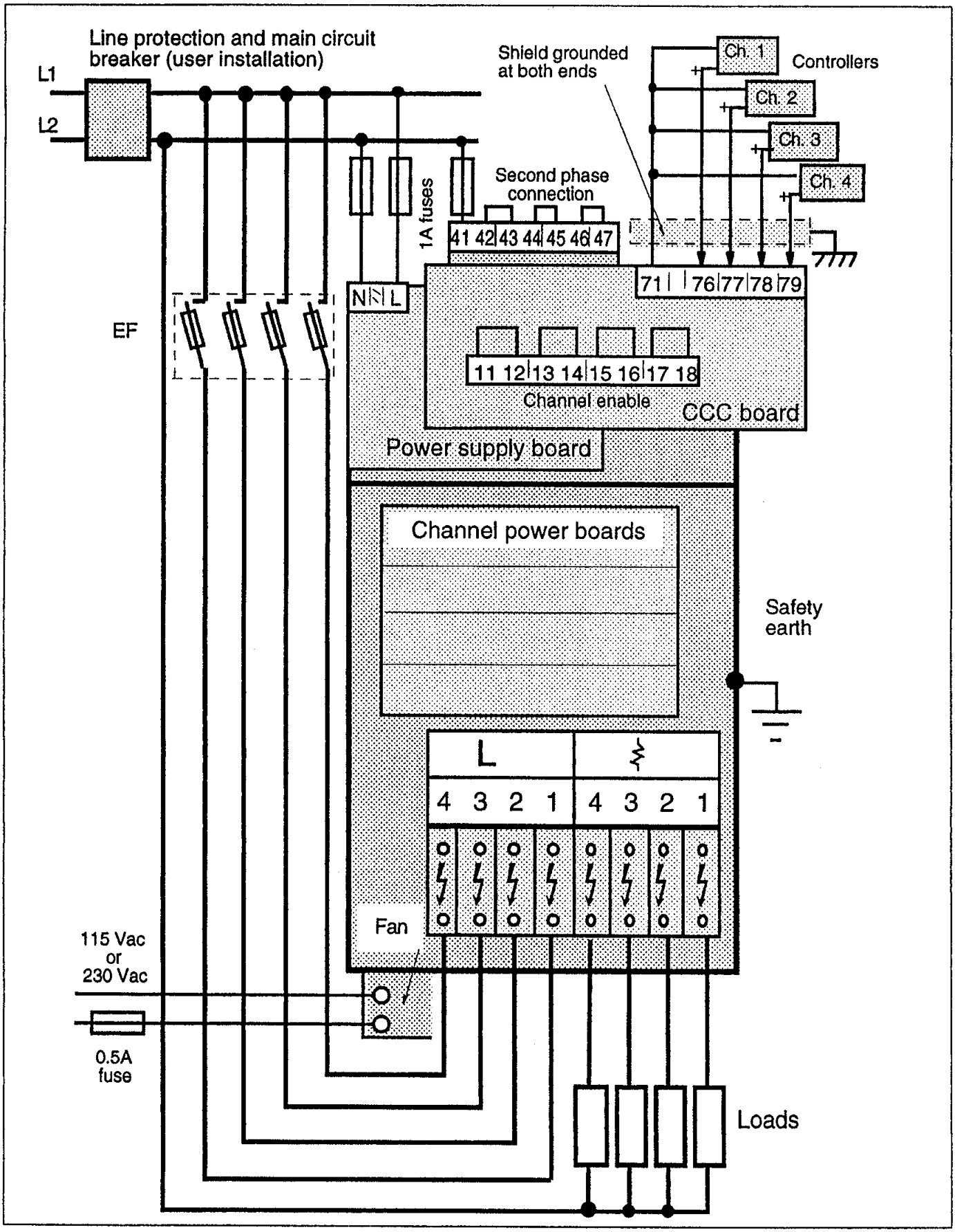


Figure 3-14 Example of TU1471 thyristor unit connection with analogue setpoints (line-to-line connection)

The control and auxiliary supply connection is identical for a TU1451.

Chapter 4

CONFIGURATION

Contents page

Chapter 4 CONFIGURATION

SAFETY DURING CONFIGURATION

The thyristor unit is configured in the factory using moveable **jumpers** located on the power supply, firing and microprocessor boards.

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, or
- **modify,** if necessary, certain characteristics of the thyristor unit on-site.

Warning !

For safety reasons, the reconfiguration of the thyristor unit using jumpers must be performed with the unit **switched off** and by qualified personnel.

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 SUPPLY BOARD

The power supply board has the following functions:

- electronics supply voltage selection,
- power control voltage selection,
- connection of an over-temperature detection circuit
- alarm relay contact type selection.

The power supply voltage is adapted by a transformer with two primary coils (corresponding to the thyristor unit operating voltage).

Five types of transformer each at **18 VA** are used.
Their part numbers and primary voltages are as follows:

CO 175080	100 and 200 V
CO 175079	115 and 230 V
CO 175081	230 and 400 V
CO 175083	230 and 440 V
CO 175082	230 and 500 V.

The electronics supply voltage is selected using the jumper **ST1** (see figure 4-1) at the supply transformer primary coil.

Setting the jumper **ST1** to **230 V** (see table 4-1) is used to supply **220-240 V** power to a thyristor unit equipped with any transformer (200 V for the transformer part No.: CO175080).

Setting the jumper **ST1** to **OTHERS** is used to supply a thyristor unit with **100, 115, 400, 440, 480** or **500 V** power depending on the type of transformer.

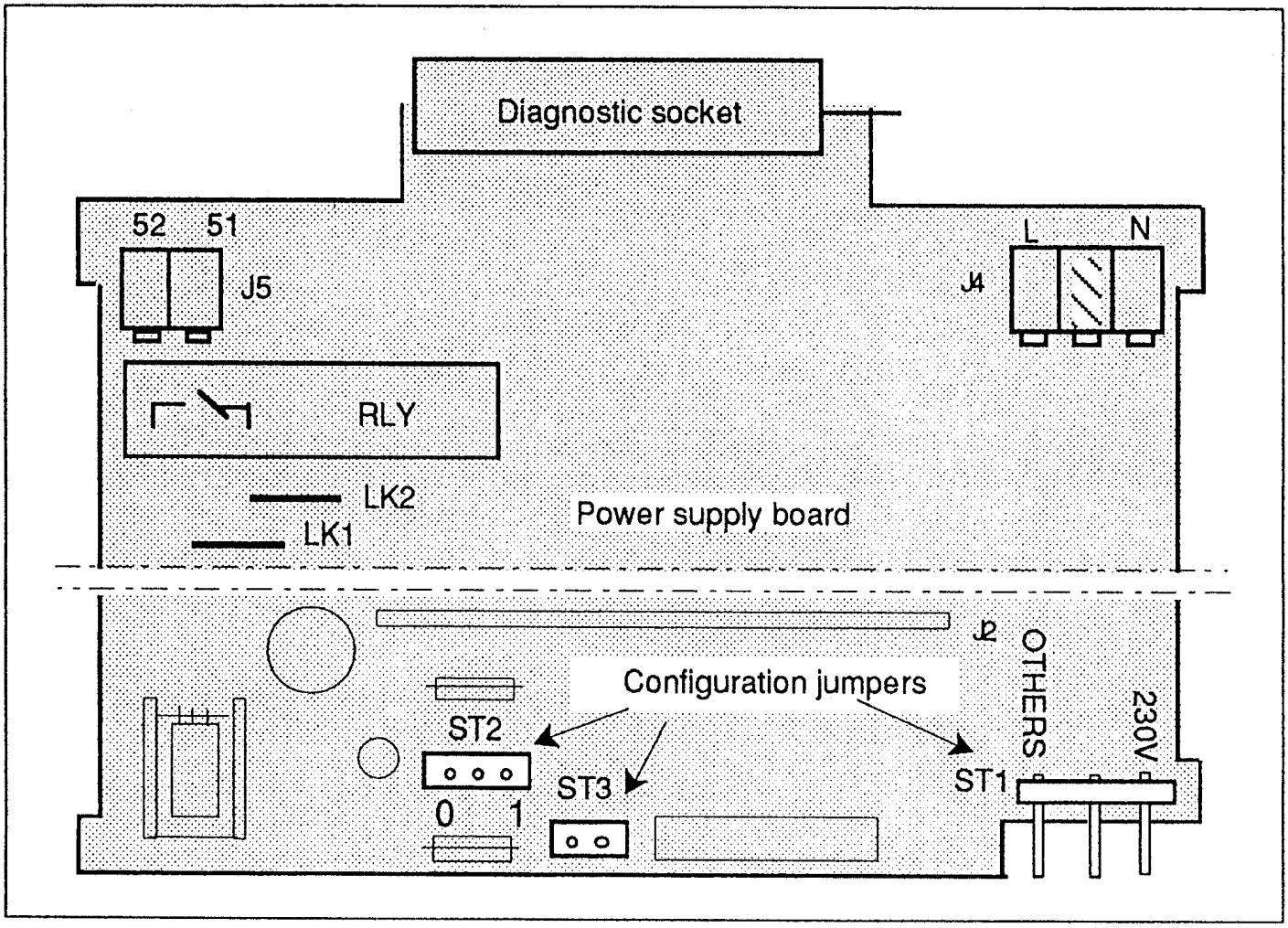


Figure 4-1 Location of the jumpers on the power supply board (component side view)

The voltage used for the power **control** on the microprocessor board is selected using the jumper **ST2.**

This voltage is the image of the line voltage connected to channel **1.**

Caution !

- The voltage of channel 1 must always be connected.
- In order to obtain correct thyristor unit control operation, the 4 power channels and the electronics supply must be connected between the same phases (see wiring diagrams figures 3-13 and 3-14).

The configuration of the power supply board is given in table 4-1.

Options		Positions of jumpers			Links	
		ST1	ST2	ST3	LK1	LK2
Primary supply voltage	220 (240) V	230 V				
	110 (120) V	OTHERS				
	380 (415) V	OTHERS				
	480 (500) V	OTHERS				
Voltage return for control			1			
Thermal safety				Wiring loom		
Type of alarm contact : open in alarm state					Soldered link	Not soldered
closed in alarm state					Not soldered	Soldered link

Table 4-1 Position of jumpers on the power supply board

Type of relay alarm contact

The type of alarm contact:

- closed in alarm state (normally closed **N/C**) or
- open in alarm state (normally open **N/O**)

is selected using the links **LK1** and **LK2** soldered in the factory according to the thyristor unit coding.

The configured alarm relay contact is available on user terminal block **50** on the power supply board.

Over-temperature detection

The **TU1451 and TU1471** thyristor units are equipped with **permanent fan cooling** using an internal fan and an **over-temperature detection circuit**.

The thermal switches (located on the heatsink) are connected in series by a **wiring loom** on the **ST3** pins which are located on the power supply board, which connects the over-temperature detection circuit (see figure 4-2).

If a thermal switch (in the event of abnormal overheating or stopping of the fan) is opened, the firing board voltage circuit is cut off which in turn stops the thyristor unit and a Total load failure alarm is triggered.

The **TU1451** thyristor units are equipped with one thermal switch for all channels.

The **TU1471** thyristor units are equipped with four thermal switches, one for each channel.

If the **ST3** circuit is opened, the thyristor unit is stopped and the Total load failure alarm is triggered.

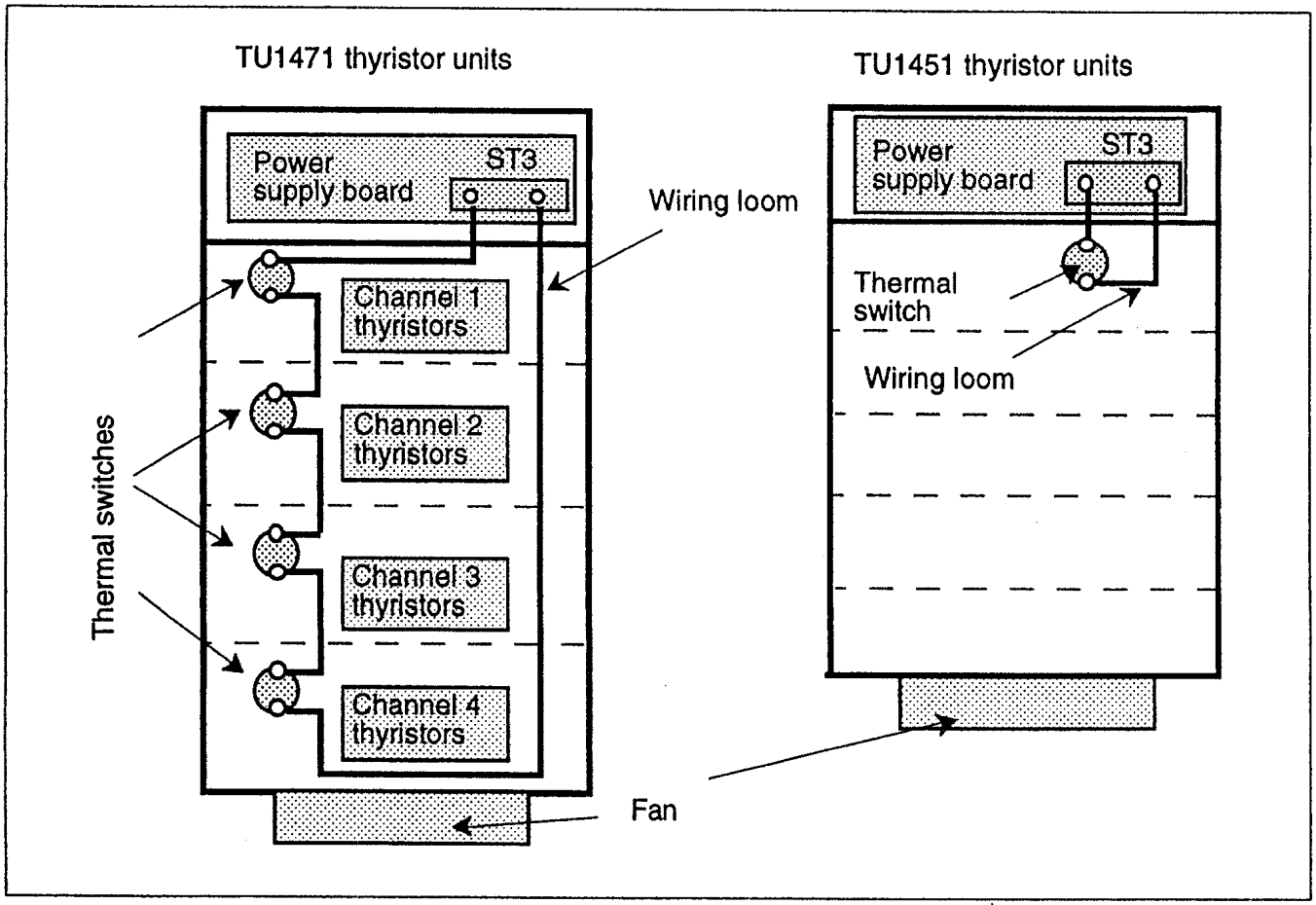


Figure 4-2 Thermal switch connection

POWER BOARDS

The line voltage data is selected for the microprocessor on the power boards.

Line voltage

The line voltage (nominal voltage) defines the position of the jumpers **KP1** and **KP2** on the power boards.

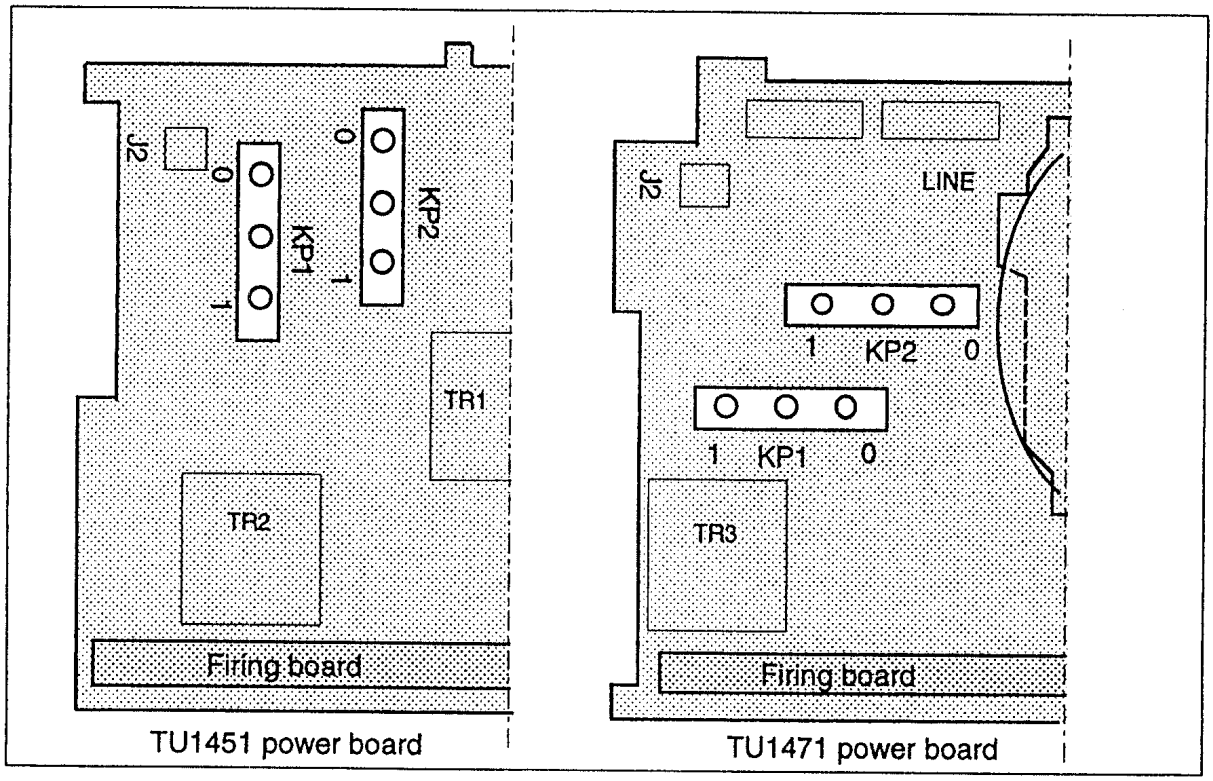


Figure 4-3 Location of the configuration jumpers on the power board

Nominal voltage (V)	Calibrated value (V)		Position of jumpers	
	Minimum	Maximum	KP1	KP2
100	85	115	0	0
120	102	132	0	0
200	170	220	1	0
240	204	264	1	0
380	323	418	0	1
415	353	456	0	1
440	374	484	1	1
500	425	550	1	1

Table 4-2 Nominal voltage configuration

The 4 power boards must be configured **in the same way** according to the nominal voltage specified for the thyristor unit. This voltage is specified on the identification label on the outer left-hand side of the unit.

FIRING BOARDS

The jumpers and mini-switches on a firing board determine the using of the basic or communications unit version, the frequency, the voltage and current data for the microprocessor board and, for basic version, - analogue input signal.

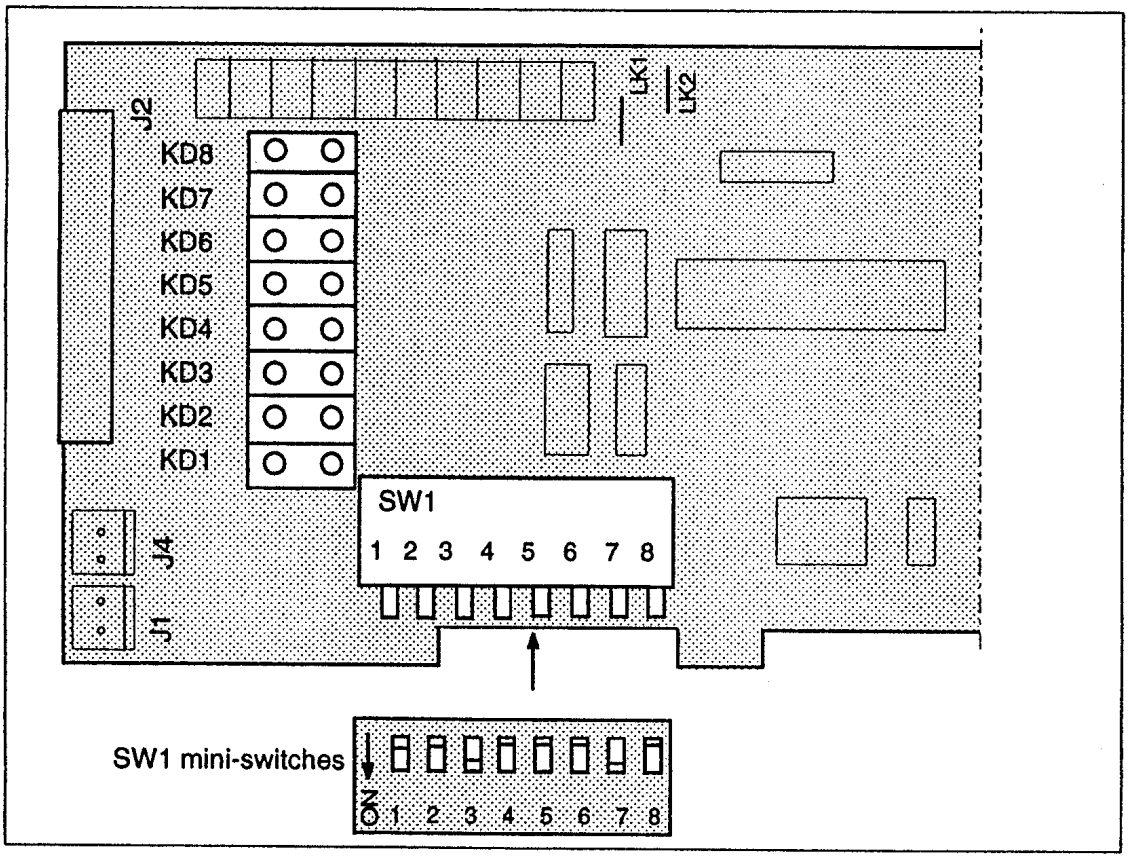


Figure 4-4 Configuration mini-switches and jumpers on the firing board

To control using the microprocessor board (communication version), the mini-switches on the **SW1** strip must be in the positions indicated in the table bellow.

Communication version SW1 position			
SW1-1	**SW1-2**	**SW1-3**	**SW1-4**
ON	OFF	ON	OFF

Table 4-3 Position of SW1-1 to SW1-4 mini-switches

ON - position indicated on the SW1 strip (switch in lower position)
OFF - switch in upper position.

For the TU1451/71 **basic** version :
the SW1-1 switch is in OFF position;
the SW1-2 to SW1-4 switches determine the analogue input levels.

The power supply frequency is configured using the **SW1-5** and **SW1-6** mini-switches, the positions of which are given in table 4-4.

Function		SW1 position		
		SW1-5	**SW1-6**	**SW1-7**
Frequency	50 Hz 60 Hz	ON OFF	ON OFF	
Line voltage data taken on channel **1**	Channel 1			ON
	Channel 2,3,4			OFF

Table 4-4 Frequency and voltage data configuration

The same table gives the positions of the **SW1-7** mini-switch on the firing boards of the 4 thyristor unit channels. This position gives the line voltage data to the microprocessor board. **Channel 1** represents the thyristor unit voltage. This choice determines the ON position of the **SW1-7** mini-switches for channel **1** and OFF positions of the **other** channels.

The **SW1-8** mini-switch not used.

The presence of the jumpers **KD1** to **KD4** (which select the current data for the microprocessor) and the jumpers **KD5** to **KD8** (which select the thyristor firing input address) is given in table 4-5.

Channel	**Jumpers**			
	KD1 and KD5	**KD2 and KD6**	**KD3 and KD7**	**KD4 and KD8**
1	Present			
2		Present		
3			Present	
4				Present

Table 4-5 Position of jumpers sending data to the microprocessor

The configuration of the 4 firing boards is standard except for the frequency selection. It is therefore not necessary to change the position of the jumpers and the mini-switches. However, if one of these jumpers is moved by mistake, the configuration given in the tables above must be observed.

MICROPROCESSOR BOARD

The selected options are configured using the **jumpers** located on the microprocessor board. In order to access the configuration, the front panel must be opened.

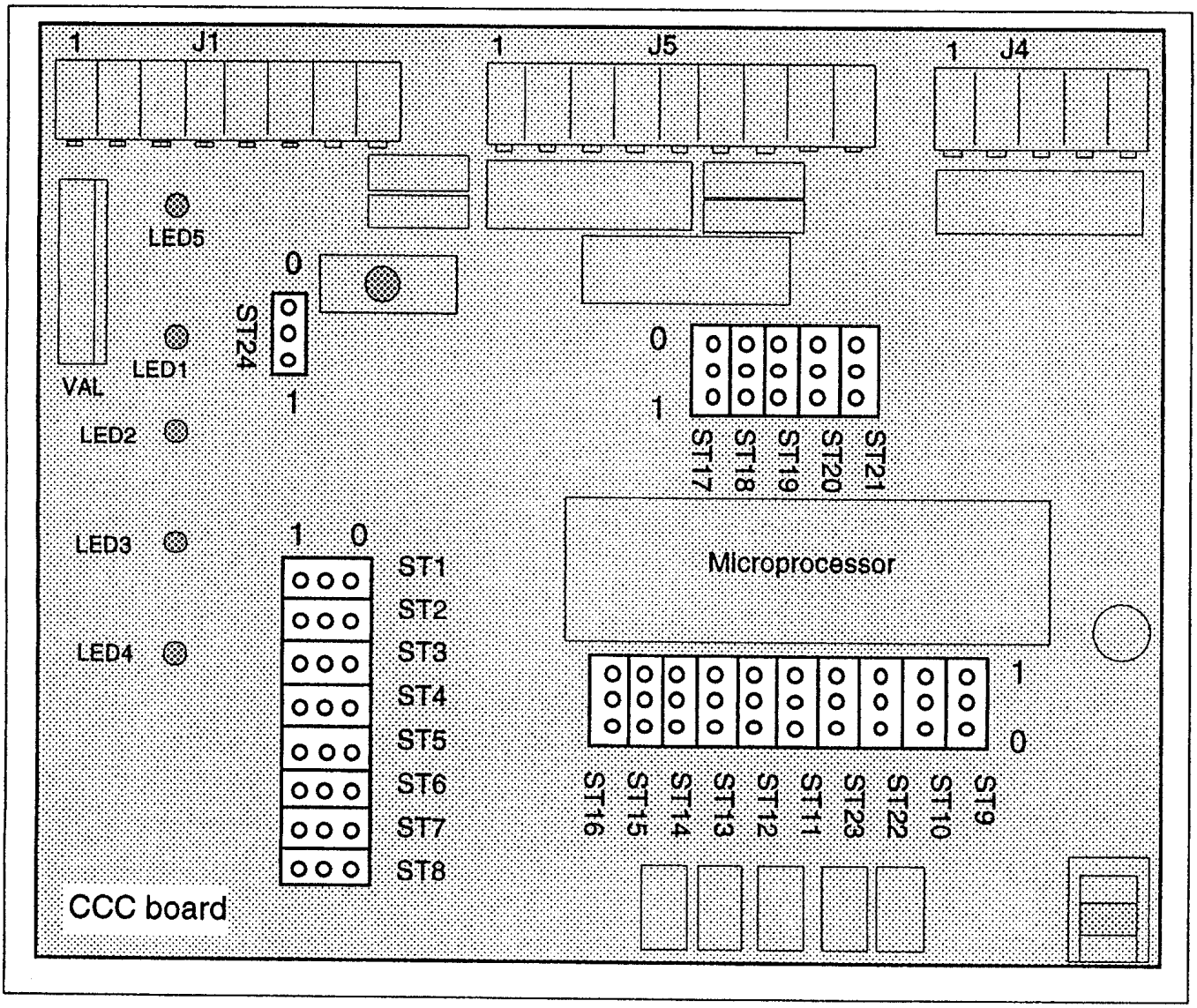


Figure 4-5 Location of jumpers on the microprocessor board

The jumper **ST9** determines the use of the digital communications:

- for use **with** digital communications, the jumper **ST9** must be set to **1**.
- the jumper **ST9** is set to **0** for use **without** digital communications.

Important !

For all the versions of the **TU1451** and **TU1471** thyristor units, the jumper **ST18** is always set to **1**.

Use without digital communications (ST9=0)

The choice of the level of the analogue signals and the parameters for use without digital communications defines the position of the jumpers according to table 4-6.

Configured parameter		Position of jumpers							
		ST1 to ST4	ST5 to ST8	ST19	ST10	ST11	ST12	ST17	ST20
Analogue input voltage (dc)	0-5 V	0	1	0					
	1-5 V	0	1	1					
	0-10 V	0	0	0					
	2-10 V	0	0	1					
Analogue input current (dc)	0-20 mA	1	1	0					
	4-20 mA	1	1	1					
Thyristor firing mode	Phase angle				1	0	0		
	Single cycle (1 supply cycle)				0	0	0		
	Burst firing (8 supply cycles)				0	1	0		
	Burst firing with soft start				0	0	1		
Control	Squared voltage							0	
	Power							1	
Load type (for PLF detection)	Resistive								0
	Infrared								1

Table 4-6 Configuration of CCC board jumpers (use without digital communications)

The jumpers **ST13** to **ST16** and **ST21** to **ST24** must be set to **0**.

Note: the jumper **ST18** is set to **1**.

Use with digital communications (ST9=1)

The configuration of the jumpers on the microprocessor board for the use of digital communications is defined in table 4-7.

Configured parameter		Position of jumpers							
		ST1 to ST4	ST5 to ST8	ST19	ST10	ST11 to ST16 ST22 ST23	ST17	ST20	ST21
Analogue input voltage (dc)	0-5 V	0	1	0					
	1-5 V	0	1	1					
	0-10 V	0	0	0					
	2-10 V	0	0	1					
Analogue input current (dc)	0-20 mA	1	1	0					
	4-20 mA	1	1	1					
Baud rate (baud)	9600				0				
	19200				1				
Thyristor unit address						see p.4-13			
Control	Squared voltage						0		
	Power						1		
Load type (for PLF detection)	Resistive							0	
	Short wave infrared elements							1	
Microprocessor protocol (see page 4-14)	EUROTHERM								0
	MODBUS®								0
	JBUS®								1

Table 4-7 Configuration of CCC board jumpers (use with digital communications)

Note: The jumper **ST18** is set to **1**.
The jumper **ST24** is set to **0**.

Address definition

For each thyristor unit, the address must be configured with the position of the jumpers **ST11** to **ST16, ST22** and **ST23**. The address of the thyristor unit is that of channel **1**.

The four addresses of the thyristor unit channels are consecutive and are numbered from **4** to **255**.

The address of channel **1** of each thyristor unit must be **divisible** by **4** (4,8,12....252).

The address of channel **2** is **1 greater** than that of channel **1** ;
the address of channel **3** - **2** greater and the address of channel **4** - **3** greater.

The positions of the jumpers **ST11** to **ST16, ST22** and **ST23** are related to the address of the thyristor unit expressed in **binary code** on **8** bits.

Example: The address of the thyristor unit is **92**.
The address of channel **2** is therefore **93**, that of channel **3** is **94**, and that of channel **4** is **95**.

92 in binary code on 8 bits is

Bit No. 7 → **0 1 0 1 1 1 0 0** ← Bit No. 0

The corresponding configuration of the jumpers on the microprocessor board is given in figure 4-6.

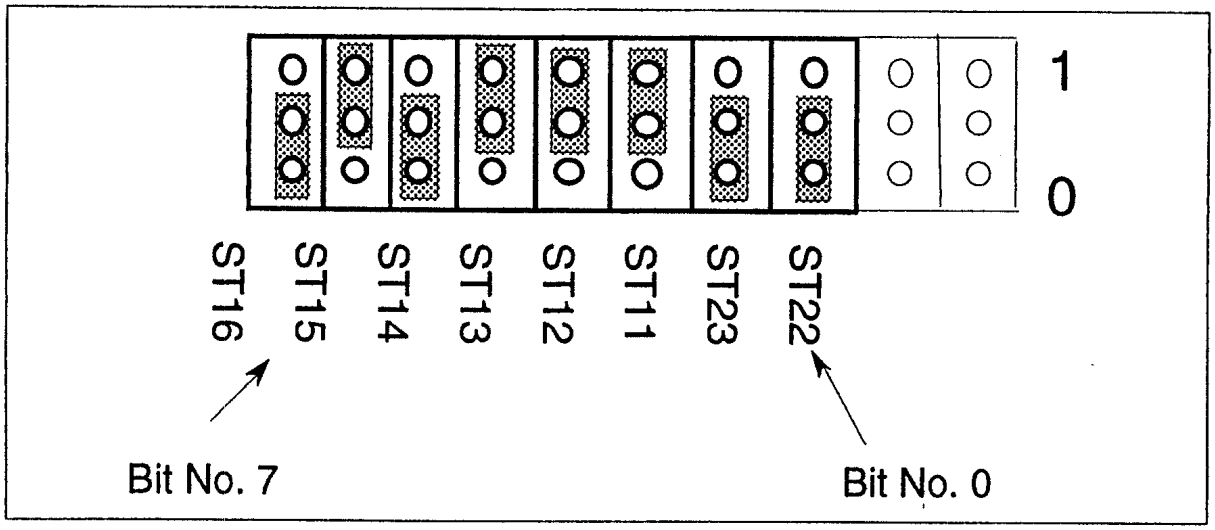


Figure 4-6 Example of address jumper configuration

The address **00** is the **distribution** address and cannot be displayed on the jumpers. It is used to send a common message to **all** the thyristor units connected to the same communication bus (see Digital communications user manual for the TU range, Part No. HA 173688).

Communication protocol

There are 2 microprocessor references:

- loaded with the **EUROTHERM** protocol
- loaded with the **MODBUS®** and **JBUS®** protocols.

The choice of the MODBUS® protocol or the JBUS® protocol is made using the jumper **ST21** (see table 4-7).

The protocol loaded in the microprocessor is determined on the order.

A label attached to the microprocessor (figure 4-7) is used to identify the type of protocol.

On this label:

EIP: EUROTHERM protocol
MOP/JBP: MODBUS® and JBUS® protocols.

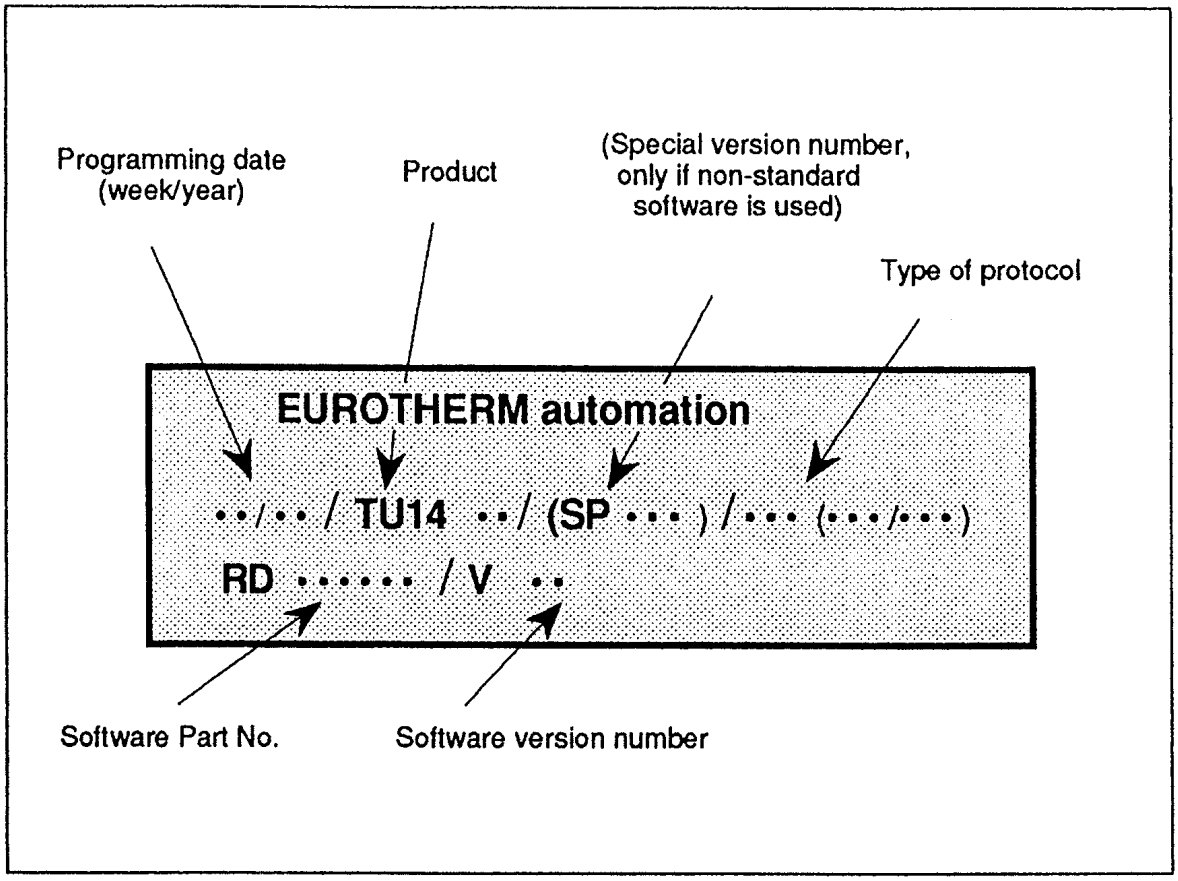


Figure 4-7 Microprocessor label

Chapter 5

OPERATION

Contents page

Chapter 5 OPERATION

THYRISTOR FIRING MODES

General

The **TU1451** and **TU1471** thyristor units have the following thyristor firing modes:

- Phase angle
- Single cycle (1 supply cycle).
- Burst firing (8 supply cycles)
- Burst firing with soft start.

They can be reconfigured by the user as described in the 'Configuration' chapter.

'Phase angle' mode

In '**Phase angle**'mode, the power transmitted to the load is controlled by firing the thyristors for a part of the power supply voltage half-cycle (see figure 5-1).
The **firing angle** (Θ) varies in the same direction as the input signal with the control system.
The power emitted is not a linear function of the firing angle.

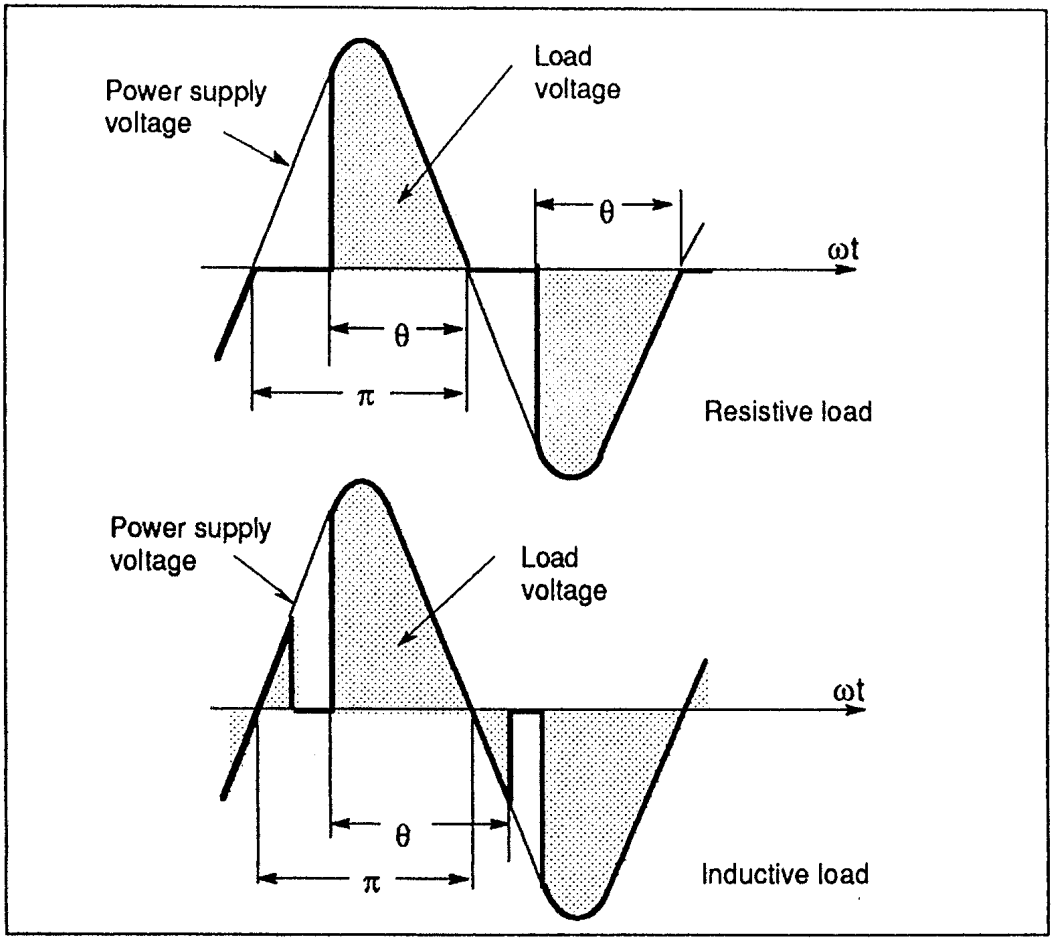


Figure 5-1 Load voltage in 'Phase angle' firing mode

'Burst firing' mode

The **'Burst firing'** mode is a **proportional cycle** which consists of supplying a series of **complete** power supply voltage **cycles** to the load.

Thyristor firing and non-firing are synchronised with the power supply and are performed **at zero voltage** for a resistive load.

This firing eliminates the steep fronts of the power supply voltage applied to the load, **does not produce interference** on the power supply and, in particular, prevents the generation of parasites.

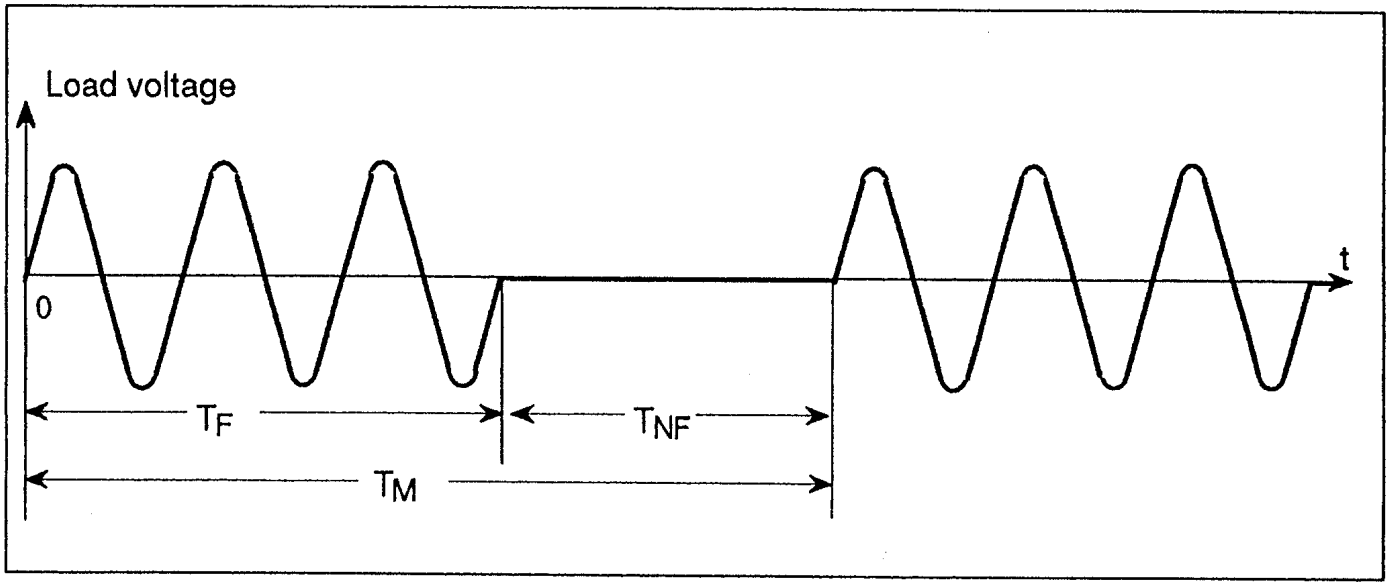


Figure 5-2 Load voltage in 'Burst firing' mode

In the **'Burst firing'** thyristor firing mode, the power supplied to the load depends on firing times T_F and non-firing times T_{NF}.

The load power is proportional to the firing rate (τ) and is defined by the ratio of the thyristor firing time and the modulation time

$$T_M = T_F + T_{NF}$$

The firing rate (or cyclic ratio) is expressed by the following ratio:

$$\tau = \frac{T_F}{T_F + T_{NF}}$$

The load power can be expressed by:

$$P = \tau \cdot P_{MAX}$$

where P_{MAX} represents the load power during thyristor firing.

Modulation time

The modulation time in 'Burst firing' mode is **variable** according to the output power.

- At **50 %** power, the typical value of the modulation time is **0.32 s** :
  - **8** firing times (**0.16 s** at **50 Hz**)
  - **8** non-firing times (**0.16 s** at **50 Hz**).

- For a zone below **50 %** of the maximum setpoint:
  - the **firing** time remains stationary (8 supply cycles)
  - the non-firing time increases and, as a consequence,
  - the modulation time also increases.

- For a power zone above **50 %** of the maximum setpoint:
  - the **non-firing** time remains stationary (8 supply cycles)
  - the firing time increases and, as a consequence,
  - the modulation time increases.

Due to this type of modulation, the TU1451 and TU1471 power thyristor units possess setting precision adapted to each specific setpoint zone.

Soft start

Soft starts can be configured in Burst firing modes.

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

The soft start duration is stationary and corresponds to **4 supply cycles.**

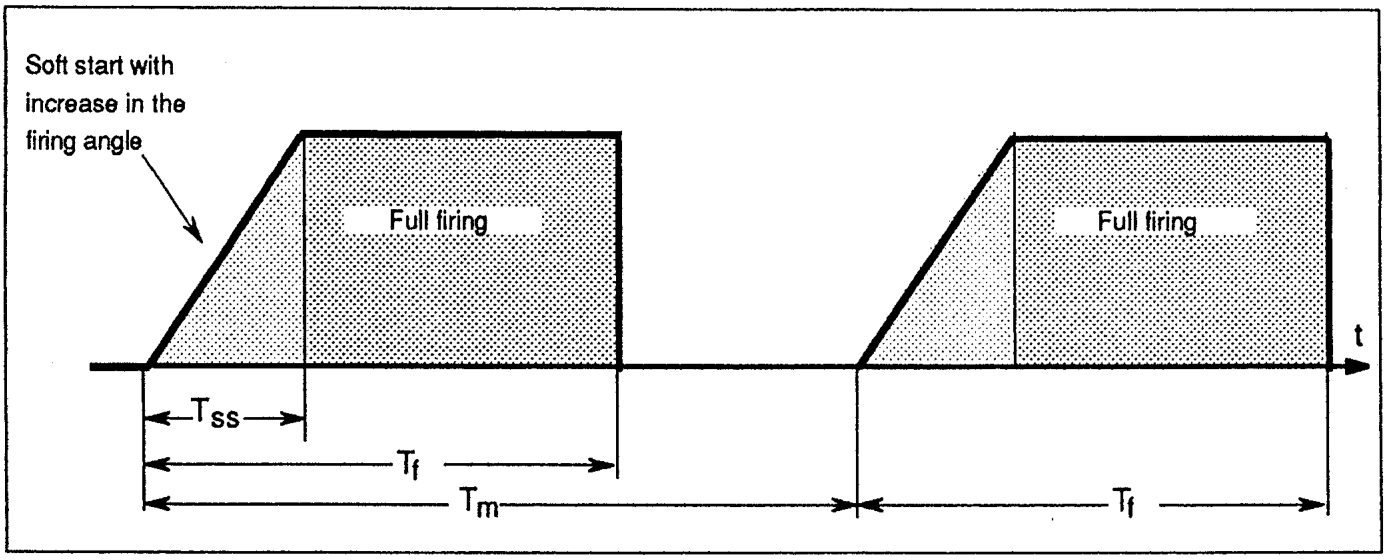


Figure 5-3 Soft start in burst firing mode

'Single cycle' mode

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

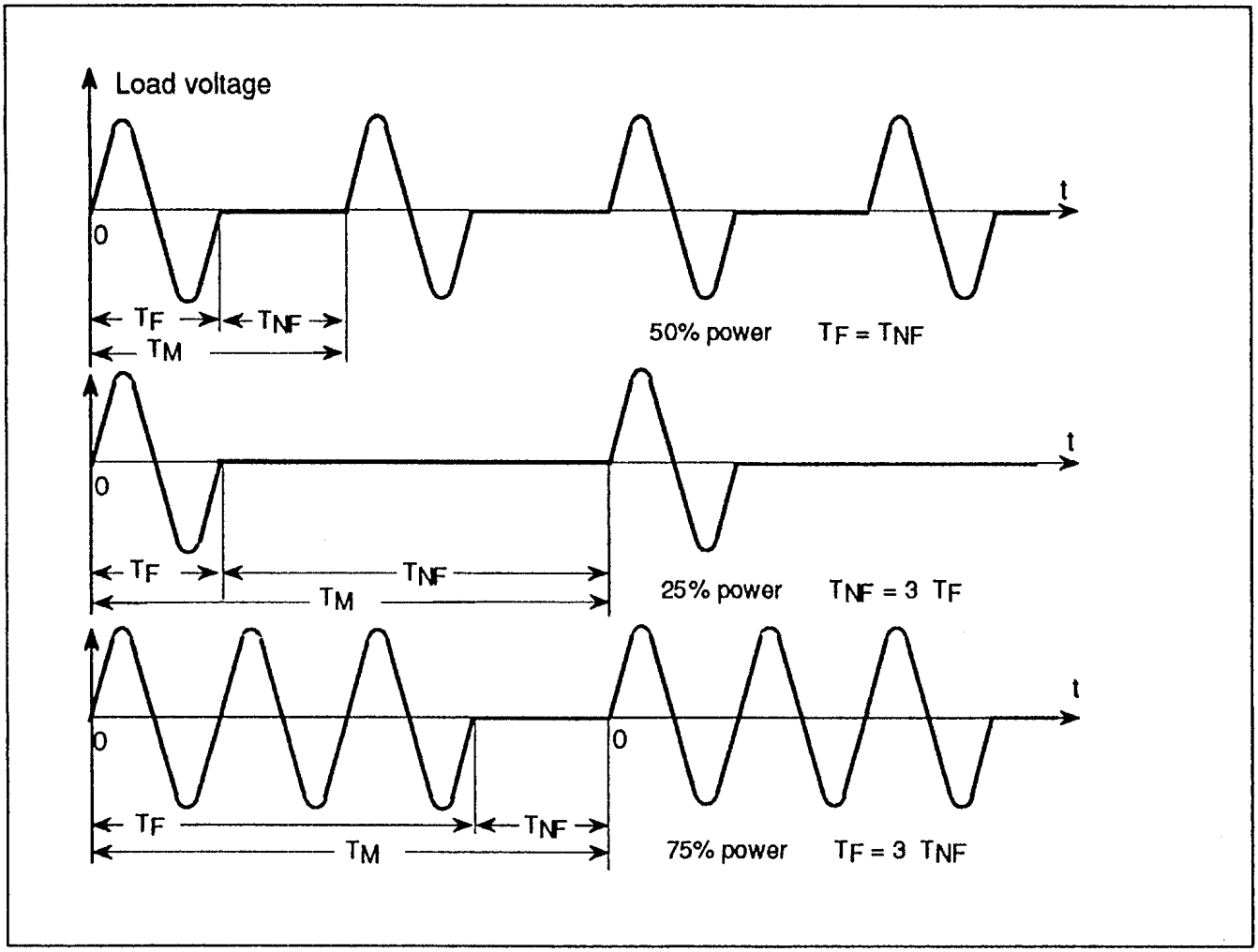


Figure 5-4 Firing in 'Single cycle' mode

- At **50 %** power, the value of the modulation time in 'Single cycle' mode is **40 ms**:
  - **1** firing time (**20 ms** at **50 Hz**)
  - **1** non-firing time (**20 ms** at **50 Hz**).

- For a zone below **50 %** of the maximum setpoint:
  - the **firing** time remains stationary (1 supply cycle)
  - the non-firing time increases and, as a consequence,
  - the modulation time also increases.

- For a power zone above **50 %** of the maximum setpoint:
  - the **non-firing** time remains stationary (1 supply cycle)
  - the firing time and the modulation time increase.

CURRENT LIMIT

The **TU1451** and **TU1471** thyristor units can use the load current measurement for the threshold current limit used to limit the RMS load current to a **specified value** independently from the input signal.

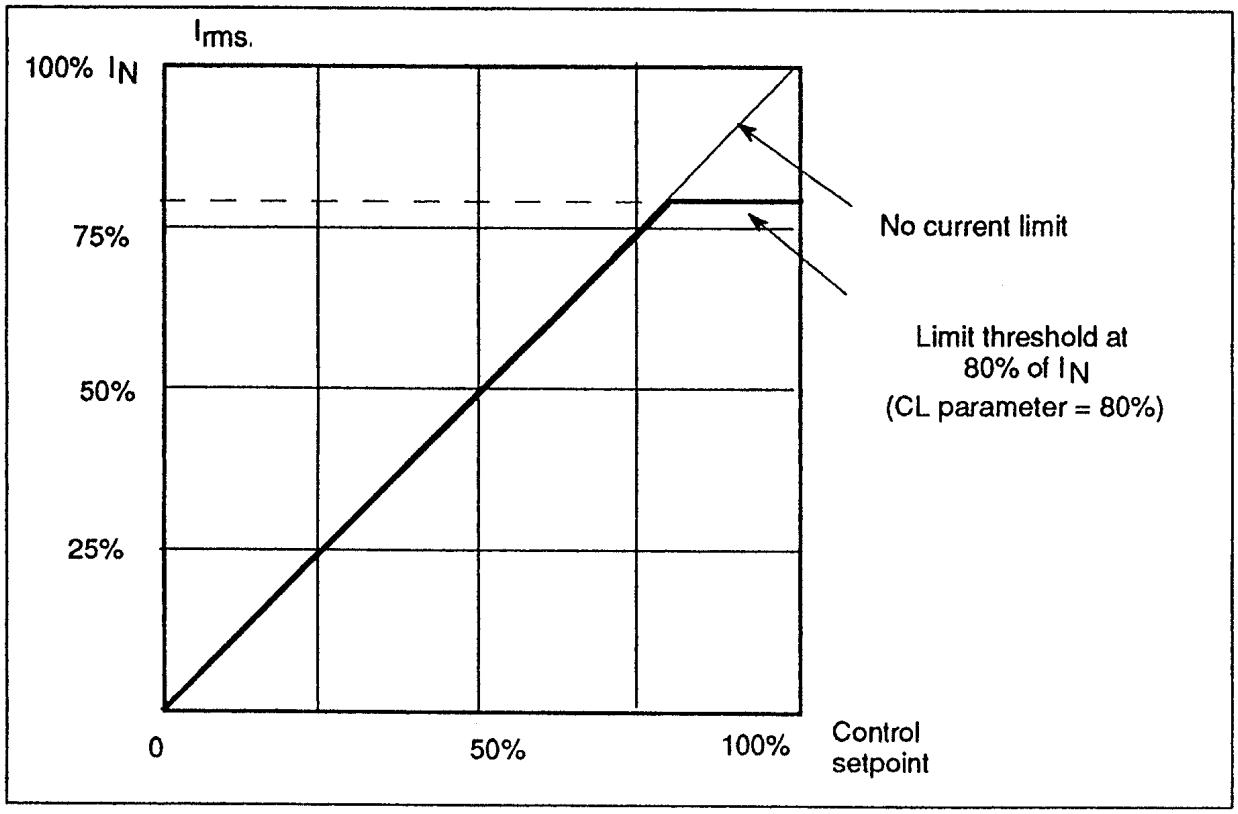


Figure 5-5 Example of current limit

For the current limit, the maximum load current threshold is set as a percentage of the nominal load current using the digital communications (**CL** parameter).

The nominal load current value after the current **calibration** of the thyristor unit channel corresponds to **100%** of the **CL** setpoint.

The current limit is **independent** for each thyristor unit channel and can be set separately for the controlled loads.

The action of the current limit is **different** for the different firing modes.

- In **Phase angle** mode, the exceeded current limit set with the **CL** setpoint causes the firing angle of the channel concerned to be decreased in order to **maintain** the RMS load current lower than the limit.
- In the **Burst firing, Burst firing with soft start** and **Single cycle** modes, if the load current exceeds the limit by 10%, the channel concerned is **inhibited.**

(See also Current limit exceeded in the 'Alarms' chapter.)

CONTROL

The **TU1451** and **TU1471** thyristor units contain an internal control loop.

The thyristor unit output power is linear between **0** and **100 %** of the maximum power and the input signal varies between **0** and **100 %** of the maximum scale (for the **digital** setpoint) and **2** and **98 %** of the maximum scale (for the **analogue** setpoint).

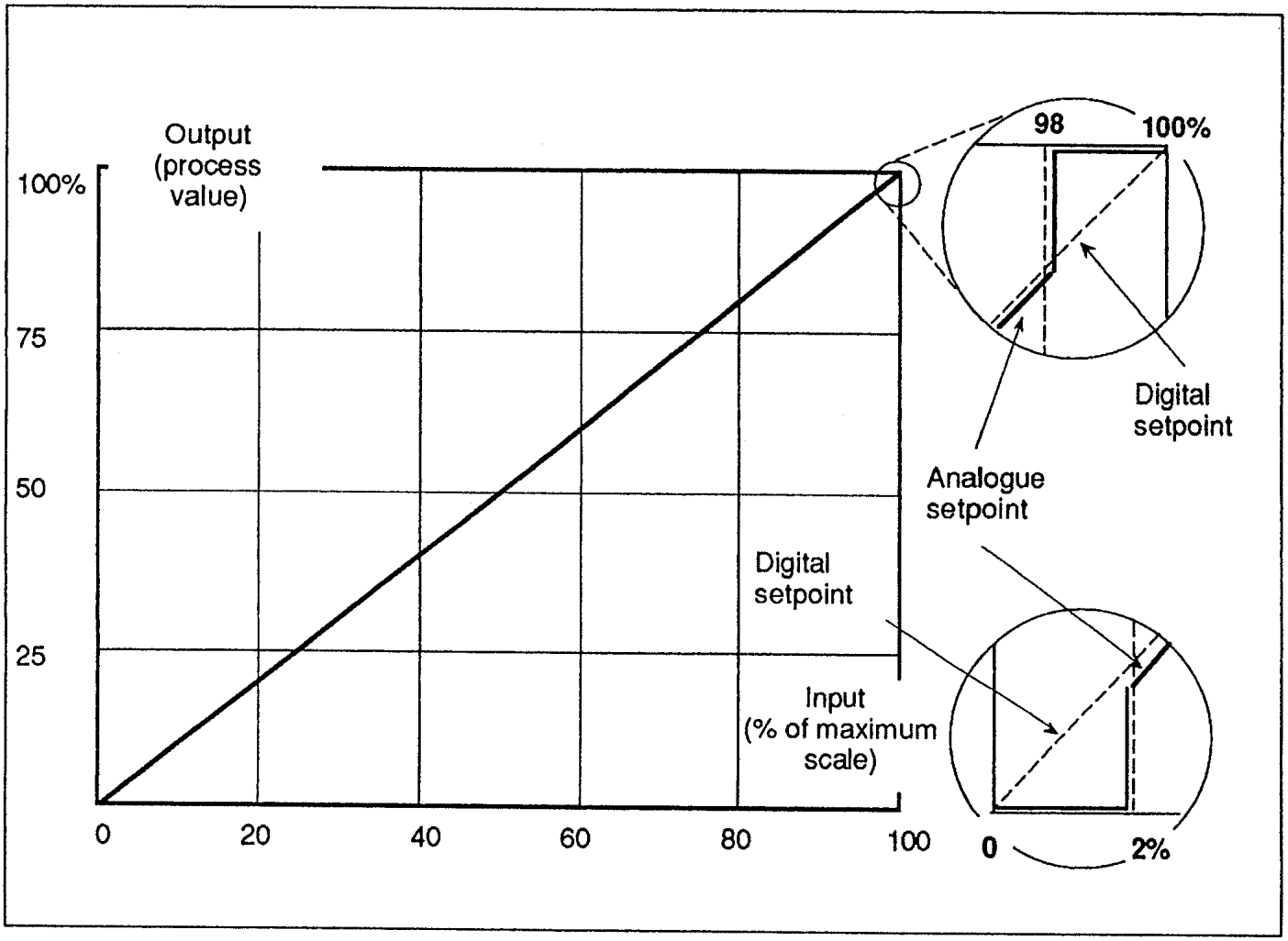


Figure 5-6 Controlled parameter as a function of the setpoint

The **squared RMS load voltage** represents the power dissipated in a purely resistive load, the value of which is constant when the temperature varies.

For loads with low resistance variation as a function of temperature (nickel, chromium, aluminium, Inconel, iron alloys, etc.), the control of V^2 is sufficient.

For loads with high temperature coefficients, power control (controlled parameter: V x I) is recommended.

The accuracy of the control is guaranteed to be within ± 2 % of the nominal value of the controlled parameter.

PULSE GATING

In the Burst firing and Single cycle modes, the **TU1451** and **TU1471** thyristor unit thyristors are fired by a gate **pulse train** of a maximum duration of **5 ms.**

It is possible to send gate pulses every **10 ms** so that the thyristors are polarised in direct mode (positive anode in relation to the cathode) or in inverse mode (negative anode).

Each thyristor is only fired when its voltage is positive, when it is negative, the anti-parallel thyristor is fired.

In certain applications, the gate pulses on the polarised thyristor in inverse mode can lead to operating problems: firing instability, fuse blow-out.

It is therefore necessary to **eliminate** the gate pulses when the thyristor is polarised in **inverse** mode.

This function is performed by the **pulse gating** circuit available for **TU1451** and **TU 1471** thyristor units.

This pulse gating is essential for configurations in which multiple thyristor units are distributed between the phases of a three-phase power supply and have an electrical configuration which could induce a **phase shift** between the voltage applied to the thyristor and the supply voltage.

For example:

- control of heating electrodes (in transformer secondary coil) immersed in the same molten glass bath
- load in star with neutral, with the central point of the star connected to the power supply neutral by a wire of non-negligible resistance with reference to that of the load.

LOAD FAILURE DETECTION

Total load failure

Thyristor unit operation with a current less than **1.5%** of the nominal load current, when the load voltage is greater than **30%** of the calibrated voltage, is considered as a total load failure.

Total load failure is detection independently on **each** channel.

If total load failure is detected on one of the channels, after an integration time of **5 s,** the channel is **inhibited** and an alarm is triggered (see the 'Alarms' chapter).

If the electronics is switched on before the power and the setpoint is present, the thyristor unit detects a Total load failure alarm.

Partial load failure

An **increase** in the load resistance can be caused by **partial load failure** composed of elements connected in parallel on one of the channels.

The partial load failure detection is used to perform preventive maintenance on the installation and retain the quality of products controlled by the **TU1451** and **TU1471** thyristor units.

The partial load failure detection circuit compares calculated load impedance values with the impedance value stored in memory during the detection setting.

The microprocessor calculation of the load impedance of each channels uses:

- the measured RMS load current values
- the calculated RMS load voltage value
  (using the power supply voltage and the thyristor firing demand).

An increase of over **20%** of the impedance value stored in memory is considered as a partial load failure.

This detection is adapted to the type of load (fixed resistive or short wave infrared elements).

For the Partial load failure alarm, see the 'Alarms' chapter.

ENABLE / INHIBIT

The **TU1451** and **TU1471** thyristor units have an active operation enable function.

This function enables thyristor unit operation by connecting two terminals on the user terminal block.

The enable is independent for each of the channels.

The thyristor unit operation is enabled (for each channel) by connecting the corresponding terminals to terminal block **10** ('Enable') on the microprocessor board (see 'Wiring' chapter).

Disconnecting the enable terminals inhibits the channel concerned (i.e. stops the operation of the channel and inhibits operation until another enable command is given).

An enable command must be given by connecting the 'Enable' terminals directly onto the enable terminal block with a permanent link or with an external contact.

A channel or all the channels can be inhibited

- by disconnecting the 'Enable' terminals
- or by sending an inhibit code via the digital communications to the address of the channel, the thyristor unit or all the thyristor units connected to the same communication bus.

A channel or thyristor unit may be inhibited due to a high level alarm (see 'Alarms' chapter).

Chapter 6

COMMISSIONING PROCEDURE

Contents Page

Chapter 6 COMMISSIONING PROCEDURE

Read this chapter carefully before commissioning the thyristor unit

COMMISSIONING PROCEDURE SAFETY

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.

Warning !

- **Never use** a thyristor unit on a power supply with a **voltage greater** than the nominal thyristor unit voltage specified in the coding.
- Dangerous live parts may be accessible when the front panel is removed.
- 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 thyristor unit is in operation.
  The heatsink remains hot approximately **15 min** after the unit has been switched off.

CHECKING THE CHARACTERISTICS

Caution !

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 must be less than or equal to the value of the nominal current of the thyristor unit taking the load and power supply variations into account.

Power supply voltage

The nominal value of the thyristor unit voltage must be greater than or equal to the voltage of the power supply used.

Caution !

Given the inhibit at 85 % of the nominal voltage, the nominal voltage of the thyristor unit must be as close as possible to the nominal voltage of the power supply used.

Auxiliary supply voltage

The auxiliary supply voltage must be **the same** as that of the power.
It is adapted by the position of the jumpers and the selection of the transformers.
This selection is made in the factory, according to the auxiliary voltage code.

Input signals

The jumper configuration on the power boards must be compatible with the levels chosen for the signal used for control (see 'Configuration' chapter).

Partial load failure detection

The voltage used for the PLF detection circuit is that of the auxiliary supply taken on channel 1 of the thyristor unit.

Digital communications

The communication protocol and the baud rate must correspond to those selected in the order and marked on the identification label.

DIAGNOSTIC UNIT

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

The **20-way switch** of the diagnostic unit is used to display the values of the thyristor unit and control parameters.

The unit displays two decimal places in order to permit the precise indication of the values measured.

Table 6-1 gives the assignment of each position of the diagnostic unit and the typical values of the signals measured.

The diagnostic unit possesses a flat cable which is plugged into the 20-pin socket (diagnostic socket) located on the power supply board of the thyristor unit.

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

Important !

The values measured are **mean dc values**.

THYRISTOR UNIT CALIBRATION

Before the thyristor unit is commissioned, it must be **calibrated.**

The thyristor unit calibration is intended to standardise the real physical installation values (nominal load current and nominal voltage of the power supply used) in relation to the nominal current and voltage of the thyristor unit in order to adjust the images of the physical values in the microprocessor to **100 %.**

The four potentiometers accessible on the front panel and labelled 'I_1' to 'I_4' are used for the current calibration of **each channel.**

The front panel potentiometer labelled **'U'** is intended for the voltage calibration of the **thyristor unit.**

Caution !

- After checking the wiring, make sure that the **'Enable'** inputs of each channel on the thyristor unit microprocessor board (terminal block 10) are connected correctly, directly or via a closed contact (see page 3-13 and figures 3-10 to 3-14).

- The electronics must be **switched on** after or **at the same time** as the power.

If the electronics is switched on before the power and the setpoint is present, the thyristor unit detects a Total load failure (TLF) alarm.

The calibration can be performed using:

- the **EUROTHERM type 260** diagnostic unit
- the **RS422 or RS485** digital link.

The calibration must be performed during **non-firing.**

Calibration with the EUROTHERM diagnostic unit

The diagnostic unit socket is located on the power supply board (see figure 3-1).

Current calibration

- Calculate the signal calibration voltage (V_{CA}) for each channel

$$V_{CA} = 5V \times \frac{I_{\text{nominal load}}}{I_{\text{nominal thyristor unit}}}$$

Caution !

The nominal load current is the current through a channel controlled using the thyristors

- Switch on the thyristor unit and connect the auxiliary supply.
- By turning the potentiometer labelled 'I_1' on the front panel, display the value V_{CA} on the **display** of the EUROTHERM type 260 diagnostic unit in position **16** (see table 6-1).

The value V_{CA} becomes the nominal value for all the current and feedback (**V x I**) calculations and for the alarm current limit of channel **1**.

Calibrate the channels **2, 3** and **4** in the same way using the potentiometers labelled 'I_2', 'I_3' and 'I_4' in positions **17, 19** and **20** of the diagnostic unit.

Example:

For a **40 A** nominal current thyristor unit and a **30 A** nominal current of the load used, the calibrated voltage must be set as follows:

$$V_{CA} = 5\ V \times \frac{30\ A}{40\ A} = 3.75\ V$$

Voltage calibration

- Turn the potentiometer labelled 'U' on the front panel until the diagnostic unit display gives **4 V** in position **15**. The calibration is nominal.

The thyristor unit is **inhibited** if the display in position **15** of the diagnostic unit falls **below 3.4 V** (nominal voltage less 15%).

Calibration using digital communications

The thyristor unit can be calibrated in terms of current and voltage using digital communications if the following information is available:

- the nominal thyristor unit current - (I_{UN})
- the nominal current of each load - (I_{LN})
- the line voltage.

The EUROTHERM 261 interface must be connected as shown in figure 3-12.

Current calibration

- Calculate the parameter **CA** (for the load of each channel)

$$CA(\%) = \frac{I_{LN}}{I_{UN}} \quad \text{x } 100\ \%.$$

- Switch on the thyristor unit and connect the electronics supply
- Adjust the potentiometers labelled from 'I_1' to 'I_4' on the front panel to obtain **the CA parameter** at the value calculated for each load.

After the calibration, the **CV** parameter expresses the value of the load current in % of the **nominal** load current.

Voltage calibration

- Read the line voltage (**LV parameter**) using the digital communications.

- Adjust the potentiometer labelled '**U**' on the front panel so that the value of the **LV** parameter is equal to **100%.** The calibration is nominal.

Caution !

The thyristor unit is **inhibited** if the **LV** parameter is less than or equal to **85 %** (nominal voltage after calibration less **15 %**).

POWER-UP

Important !
The control must be switched on after or **at the same time** as the power.

There are three possible types of control:

- the **digital** setpoint (**SL** parameter)
- the **analogue** setpoint (**RI** parameter) **with** digital communications
- the **analogue** setpoint (**RI** parameter) **without** digital communications.

Control with the digital setpoint

Control is performed via the RS422 or RS485 digital link.
Before switching on the unit, refer to the Digital communications manual (Part No. HA 173688) to use and check the operation of the transmission.

Thyristor unit

- Check that the jumpers **ST9** and **ST18** are set to **1.**
- Check that the position of the jumpers **ST10** to **ST16** and **ST22, ST23** corresponds to the communication **parameters** and to **the address** of the thyristor unit (see table 4-7).
- Connect the input '**A/N**' (terminal 74) on the microprocessor board to '**10V**' (terminal 73).
- **Switch on** the thyristor unit.
- Check that the load current is equal to **0.**
- Read the **LV** (line voltage) signal, and, if necessary, adjust the voltage calibration using the '**U**' potentiometer.
- Send the codes corresponding to the thyristor firing mode and the control mode.

Each channel

- Read the **CA** (current calibration) signals, and, if necessary, set the current calibration signals.
- Send the signal **SL = 0%**(digital setpoint) to the address of the channel.
- Send the selected current limit (**CL**) signal.
- Increase the **SL** signal and check that the current passes in the load and that the **CV** (load current) parameter varies as a function of the **SL** value.
- Measure the current and make sure that the RMS current **does not exceed** the nominal current when **SL** is at its maximum value.

The thyristor unit is ready for use.

Recommendation:

Connect the analogue input terminals (terminals **76** to **79** of the microprocessor board) to '0V' (terminal **71** or **72**) when the analogue setpoint terminals are not used.

Control with the analogue setpoint

Control is performed with the analogue signals applied to the inputs **RI 1 to RI 4** for the corresponding channels (terminals **76** to **79**).

The analogue setpoint configured using the jumpers **ST1** to **ST8** and **ST19** must be compatible with the levels of the analogue signals used (see table 4-6 or table 4-7).

- Check that the jumper **ST18** is set to **1**.
- Connect the '**A/N**' input on the microprocessor board to '**0V**' or leave it 'free'.

The analogue setpoint control can be used **with** or **without** digital communications.

Use with digital communications

- Set the jumper **ST9** to **1**
- Send **the codes**, corresponding to the thyristor firing mode and the control mode in the status word **SW** to the thyristor unit address (refer to the 'TU range. Digital communications' manual Part No. HA 173688).

Use without digital communications

- Set the jumper **ST9** to **0**
- Configure the operating mode using the corresponding jumpers (see table 4-6).

Power-up

- Set the analogue control signal to **0** on the input of each channel (terminals **76** to **79**)
- Switch on the thyristor unit and check that the current does not pass
- Successively apply a control signal to the input of each channel and check that the load current is increased when the input signal is increased
- Check that the RMS load current (**line** current) does not exceed the nominal thyristor unit current when the signal is at the maximum.

After switching on the thyristor unit, optimise the control as a function of the real load current of each channel (using the potentiometers '$\mathbf{I_1}$' to '$\mathbf{I_4}$').

The line voltage used may be slightly different to the calibration voltage. It is possible to recalibrate the thyristor unit in terms of voltage using the potentiometer '**U**' to obtain an improved control response.

The thyristor unit is ready for use.

Start-up

Firing mode

The firing mode at start-up depends on the use of digital communications.

- If the digital communications are not enabled (**ST9 = 0**), after each power-up, the thyristor unit is started up with the firing mode **selected** using the jumpers on the microprocessor board.

- If the digital communications are enabled (**ST9 = 1**), at start-up, the thyristor unit is always in Phase angle firing mode.

The thyristor firing mode is **common** for the 4 thyristor unit channels. Since it is configured by the **jumpers** of the CCC board, it can be modified using the control **codes** sent by the digital communications to the thyristor unit address.

To modify the thyristor firing selected using the jumpers **ST10 to ST12,** the corresponding control **code** must be sent via the digital communications on the status word **SW** (EUROTHERM protocol) or on **CW** (MODBUS® and JBUS® protocols) to the thyristor unit address:

08 for **Phase angle** operation
0B Hex for **Burst firing** (8 supply cycles).
09 for **Burst firing with soft start**
0A Hex for **Single cycle** (1 supply cycle)

Control mode

Two control modes (squared RMS voltage: V^2 or power: V x I) are available.
The control mode is **common** for the 4 thyristor unit channels.

After each power-up, the thyristor unit is started up with the control mode selected using the jumper **ST17** on the microprocessor board.

Sending the **code 06** (power control) or the **code 07** (voltage control) via the digital communications to the address of the thyristor unit **modifies** the control mode selected using the jumper **ST17.**

Important !

When the current is composed of whole cycles, the measurement on the ammeter is not stable (oscillation following the burst), except at full power.

Partial load failure detection setting

The partial load failure detection threshold is set automatically.
All the channels of the same thyristor unit can be set at the same time.

The nominal operating values must be adjusted (see 'Calibration'), in order to obtain optimum sensitivity for the partial load failure detection.

Select a type of setting from the following 3 possibilities:

- Press the '**PLF**' push button on the front panel
- Apply the **0 V** signal to the '**PLF Setting**' input on the analogue control terminal block on the microprocessor board (terminal **75**)
- Send the code **05** in the status word **SW** via the digital link, to the thyristor unit address or to the distribution address **00** (all the thyristor units on the same communication bus are set).

The partial load failure detection setting takes into account the mean values of the RMS current (CV) and the RMS operating voltage (VV).

Caution !

This setting is only possible if the following conditions are met:

- Current calibration greater than 25% of the nominal unit current (CA > 25%)
- Load current greater than 30% of the nominal load current (CV > 30%)
- Load voltage greater than 30% of the nominal load voltage (VV > 30%).

Setting check using digital communications

If bit No. **14** of **SW** is displayed as **1**, the setting sequence is been performed correctly. Otherwise, the value of bit No. **14** of **SW** is equal to **0.**

The setting value (the impedance calculated by microprocessor) is stored in permanent memory (EEPROM). If the EEPROM is non-initialised, no parameter values have been stored.

In the event of non-initialisation or damage to the EEPROM, irrespective of the cause:

- the microprocessor initialises the current limit parameter at 100%
- the partial load failure is not set and the corresponding status word remains unchanged.

CHECKS IN THE EVENT OF ABNORMAL OPERATION

Symptom	Action
1. The thyristor unit does not communicate	1.1. Check that the electronics supply is present (Green Vdc indicator light on the front panel) 1.2. Check that the position of ST9 = 1 (CCC board) 1.3. Check the thyristor unit addressing (ST11 to ST16, ST22 and ST23) and that no other thyristor unit of the same bus is located at the same address 1.4. Check the baud rate (position of ST10) 1.5. Check the protocol used (ST21) and that marked on the microprocessor label 1.6. Check the digital link wiring and that the 'Rx' and 'Tx', '+' and '-' terminals are not inverted (terminal block 60 on the CCC board) 1.7. Check that the thyristor unit has been 'reset' (electronics switched off and on again) after modifying the configuration.
2. The thyristor unit is not fired after a firing demand via the digital signal (the digital communications are operating correctly)	2.1. Check the power supply phase wiring and that the voltage is present 2.2. Check the load connection 2.3. Check that the electronics supply is present (green Vdc indicator light on the front panel is on) and in phase with with the line voltage (the 'L' terminal on the power supply board is connected to the Phase) 2.4. Check the control mode selection wiring: the 'A/N' input (terminal 74 on the CCC board) must be connected to +10 V (terminal 73) 2.5. Check that the enable terminals (on each channel) are connected correctly 2.6. Check that the thyristor unit channel(s) are not in TLF alarm state (red LED on the front panel on; indication with digital communications or relay in alarm state: position 14 of the diagnostic unit at 0 V).

Symptom	Action
	2.7. Check that the thyristor unit channel(s) is/are not inhibited due to the current limit action (Burst mode or Single cycle firing) 2.8. Check the state of the alarms and that they are acknowledged 2.9. Using the diagnostic unit, check the current calibration 2.10. Using the digital communications, read the current limit level 2.11. Check the connection of the thermal switches 2.12. Check that the digital setpoint has been received (SL ≠ 0).
3. In digital communications, the thyristor unit is not fired after a firing demand using the analogue setpoint	3.1. Check that the jumper ST9 on the CCC board is at 1 3.2. Check the 'A/N' input control mode selection wiring (terminal 74 on the CCC board must not be connected to terminal 73) 3.3. Check the analogue signal wiring on the CCC board between the 0V (terminals 71 or 72) and the channel inputs (terminals 76 to 79) 3.4. Check that the input signal configuration corresponds to the signals used (jumpers ST1 to ST8 and ST19 on the CCC board) 3.5. Check the SW1 mini-switch configuration on the firing boards. The following actions correspond to the actions 2.1 to 2.3 and 2.5 to 2.11
4. The thyristor unit, which does not use the digital communications, is not fired after a firing demand using the logic signals (basic version)	4.1. Check that the jumper ST9 on the CCC board is at 0 4.2. Check the logic input wiring and that the logic signal is present on the terminal blocks 10 of the CCC board. 4.3. Check the configuration of the SW1 mini-switches on the firing boards. The following actions correspond to the actions 2.1 to 2.3 and 2.5

Symptom	Action
5. The thyristor unit is at full power, but the input signal is zero	5.1.The thyristors are short-circuited 5.2.The firing circuit is faulty if the red LEDs on the power boards are not lit 5.3.The control electronics is faulty or the microprocessor is not operational if the red LEDs on the power board are lit.
6. Absence or low value of output power after 100% demand	6.1.Check the value of the CL parameter 6.2.On the serial number label, check the value of the nominal thyristor unit current 6.3.Check the current calibration 6.4.Check the 'Current limit exceeded' alarm state; if the limit has been exceeded, the thyristor unit is inhibited in the Burst and Single cycle firing modes.
7. 100% output power after low demand	7.1.On the serial number label, check the value of the nominal thyristor unit current 7.2.Check the current calibration 7.3.Check the firing mode and the control mode 7.4.Check that the current transformers are connected correctly

Symptom	Action
8. The control reading is unreliable	8.1. Check the communication protocol configuration (ST21) 8.2. Check that the microprocessor label corresponds to the protocol specified in the order 8.3. Check the position of the jumper ST24 on the CCC board.
9. The green CCC board supply presence LED does not light up after power-up	9.1. Check the connection and presence of the auxiliary supply voltage (terminals 'L' and 'N' on the power supply board) 9.2. Check that the power supply voltage corresponds to the voltage marked on the serial number label. 9.3. Check the configuration of the jumper ST1 on the power supply board 9.4. Check the +15 V ,-15 V and +5V voltages using the diagnostic unit (positions 9, 10 and 13).

Symptom	Action
10. The PLF cannot be set (bit No. 6 of the SW of each channel is equal to 0)	10.1.Try the different setting methods (using digital communications, using an external signal applied to terminal 75 of the CCC board, or using the push button on the front panel of the thyristor unit) 10.2.Check that the setting conditions are met: - CA > 25% - CV > 30% - VV > 30%
11. The thyristor unit is calibrated in terms of voltage, but for the nominal voltage the LV parameter ≠ 100% and the diagnostic unit does not give 4 V in position 15	11.1.On the serial number label, check that the thyristor unit voltage complies with the applied voltage 11.2.Check the presence and value of the electronics supply voltage 11.3.Check the position of the jumper ST1 on the power supply board 11.4.On the CCC board, check that the jumper ST18 = 1

If a problem persists, contact your nearest EUROTHERM office (see last cover page)

Chapter 7

ALARMS

Contents Page

Chapter 7 ALARMS

GENERAL

The alarms used by the **TU1451** and **TU1471** thyristor units protect the thyristors and the thyristor unit against **abnormal operation** and give the user **information** on the type of failures that have occurred.

Warning !

- **Alarms cannot be used to replace personnel or installation protection to be provided by the user.**
- It is the user's responsibility and it is highly recommended, given the value of the equipment controlled by the TU1451 and TU1471, to install **independent safety devices which should be checked regularly.**
  For this purpose, Eurotherm can supply several types of alarm detectors.

The alarms are entirely **managed by the microprocessor** which retransmits its data (alarms enabled or not) using the digital communications and the alarm relay.

The partial or total load **failure** of a load on the channels is displayed on the front panel using one of the four red indicator lights on the corresponding channel.

There are two types of alarm:

- **general** - common to the 4 channels - (line voltage sensors)
- **local** - specific to each channel -(load, heatsink temperature and channel current sensors).

The following failures are detected:

- Over- and under-voltage
- Abnormal overheating (for the TU1471 thyristor unit)
- Over-load and over-current
- Thyristor short-circuit
- Current limit exceeded
- Total or partial load failure.

The under-voltage, current limit exceeded, total load failure, overheating (TU1471) and thyristor short-circuit alarms in the Burst or Single cycle firing modes cause the channels concerned or the thyristor unit **to be stopped immediately.**

The alarms are **given levels.** The **higher** level alarms are alarms which **inhibit** the thyristor unit. The active state of certain levels inhibits the processing of lower level alarms. However, all the alarms are retransmitted by the digital link.

All the alarms, except the over-load and the over-current, change the state of the **alarm relay.**

GENERAL ALARMS

General alarms detect significant line voltage variations.
The line voltage is taken on the supply of channel **1**.
It is monitored on a permanent basis.

The data on the state of the general alarms is available using the digital communications in the **least significant** bit of the status word of each channel.

This SW bit is labelled SW_L - (**L** - Low).

The numbers of the bits of SW_L correspond to those of the **status word SW.**

Under-voltage

If the line voltage drops by over **15%** in relation to the nominal value, the thyristor unit switches to the Under-voltage alarm state and:

- **inhibits** the 4 channels
- **activates** the alarm relay
- **sets** bit No. **4** of SW_L to **1.**

The thyristor unit is started up again automatically, if the voltage returns to over **90%** of the nominal voltage (re-enabled and bit No. **4** of SW_L set to **0**).

Over-voltage

If the line voltage is greater than the nominal thyristor unit voltage by more than **10%**:

- the Over-voltage alarm is detected
- the alarm relay **is activated**
- bit No. 5 of SW_L is set to **1.**

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

If the unit returns to a voltage less than **105%** of the nominal thyristor unit voltage, the relay returns to the non-alarm state and sets bit No. **5** of SW_L to **0.**

LOCAL ALARMS

The following failures are detected on each of the channels:

- Thyristor short-circuit
- Abnormal heatsink overheating (for the TU1471 thyristor units)
- Over-load
- Over-current
- Total load failure
- Partial load failure
- Current limit exceeded.

The local alarm data is available using the digital communications in the **most significant** bit of the status word of each channel.
This **SW** bit is labelled SW_H (**H** - **H**igh). The bit numbers of SW_H are **8** less than those of **SW**.

Thyristor short-circuit

The short-circuit detection is active if the measured current is greater than **70%** of the calibrated load current, when the thyristor firing demand is zero.
Thyristor short-circuit alarm detection is not performed if the current calibration is less than **10%** of the nominal thyristor unit current.

In the event of a thyristor short-circuit detection, the channel concerned is **inhibited** and the alarm relay is **activated.** Depending on the short-circuited thyristor channel, bit No. **2** of SW_H is set to **1.**

To deactivate this alarm and restart the thyristor unit, the alarm must be acknowledged or the thyristor unit must be started up again.

The detection of other alarms is disabled since the channel is inhibited.

Over-temperature detection

The temperature of thyristor units is monitored using **four thermal switches**, one per channel, for **TU1471** and using **one common thermal switch** for **TU1451**.
In the event of abnormal overheating of the heatsink, the thermal switch is opened to **inhibit** the thyristor unit operation.

The microprocessor then detects a total load failure which:

- activates the alarm **relay**
- sets bits **4** and **5** of SW_H (bits **12** and **13** of **SW**) to **1**
- lights up the four red **LEDs** indicating the load alarms.

To start up the thyristor unit again, the alarm must be acknowledged (code **04** in the status word **SW** must be sent to the thyristor unit address).

Over-load

The over-load is detected on each of the thyristor unit channels with a comparison between the ratio

$$R_{LN} = \frac{\text{V nominal load}}{\text{I nominal load}}$$

and the ratio

$$R_L = \frac{\text{V load}}{\text{I load}}$$

This comparison is made automatically by the microprocessor of the CCC board after each partial load failure detection setting demand.

The over-voltage alarm is active when $R_L < R_{LN}$

The Over-load alarm is caused by either a low resistance load or an incorrect voltage or current calibration setting.

The detection takes **the load type** into account (e.g. linear or non-linear resistive, such as short wave infrared elements).

In the event of over-load detection (decrease in the resistance of one of the channels), bit No. **9** of **SW** (bit No. **1** of SW_H) of the channel concerned is set to **1**.

The alarm relay does not change the state.

The alarm is acknowledged after a new partial load failure detection setting demand if the error has disappeared, or by sending the code **04** in the **SW** via the digital communications to the address of the channel concerned.

If the over-load alarm has disappeared, bit No. **1** of SW_H is set to **0**.

Over-current

If the RMS current (I_L) exceeds the nominal load current (I_{LN}) : $I_L > I_{LN}$
the Over-current alarm is detected.

Bit No. **4** of SW_H (bit No. 12 of **SW**) is set to **1**.
The **PLF** setting is no longer enabled.

The active state of the Over-current alarm disappears when the current returns to a value less than the nominal load current value or when the alarm is acknowledged.

Total load failure (TLF)

Thyristor unit operation with the current less than **1.5%** of the nominal load current, when the load voltage is greater than **30%** of the calibrated voltage, is considered as total load failure.

If the RMS load current

$$I_L < 1.5\% \; I_{CA}$$ (current adjust equal to nominal load current)

when the RMS load voltage

$$V_L > 30\% \; V_{CA}$$

a total load failure alarm is detected.

TLF detection is performed on each channel.

If total load failure is detected on one of the channels, after an integration time of **5 s**, the channel is **inhibited** and the alarm relay is **activated**.
The **red indicator light** on the front panel of the thyristor unit corresponding to channel concerned is lit.

The **TLF** data sets bit No. **5** of SW_H (bit No. **13** of the status word **SW** at the address of the channel concerned) to **1**.

The inhibited channel is started up again after the alarm is acknowledged (code **04** in the status word **SW** sent via the digital communications).

The **TLF** detection is only active for a channel calibration greater than **10%** of the nominal thyristor unit current.

The **TLF** alarm is caused by any of the following cases:

- total load failure
- fuse failure (thyristor or power supply protection)
- connection failure
- thyristors in open circuit
- faulty thyristor firing system
- absence of power supply voltage on one of the channels
- abnormal overheating of the heatsink (thermal switch protection).

Partial load failure (PLF)

The PLF alarm detects an increase in the load resistance on one of the channels due to a partial load failure composed of elements connected in parallel.

The partial load failure detection circuit uses the comparison of the calculated values of the load impedances with the impedance value stored in memory during the detection threshold setting.

The measured values of the RMS supply voltage and the RMS load currents enable the microprocessor to calculate the load impedances.

This calculation is made **during** the partial load failure **setting** sequence on the values of the parameters **CV** (current value as a percentage of the current adjust) and **VV** (voltage value as a percentage of the calibrated voltage).

The PLF detection is adapted to the load type (fixed resistive or short wave infrared elements).

The detection cannot take place if the partial load failure detection setting has not been made or if it has failed. In this case, bit No. **6** of SW_H (bit No. **14** of **SW**) is set to **0**.

The PLF alarm detects the failure of **one out of five** identical heating elements mounted in parallel in the channel **controlled by the thyristors**.

In the event of partial load failure detection:

- bit No. **7** of SW_H (bit No. **15** of **SW** of the load concerned) is set to **1**
- the **LED** on the front panel of the channel concerned is lit
- the alarm relay is **deactivated.**

The alarm is acknowledged if:

- the failure disappears
- an alarm acknowledgement is sent via the digital communications (code **04** in **SW**)
- another PLF **setting** is made.

Current limit exceeded

The Current limit exceeded setpoint sets the maximum level of the RMS current allowed in each load.

The nominal load current value (I_{LN}) corresponds after the calibration to **100%** of the current limit setpoint (**CL**). The load current limit (I_{LIM}) is set at the level:

$$I_{LIM}(A) = \frac{I_{LN}(A) \times CL(\%)}{100}$$

Example:

Nominal thyristor unit current	$I_{UN} = 250$ A
Nominal load current of channel	$I_{LN} = 200$ A
Current limit setpoint	CL = 80%

The current limit:

$$I_{LIM} = \frac{200\ A \times 80\%}{100} = 160\ A$$

The action of the Current limit exceeded alarm and the action threshold differ according to the thyristor firing mode.

- **Phase angle** firing mode:
  if the RMS load current exceeds the **limit threshold**, the limit circuit modifies the thyristor firing angle in order to **keep** the RMS current of the channel concerned lower than the current limit threshold.
  The thyristor unit **continues to operate**

- **Burst firing, Soft start** and **Single cycle** modes:
  if the RMS current exceeds the current limit threshold by **10%**, the channel concerned is **inhibited.**
  Another start-up is only possible after the alarm has been acknowledged (code **04** sent in the **SW**).

Note: In the Burst firing (with or without Soft start) and Single cycle modes, the RMS load current value is calculated by microprocessor over the burst modulation time; it is compared to the current limit setpoint **CL** at each modulation time.

The state of the Current limit exceeded alarm is indicated by bit No. **3** of SW_H (bit No. **11** of SW). Bit No. **3** of SW_H is set to **1** when the alarm is active.

ALARM RELAY

The alarm relay changes state when one of the alarms (except Over-current and Over-load) is active. Its contact can be used to indicate the state of certain alarms. The type of contact (normally open: **N/O**, or normally closed: **N/C**) is configured in the factory according to the order code.

The alarm relay is **de-energised** in the alarm state or when the thyristor unit is switched off.
The contact cut-off capacity is **1 A (230 Vac** or **30 Vdc).**
The contact cut-off voltage must never be greater than **250 Vac.**

The alarm relay is located on the power supply board.
The relay contact is connected on terminals **51** and **52.**

ALARM ACKNOWLEDGEMENT

The following alarms must be acknowledged if they are active:

- Total or partial load failure
- Thyristor short-circuit
- Over-load
- Over-current
- Current limit exceeded (Burst firing mode).

To acknowledge these alarms, the auxiliary power supply can be switched **off** or the code **04** sent in **SW.**

When the digital communications are not used (**ST9 = 0**), applying a positive signal between the '**RX-**' and '**RX+**' inputs (terminals **61** and **62** of the CCC board) implies that the alarms have been acknowledged.

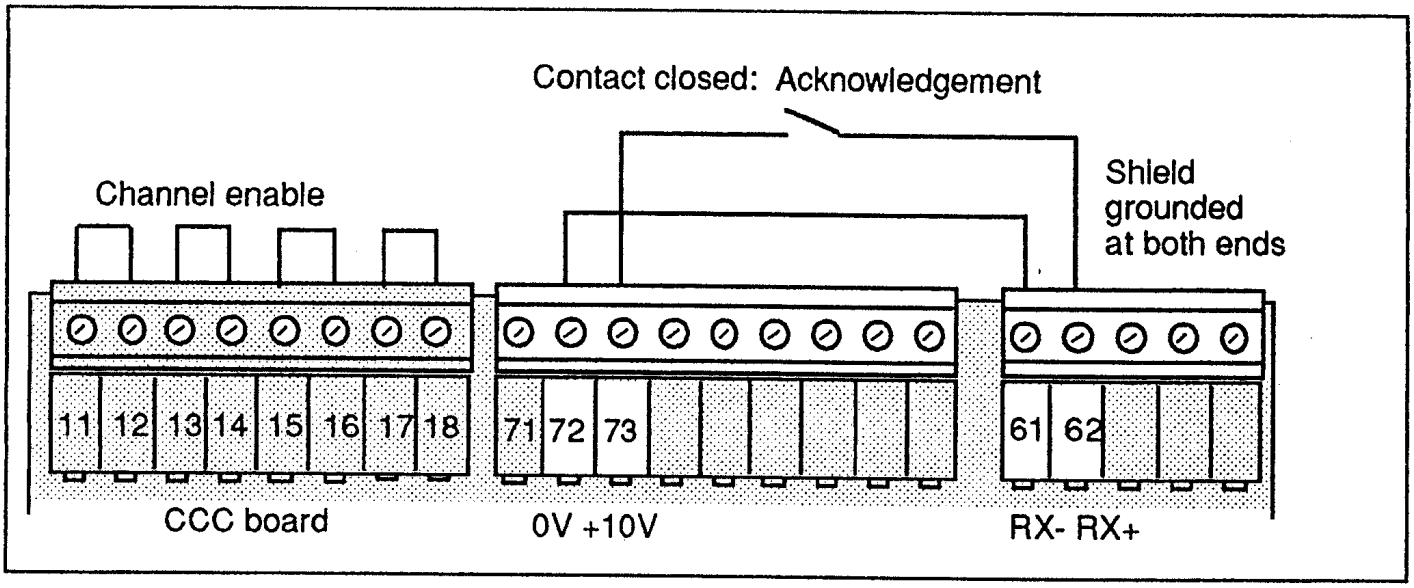


Figure 7-1 Alarm acknowledgement when communications are not used

ALARM MANAGEMENT

In order to give a clearer indication of alarm operation, the main characteristics of all the thyristor unit alarm types are given in table 7-1 (page 7-11).

Table 7-2 (page 7-12) gives the states of the alarm relay, thyristors and front panel 'Alarm Channels 1 to 4' (alarm LEDs) indicator lights in alarm state and the observations.

In these tables:

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

I_L - load current
I_{LN} - nominal load current
I_{UN} - nominal thyristor unit current
I_{LIM} - limited current

R_L - load resistance
R_{LN} - nominal load resistance
R_M - resistance R_{LN} stored at the time of the PLF adjustment

OP - output power.

Alarm			Firing conditions
Type	**Monitored value**	**Fault**	
General	Voltage	Over-voltage	$V_{LINE} > 110\% V_N$
		Under-voltage	$V_{LINE} < 85\% V_N$
Local	Load	Over-load	$R_L < (R_{LN} = R_M)$ and PLF setting made
		Partial load failure (PLF)	$R_L > 120\% R_M$ CA > 25%, CV > 30% and VV >30%
		Total load failure (TLF)	$I_L < 1.5\% I_{LN}$ $V_L > 30\% V_{LN}$ OP ≠ 0 (CA > 10%)
	Current	Thyristor short-circuit	$I_L > 70\% I_{LN}$ (CA > 10% OP = 0)
		Over-current	$I_L > I_{LN}$
		Current limit exceeded	Burst and Single cycle: $I_L > 110\% I_{LIM}$ Inhibit
			Phase angle : $I_L > I_{LIM}$ Current control
	Temperature	Abnormal overheating	Thyristor heatsink temperature greater than that allowed or fan stopped

Table 7-1 General alarm characteristics

Fault		Relay in alarm state	Thyristor inhibit	LED lit up	SW bit number equal to 1	Acknow-ledge-ment	Relay in non-alarm state	PLF detection
Over-voltage		Yes	No	No	5	No	105%V_N	Active
Under-		Yes	Yes	No	4	No	90%V_N	Disabled after inhibit
Over-load		No	No	No	9	Yes	-	Active
Partial load failure		Yes	No	Yes	15	Yes	$R_L = R_M$	Active
Total load failure		Yes	Yes	Yes	13	Yes	After acknow-ledgement	Disabled
Over-current		No	No	No	12	Yes	-	Active (setting disabled)
Thyristor short-circuit		Yes	Yes	No	10	Yes	After acknow-ledgement	Inactive
Current limit exceeded	Burst firing	Yes	Yes	No	11	Yes	After acknow-ledgement	Disabled after inhibit
	Phase angle	No	No	No	11	No	-	Active

Table 7-2 Alarm data and observations

Chapter 8

MAINTENANCE

Contents Page

Chapter 8 MAINTENANCE

Warning !

The thyristor unit must be maintained by qualified personnel authorised to work in industrial low voltage electrical environments.

THYRISTOR PROTECTION

The thyristors of the **TU1451** and **TU1471** units are protected as follows:

- the external high speed fuse against over-currents
- the RC snubber circuit and the varistor against excessively 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 or if the fan stops, the thermal switch opens, which causes the thyristor firing to be stopped.

Warning !

- The high speed fuse is only used for the internal protection **of thyristors** against wide amplitude over-loads.
- The high speed fuse may under no circumstances be **used** to protect the installation.
- The installation **must be protected upstream by the user** (non-high speed fuses, thermal or electromagnetic circuit breaker, suitable fuse-isolator) and comply with current standards.

THYRISTOR PROTECTION FUSES

The thyristor protection fuses (one fuse per channel) are ordered separately.

Table 8-1 contains all the part numbers of the original external high speed fuses designed to protect the **TU1451** and **TU1471** thyristor units and the fuses which can be used for replacements during maintenance.
The thyristor unit guarantee is subject to the use of the high speed fuses in this table.

Caution !

- The use of any **other** fuses **invalidates the thyristor unit guarantee.**
- For the use of high speed fuses with short wave infrared elements and tungsten (causing transient over-currents in Burst firing modes), please consult your Eurotherm office.

Thyristor unit model	Nominal thyristor unit current	Fuse Part Number	
		EUROTHERM	FERRAZ
TU1451	25A	CH 260034	M330015
	40 A	CH 330054	B093910
TU1471	40 A	CS173087U050	W094779
	60 A	CS173087U080	A094829
	75 A	CS173087U100	Y094827
	100 A	CS173246U125	S078331
	125 A	CS173246U160	X076311

Table 8-1 High speed fuses for thyristor protection

Thyristor unit model	Nominal thyristor unit current	Part Number		
		Fuse holder		Assembly
		Eurotherm	Suppliers	
TU1451	25A	CP 018525	FERRAZ G81219	FU1038
	40 A	CP 171480	FERRAZ J81221	FU1451
TU1471	40 A to 75 A	CP173083	LEGRAND 216.01	FU2258
	100 A and 125 A	CP173245	FERRAZ H220071	FU2760

Table 8-2 Fuse holder and 'Fuse and fuse holder' assembly

AUXILIARY SUPPLY PROTECTION FUSES

The electronics and synchronisation voltage supply circuits are protected with **1 A** fuses (see pages 3-7 and 3-9).

The fan supply circuit is protected with a **0.5 A** fuse.

The part numbers of these fuses, their fuse holders and fuse-isolators are given in table 8-3 .

Line voltage (max)	FERRAZ Part Number			
	6.3x32 mm fuse		Fuse holder	Fuse-isolator
	0.5 A	1 A		
250 V	J84303	K84304	M91482	N91483
500 V	-	D84206	M91482	N91483

Table 8-3 Auxiliary circuit protection fuses

FUSE DIMENSIONS

Table 8-4 gives the dimensions of the 'Fuse - Fuse holder' assembly which protects the power elements and the auxiliary circuits.

Type of protection		Height	Width	Depth
Thyristors	TU1451, 25A	81	17.5	68
	TU1451, 40A	95	26	86
	TU1471, 40 to 75A	140	35	90
	TU1471, 100 and 125A	240	38	107
Auxiliary	1A, 500 V	61	13.5	35

Table 8-4 'Fuse - Fuse holder' assembly dimensions (mm)

Fuse holder mounting clips on symmetrical DIN rails: Part No. **B92093**;
Fuse holder mounting clips on asymmetrical DIN rails: Part No. **K97046.**

SERVICING

TU1451 and **TU1471** 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.

Caution !

If multiple units are installed in the same cabinet, they should be arranged in such a way that the air from 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 mesh** of the fan regularly according to the degree of environmental pollution.
Cleaning must be performed when the thyristor unit is switched off and at least 15 min. after the operation has stopped.

Warning !

Every **six months**, check that the screws of the power cables and safety earth are **tightened** according to the recommendations in the 'Wiring' chapter.

TOOLS

Operation	Screwdriver	Wrench	Electrical equipment
Mounting	-	Depending on M6 screw heads selected by the customer	-
Opening (closing) of front panel	4 - 5.5 mm	-	-
Earth connection		HEX13 (M8)	
Power connection	1 x 6.5 mm	-	-
Control and fan connection	0.5 x 3.5 mm	-	-
CCC board mounting	-	CHc M4	-
Commissioning and calibration	0.4 x 2.5 mm	-	Ammeter or RMS clip. Oscilloscope (recommended) EUROTHERM type 260 diagnostic unit (recommended)

Table 8-5 Tools for installation, commissioning and maintenance of thyristor unit