TC1028 series

Thyristor units

Control of single-phase resistive or inductive loads

User manual
(300A to 500A rated units)

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TC1028 USER MANUAL

SCOPE OF MANUAL

This TC1028 User Manual (Ref: HA 174804 ENG) is intended for 300A to 500A rated units in the TC1028 series carrying the CE mark, manufactured from December 1995.

The TC1028 Manual (Ref: HA 172963) is valid for units manufactured before this date.

The TC1028 Addendum (Ref: HA 174804 ENG 001) is intended for 750A to 1200A rated units.

CONTENTS

RELEVANT EUROPEAN DIRECTIVES

CE MARKING AND SAFETY

TC1028 products carry the CE mark in compliance with the essential requirements of the European Low Voltage Directive 73/23/EEC, amended by the Directive 93/68/EEC.

Declaration of CE conformity

For safety reasons, Eurotherm certifies that TC1028 products, installed and used in compliance with this User Manual, meet the essential requirements of the European Low Voltage Directive mentioned above.

A declaration of CE conformity is available on request.

Validation by Competent Body

Eurotherm has validated the compliance of TC1028 products with the European Low Voltage Directive and with the EMC test standards listed below through product design and laboratory testing. These are described in a Technical Construction File, validated by a Recognised Competent Body: the LCIE (Central Laboratory for the Electrical Industries).

ELECTROMAGNETIC COMPATIBILITY (EMC)

The electromagnetic compatibility of TC1028 products has been designed specially for an industrial environment; they must not be used in domestic environments.

Statement of EMC conformity

Eurotherm certifies that TC1028 products, installed and used in compliance with this User Manual, meet the following EMC test standards and enable the system which incorporates them to comply with the EMC Directive, as far as the TC1028 products are concerned.

EMC tests		**EMC test standards**
Immunity	Electrostatic discharge	EN 61000-4-2 (06/1995)
	Fast transients (bursts)	EN 61000-4-4 (01/1995)
	RF electomagnetic fields	prEN 61000-4-3 (1984)
Emission	Radiated	EN 55011 (1991) EN50081-2 Class A
	Conducted	EN 55011 (1991) IEC 1800-3 for 2nd environment

PRECAUTIONS

Safety symbols

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

DANGER

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

WARNING

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

- have serious consequences for the installation or
- lead to the incorrect operation of the unit.

These symbols must be observed for particular points.

However the whole of the manual remains applicable.

Personnel

The installation, configuration, commissioning and maintenance of the unit must only be carried out by personnel qualified and trained to work with low voltage electrical equipment in an industrial environment.

EMC Guide

In order to help you reduce the effects of electromagnetic interference depending on the product installation, Eurotherm can supply you with the 'Electromagnetic Compatibility' Installation Guide (Ref: HA 025464).

This guide lists the rules generally applicable for EMC.

Independent alarm

Given the safety regulations concerning personnel and property, and the value of the equipment controlled by TC1028 products, we recommend the use of an independent safety device (alarm), which must be tested regularly.

Eurotherm can supply various types of alarm systems for this purpose.

Further information

For any further information, or if in doubt, please contact Eurotherm Controls where qualified staff are available to advise or assist you with the commissioning of your installation.

Chapter 1

IDENTIFYING THE THYRISTOR UNITS

Contents **Page**

Chapter 1 IDENTIFYING THE THYRISTOR UNITS

GENERAL INTRODUCTION TO THE TC1028 SERIES

The TC1028 series of thyristor units are designed for the control of industrial single-phase loads.

The TC1028 series is designed to control:
- inductive loads (transformer primaries in particular) or
- resistive loads with a large temperature coefficient.

A thyristor unit comprises a pair of thyristors connected in anti-parallel and mounted on a heat sink, together with control and alarm circuits.

The TC1028 series of thyristor units control currents up to 1650A.
This User Manual is valid for TC1028 units rated between 300A and 500A.

The nominal line-to-line voltage is between 100V and 690V (depending on the product code).

The control signal, which can be reconfigured by the user, has four voltage levels:
0-5V; 0-10V; 1-5V; 2-10V,

and two current levels:
0-20mA; 4-20mA.

Manual control using an external potentiometer is possible.

The TC1028 series is equipped with the following functions:
- electrical power control of inductive and resistive loads
- various thyristor firing modes
- current reduction by soft starting for loads with large temperature coefficient
- elimination of overcurrent when starting inductive loads
- current limit
- partial load failure detection
- logic output to control other power units (‘Slave firing’ output)
- selective pulse blocking circuit
- inhibit input available on user terminal block
- retransmission of load current and voltage
- bargraph current level display on front panel.

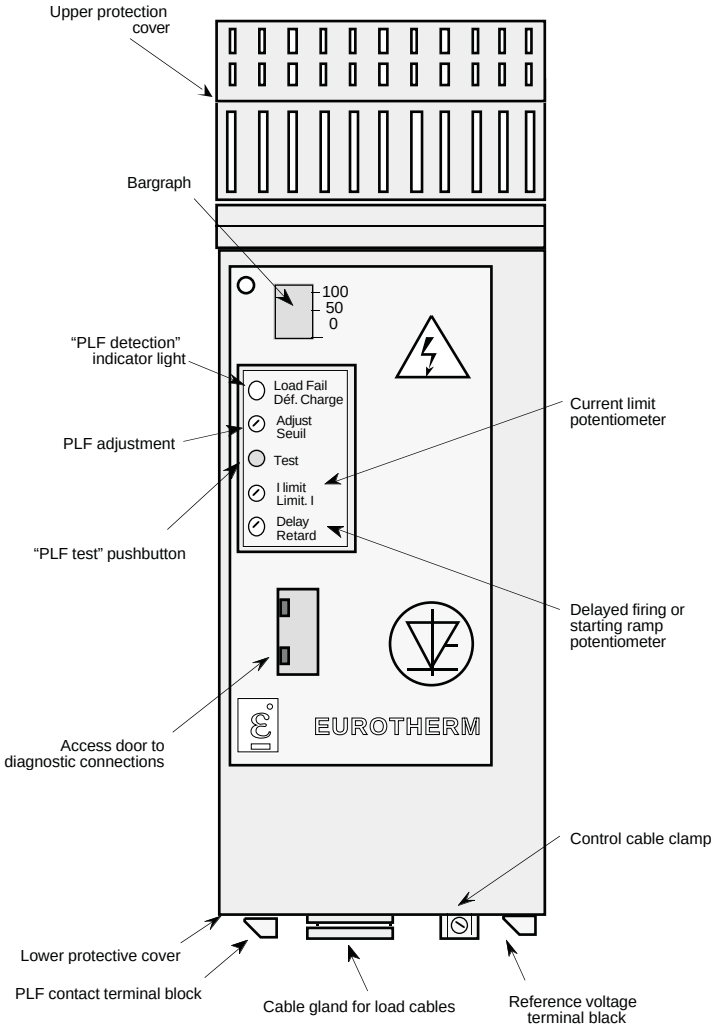


Figure 1-1 Overview of TC1028 series thyristor unit (500V version)

The standard (basic) version of the TC1028 series of controllers is fitted with:

- a thyristor firing board **('power board')** which generates thyristor firing pulses and provides current and voltage measurement
- a **'driver board'** which produces signals to control thyristor firing
- a **'potentiometer board'** to allow adjustment of delayed firing (inductive loads), and soft start time
- a **'filter board'** to protect thyristor unit operation from transient interference.

As an option, the TC1028 may be fitted with a board which plugs into the driver board and which converts the instantaneous current into an rms current measurement (**'RMS option board'**). The RMS value of the load current is displayed on a bargraph and is retransmitted via a signal available on the user terminal block.

The control system uses analogue feedback of load voltage squared (V2) or load current squared (I2), the highest value being automatically selected.

TC1028 units compensate for supply variations in the range +10% to -15% of the nominal voltage.

TC1028 series thyristor units are used for control of electrical loads such as:

- loads with large resistance variations as a function of temperature
- transformer primaries
- inductors.

The following features are found on the front panel:

- **potentiometer** to adjust the **initial firing delay** on inductive loads, or **soft start duration**
- **diagnostics connector**
- **bargraph** showing the mean or RMS current (optional)
- **potentiometer** for **partial load failure detection** adjustment
- **'Test'** pushbutton to test the PLF alarm adjustment
- **indicator light** to display PLF detection.

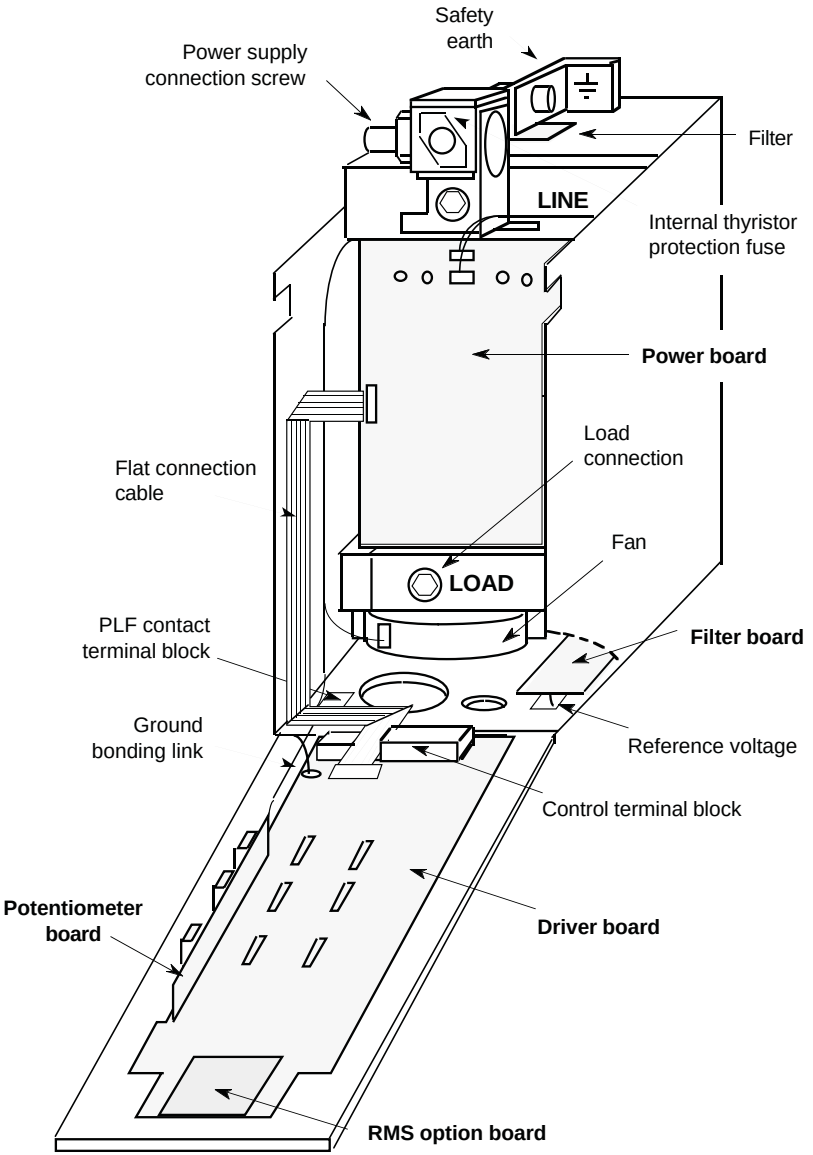


Figure 1-2 Circuit boards for the TC1028 series thyristor unit (500V version)

TC1028 thyristors have the following thyristor **firing modes**:
- **'Phase angle' -** variation in the thyristor firing angle
- **'Burst-firing' -** modulation of burst-firing duty cycle from 0 to 100%

'Burst mode' firing is characterised by various modes:
- **'Single-cycle'** one cycle of firing or non-firing
- **'slow cycle'** burst-firing (modulation time 8s at 50% setpoint)
- **'fast cycle'** burst-firing (modulation time 0.8s at 50% setpoint)
- **burst-firing (fast or slow cycle) with phase angle soft start**
- **burst-firing (fast or slow cycle) with phase angle soft start and end**

The soft start for large temperature coefficient resistive loads and the delayed firing angle in the first half-cycle when controlling inductive loads, minimise transient overcurrents. (Which otherwise can cause fuse blowing or trigger a protective circuit breaker.)
The soft start and end time can be adjusted between 0 and 0.25s via the potentiometer on the front panel.

TC1028 units have two types of **current limit**:
- **linear limit** (adjusted by potentiometer on front panel)
- **threshold limit** (adjusted by external potentiometer)

The partial load failure detection circuit (PLF) detects 25% increases in load impedance (independent of supply voltage variations).

PLF detection is adjusted by a potentiometer on the front panel, which is used to set the actual load current.

PLF alarm signalling is provided by the alarm relay contacts and by the 'Load Fail' indicator light on the front panel.

Thermal protection is provided by means of a thermal switch which senses fan failure or heatsink over-temperature.

TC1028 units have active **"enable"**.

An external 10V signal (32V max.) or a switch connected to the user terminal block are used to **enable** operation.

Absence of the enable voltage or opening of the switch contacts causes **inhibition** of the controller.

TECHNICAL SPECIFICATION

(units rated between 300A and 500A)

The TC1028 is a power thyristor unit designed to control an inductive industrial load or a load with a high current requirement at start-up.

Warning!

It is the user's responsibility to ensure, before commissioning the controller, that all the nominal ratings of the controller are compatible with the conditions of use and the installation.

Power

Nominal current	300A, 400A, 500A
Nominal line-to-line voltage	100Vac to 690Vac (+10%, -15%) Inhibition below 80% of nominal voltage; response time <10ms; automatic reset 2s after return to nominal
Supply frequency	50Hz or 60Hz (±2Hz)
Dissipated power	1.3W per amp. (Allow 2W per amp to include fuse)
Fan	6.5W consumption, (24Vdc fan) Self-supplied by power circuit for 300A to 500A rated units External supply for other ratings (see addendum HA17804ENG001)
Load	Resistive with large temperature coefficient or inductive (transformer primary or inductor)

Environment

Operating temperature	0°C to +50°C in vertical position (+40°C for 500A nominal; at +50°C, derate to 450A)
Storage temperature	-10°C to +70°C
Protection	Two covers provide IP20 protection on the front panel
Thyristor protection	Internal high-speed fuse, with 'fuse-blown' indication microswitch option, MOV (varistor) and RC snubber
Wiring	To be carried out in compliance with Standard IEC 364
Atmosphere	Non-explosive, non-corrosive & non-conductive
Humidity	RH: 5% to 95%, non-condensing
Pollution	Pollution degree 2 permissible, defined by IEC 664
Altitude	2000m maximum
Dimensions (Up to 500V)	570mm (H) x 133mm (W) x 268mm (D) Weight 10kg
(690V)	570mm (H) x 248mm (W) x 268mm (D) Weight 19kg

Control

Power supply	Self-supplied from power circuit (300A to 500A rated units) with reference phase (or neutral) connection Consumption: 20VA
Input type	Analogue
Range	Voltage : **0-5V; 1-5V; 0-10V or 2-10V** Current : **0-20mA; 4-20mA**
Input impedance	Voltage : ≥**50kΩ** Current : **250Ω**
Manual control	5kΩ external potentiometer
Thyristor firing modes	The following may be reconfigured by the user: • **Phase angle** • **Single-cycle** (Burst-firing with one firing or non-firing cycle) • **Fast cycle** burst-firing (typical modulation time at 50% power : 0.8s) • **Slow cycle** burst-firing (typical modulation time at 50% power : 8s) • **Fast cycle with adjustable soft start** between 0 and 250ms **(with or without soft end)** • **Slow-cycle with adjustable soft start** between 0 and 250ms **(with or without soft end)**
Delayed thyristor firing	For inductive loads, delayed firing in the first half-cycle of burst-firing (without soft start) eliminates transient overcurrents
Enable / Inhibit	Using external contacts or external voltage (10VDC) to enable Response time : enable, 2s; inhibit < 25ms
Diagnostics	Connector for diagnostic unit permits adjustment and test of thyristor unit.
Control type	Control of load voltage squared or load current squared Supply variation compensation
Wiring	Shielded cable connected to ground at both ends
Connections	0.5^2mm to 1.0^2mm conductors Tightening torque 0.7Nm

RMS option board

Retransmissions	**RMS load current** DC signal (0-10V) proportional to the actual load current. Retransmission output on the user terminal block
Display	Display of RMS current using **10-segment bargraph**

Current limit

Linear limit	**Proportional load current limit** (from 20 to 100% of the nominal current) Adjustment using potentiometer on front panel
Threshold limit	**Maximum load current limit** Adjustment using external potentiometer

Partial load failure detection

Alarm	**Detection of 20% decrease in current** Adjustment by potentiometer marked 'Adjust' on front panel
Test	Using 'Test' push button on front panel
Signalling	'Load fail' indicator light on front panel Alarm relay contacts open in alarm state (in standard version) Alarm relay contacts closed in alarm state (IPF option)

Bargraph

Display

- **Instantaneous current** (filtered mean value) for the adjustment of initial firing of thyristors in the case of inductive loads (basic version)
- **RMS value of load current** in 'Phase angle' and 'Fast cycle' firing modes with or without soft start or end (with RMS option board)

Warning!

In order to maintain its 'leading edge', Eurotherm may have to make changes to its specifications without advance notice.For any further information, or if in doubt, please contact Eurotherm Controls.

PRODUCT CODE FOR TC1028 SERIES

TC1028	Nominal current	Nominal voltage	Fan supply	Input signal	Firing mode	Manual	Options	96	00

Nominal current	Code
300 amps	300A
400 amps	400A
500 amps	500A
750 amps *	750A
900 amps *	900A
1200 amps *	1200A
1650 amps *	1650A

Nominal voltage	Code
100 volts	100V
110 volts	110V
115 volts	115V
120 volts	120V
200 volts	200V
220 volts	220V
230 volts	230V
240 volts	240V
277 volts	277V
380 volts	380V
400 volts	400V
415 volts	415V
440 volts	440V
480 volts	480V
500 volts	500V
690 volts	690V

Fan supply	Code
Self-supplied (300A to 500A rated units)	000
External voltage * (ratings ≥ 750A) :	
115 volts	115V
230 volts	230V

Input signal	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

* See addendum HA174804ENG001

Input signal	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

Thyristor firing mode	Code
Phase angle	PA
Single-cycle	SGL
'Fast cycle' burst-firing (0.8s)	FC
'Fast cycle' burst-firing with soft start	SFC
'Fast cycle' burst-firing with soft start & end	SDF
'Slow cycle' burst-firing (8s)	SC
'Slow cycle' burst-firing with soft start	SSC
'Slow cycle' burst-firing with soft start & end	SDS

Manual language	Code
English	ENG
French	FRA
German	GER
Italian	ITA
Dutch	NED
Swedish	SWE

Options	Code
RMS current retransmission and display	RMS
60Hz frequency	60H
PLF alarm contacts closed in alarm state	IPF
Fuse-blown indicator microswitch	FUMS
No internal fuse	NOFUSE
Separate MC control unit * for ≥ 750A rated units; not available for 690V	MC

Example of product code

TC1028 controller and installation parameters

Nominal load current	250 amps
Nominal supply voltage	440 volts line-to-line
Analogue input signal	0 to 10 volts
Firing mode	'Fast cycle' burst-firing with soft start
Options	RMS current display and retransmission 'Partial load failure' detection alarm relay contacts closed in alarm state Fuse-blown indication microswitch

Controller code:

TC1028 / 300A / 440V / 000 / 0V10 / SFC / ENG / RMS / IPF / FUMS / 96 / 00

Warning!

The nominal voltage of the TC1028 controller must correspond to the supply voltage used in order to eliminate problems of the controller not operating below 80% of the nominal voltage

SERIAL NUMBER LABELS

Two identification labels (which include the controller product code) and one configuration label provide all the information relating to the factory settings of the controller.

One identification label is located externally on the right hand side of the unit.

EUROTHERM 2.20
WORTHING, ENGLAND : 1903 268500
MODEL : TC1028/300A/440V/000/0V10/SFC/RMS/ENG/IPF/FUMS/96/00

SERIAL No. : LC1111/001/001/11/97

RATING : 1 PHASE 300A 440V 50Hz
AUXILIARY POWER SUPPLY : SELF-SUPPLIED

MADE IN FRANCE

Figure 1-3 Example of identification label for a TC1028 controller
The information corresponds to the product code example

The second identification label and the configuration label are located inside the controller.

SERIAL No : LC1111/001/001/11/97 TC1028

FACTORY SETTINGS :

INPUT	:	0-10V DC
FIRING	:	FAST CYCLE BURST MODE
OPTION(S)	:	FUSE-BLOWN INDICATION SWITCH CONTACTS CLOSED IN ALARM STATE RMS BOARD

ANY NON-SPECIFIED FUSE INVALIDATES GUARANTEE (SEE USER MANUAL HA174804ENG)

Figure 1-4 Example of configuration label for a TC1028 controller

Warning!

Following any re-configuration on the part of the user, there is no guarantee that the controller will correspond to the label information.

Chapter 2

INSTALLATION

Contents **Page**

Chapter 2 INSTALLATION

INSTALLATION - SAFETY

Danger!

TC1028 units must be installed by personnel trained to work with low voltage electrical equipment in an industrial environment.

Units must be installed in fan-cooled electrical cabinets, to ensure that condensation and pollution are excluded.

The cabinet must be closed and bonded to the safety earth in accordance with IEC 364 or current national Standards.

For installations which are fan-cooled, it is recommended that a fan-failure detection device or a thermal safety cut-out should be fitted in the cabinet.

The TC1028 series of units may be bulkhead mounted.

The units must be mounted with the heatsink positioned vertically, with no obstructions above or below which could inhibit or impede airflow.

If several units are mounted in the same cabinet, they must be arranged in such a way that air expelled from one cannot be drawn into the unit located above it.

Warning!

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

Leave a minimum gap of 5cm between two units placed side by side.

Excessive overheating may lead to incorrect operation of the unit. This may in turn cause damage to the components.

TC1028 series power units have permanent fan cooling.

DIMENSIONAL DETAILS

Dimensions and weights of TC1028 controllers (units rated between 300A and 500A) are given

- in Figure 2-1
- and in Table 2-1

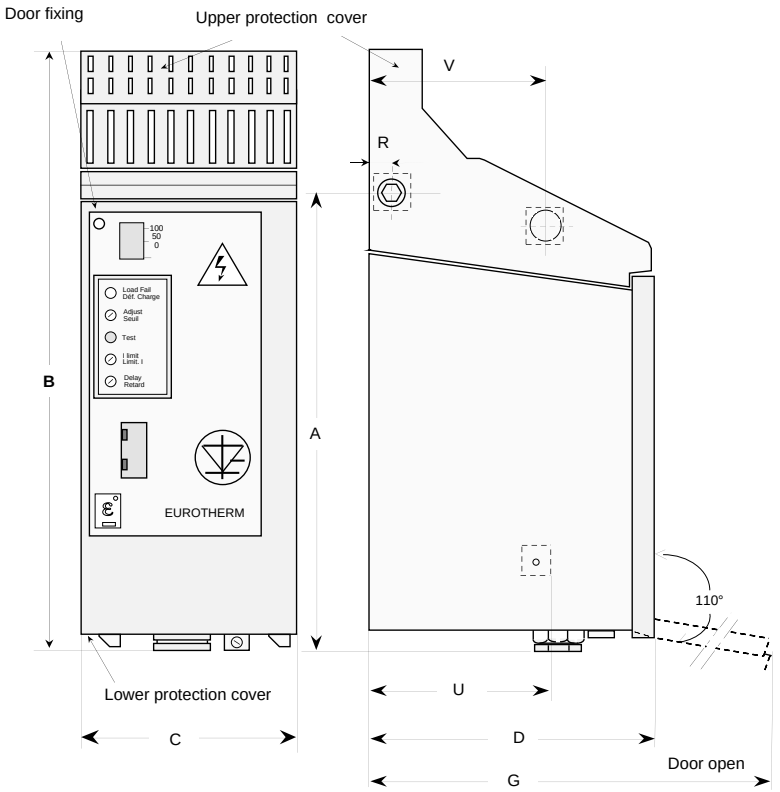


Figure 2-1 Overall dimensions with upper protective cover

Dimensions	Values	Description
A	425mm	Height without protective cover
B	570mm	Height with cover
C	133mm 248mm	Width (up to 500V) Width (690V)
D	268mm	Depth
E	88mm 203mm	Width between fixing holes (up to 500V) Width between fixing holes (690V)
F	328mm	Height between fixing holes
G	557mm	Depth with door open
K	350mm	Height of side faces
R	20mm	Distance between ‘Earth’ busbar and panel
U	150mm	Depth between ‘LOAD’ terminal and panel
V	170mm	Depth between ‘LINE’ terminal and panel
Weight	10kg 19kg	Up to 500V 690V

Table 2-1 Dimensions and weights of TC1028 units (300A to 500A)

MECHANICAL MOUNTING

TC1028 controllers have two protective covers (upper and lower).

The controllers may be mounted with their protective covers in position. However, the upper protective cover must be removed to make electrical connections.

Having drilled the support panel to the dimensional values given above, insert the fixing screws halfway into the bulkhead / mounting plate holes.

Offer up the controller by first engaging the heads of the upper screws in the respective holes on the upper section.

Lower the unit making sure that it engages properly on the lower screws.

Then slide the unit down completely until it is in position.

Tighten the four screws correctly.

INSTALLATION DETAILS

TC1028 series units are designed to be mounted directly on to a panel using the fixing points located on the rear of the units.

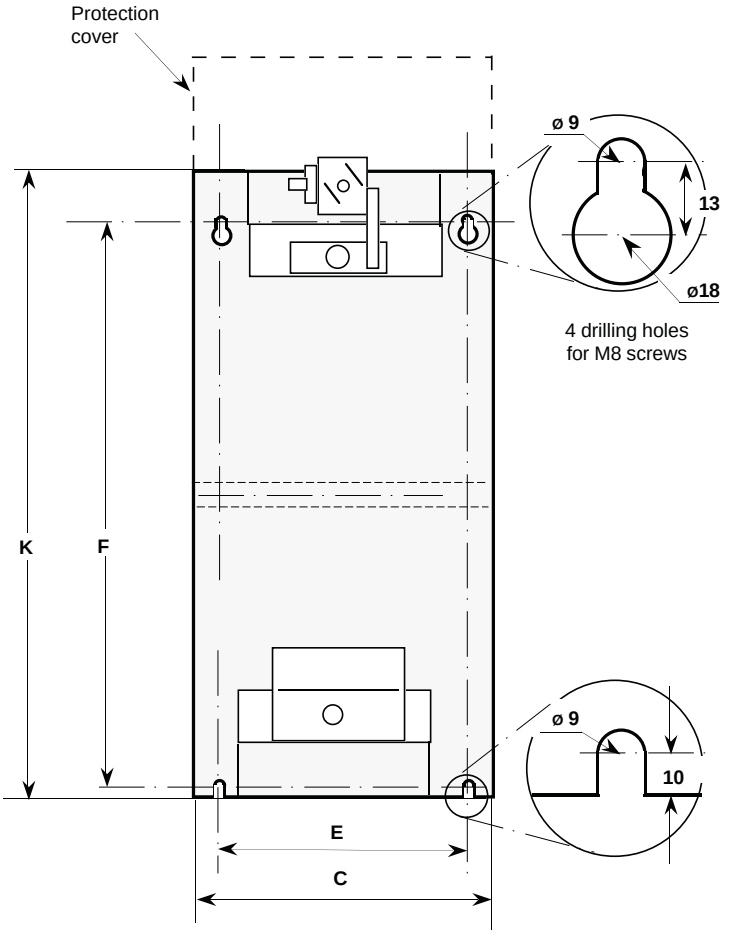


Figure 2-2 Mounting details (300A to 500A rated units)

Chapter 3

WIRING

Contents **Page**

Chapter 3 WIRING

WIRING- SAFETY

Danger!

Wiring must only be carried out by personnel who are qualified to work in a low voltage industrial environment.

It is the user's responsibility to wire and protect the installation in accordance with current professional Standards.

A suitable device ensuring electrical isolation between the equipment and the supply must be installed upstream of the unit in order to permit safe maintenance.

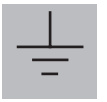
TC1028 series units have two protective covers : upper and lower.

In order to make wiring easier, the upper cover should be removed.

After connection and before powering up, replace the upper protective cover to ensure the specified degree of protection.

Danger!

- Before any connection or disconnection, ensure that power and control cables or leads are isolated from voltage sources.
- For safety reasons, the safety earth cable must be connected before any other connection is made during wiring and it must be the last cable to be disconnected.

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

Danger!

- To ensure correct grounding of the TC1028 unit, make sure that it is properly mounted on the reference ground surface (panel or bulkhead). Failing this, it is necessary to add a ground connection at most 10cms long between the earth connection and the reference ground surface.
- This connection, which is intended to ensure good ground continuity, can never be used to replace the safety earth connection.

CONNECTING THE POWER CABLES

The supply power cable passes through an opening in the upper protective cover of the TC1028 unit.

In order to make connection of this cable easier, the upper cover of the unit is removed.

To remove the cover:

- open the access door by undoing the front screw located on the top left hand side of the door
- lift the door in order to release it from its slots
- open the door completely by pulling it towards you
- remove the upper cover by unscrewing the two fixing nuts (by sliding it 1cm forwards to release the two catches located at the rear), and then raising it.

The supply connection is made on the fuse stud on the upper part of the unit labelled LINE (see Figure 3-1).

The load power cable passes inside the unit through a cable gland located below the unit. The aperture of this cable gland is up to 38mm.

The load connection is made on the screw located on the lower part of the unit, labelled LOAD (see Figure 3-1).

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

Tightening torques should not exceed the limits given in this table.

Terminal	Wiring details
Supply and load Earth cable	185 to 2 x 150mm^2 95 to 185mm^2
Fuse stud Tightening torque	M10 25Nm
Load screw Tightening torque	M12 43.5Nm
Earth screw Tightening torque	M12 43.5Nm

Table 3-1 Power connection details (300A to 500A)

The cross-section of the conductors to be used must comply with Standard **IEC943**.

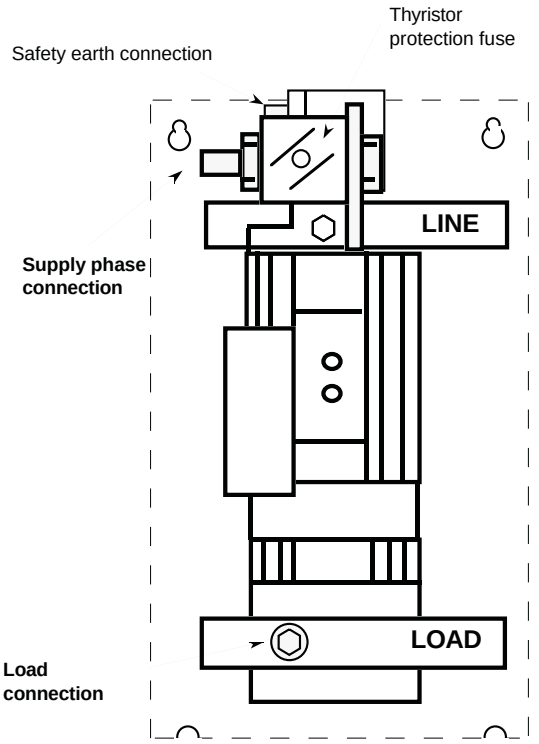


Figure 3-1 Fixing points for power cables (300A to 500A unit)

Distance between:	Dimensions
'Earth' busbar and upper fixing hole	30mm
'Earth' busbar and left fixing hole	96mm
'LOAD' terminal and lower fixing hole	70mm
'LOAD' terminal and left fixing hole	20mm
'LINE' terminal and upper fixing hole	20mm

Table 3-2 Details of power cabling

Warning!

The power cables leading to a load pass through a cable gland (aperture to 38mm), which must be tightened carefully after wiring.

REFERENCE VOLTAGE CONNECTION

The reference voltage (second phase or neutral) used by the electronics is connected to a plug-in user terminal block, located on the right hand side below the unit.

The maximum cross-section of the conductors is 1.5 mm^2; tightening torque of control terminals : 0.7Nm.

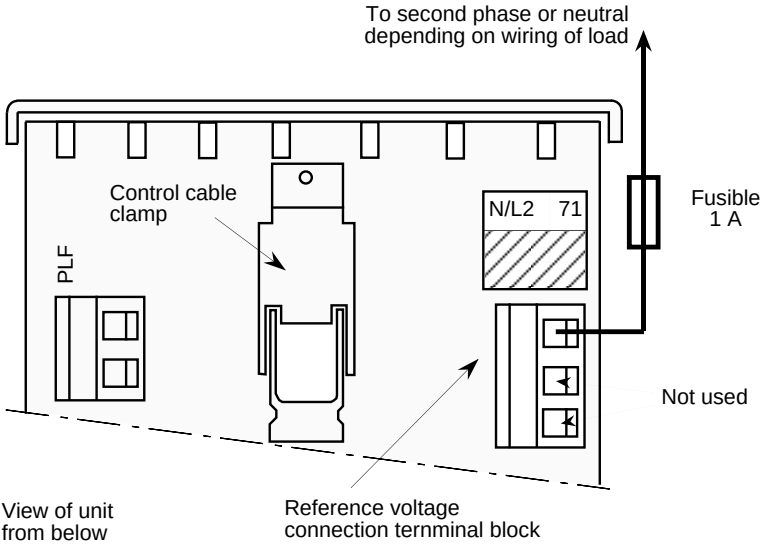


Figure 3-2 Reference voltage connection terminal block

The reference voltage (second phase or neutral) **must correspond to the load configuration voltage**.

A 1A external fuse must be fitted to protect the reference voltage wiring.

CONTROL CABLES

Warning!

Control connections should be made using shielded cables grounded at both ends in order to ensure satisfactory immunity against interference.

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

Mounting

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

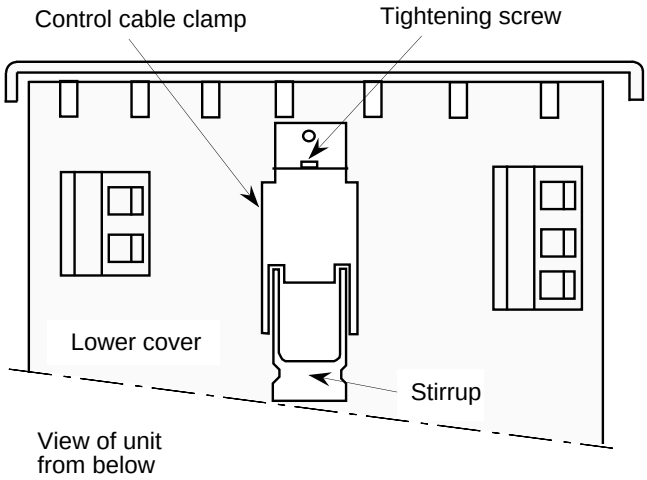


Figure 3-3 Location of control cable clamp

Important!

To facilitate earthing of the cable shield and to ensure maximum immunity from electromagnetic interference, the metal cable clamp is bonded directly to the ground of the unit.

Connection of the shield to the ground

To insert the control cable and earth its shield:

- Strip the shielded cable as shown in Figure 3-4a

The control wires must be long enough for connection to be made to the user terminal blocks on the boards, whilst the bare screen is grounded at the metal cable clamp, when the door is open.

Wiring inside the unit should be as short as possible.

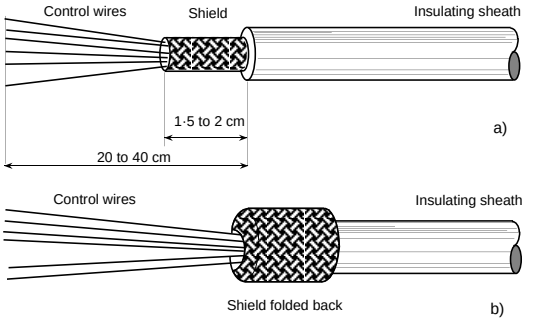


Figure 3-4 Control cable stripping

- Fold back the shield on to the insulating sheath (Figure 3-4b)
- Insert the cable into the metal cable clamp so that the shield is located in the stirrup and not inside the unit (at least, not beyond the lower cover).
- Tighten the stirrup (4x1 flat-bladed screwdriver; tightening torque 0.7Nm)

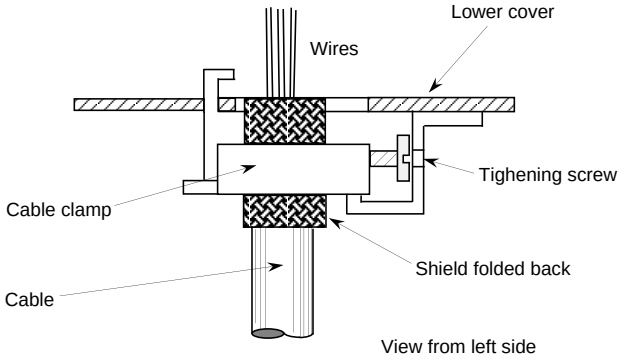


Figure 3-5 Cable tightening and shield grounding

The possible diameter of the cables with the shield folded back is from 5mm to 10mm per cable clamp.

CONTROL TERMINAL BLOCK

The following connections are made on the driver board user terminal block:

- **input signal** (external or manual)
- **"enable"** for controller operation
- threshold **current limit**
- load current and voltage **retransmission**
- **logic signal output** to drive a solid state relay in 'Master-Slave' operation

Access to the user terminal block is by opening the front door.

Danger!

Live parts may be exposed when the door is open if the TC1028 controller is powered up.

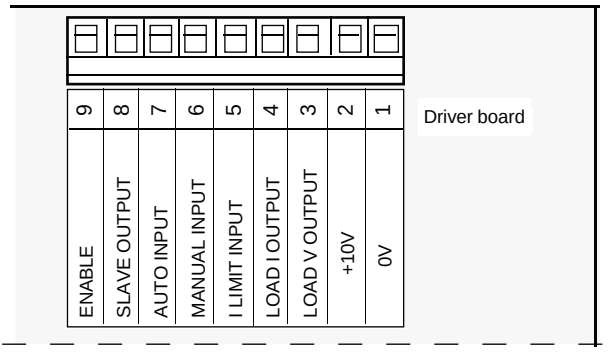


Figure 3-6 Labelling of TC1028 control terminals

Control terminal block terminal capacity 0.22mm² to 1.5mm².

Control terminal tightening torque : 0.7Nm

The input is isolated from the power supply and from the load circuit.

Terminal	Labelling	Function
1	0V	Common 0V
2	+10V	+10V user voltage
3	LOAD V OUTPUT	Output for load voltage measurement retransmission
4	LOAD I OUTPUT	Output for load current measurement retransmission
5	I LIMIT INPUT	Input for threshold current limit
6	MANUAL INPUT	Input for manual control signal
7	AUTO INPUT	Input for automatic control signal
8	SLAVE FIRING OUTPUT	Logic output to drive other units in 'Master-Slave' operation
9	ENABLE INPUT	Enables thyristor operation

Table 3-3 Terminal designation of TC1028 thyristor unit control terminal block

INPUT SIGNALS

The control wires are connected on the plug-in user terminal block located on the driver board.

The user terminal block can be accessed with the front door open.

To open the door undo the front screw, release the door from its notches by lifting it up, then pull it towards you.

Danger!

Live parts may be exposed when the door is open if the controller is powered up.

The units may be controlled by an external analogue signal (from a temperature controller or another signal source) or manually by an external potentiometer.

External analogue input

The TC1028 may be configured for voltage input or current input signals.

Signal type	Signal level	Input impedance
Voltage	0 - 5V	50kΩ
	1 - 5V	
	0 - 10V	
	2 - 10V	
Current	0 - 20mA	
	4 - 20mA	250Ω

Table 3-4 TC1028 Input signals

The external signal is applied to terminals 1 & 7 of the control terminal block ('+' on terminal 7).

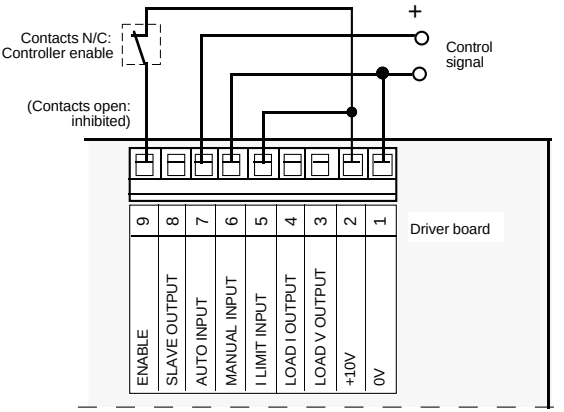


Figure 3-7 Wiring of external control signal

For normal operation of the TC1028 series controller, also connect:

- **'Enable' input** (terminal 9) to the **'+10V user' voltage** (terminal 2)
- **'Current limit' input** (terminal 5) to the **'+10V user' voltage**
- **'Manual control' input** (terminal 6) to **terminal 1 '0V'**.

Control of multiple units

The inputs of several controllers may be wired in parallel or in series.

For this type of wiring all the thyristor units must have the same mode of firing and the inputs must be configured for the same signal type.

Wiring in parallel

The inputs must be configured as voltage inputs

The input impedance per controller is 50kΩ

The current required for each controller is 0.2mA at full scale.

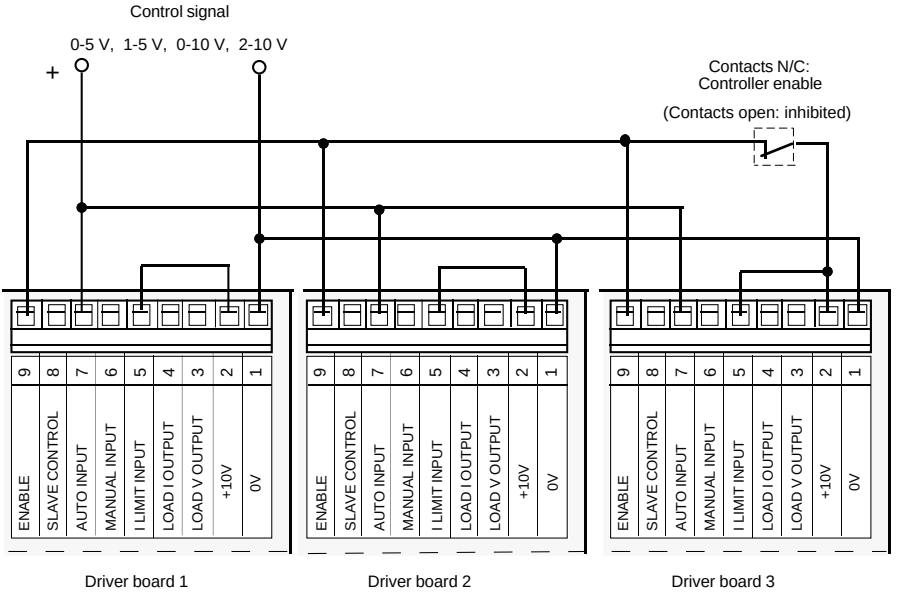


Figure 3-8 Parallel input wiring

Wiring in series

The inputs must be configured as current inputs.

Wiring in series is possible if all the controllers are configured for the same current signal (0 to 20mA, for example).

For 0 to 20mA and 4 to 20mA inputs, the impedance of an input is 250Ω.

For each input, 5 volts are required (for a current of 20mA).

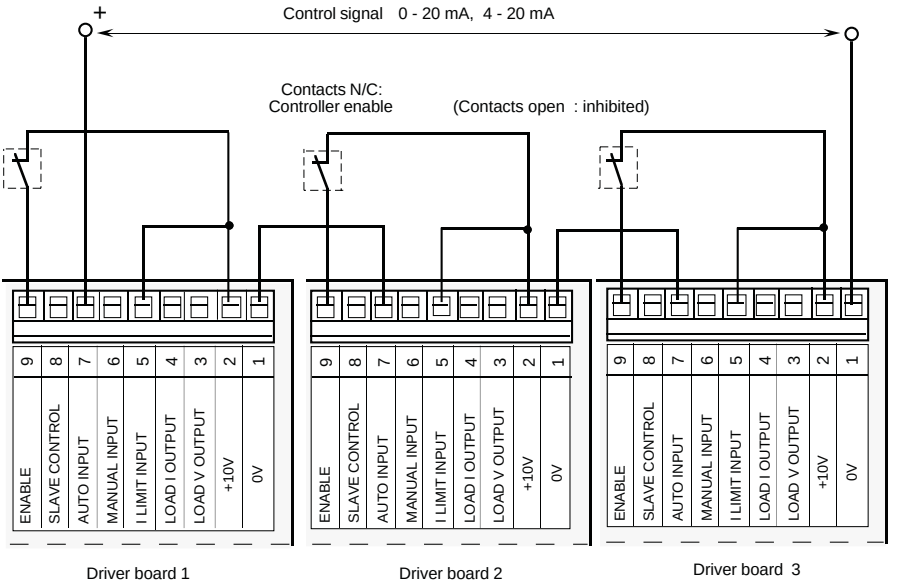


Figure 3-9 Series input wiring

Manual control wiring

The TC1028 can be controlled by an external potentiometer **(manual control)**.

A 4.7kΩ to 10kΩ potentiometer should be connected between **terminals 1 ('0V') and 2 ('+10V')**. The wiper is connected to **terminal 6 ('Manual input')**.

To use manual control, the controller input should be configured to 0 - 10V (see Product code).

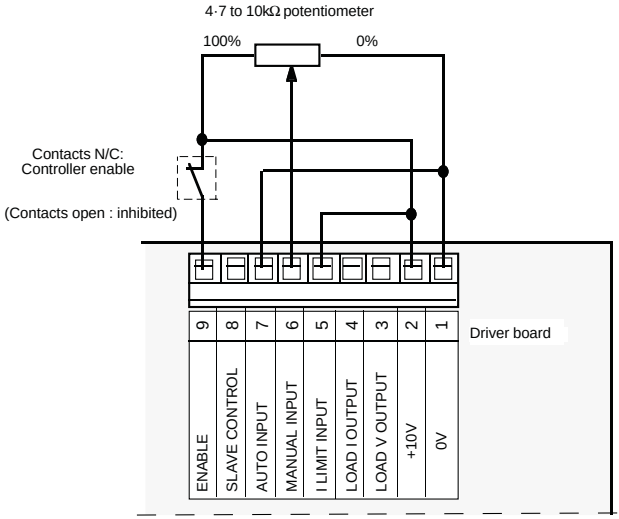


Figure 3-10 Wiring of manual input for TC1028

When manual control is used, terminal 7 of the external input labelled 'Automatic input' must be connected to '0V' (terminal 1).

Warning!

If the input signal is not disconnected from terminal 7, the two signals (external and manual) are added together.

External current limit wiring

TC1028 series thyristor units have two types of **current limit** (see Chapter 5 'Operation'):

- **linear limit** (internal limit) and
- **threshold limit** (external limit).

External current limit is controlled by a voltage level or by an external potentiometer, and may be used with automatic external control as well as with manual control.

External current limit may be adjusted in three different ways.

1. Adjustment by external voltage

To implement **threshold limit**, a **0 - 10V** external voltage should be connected between **terminals 5 ('I Limit') and 1 ('0V')**, terminal 5 is positive.

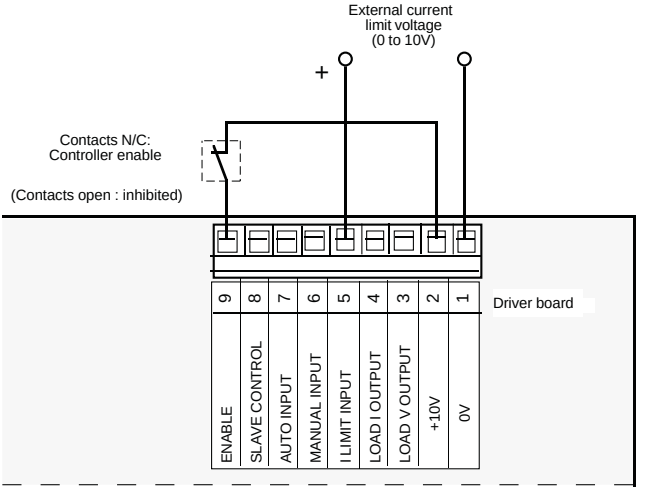


Figure 3-11 Wiring of external voltage for threshold current limit

2. Adjustment by potentiometer

For **threshold current limit**, it is possible to use an **external potentiometer**.

A 4.7kW to 10kW potentiometer is connected between **terminals 1 ('0V') and 2 ('+10V')**, its wiper is connected to **terminal 5 ('I Limit')**.

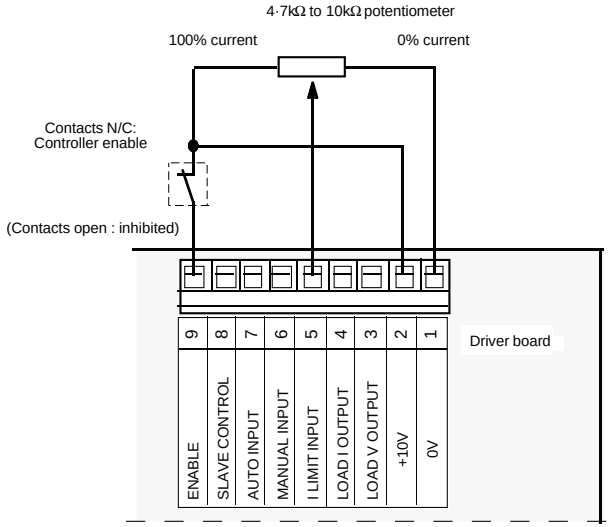


Figure 3-12 Wiring of external potentiometer for threshold current limit

3. Fixed external limit

A **fixed current limit of 110%** of the nominal controller current is provided by connecting the **'I Limit' (terminal 5) to '+10V' (terminal 2)**.

Warning!

If the external current limit is not used, terminals 5 and 2 must be connected.

Retransmission signal wiring

Load current and voltage measurements are available on the control terminal block.

The **voltage measurement** is retransmitted as a **full-wave rectified signal proportional** to the **instantaneous value of the load voltage**.

The value of this signal is 5V rms (4.3V mean) for the nominal voltage.

The **voltage measurement** is available between **terminals 3 (‘Load V output’) and 1 (‘0V’)**.

Retransmission of the **current measurement** requires the RMS board option.

- In the **basic version** (without RMS option) the signal available between **terminals 4 (‘Load I output’) and 1 (‘0V’)** is a **full-wave rectified signal proportional to the instantaneous value of the load current.**

  The value of the retransmitted signal is 5V RMS (4.3V mean) for the nominal current of the power controller.

- **With the rms option**, the signal retransmitted between **terminals 4 and 1** of the driver board is **proportional to the true rms value of the load current**.

The value of this signal is 10V for the nominal current of the controller.

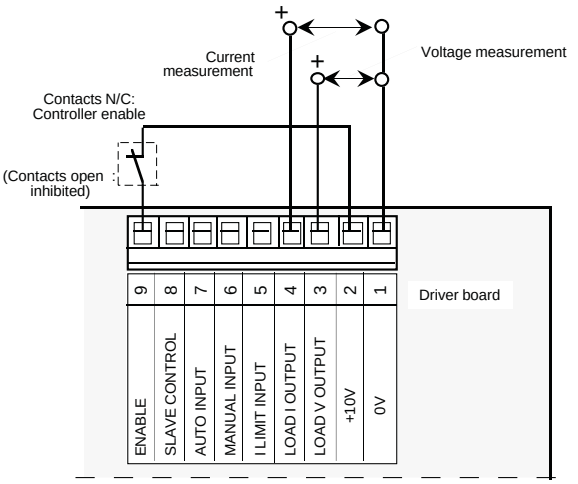


Figure 3-13 Wiring for retransmission signals

The current measurement signal (with or without the RMS option) is displayed by the bargraph on the front panel of the controller. This bargraph has 10 segments, each segment represents 10% of the nominal current of the thyristor unit.

SINGLE-PHASE LOAD WIRING DIAGRAM

Below is the wiring diagram for the power, safety earth and reference voltage for the control of a single-phase load in the TC1028 series of controllers.

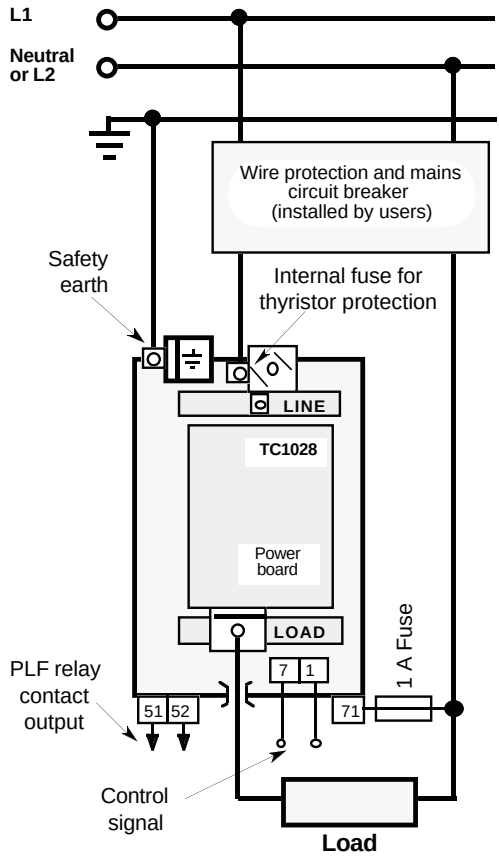


Figure 3-14 Wiring of a TC1028 controller with a single-phase load

THREE-PHASE LOAD WIRING DIAGRAMS

Although TC1028 series controllers are single-phase units, they may be used in combination to control three-phase loads.

In three-phase use, the power and reference voltage wiring is determined by the load configuration.

The most economical three-phase application is to use the TC1028 controller as the ‘Master’ with TC1027 series solid state relays acting as ‘Slaves’.

The ‘Slave’ logic signal output is provided on the TC1028 control terminal block.

The TC1027 solid state relay inputs must be configured for a 10V logic signal and connected in parallel.

Important!

In ‘Master-Slave’ three-phase operation, only ‘burst-firing’ modes (Single-cycle, fast cycle and slow cycle) without soft operation are possible.

Load type - star with neutral

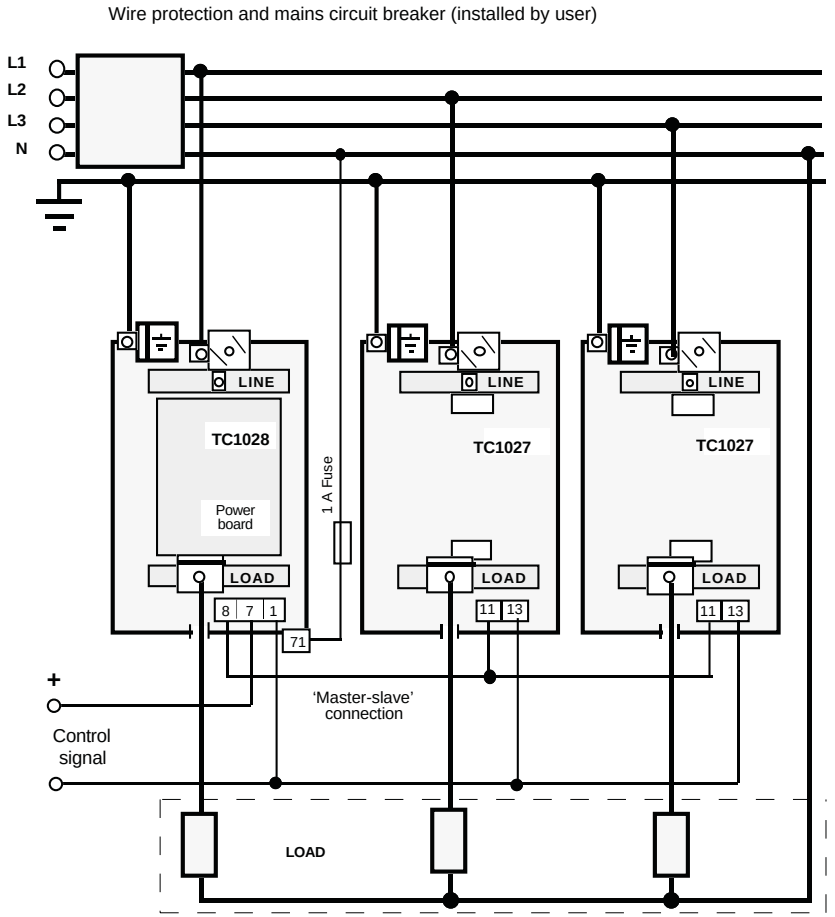


Figure 3-15 Wiring of a TC1028 controller ('Master') and two TC1027 solid state relays ('Slaves') for 'star with neutral' load configuration (for low temperature coefficient resistive loads only)

Load type - open delta

For open delta load configuration (6-wire configuration), three TC1028 power controllers can be used with all the available firing modes.

The power wiring given in the diagram below should be followed.

Danger!

The controllers and reference voltage circuits are at line-to-line voltage.

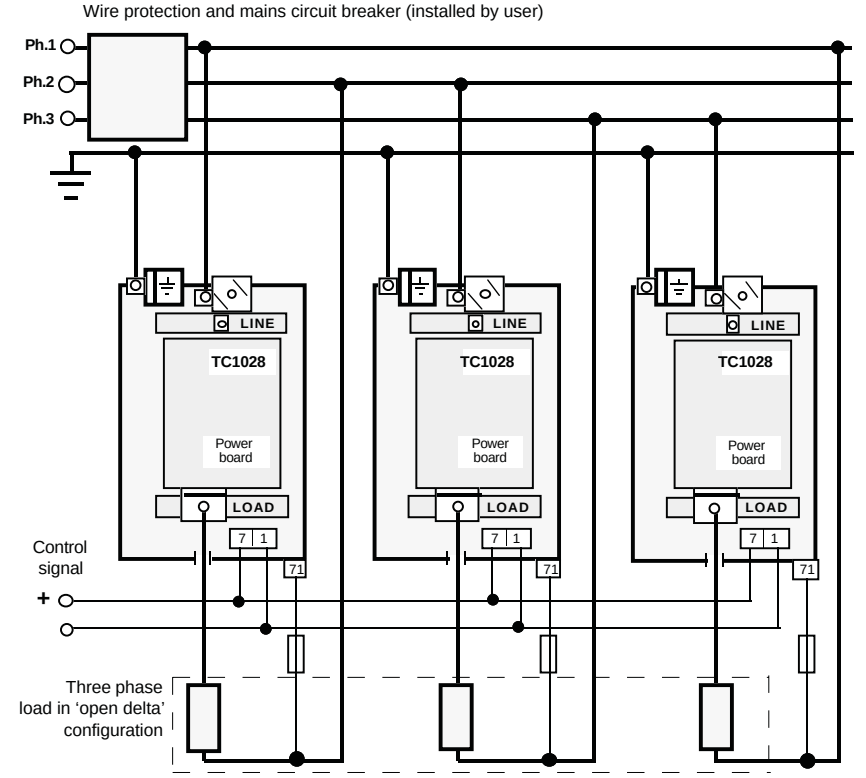


Figure 3-16 Wiring diagram of three TC1028 controllers in 'open delta'

(do not use for three phase transformer primaries)

Load type - star without neutral or in closed delta (two-phase control)

For three-phase loads connected in star without neutral, or in closed delta (3-wire configuration) it is advisable to use two-phase control.

One supply phase is direct (not controlled).

In the two controlled phases a TC1028 controller, which operates as a ‘Master’, and a TC1027 operating as a ‘Slave’ must be connected together.

The ‘Slave’ control logic output (terminal 8) is provided on the TC1028 driver board user terminal block.

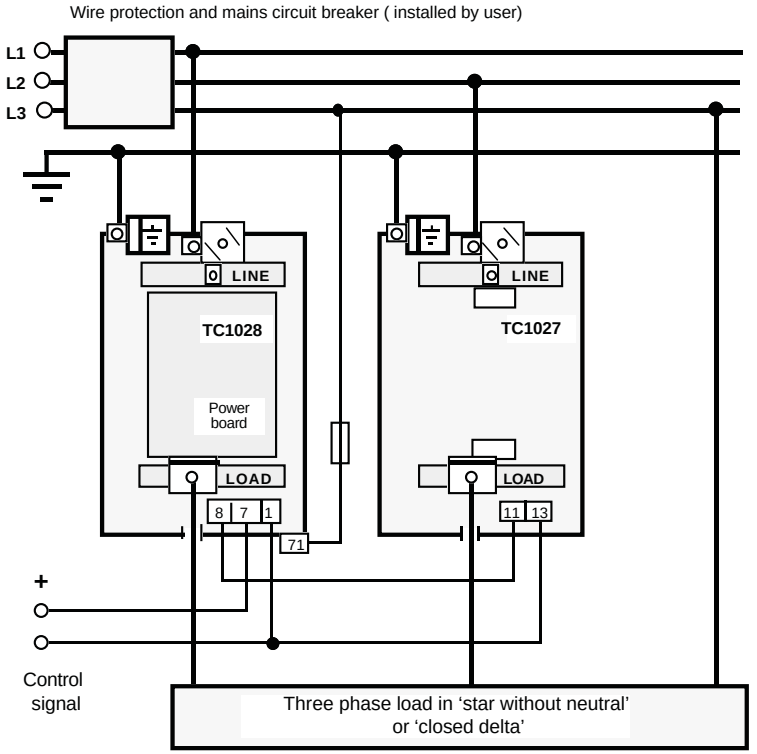


Figure 3-17 Wiring of a controller and a solid state relay in two-phase control

(do not use for three phase transformer primaries)

PLF ALARM

The partial load failure (PLF) detection alarm relay contacts, which signal the active state of the alarm, are connected to the user terminal block located below the unit on the left hand side.

The contact output terminals are 51 & 52.

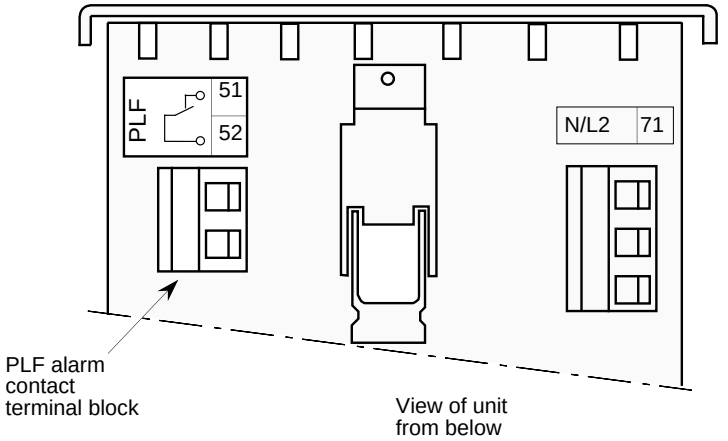


Figure 3-18 PLF alarm relay contact connection

The PLF alarm relay is de-energised in the alarm state and in the absence of the power supply voltage.

In the **standard version**, the relay contacts between **terminals 51 & 52 are open in the alarm state**.

In the **IPF option**, the alarm relay contacts are **closed in the alarm state**.

The partial load failure detection alarm relay contacts are protected from interference by an RC snubber on the driver board.

Warning!

The PLF alarm relay contacts must be only be connected to circuits energised by 230V or less (single-phase or three-phase 230V supply).

Chapter 4

CONFIGURATION

Contents **Page**

Chapter 4 CONFIGURATION

CONFIGURATION - SAFETY

The thyristor unit is factory configured using moveable jumpers and soldered links. It can be reconfigured on site by using these jumpers.

Important!

The controller is supplied fully configured in accordance with the product code on the identification label.

This chapter is included in order to:

- Check that the configuration is suitable for the application
- Modify if necessary, certain characteristics of the unit on site.

Danger!

For safety reasons, re-configuration of the controller using jumpers must be carried out with the unit switched off and by qualified personnel only.

Before starting the re-configuration procedure, check that the unit is isolated and that any accidental power-up is not possible.

After re-configuring the unit, amend the codes on the identification label to prevent any subsequent maintenance problems.

POWER BOARD

There are **two types of power board for the TC1028 series**:

- **a board for operating voltages from 100V to 500V and**
- **two specific boards for the 690V operating voltage**.

Selection of the supply voltage is only performed on the 500V power board.

Supply voltage selection (100V to 500V)

The nominal line-to-line voltage (specified when ordering) is configured by the position of **jumpers JP1 to JP6 and by the type of auxiliary power supply transformers**. Three types of transformer are used (see Table 4-1 below).

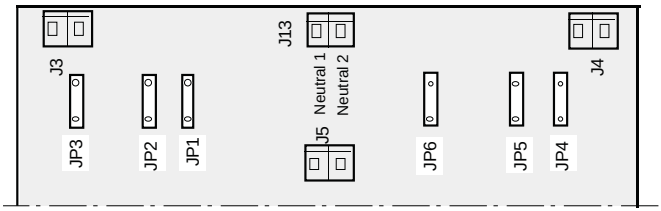


Figure 4-1 Location of jumpers on power board (100V to 500V)

Line-to-line voltage	Jumpers 0 = absent; 1=present			Transformer reference number
	JP1 JP4	JP2 JP5	JP3 JP6	
100V	0	0	1	CO 174973
110V to 120V	0	0	1	CO 174544
127V	0	0	1	CO 174613
200V	0	1	0	CO 174973
220V to 240V	0	1	0	CO 174544
277V	0	1	0	CO 174613
380V to 415V	1	0	0	CO 174544
440V	1	0	0	CO 174973
480V to 500V	1	0	0	CO 174613

Table 4-1 Voltage configuration (100V to 500V)

Warning!

The voltage given in the table above must be greater than or equal to the line-to-line supply voltage.

As shipped from the factory, the voltage is configured according to the product code on the identification label of the controller.

DRIVER BOARD

The jumpers on the driver board are used to configure the thyristor firing mode, the input signals, the rms option, and the frequency of the supply used.

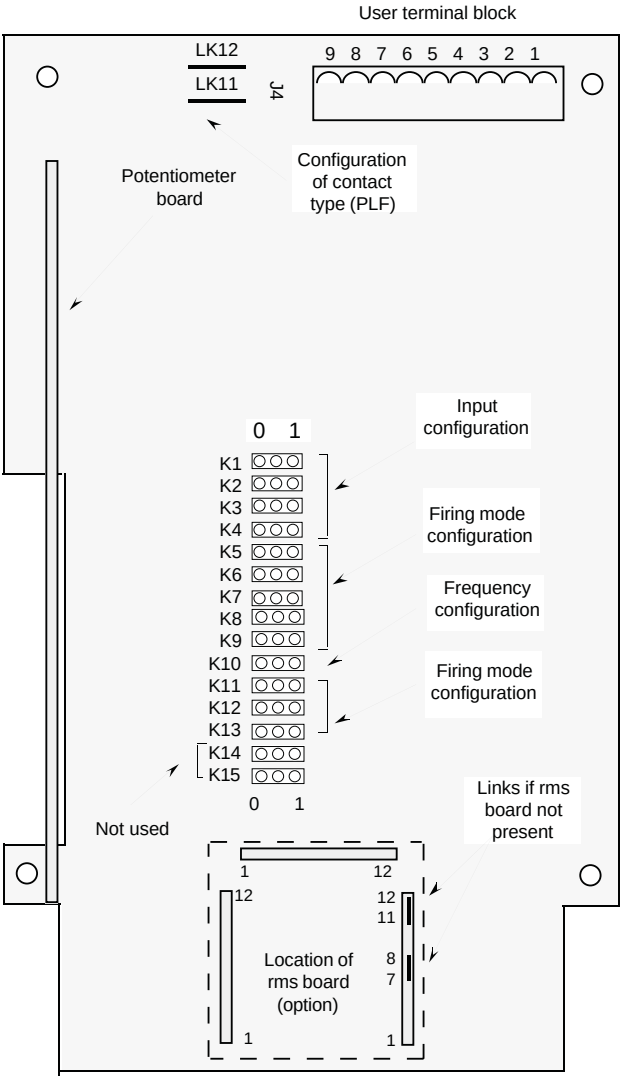


Figure 4-2 Location of configuration jumpers on driver board

Input signal

Control signal type

The specifications for control signals are given in Table 4-2.

Input	Control signal		Input impedance
	Lower threshold (0%)	Upper threshold (100%)	
0-5V	0.2V	4.2V	50kΩ
1-5V	1.16V	4.36V	
0-10V	0.4V	8.4V	
2-10V	3.3V	8.7V	
0-20mA	0.8mA	16.8mA	250Ω
4-20mA	4.6mA	17.4mA	

Table 4-2 Control signal specifications

Input configuration

The input signal may be configured with a selection of four voltage levels and two current levels. Jumpers K5 to K10 are used for this configuration.

Control	Input level	Jumper position			
		K1	K2	K3	K4
External	0-5V	0	0	0	0
	1-5V	1	0	0	0
	0-10V	0	1	0	0
	2-10V	1	1	1	0
	0-20mA	0	0	0	1
	4-20mA	1	0	0	1
Manual	0-10V	0	1	0	0

Table 4-3 TC1028 unit input configuration

Thyristor firing mode

The firing modes available for the power controllers may be configured using jumpers K5 to K9 and K11 to K13 located on the driver board.

Thyristor firing mode	Jumper position							
	K5	K6	K7	K8	K9	K11	K12	K13
Phase angle	0	0	0	0	0	0	0	0
Single-cycle	1	0	0	1	0	0	1	1
Fast cycle burst-firing	1	1	0	1	0	0	1	1
Fast cycle burst-firing with soft start	1	1	1	1	0	0	1	1
Fast cycle burst-firing with soft start and end	1	1	1	0	0	0	1	1
Slow cycle burst-firing	1	1	0	1	1	-	-	-
Slow cycle burst-firing with soft start	1	1	1	1	1	-	-	-
Slow cycle burst-firing with soft start and end	1	1	1	0	1	-	-	-

Table 4-4 Thyristor firing mode configuration

Note:

Jumpers K11 to K13 are used to select filter characteristics for the RMS current measurement (RMS option).

(-) in Table 4-4 indicates that operation is indifferent to position of jumpers (‘don’t care’).

Retransmission of RMS current (option)

Retransmission of the load current RMS value is achieved (except for ‘slow cycle’ burst-firing mode) by installing the ‘RMS option board’ on the driver board at the factory (see Figure 4-2).

This board is installed using three groups of pins labelled 1 to 12.

If the RMS option board has not been fitted (thus the current retransmission and bargraph display use instantaneous values), **pins 11 & 12 and pins 7 & 8 must be short-circuited** using the jumpers provided (see Figure 4-2).

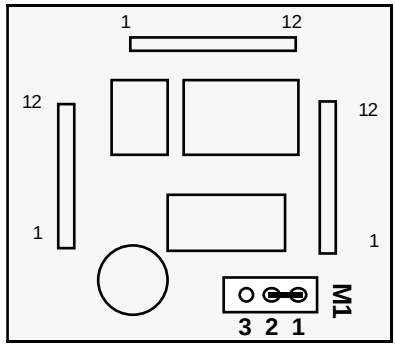


Figure 4-3 RMS option board

With the RMS option, jumper M1 on the RMS option board must be in position 1-2, as shown in Figure 4-3.

Frequency

In the standard version, the operating frequency of the TC1028 is 50Hz.

As an option (code 60H) the frequency is 60Hz.

The value of the frequency used is configured by means of jumper K10 on the driver board.

Frequency	Position of K10 jumper
50Hz	1
60Hz (option)	0

Table 4-5 Frequency configuration for supply used

PLF alarm relay contact type

The **PLF alarm relay** is de-energised in the alarm state and when the power supply is cut.

In the standard version, the relay contacts provided between **terminals 51 & 52 are open in the alarm state**.

In the **IPF option**, the relay **contacts are closed in the alarm state**.

Configuration of the contact type is done at the factory, depending on the product code ordered.

Soldered links LK11 & LK12 on the driver board are used to configure the contact type. The location of links LK11 & LK12 is given in Figure 4-2.

Contact type	Configuration links	
	LK11	LK12
Open in alarm state (standard)	Cut	Soldered
Closed in alarm state (option)	Soldered	Cut

Table 4-6 Configuration of alarm relay contact type

Chapter 5

OPERATION

Contents **Page**

Chapter 5 OPERATION

THYRISTOR FIRING MODES

General

The TC1028 series of power controllers have the following thyristor firing modes:

- Phase angle
- Single-cycle
- 'Fast cycle' burst-firing (modulation period at 50% power: 0.8s)
- 'Slow cycle' burst-firing (modulation period at 50% power: 8s)
- 'Fast cycle' burst-firing with soft start and end, adjustable between 0 and 250ms
- 'Slow cycle' burst-firing with soft start and end, adjustable between 0 and 250ms

They may be re-configured by the user (refer to Chapter 4 'Configuration').

'Phase angle' mode

In 'Phase angle' mode the power transmitted to the load is controlled by firing the thyristors for a part of each half-cycle of the supply voltage (see Figure 5-1).

The firing angle (Θ) is varied in the same sense as the power demand by the control system. The power delivered is not a linear function of the firing angle.

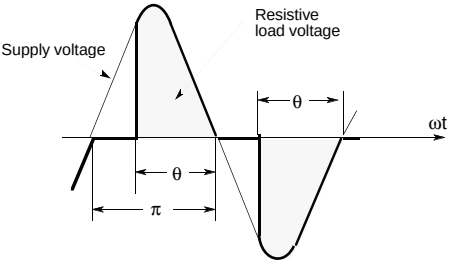


Figure 5-1 'Phase angle' firing mode

‘Burst-firing’ mode

‘Burst-firing’ mode is a duty cycle mode which consists of supplying a series of complete mains voltage cycles to the load.

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

This type of firing eliminates steep rates of voltage applied to the load, minimises interference to the supply network and, above all, avoids generating radio frequency interference (RFI).

In ‘Burst-firing’ mode, the power delivered to the load depends on firing cycles T_F and non-firing cycles T_{NF}. The load power is proportional to the firing rate (t) and is defined by the ratio of the thyristor firing cycle T_F and the modulation period ($T_M = T_F + T_{NF}$).

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

$$t = \frac{TF}{T_F + T_{NF}}$$

The load power can be expressed by:

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

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

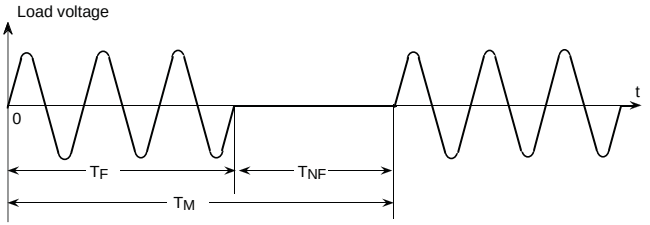


Figure 5-2 Periods of a Burst-firing cycle

‘Single-cycle’ mode

The ‘Burst-firing’ mode with a single cycle of firing or non-firing, is called ‘Single-cycle’.

Modulation period

The modulation period in ‘Burst-firing’ mode is variable according to the output power demanded by the feedback. As a result of this type of control function, the TC1028 offers precision adjustment which adapts to each particular setpoint zone.

- At 50% power, the typical value of the modulation period is 0.8s for ‘fast cycle’ burst-firing and 8s for ‘slow cycle’.
- For a zone less than 50% of the maximum setpoint, the firing cycle is decreased and the modulation period increased
- For a power zone greater than 50%, the non-firing cycle is decreased with the increase in the modulation period.

For example in ‘fast cycle’ burst-firing:

- For 5% power, T_F = 0.25 s, TM = 5s
- For 90% power, T_F = 2.25s, TM = 2.5s

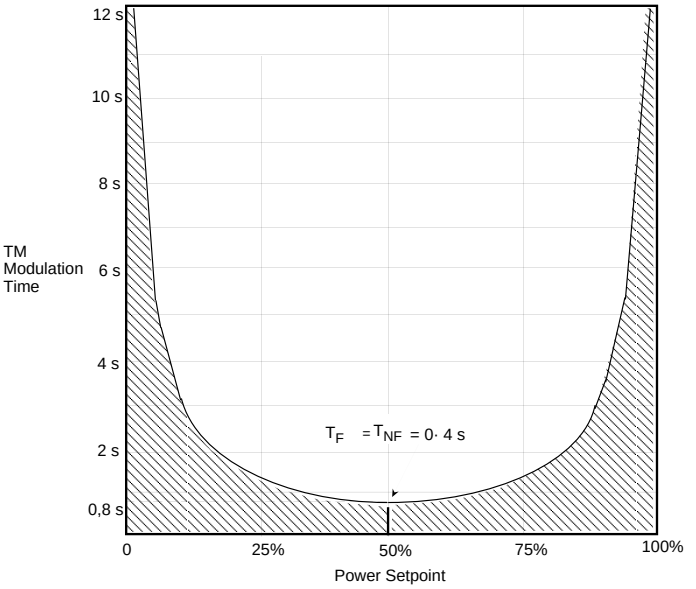


Figure 5-3 Modulation period as a function of power (‘fast cycle’ burst-firing)

Soft start / end

Soft operation (start or start & end) may be configured in both the ‘slow’ and ‘fast’ cycle burst-firing modes.

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

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

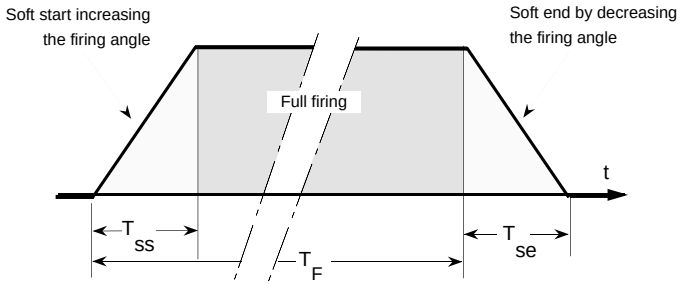


Figure 5-4 Soft start and end in burst-firing mode

The soft end time (T_{se}) is not included in the firing cycle (T_F), but all the power delivered to the load is taken into account in the feedback.

After soft starting by varying the thyristor firing angle, the unit remains in full conduction during the firing time.

Note:

For soft starts of loads with very large resistance variation (for example, **Kanthal Super**) use the **TC1028 Special 603**.

Overcurrent elimination for inductive loads

'Fast' and 'slow' cycle burst-firing modes, composed of whole cycles, start at zero voltage for loads which are purely resistive.

For an inductive load, firing at zero voltage creates transient overcurrents (Figure 5-5, a), which could, in certain cases, cause saturation of a magnetic circuit and a blow-out of the high-speed thyristor protection fuse.

Non-saturable inductive load, (for example, an inductor)

To avoid overcurrent, the initial firing of the thyristors can be delayed with reference to the zero crossing (Figure 5-5, b).

The delay angle (ϕ) should be adjusted using the 'Delay / Retard' potentiometer on the front panel (see Commissioning section) for optimum load conditions.

Saturable inductive load, (for example, transformer primary)

To avoid overcurrents, use the '**Phase angle**' firing mode or '**Burst-firing with slow start**'.

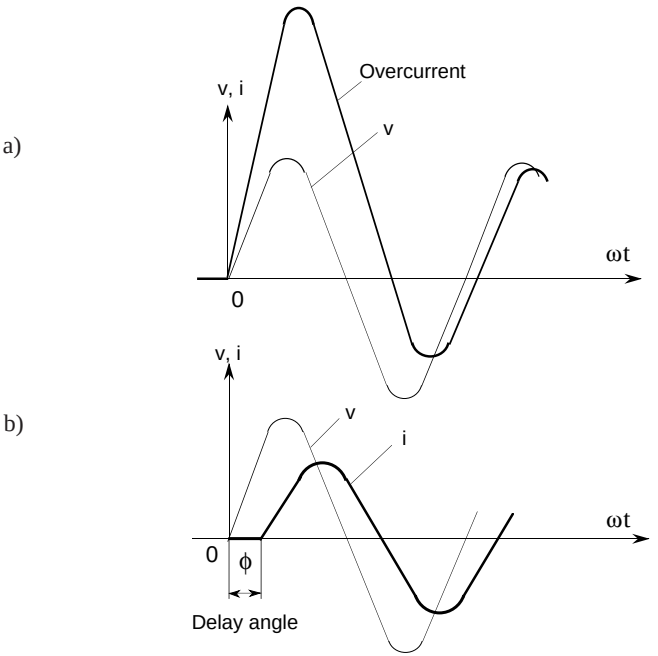


Figure 5-5 Inductive load switching at zero voltage a) and with delay angle b)

CONTROL OPERATION

Feedback function

TC1028 series thyristor units include an internal control loop. The output power of the controller is **linear between 0% and 100% of maximum voltage for an input signal varying between 4% and 84% of full scale.**

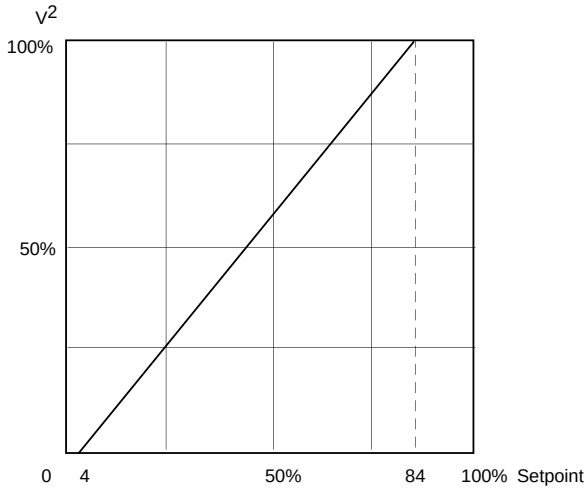


Figure 5-6 Controlled parameter as a function of setpoint

The square of the RMS load voltage represents the power dissipated in a purely resistive load the value of which is constant with temperature. The accuracy of the power control function is guaranteed to ±2% of the maximum voltage.

The feedback system automatically selects the greater of the two values (V^2 or I^2).

For loads with a small resistance variation as a function of temperature (iron alloys, nickel, chrome, aluminium, Inconel, etc.) feedback by **V^2 is sufficient.**

Feedback having **automatic transfer between the two measured values** is very important for loads with a **large resistance variation** as a function of temperature (molybdenum, molybdenum disilicide, tungsten, platinum, etc.). For this type of load, operation is as follows:

- I^2 feedback at start, when cold
- automatic changeover to V2 feedback when hot,
  which gives optimum control and feedback at all temperatures.

Compensation for supply voltage variations

Compensation for variations in supply voltage acts in the range: **+10% to -15% of the nominal voltage**. This voltage is self-supplied on the power and reference phases.

Without compensation for supply voltage variations, a 10% increase or decrease in the supply voltage would lead to a 20% increase or decrease in the power supplied to the controller load.

For a constant resistive load, feedback with compensation for supply variations enables the output power to be kept constant despite variations in the supply voltage.

Range of variation in supply voltage %	Setpoint (%)	Power supplied (%)	
		With compensation	Without compensation
0 to +10	100	100	100 to 121
-5 to +10	90	90	81 to 109
-10 to +10	80	80	65 to 97
-15 to +10	70	70	50 to 85

Table 5-1 Control operation with compensation for supply voltage variation

Table 5-1 demonstrates stabilisation of the output power on a constant resistance load, as a function of supply variations.

If the voltage drops below **80%** of its nominal value, the controller will be **inhibited**.

A compensation circuit simultaneously adjusts thyristor firing time depending on supply variations. This compensation action prevents power fluctuations without the intervention of the control loop, enabling a faster response.

Selective blocking of trigger pulses

Thyristors in the TC1028 controller are triggered by a **pulse train of 5ms maximum duration**.

To reduce the cost of the electronics, in most single-phase applications it is possible to send trigger pulses every 10ms so that the thyristors are polarised in direct mode (positive anode in relation to the cathode) or in inverse mode (negative anode).

Each thyristor will only fire when its voltage is positive; when it is negative the anti-parallel thyristor will fire.

In certain applications, trigger pulses on the inverse-polarised thyristor may lead to operating problems: firing instability, fuse blowing.

It is therefore very important to eliminate trigger pulses when the thyristor is inverse-polarised.

This function is performed by the selective trigger pulse blocking circuit available for TC1028 units.

Selective blocking of trigger pulses is essential for configurations in which multiple controllers are distributed between the phases of a three-phase supply and have an electrical configuration which could induce a voltage phase shift.

For example:

- control of heating electrodes (in transformer secondary) immersed in the same pool of molten glass.
- load in star with neutral, with the central point of the star connected to the supply neutral by a conductor of significant resistance compared with that of the load.

CURRENT LIMIT

TC1028 thyristor units have two types of current limit using the load current measurement:

- a **linear** current limit and
- a **threshold** current limit.

These two limits are independent.

Linear current limit

This function limits the RMS load current squared (I^2).

In current limit, the relationship between the load current and the input signal is adjusted using the potentiometer labelled '**I Limit / Limit I**' on the front panel.

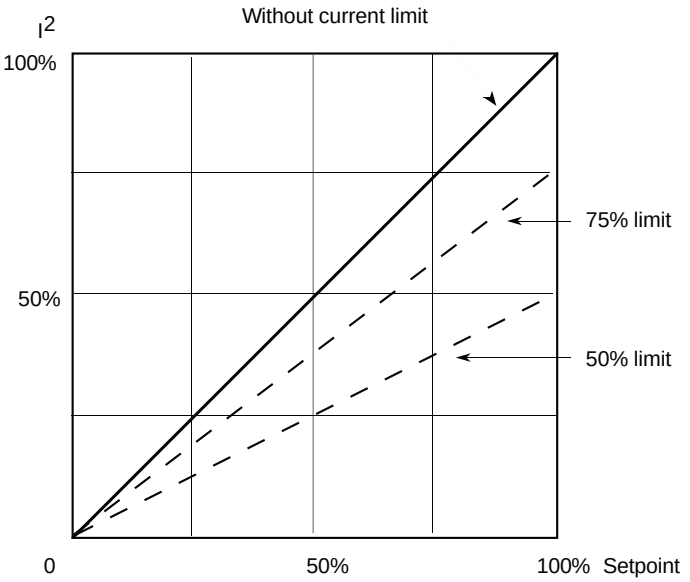


Figure 5-7 Linear current limit

Power feedback in $\mathbf{V^2}$ and current limit in $\mathbf{I^2}$ provide the best performance in all the feedback zones.

Threshold current limit

This type of limit is used to **limit the load current to a desired value, independent of the input signal and the linear current limit**.

The '**Threshold limit**' input (terminal 5 on the control terminal block) may be controlled:

- using an external potentiometer
- by a 0 to 10V external DC voltage.

Warning!

When the threshold limit (by potentiometer or by voltage) is not used, terminal 5 on the driver board user terminal block must be directly connected to the +10V user voltage (terminal 2). This limits the current to 110% of nominal. Otherwise the threshold current limit is at zero and the controller cannot deliver current.

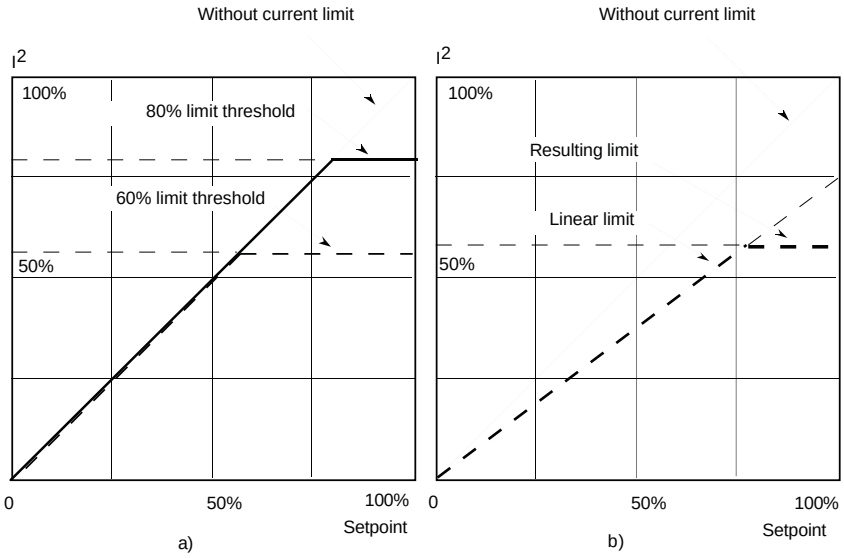


Figure 5-8 a) Threshold current limit only. b) Threshold **and** linear current limit

PARTIAL LOAD FAILURE DETECTION

The 'partial load failure' (PLF) alarm detects an increase in the load impedance due, for example, to the failure of heating elements.

The sensitivity of the PLF circuit enables the user to detect a 20% increase in load impedance. This will detect the failure of one in five identical elements connected in parallel.

The alarm is indicated:

- by an indicator light mounted on the front panel and labelled 'Load fail' (illuminates when a partial load failure is detected)
- by the alarm relay contacts (contact output is available on terminals 51 and 52 on the user terminal block at the bottom left hand side of the unit).

The alarm relay is **energised** when **not in the alarm state** if the unit is powered.

In the standard version, the **alarm contacts** (breaking capacity 0.25A at 250 Vac or 30 Vdc) are **open in the alarm state** or in the event of a supply failure.

In the **IPF option**. The contacts are **closed in the alarm state**.

The PLF alarm relay contact output is suitable for controlling an alarm unit.

The **PLF alarm** relay is **reset** either by switching off or by returning to the nominal current.

RETRANSMISSION

TC1028 thyristors are able to retransmit load current and voltage measurements which are available on the control terminal block. Also there is a a bargraph display of current on the front panel.

Retransmission signal

Load current measurement

The ‘Load current’ retransmission is available between terminals 4 (‘Load I O/P’) and 1 (‘0V’).

It can be used for tests or external measurement.

In the **standard version, the full-wave rectified output signal is directly proportional to the instantaneous load current** (4.8V mean for the nominal controller current in full conduction).

As an option (RMS option board), the 0 - 10 V retransmission signal is proportional to the RMS load current. The value of this signal is 10 V for the nominal controller current.

Retransmission of the RMS load current values is correct only for ‘Phase angle’, ‘Single-cycle’ and the various ‘Fast cycle’ firing modes.

Load voltage measurement

The ‘Load voltage’ retransmission output is available between terminals 3 (‘Load V O/P’) and 1 (‘0V’) on the driver board user terminal output.

In the standard version and in the RMS option, this output is a full-wave rectified signal (5V rms, 4.3V mean) representative of the load voltage in full conduction, produced using the **auxiliary power supply**.

Bargraph display

The 10-segment bargraph on the front panel displays the load current with a resolution of 10% of the nominal load current as follows:

- in standard version : instantaneous load current
- in RMS option : RMS value of load current (in ‘Phase angle’, ‘Single-cycle’ and ‘Fast cycle’ firing modes with or without soft start / end).

ENABLE / INHIBIT

TC1028 thyristors have active ‘ENABLE’ for allowing operation, requiring a 10V DC to be applied to terminal 9.

If the enable voltage is absent, operation is inhibited which means that the thyristors are unable to fire, irrespective of the input signal.

The thyristor is **enabled** when a **+10V DC** voltage is applied to **terminal 9** (4V min, 32V max.) **with reference to terminal 1** (see Figure 3-7 on page 3-12).

To enable the controller, a connection (via normally closed contacts) between the ‘Enable’ terminal and the ‘+10V user’ voltage (terminal 2) may be used.

Opening these contacts will inhibit the controller.

‘MASTER / SLAVE’ OPERATION

A logic signal (10Vdc, 10mA) is available on the ‘Slave’ output: between terminals 8 (‘Slave’) and 1 (0V) when the TC1028 controller is firing in slow cycle, fast cycle or single-cycle ‘Firing’ modes.

The ‘Slave’ output is used to control external solid state relays.

By using this logic signal output, it is possible to implement ‘Master-Slave’ operation with a TC1028 (‘Master’) controlling one or more TC1027 series solid state relays (‘Slaves’) for both single-phase and three-phase loads (see Chapter 3 ‘Wiring’).

Chapter 6

COMMISSIONING PROCEDURE

Contents **Page**

Chapter 6 COMMISSIONING PROCEDURE

Read this chapter carefully before commissioning the controller

COMMISSIONING PROCEDURE - SAFETY

Warning!

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

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

Danger!

Live parts may be exposed when the door is open.

Only personnel qualified and trained to work with low voltage electrical equipment in an industrial environment should have access to the interior of the unit.

Access to internal components of the controller is prohibited to users who are not authorised to work in an industrial low voltage electrical environment.

The temperature of the heatsink may exceed 100°C.

Avoid all contact, even occasional, with the heatsink when the unit is operational. The heatsink remains hot for around 15mins after the unit has been switched off.

CHECKING THE CHARACTERISTICS

Warning!

Before powering up the unit, make sure that the identification code complies with the product code specified when ordering and that the characteristics 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 unit, taking into account load and power supply variations.

In three-phase operation, if three identical loads are configured in **closed delta, the line current** of the controller (both 'Master' & 'Slave') **is √3 times greater than the current in each branch of the load**.

Supply voltage

The nominal value of the TC1028 voltage must be greater than or equal to the line-to-line voltage.

Danger!

Never use a thyristor with a supply voltage greater than the nominal voltage specified in the product code

If the line voltage is **less than 80% of the nominal voltage**, the thyristor is **inhibited**.

The **unit is re-enabled automatically** if the voltage returns to a value greater than or equal to 80% of the nominal value.

Warning!

It is essential that the nominal voltage of the controller should be as close as possible to the supply voltage, given that inhibition occurs at 80% of nominal voltage.

Reference voltage

The **reference voltage** for the electronics (second phase or neutral, depending on the supply wiring) **must correspond to the power voltage**.

Selection of this voltage is made using the jumpers and by the choice of transformer on the power board.

Transformers for the **electronics power supply are selected at the factory** as specified by the voltage code (see 'Configuration' chapter, page 4-3).

Input signals

Jumper settings on the driver board must be compatible with the signal chosen for control (see page 4-5).

Partial load failure detection

The voltage used for the partial load failure detection circuit is that of the reference phase / neutral.

Check that this voltage corresponds to the power voltage.

Check that the PLF alarm relay contacts are connected to a signalling or alarm circuit energised by 230V or less (single-phase or three-phase 230V supply).

DIAGNOSTIC UNIT

To make adjustments and commissioning easier and to diagnose the state of the controller, it is advisable to use the **Eurotherm type 260** diagnostic unit.

Provided with a 20-way switch, the diagnostic unit is used to view controller values and feedback parameters on a digital display. The unit shows two decimal places to give a precise reading of the selected values.

The diagnostic unit has a ribbon cable which plugs into the 20-pin connector (diagnostic connector) provided on the front panel of the controller.

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

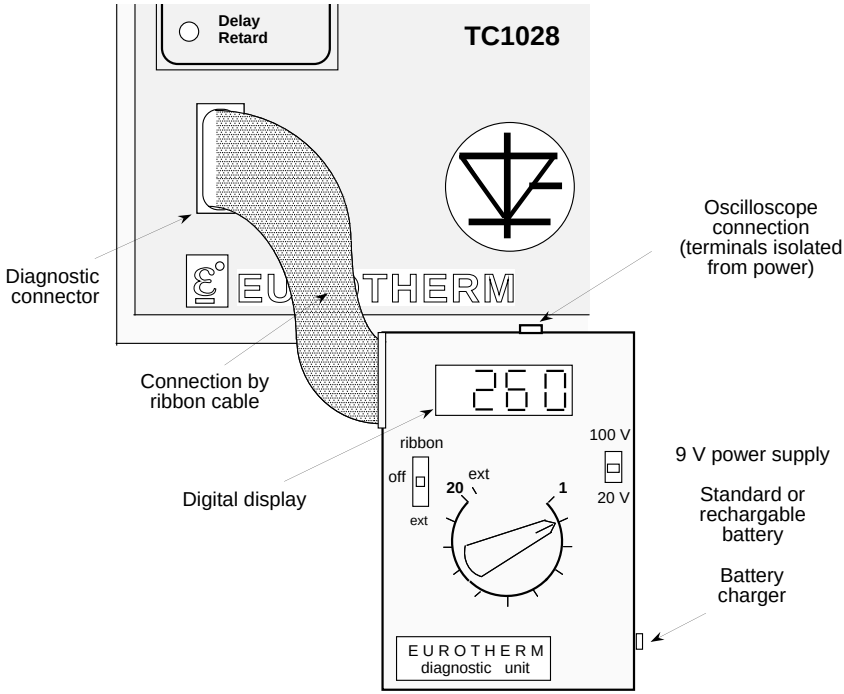


Figure 6-1 Connection of the EUROTHERM type 260 diagnostic unit to the thyristor unit

The following tables give a description of each position of the diagnostic unit selector switch, together with typical values of the measured signals (**mean DC values**).

Position	Function	0% setpoint Θ = 0°	50% setpoint Θ = 90°	100% setpoint Θ = 180°
1	Current measurement (nominal load)	0V	2.5V	5V
2	Manual input (if used)	0V	2.5V	5V
3	PLF output: In alarm : Not in alarm	-12.6V +13.5V		
4	External setpoint Example: 0-10V	0V	5V	10V
5	Threshold limit (max)	approx. 10V		
6	Current measurement for PLF	0V	-2.5V	-4.6V
7	Load voltage measurement	0V	2.25V	4.3V
8	Amplified setpoint	0V	-2.5V	-5V
9	'Slave' output	not used		
10	Firing demand	0V mean 1V peak	8.4V	12.7V
11	'+10V' reference	10V ±0.1V		
12	-24V full-wave recified	-20V		
13	Pulse output	20V no pulses	20V pulses	20V pulses
14	'-15' power supply	-15V ±0.15V		
15	Oscillator input	0V	1.2V, 6.4V peak 90° pulses	1.2V,6.4V peak 90° pulses
16	'15V' power supply	+15V±0.15V		
17	'0' voltage crossing pulse	-10.5V ±12V peak, 0.5ms		
18	0V	0V		
19	Saw-tooth generator	3.6V 8.4V peak, 10ms		
20	Enable	<-10V		

Table 6-1 Description of positions on Eurotherm type 260 diagnostic unit

Thyristor firing angle variation (Θ)

Position	Function	0% setpoint	50% setpoint	100% setpoint
1	Current measurement (nominal load)	0V	Modulation 2.5V	5V
2	Manual input (if used)	0V	2.5V	5V
3	PLF output: In alarm : Not in alarm	-12.6V +13.5V		
4	External setpoint Example: 0-5V	0V	2.5V	5V
5	Threshold limit (max)	approx. 10V		
6	Current measurement for PLF	0V	Modulation 0 to -4.6V	-4.6V
7	Load voltage measurement	0V	Modulation 0 to 4.3V	4.3V
8	Amplified setpoint	0V	-2.5V	-5V
9	'Slave' output	0V	Modulation 0 - 13.5V	10.2V (0-13.5V)
10	Firing demand	0V mean 1V peak	6.25V 12.5V peak	12.5V
11	'+10V' reference	10V ±0.1V		
12	-24V full-wave recified	-20V		
13	Pulse output	20V no pulses	26V pulses	26V pulses
14	'-15' power supply	-15V ±0.15V		
15	Oscillator input	0V	6.4V peak	1.2V 6.4V peak
16	'+15V' power supply	+15V±0.15V		
17	'0' voltage crossing pulse	-10.5V ±12V peak, 0.5ms		
18	0V	0V		
19	Saw-tooth generator	3.6V 8V peak, 10ms		
20	Enable	<-10V		

Table 6-2 Description of positions on Eurotherm type 260 diagnostic unit

Fast cycle burst-firing and Single-cycle

PRELIMINARY ADJUSTMENTS

Preliminary adjustments are made to adapt the thyristor firing to suit the type of load:

- first thyristor firing in 'Burst firing' mode

- duration of the soft start ramp in 'Phase Angle' firing mode

- For resistive loads with **low resistance variation**, thyristor firing is at **zero voltage**. This prevents steep rates of change of voltage, thus minimising the electromagnetic interference produced.
- For resistive loads with **high resistance variation** and for **saturable inductive loads**, the '**Burst-firing with soft start**' operation reduces the current requirement and thus prevents fuse blowing or saturation of magnetic systems. The duration of the start ramp may be adjusted between 0 and 250ms.
- For **non-saturable inductive loads**, **delayed first firing** eliminates transient overcurrents in 'Burst-firing' (see 'Operation', Chapter 5).

  This delay may be adjusted between 0° and 90° and only acts on the first half-cycle of each burst.

Preliminary adjustments are made using the 12-turn potentiometer labelled 'Delay/Retard' on the front panel.

The effect of the 'Delay/Retard' potentiometer depends on the thyristor firing mode.

Thyristor firing mode	Effect of adjustment potentiometer
Phase angle	No effect
Single-cycle Fast cycle Burst-firing Slow cycle Burst-firing	Delay of first thyristor firing at the start of each firing cycle (0 to 90°)
Burst-firing with soft start	Duration of soft start in thyristor firing angle variation (0 to 250ms)
Burst-firing with soft start and end	Duration of soft start and end in thyristor firing angle variation (0 to 250ms)

Table 6-3 Effect of 'Delay/Retard' potentiometer

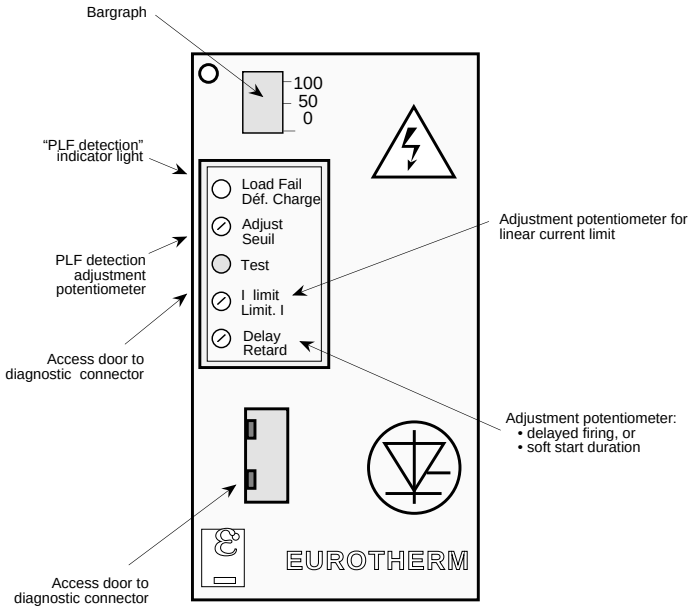


Figure 6-2 Front panel of TC1028 controller - location of adjustment potentiometers

Factory settings

As shipped from the factory the controller is pre-set with a firing mode configured.

Thyristor firing mode	Position of 'Delay/Retard' potentiometer
Fast cycle Burst-firing	Completely clockwise
Slow cycle Burst-firing	Zero voltage switching; Firing delay = 0°
Soft start or soft start and end	Completely anti-clockwise Maximum ramp 250ms
Phase angle	No effect

Table 6-4 Factory settings

Resistive load with low resistance variation with temperature

For loads with a **low temperature coefficient**, use '**Single-cycle**' or '**Burst-firing**' modes. This type of load **does not require** either **delayed firing** or **soft start**.

- Turn the 'Delay/Retard' potentiometer on the front panel completely **clockwise** (the ramp duration is zero).
- Power up the controller.
- On the external input ('Auto Input', terminal 7 on the control terminal block) apply a signal corresponding to 0%.
  Using an RMS ammeter check that there is no load current.
- On the external input ('Auto Input', terminal 7) or manual input ('Manual input', terminal 6) apply a signal corresponding to 100% of the control signal.
  Using an RMS ammeter check that the current is equal to the nominal load current and that it does not exceed the nominal thyristor unit current.

Resistive load with high resistance variation with temperature

For loads with a **high temperature coefficient**, use the following firing modes:

- '**Phase angle**' **with current limit**, or
- '**Burst-firing with soft start**'.

The soft start (or start and end) ramp may be adjusted from 0 to 250ms.

- Make sure that the 'Delay/Retard' potentiometer on the front panel is turned completely **anti-clockwise** (the ramp duration is maximum).
- Power up the controller.
- On the external input ('Auto Input', terminal 7 on the control terminal block) apply a signal corresponding to 0%.
  Using an RMS ammeter check that there is no load current.
- On the external input ('Auto Input', terminal 7) or manual input ('Manual input', terminal 6) apply a signal corresponding to 100% of the control signal.
  Using an oscilloscope or the bargraph on the front panel, check that the overcurrent at the start does not exceed the values permitted by the load and the thyristor unit.

When controlling a load with a very large temperature coefficient (Kanthal Super, for example) in 'Burst-firing with soft start' mode, use the TC1028 in Special 603 mode (on request).

Non-saturable inductive load

When the load includes a non-saturable inductive component (inductor, for example), firing at zero voltage in 'Burst' mode produces a transient overcurrent at the start of each burst (see Chapter 5 'Operation').

Transient overcurrents may cause safety systems to trip and, in some cases, high-speed thyristor protection fuses to blow.

To prevent these overcurrents at the start of each burst, the first thyristor firing must be delayed relative to the corresponding zero voltage.

Depending on the load, the optimum delay angle for thyristor firing must be adjusted by the 'Delay/Retard' adjustment potentiometer.

For this adjustment:

- Make sure that the '**Delay/Retard**' potentiometer is turned **completely anti-clockwise** (90°delay).
- **Apply a control signal** corresponding to approximately **20%** of the maximum setpoint.
- Turn the '**Delay/Retard**' potentiometer **clockwise** to obtain the **minimum peak current** (displayed by bargraph without RMS option) or the minimum overcurrent (visible on the screen of an oscilloscope) at the start of each burst.

Saturable inductive load

When controlling a saturable inductive load (transformer primary, for example) transient overcurrents are limited by reducing the thyristor firing angle.

Transformer primary with small temperature coefficient resistive load:

Use the 'Phase angle' or 'Burst-firing with soft start' firing modes;

the 'Delay/Retard' potentiometer is adjusted as for loads with a large resistance variation (see previous page).

Transformer primary with large temperature coefficient resistive load:

Use the 'Phase angle' or 'Burst-firing with soft start' firing modes and the TC1028 Special 603 version;

the 'Delay/Retard' potentiometer is adjusted as for loads with a large resistance variation (see previous page).

PARTIAL LOAD FAILURE DETECTION ADJUSTMENT

Partial load failure detection (**PLF**) is adjusted using the **potentiometer marked 'Adjust/Seuil'** on the front panel (see Figure 6-2).

The purpose of this is to adjust the PLF detection sensitivity to match the actual load of the thyristor unit.

To guarantee correct operation of the PLF detection circuit, **the load current must not be less than 10% of the nominal current** (when using a bulb as a load in a thyristor test, the load fail indicator will always be illuminated).

When commissioning it is essential to make the following adjustment:

- First make sure that the controller is connected correctly and that the **thyristors are permanently on.**
- Turn the **PLF detection adjustment potentiometer** completely **anti-clockwise** and check that the 'Load Fail' indicator light on the front panel is **off**.
- Turn the **'Adjust/Seuil' potentiometer slowly clockwise** until the indicator light is **on**.
- Turn the potentiometer slowly **anti-clockwise until** the 'Load Fail' light has just gone **off**.

Adjusted in this way, the potentiometer is used to obtain maximum sensitivity in detecting partial load failure for a specific load.

The pushbutton on the front panel (marked 'Test'), which simulates a current drop of 10% in the load, is used to check that the PLF circuit is operating correctly without having to disconnect the load. This button will put the thyristor unit into the alarm state, if the adjustment has been performed correctly.

Reminder:

The PLF detection circuit does not use the load voltage, but the reference voltage.

CURRENT LIMIT ADJUSTMENT

Linear limit

The **linear current limit** is adjusted by the **'I limit/Limit. I' potentiometer** on the front panel.

- **Make sure the load is connected.**
  If using in conjunction with the threshold current limit (potentiometer or external signal), first make sure that the 'Threshold limit' setpoint (terminal 5 'I Limit input' on the control terminal block) is **set to its maximum value**.
- Turn the '**I limit/Limit. I**' linear current limit potentiometer completely **anti-clockwise** (minimum current).
- Apply a 0V signal to the input and connect the power voltage.
  The RMS voltage at the load terminals should be zero.
- Increase the input signal to 100%.
  The load voltage must represent approximately 15% of the supply voltage.
- Turn the current limit potentiometer gradually clockwise and check that the load current slowly increases.

Adjust the 'I limit/Limit. I' potentiometer in order to obtain the maximum current permitted for the load.

Warning!

To adjust current limit, use only a true RMS-reading ammeter to measure load current. This avoids the risk of errors which could reach 50%.

For a three-phase installation using two or three TC1028 controllers, take care to turn each of the current limit potentiometers gradually in succession in order to maintain the current balance in each of the phases.

Warning!

When controllers are configured in '**Star with neutral**', the **neutral current** for a large temperature coefficient load, when starting from cold, **can be 1.7 times greater than the phase currents** limited by the current limit.

As a consequence, check the design of the installation.

Threshold limit

Threshold current limit is independent of the control signal, it is:

- either **110% of the nominal current**
  (terminal 5 of the control terminal block directly connected to terminal 2; 10V),
- or controlled by an **external potentiometer** of approximately 5kΩ connected between terminal 2 (+10V) and terminal 1 (0V); the wiper is connected to terminal 5,
- or controlled by an external **DC voltage** (0 to 10 V).

The threshold 'I limit' input impedance (terminal 5) is greater than or equal to 150kΩ. To adjust the threshold current limit:

- After adjusting the linear limit (using the potentiometer on the front panel), switch on the controller, set the control to maximum.

  Reduce the 'Threshold current limit' setpoint gradually until the current begins to decrease.
- Record the above current limit setpoint read from the diagnostic unit in position 5, then increase it by approximately 10% so that the limit acts only as a back-up (safety measure) for the linear current limit.

Warning!

The threshold current limit can be pre-adjusted when a controller is switched on but not firing.

The value of the RMS load current squared is proportional to the 'Threshold current limit' setpoint displayed in position 5 of the diagnostic unit.

Current limit signal (position 5 on diagnostic unit)	I_{RMS}^2 (%)	I_{RMS} (%)
10V	120	110
9.1V	100	100
4.1V	50	71

Table 6-5 Example of threshold current limit

It is possible to use these two current limits simultaneously:

- to set an absolute current limit with the **threshold limit** and
- to adjust the **linear current limit** with the **potentiometer on the front panel**.

TROUBLESHOOTING

Symptom	Action
1. Thyristor does not fire when demanded.	1.1 Check that the **'Enable' input** (terminal 9 on the driver fire board is connected properly to '+10V' (terminal 2). 1.2 Check that the **control signal** is reaching the user terminal block on the driver board: • on terminal 7 with external control • on terminal 6 in manual control and that the polarity is correct. 1.3 Check that the input **signal level and type** are compatible with the level and type of signal configured. 1.4 Check the wiring of the **thermal switches** on the power board. 1.5 Check that thyristor **firing pulses are present**: • 20 V pulses for 'Phase angle' firing • 26 V pulses in 'Burst-firing' mode (in position 13 of the diagnostic unit). 1.6 Check that the **current limit** is not at zero (position 5 of the diagnostic unit) and that the setpoint is present (external input in position 4 or manual input in position 2). 1.7 Check that the **supply voltage** is greater than or equal to **80%** of the nominal. 1.8 Check that the **electronics are correctly powered** (+15V, -15V, & +10V voltages present).

Symptom	Action
2. In ‘Burst-firing’ mode transient overcurrent is too great when starting an inductive load.	2.1 Check that load cabling is correct. 2.2 Check the level of the oscillator input signal (position 15 of the diagnostic unit) is 6.4 V peak; to measure, use an oscilloscope). 2.3 **Check the adjustment of the ‘Delay/Retard’ potentiometer** on the controller front panel; if necessary, turn the potentiometer anti-clockwise. See under heading ‘Preliminary adjustments’, page 6-11.

If the fault persists after all of these checks, please contact your nearest EUROTHERM office, where qualified staff will be able to advise or assist you.

Chapter 7

MAINTENANCE

Contents **Page**

Chapter 7 MAINTENANCE

Danger!

The unit must be maintained by qualified personnel.

THYRISTOR PROTECTION

Thyristors in the TC1028 series of controllers are protected in the following way:

- an internal **high-speed fuse** against **overcurrents**
- an **RC snubber and MOV** (varistor) which protect against excessive **rate of change** of voltage and **transient overvoltages** when the thyristors are not conducting
- a **thermal switch** (if the heatsink **overheats**, the thermal switch opens, causing the thyristors to cease firing).

THYRISTOR PROTECTION FUSE

The standard version of the TC1028 series of power controllers is supplied with a high-speed fuse mounted on the line busbar.

Warning!

A high-speed fuse is used only for the internal protection of thyristors against large amplitude overloads.

Under no circumstances must this fuse be used to protect the installation.

Danger!

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

Table 7-1 contains all the references for the original internal fuses (as shipped from the factory) and the recommended replacement fuses which can be used during maintenance.

Maximum line-to-line voltage: **690 V**

Nominal current		Reference		
Controller (A)	Fuse (A)	EUROTHERM	FERRAZ	BUSSMAN
300	400	LA172486U400	H300065	170M5458
400	500	LA172468U500	K300067	170M5460
500	630	LA172468U630	M300069	170M5462

Table 7-1 Recommended high-speed fuses for thyristor protection

Warning!

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

FUSE-BLOWN INDICATION MICROSWITCH

As an option, the high-speed fuse can be fitted with a fuse-blown indication microswitch (FUMS option) with the reference:

for BUSSMANN fuses:

EUROTHERM DC172267 or FERRAZ P96015 or BUSSMANN 170H0069

for FERRAZ fuses:

EUROTHERM DC172997 or FERRAZ G310 000

To ensure better isolation between the wiring of the microswitch terminals, the power and the cover, TC1028 power controllers are supplied with 'flag' type cable lugs with insulating sleeves.

Each external terminal on the fuse-blown indication microswitch must be wired with a 'flag' lug fitted with an insulating sleeve to comply with Figure 7-1.

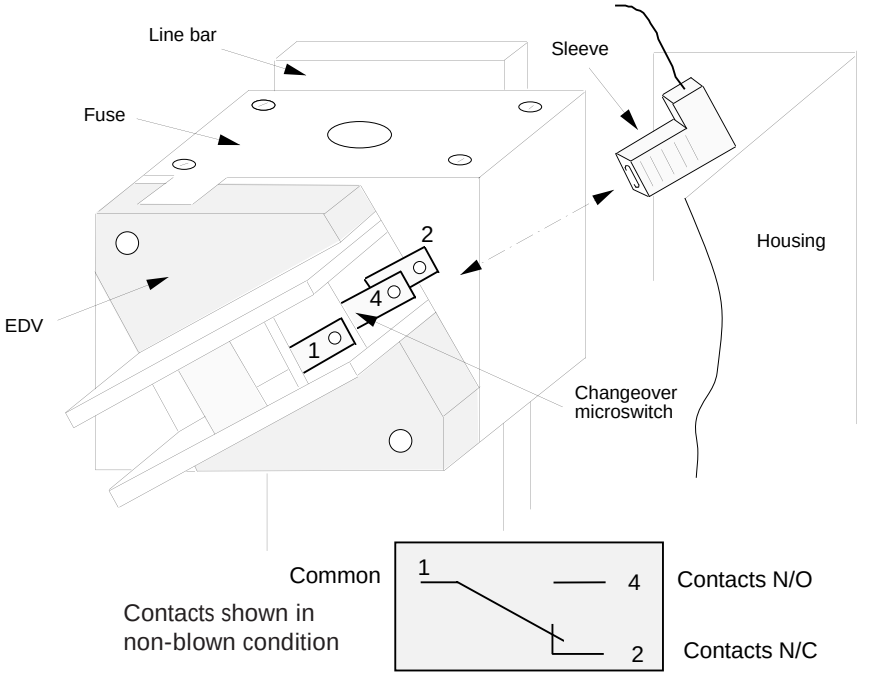


Figure 7-1 Use of 'flag' lugs and insulating sleeves to comply with electrical clearance distances

PROTECTION FUSES FOR REFERENCE VOLTAGE CONNECTION

These fuses must be installed in the connection wires of the reference voltage leading to the second phase if the controller is wired between two phases (see Chapter 3 'Wiring').

Reference voltage (max.)	1A fuse 6.3 x 32mm	Fuse holder isolator	Dimensions of 'fuse-isolator' assembly (mm)
500 V	CS174289U1A0	CP174293	63 x 15 x 52
690 V	CS174291U1A0	CP174293	63 x 15 x 52

Table 7-2 Recommended protection fuse for reference voltage connection

For the 'Fuse-isolator' assembly, order the fuse and fuseholder isolator separately using their respective part numbers.

SERVICING

TC1028 controllers must be mounted with the heatsink positioned vertically, with no obstructions above or below which could inhibit or impede airflow.

Warning!

If several units are mounted in the same cabinet, they must be arranged in such a way that air expelled from one cannot be drawn into the unit located above it.

In order to ensure correct cooling of the unit, it is advisable to clean the heatsink and the protective fan guard regularly, depending on the degree of environmental pollution.

Danger!

Every six months check that the screws of the power and safety earth cables are correctly tightened (see ‘Wiring’ page 3-3).

TOOLS

Task	Flat-blade screwdriver (mm)	Hex key/ wrench	Electrical apparatus
Mounting		Depending on M8 screw head style chosen	
Opening (closing) of front door		4mm HEX socket for M5 screw	
Safety earth connection		HEX 19 (M12)	
Power connection (supply-side) and thyristor fuse change		HEX 17 (M10)	
Load connection		HEX 19 (M12)	
Cable clamp tightening	0.5 x 3.5		
Control and reference voltage connection	0.5 x 3.5		
Board fixing	0.8 x 5.5	For M4 nut	
Commissioning and calibration	0.4 x 2.5		RMS ammeter or clip-on current probe. Eurotherm type 260 diagnostic unit recommended.

Table 7-3 Tools