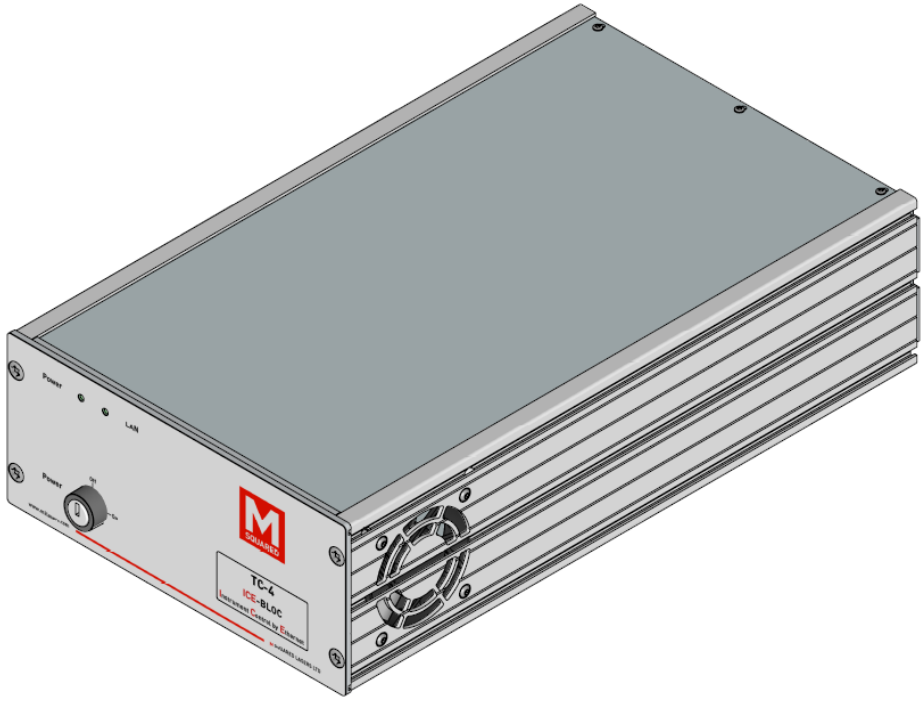
M Squared Lasers Ltd



TC-4 ICE-BLOC®

Temperature Controller
User Manual v2.1

Tools to Help You Lead, Not Follow™

Contents

A Preface

This manual is a guide to your TC-4 ICE-BLOC®. It contains important information that you will need for unpacking, installing, operating, maintaining and servicing your system correctly and safely.

It is strongly advised that you read this manual thoroughly before attempting to unpack or use your TC-4, to avoid taking actions that may damage your TC-4 or cause safety hazards.

If, after reading this manual, you are unsure about any aspect of your system, please contact M Squared Lasers Ltd, or your authorised representative, via the contact information listed in Section 8.

Thank you for your purchase of the TC-4.

B Warning Symbols

The following symbols are used in this manual to highlight procedures or situations that require extra attention:

 Danger!	**Danger!** Laser radiation is present.
 Danger!	**Danger!** Condition or action may present an electrical hazard to the user.
 Warning!	**Warning!** Condition or action may cause equipment damage, safety hazard, or poor performance.
 Caution!	**Caution!** Exercise particular care and/or refer to the manual before proceeding.
 Note!	**Note!** Text noting special circumstances or tips.

C Receiving & Unpacking the TC-4 ICE-BLOC

Note! Please keep all shipping containers. You may need these containers in the event that you need to provide evidence of shipping damage, or if you need to return the system for service or upgrade at some later date.

When you receive your system, please inspect the shipping containers immediately. If you discover any damage (holes or dents in the containers or crushing, for example) please notify the carrier immediately, and insist that a representative of the carrier be present to document the damage with you. Please also be sure to inspect each system component carefully for damage as it is removed from its protective packaging. If you find any damage to system components (dents or scratches in covers, for instance), document this damage, and notify the carrier and M Squared Lasers (or your distributor) immediately.

Note! If you need to return your system to M Squared Lasers within your warranty period, and your original shipping containers were intact at time of delivery but have since been discarded, M Squared Lasers may levy a charge to replace these containers.

C.1 Items Packed With Your System

Item	Quantity
TC-4 ICE-BLOC Temperature Controller	1
Phoenix FMC 1,5/ 2-ST-3,5 connector (thermistor)	4
Phoenix FKC 2,5 HC/ 2-ST connector (TEC/heater)	4
TC-4 On/Off key	2
IEC mains cable	1
Ethernet cable	1
USB memory stick (loaded with User Manual)	1

D Important Safety Information

D.1 General Safety Precautions

Caution! Use of controls or adjustments or performance of procedures other than those specified herein, or in associated system manuals, may result in a hazard.

- NO USER SERVICEABLE PARTS INSIDE. REFER SERVICE TO AUTHORISED PERSONNEL.
- REMOVAL OF COVERS IS PROHIBITED AND VOIDS WARRANTY.
- DO NOT OBSTRUCT THE AIRFLOW FROM THE REAR INTAKE TO THE SIDE EXHAUST.
- SYSTEM MUST BE EARTHED.
- DISCONNECT AC CORD BEFORE CHANGING FUSE.

- PRIOR TO USE, REVIEW AND REFER TO ALL INSTRUCTIONS AND SAFETY PRECAUTIONS LISTED IN ALL MANUALS PROVIDED WITH THIS SYSTEM.

D.2 System Safety Features

Warning! The TC-4 ICE-BLOC system meets regulatory design & safety standards declared within this manual only if used in the as-designed configuration.

Caution! To ensure a full understanding of the safety features, labelling and operation of your TC-4 ICE-BLOC, please refer to all manuals associated with the system. If, after consulting your manual(s), anything remains unclear, please consult M Squared Lasers or an authorised representative before attempting to operate your system.

The TC-4 includes the following safety features:

Key Switch

The TC-4 includes a key switch on the front panel that must be set to the 'On' position before the module can be operated. Once set in the 'On' position, the key cannot be removed without returning it to the 'Off' position.

Protective Housing

Danger! Operating with any cover removed is prohibited, voids your warranty, risks contamination of optical surfaces, and may expose users to high voltages.

The TC-4 contains no user-serviceable parts and must never be opened by the user. All covers are sealed with 'warranty void' stickers. Only M Squared Lasers personnel or their authorised representatives should be allowed to service the system.

D.3 Maintaining IEC/CE Safety Compliance

To keep the TC-4 in compliance with applicable safety regulations, once a year, or whenever the product has been subjected to adverse environmental conditions (e.g. fire, excess moisture, mechanical shock, spilled solvent, etc.), check to ensure that all safety features of the module described in the previous section are still functional. Make sure that all warning labels are still attached firmly to the module and are legible, that all covers are still correctly sealed, and verify that the module can only turned on by using the front panel key switch.

If you find that your module fails these safety checks, please stop the use of your module immediately, prevent others from using it, and contact M Squared Lasers or an authorised representative to correct the problem.

E RoHS/WEEE Compliance Statement

M Squared Lasers is committed to minimising the environmental impact of our products and operations, and to complying with related relevant legislation and directives. M Squared Lasers' products are subject to the European Union (E.U.) Restriction of Hazardous Substances Directive (RoHS) that became effective July 1 2006, and also to the PRC Management Methods for Controlling Pollution by Electronic products (more commonly known as China RoHS) effective March 1 2007.

E.1 RoHS Directive (2002/95/EC)

The RoHS Directive affects manufacturers, sellers, distributors and recyclers of electrical and electronic equipment containing lead, cadmium, mercury, hexavalent chrome, polybrominated biphenyl (PBB) and polybrominated diphenyl ether (PBDE). From July 1, 2006 the use of these materials has been severely restricted in most electrical and electronic products sold in Europe.

All of M Squared's products sold in Europe after July 1, 2006 are fully RoHS compliant, and a full Declaration of RoHS Compliance is available upon request. If you have questions regarding the RoHS compliance of M Squared products, please contact us, or your distributor, using the information listed in Section 8.

E.2 WEEE Directive (2002/96/EC)

The Waste Electrical and Electronic Equipment Directive (WEEE) applies to companies that manufacture, sell, and distribute electrical and electronic equipment in the E.U. It covers a wide range of large and small electrical and electronic appliances, tools and instruments. This Directive aims to reduce the waste arising from electrical and electronic equipment, and to improve the environmental performance of everything involved in the life cycle of electrical and electronic equipment. This translates into the following requirements for producers (manufacturers or importers) of electrical and electronic equipment: a) register in their countries; b) achieve a series of demanding recycling and recovery targets; c) mark any products that must NOT be thrown into general waste with a crossed out, wheeled bin icon.

Figure 1 The E.U. WEEE symbol used to mark products that must not be thrown into general waste, and must be recycled or disposed of according to local regulations.

The symbol shown in Figure 1 indicates WEEE material, and anything carrying this mark should be collected separately and processed according to local regulations. M Squared products subject to the WEEE directive are marked with this symbol. In order to prevent WEEE, the Directive encourages re-use, recycling and other forms of recovery over disposal. Arrangements for the separate collection of WEEE will vary in each member E.U. country. If disposal is necessary then this should only be undertaken by an approved authorised treatment facility (AATF).

As needed, M Squared will work with end users and/or distributors, to aid in the correct handling of an M Squared product that has reached the end of its useful life. This may include, as appropriate, return shipment of the product free of charge to M Squared Lasers Ltd for re-cycling (only after prior agreement and issue of an RMA number directly by M Squared Lasers Ltd). A copy of M Squared's full WEEE Compliance Policy Statement is available upon request. For more information, please contact M Squared Lasers Ltd, or your distributor, using the information listed in Section 8.

F CE Declaration of Conformity

Note! The attention of the specifier, purchaser, installer, or user is drawn to special measures and limitations to use of this equipment, which must be observed when these products are taken into service to maintain compliance with the above directives. Details of these special measures and limitations to use are available on request, and are also contained in this manual.

The Manufacturer of the Products covered by this Declaration is:
M Squared Lasers Ltd.

The address of the head office is:
1 Kelvin Campus,
West of Scotland Science Park,
Maryhill Road,
Glasgow,
G20 0SP,
UK

The product covered by this declaration is:
TC-4 ICE-BLOC, Temperature Controller.

The above mentioned product complies with the essential requirements, which are specified in the directives 2004/108/EC and 2006/95/EC on the approximation of the Member States relating to electromagnetic compatibility and electrical safety.

The product of the declaration above has been designed and manufactured to be in compliance with the requirements of the following standards and the results of testing and assessment are included in the Technical Documentation:
EN 60825-1 Edition 2.0 2007-03 Safety of Laser Products

EN 61010-1:2010 3rd Edition Safety requirements for electrical equipment for measurement, control and laboratory use

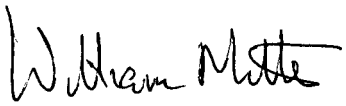
EN 61326-1:2006 (Emissions only) Electrical equipment for measurement, control and laboratory use. EMC Requirements. General Requirements.

EN 55011:2007 (Conducted and radiated emissions to Class B) Equipment electromagnetic disturbance characteristics. Limits and methods of measurement.

EN 55022:2006 (Conducted emissions) Information technology equipment. Radio disturbance characteristics. Limits and methods of measurements

The technical documentation required to demonstrate that the product meets the essential requirements of the above directives has been complied and is available for inspection by the relevant enforcement authorities.

The CE mark was first applied in November 2013.

Signed: 

Name: *Bill Miller*

Authority: *Director of Systems Engineering*

G Standard Units & Abbreviations

The following is a list of units, prefixes, and abbreviations used in M Squared Lasers' manuals:

Physical Quantity	Unit	Symbol
Mass	kilogram	kg
Length	metre	m
Time	second	s
Frequency	hertz	Hz
Power	watt	W
Energy	joule	J
Temperature	degrees Celsius	°C
Pressure	pascal	Pa
Electric Current	ampere	A
Electric Potential	volt	V
Resistance	ohm	Ω
Capacitance	farad	F
Inductance	henry	H
Angle	degree (radian)	deg (rad)
Magnetic Flux Density	tesla	T
Force	newton	N

AC	Alternating current
AOM	Acousto-optic modulator
APAM	Automated pump alignment module
AR	Anti-reflection
BRF	Birefringent filter
CDRH	Centre for Devices and Radiological Health
CW	Continuous wave
DC	Direct current
DPSS	Diode-pumped solid-state
DSP	Digital signal processing
EO(M)	Electro-optic (modulator)
fs	femtosecond (10^{-15} second)
FSR	Free spectral range
GVD	Group velocity dispersion
HR	High reflector
ICE	Instrument Control by Ethernet
IR	Infrared
OC	Output coupler
OPO	Optical parametric oscillator
ns	nanosecond (10^{-9} second)
PC	Personal computer
ps	picosecond (10^{-12} second)
PIK	Pump integration kit
POM	(SolsTiS) Pump optics module
PSU	Power supply unit
PZT	Piezo-electric transducer
RF	Radio frequency
SLM	Single longitudinal (frequency) mode
TEM	Transverse electromagnetic (spatial) mode
Ti:S	Titanium-doped sapphire
THz	Terahertz
(D)UV	(Deep) Ultraviolet
λ	Wavelength

Prefixes					
Tera	10^{12}	T	Milli	10^{-3}	m
Giga	10^{9}	G	Micro	10^{-6}	µ
Mega	10^{6}	M	Nano	10^{-9}	n
Kilo	10^{3}	k	Pico	10^{-12}	p
Centi	10^{-2}	c	Femto	10^{-15}	f

H List of Figures

I Copyright Information

M Squared Lasers Ltd,
1 Kelvin Campus,
West of Scotland Science Park,
Maryhill Road,
Glasgow,
G20 0SP,
UK

1 Introduction

Thank you for your purchase of a TC-4 ICE-BLOC. We pride ourselves on supplying next-generation, reliable products that provide our customers with new, often unique performance capabilities with which they can push their application boundaries. We welcome your feedback, comments and suggestions.

If you have any questions, concerns or comments, please do not hesitate to contact us, or your M Squared Lasers representative (please see contact information listed in Section 8).

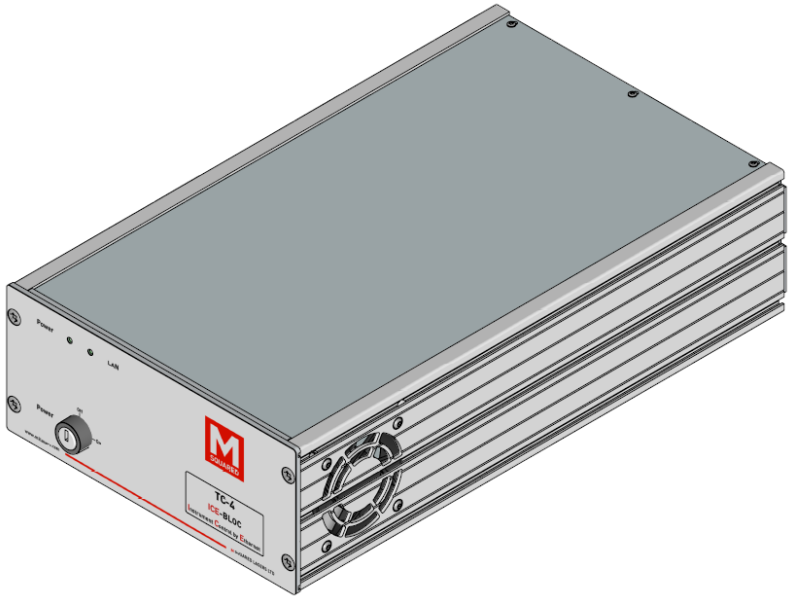


Figure 2 TC-4 ICE-BLOC

2 System Description

2.1 System Overview

Warning!

Warning! The TC-4 ICE-BLOC system meets regulatory design & safety standards declared within this manual only if used in the as-designed configuration.

The TC-4 (shown in Figure 2) is a four-channel, high-precision temperature controller with unique Instrument Control by Ethernet (ICE). ICE functionality allows users to control and monitor the TC-4 – as well as log performance data – all via a standard Ethernet/LAN connection and standard web browser. The facility to interface between the ICE-BLOC and third party equipment is also available using the IP remote command instruction set; please contact M Squared Lasers or your local representative for further details.

Highly versatile, the TC-4 can control any combination of TECs or resistive heaters, with user-programmable output current, current polarity, voltage limits, PID feedback parameters and ramp time. Its compact form factor allows easy integration of the TC-4 into experiments or OEM setups.

The standard TC-4 specification can be found in Table 1.

2.2 TC-4 Standard Specifications

Table 1 lists standard specifications for the TC-4.

Parameter	Standard Specifications
Output Voltage Per Channel	≤ ± 21.6V
Output Current Per Channel (single channel use)	≤ ± 8A
Output Current Per Channel (double channel use)	≤ ± 7A
Output Current Per Channel (quad channel use)	≤ ± 5A
Maximum Output Power	300 W across all four channels
Set Point Resolution	0.001 °K – typical value, steady state
Set Point Temp. Coefficient	< 5 ppm / °K (ICE-BLOC temperature)
Set Point Range	-20.15 °C to +79.85 °C
Thermistor Range	10 kΩ – 100 kΩ
Extended Thermistor Range	1 kΩ – 1 MΩ (slightly lower resolution)
Mains Input Power	100 – 240 VAC, 50 / 60 Hz, 350VA (typical power: 15 W)
Fuse Rating	T3.15AL250V (3.15A 250V-rated low-breaking time-lag fuse. Suitable for use with 110-240V power supplies)
Overvoltage category classification as per IEC60664-1	Category II (can withstand 2500V peak mains transient, 300V RMS mains voltage line-to-neutral)
Size (W x H x D)	Half Rack (203mm) x 2U (89mm) x 345 mm (8''x3.5"x13.6")
Weight	4.1 kg

Table 1 TC-4 specifications.

Table 2 lists standard environmental operating conditions for the TC-4.

Parameter	Standard Specifications
Operating Temperature	0°C to 70°C
Storage Temperature	-20°C to 85°C
Relative Humidity	<90% humidity, non-condensing
Indoor/Outdoor Use	Indoor use only
Altitude	<2000m

Table 2 TC-4 environmental operating conditions

2.3 Controlling TC-4

The TC-4 is controlled by M Squared Lasers' proprietary *ICE-BLOC*® photonic control platform, which allows users to communicate with *ICE-BLOC* modules via any standard direct/ LAN/ WAN/ Internet-based Ethernet connection.

The advantages of Ethernet control over more conventional communication protocols are many, making Ethernet control the best choice whether seeking to communicate with an instrument placed next to the control PC (direct cable connection), or remotely over very long distances (via an Internet connection). These many advantages include: higher speed; greater robustness; effectively infinite communication distance without the need for repeaters; elimination of dedicated software drivers (because control is via Web-based browser interface); and the ability to network multiplex multiple *ICE-BLOC* modules, providing simple system expansion and highly flexible control architectures.

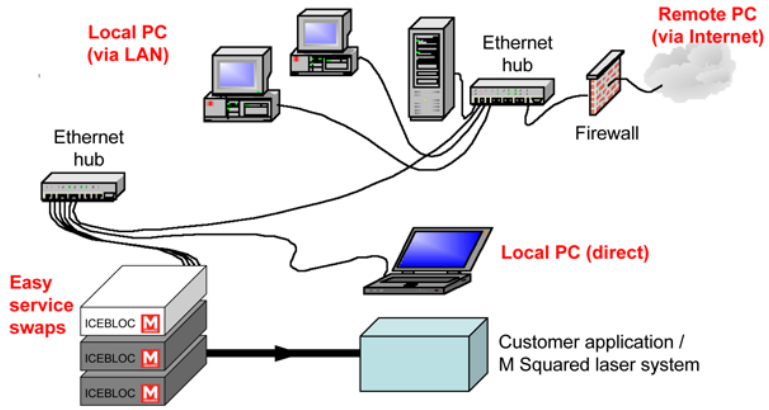


Figure 3 Illustration of the ICE-BLOC control concept.

3 Controls, Indicators & Connectors

This section defines the operator controls, indicators and connections of the TC-4. If your system includes a laptop computer for Ethernet control of the TC-4, information on the laptop can be found in the accompanying laptop's user's manual.

Controls

The module has an On/Off key control on the front panel, Figure 4. All other controls are accessed via the web interface (see Section 5).

Indicators

The module has the following LED indicators: Power and LAN.

Connectors

Table 3 shows the connections of the TC-4.

Connector	Linking	Illustration	
Sensor (Ch 1 – 4)	Thermistor	Figure 5	
Drive (Ch 1 – 4)	TEC/Heater	Figure 5	

Table 3 TC-4 connections

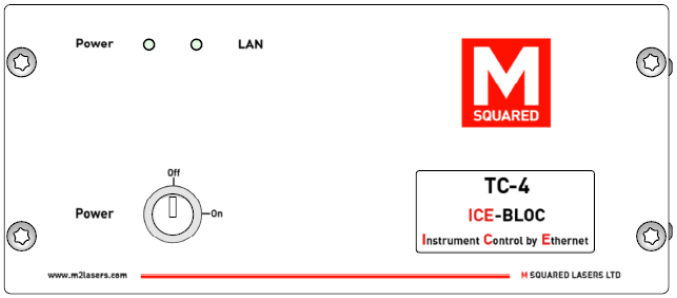


Figure 4 TC-4 front panel

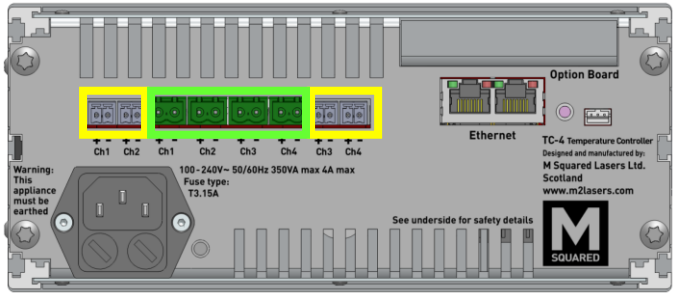


Figure 5 TC-4 rear panel

Warning!

Warning! The four drive outputs must never be electrically connected together. Doing so could result in damage to the connected temperature coolers/heaters or to the TC-4.

Warning!

Warning! An active drive channel outputs ≥12V with respect to ground. Do not connect any of the drive outputs to ground.

4 Installation

Note! If your system includes a laptop for Ethernet control of the TC-4, please refer to the manual that accompanied your PC for information on its use.

4.1 Unpacking Your System

When you receive your system, please inspect the shipping containers immediately. If you discover any damage (holes or dents in the containers or crushing, for example) please notify the carrier immediately, and insist that a representative of the carrier be present to document the damage with you.

Please also be sure to inspect each system component carefully for damage as it is removed from its protective packaging. If you find any damage to system components (dents or scratches in covers, for instance), document this damage, and notify the carrier and M Squared Lasers (or your authorised distributor) immediately.

4.2 Installation – An Overview

There are no internal user adjustments needed or permissible in the TC-4 during normal operation.

It is strongly recommended that the instructions contained in the following sections are followed in sequence by the user, namely: start with an overview of general installation guidelines and precautions; review the basic principles of Ethernet control; install and prepare the TC-4 for Ethernet control; learn how to configure the module for Ethernet connection to a control laptop; and complete the installation of all other system components.

4.3 Preparing for Installation

In addition to the operating environment please consider the following factors and precautions when planning the installation and placement of your system:

- Avoid placing the system in an area subject to large (uncontrolled) temperature changes, or with high atmospheric particulate / dust / contaminant / moisture content - an air-conditioned laboratory environment is strongly recommended.

- Avoid placing the system in an area subject to strong vibration.

Warning! Attach all power cords first to the electronic instrument, then to the power source.

Warning! All controllers for your system (e.g., ICE-BLOC modules, pump laser, laptop control computer) must always be positioned so that the laser-emission warning indicator on the pump laser head is <2m (< 6ft) away, and easily visible, from all of them. Failure to follow this instruction could result in a laser safety hazard for the user.

Warning! Do not cover vents or restrict airflow around electronic modules. Allow at least 15cm (6 inches) of clearance on all sides to ensure proper cooling. Position all modules to prevent heated air exhausted from any unit returning to its own intake, or entering the intake of another unit.

Caution! If a laptop was supplied with your system, it should be used only with your M Squared laser system. Use of the laptop for any other purpose and/or with other software could corrupt your system control interface, which may cause system damage, result in a safety hazard, and void your warranty.

4.4 Installing the TC-4

1. Connect the required sensors and drives to the Channels of the TC-4.

2. Connect an Ethernet cable to the TC-4 then to the laptop or Ethernet hub. See Appendix B for an overview of Ethernet.

4.5 Factory Default Password Settings

Three password levels are provided. In order of increasing access privileges, these are:

User **–** user level accounts are designated for normal, everyday operation of the laser. These accounts can be accessed using a user or supervisor username/password, or by M Squared Lasers personnel.

Supervisor **–** supervisor level account can define and alter passwords, network settings, system firmware and safety-related parameters. These accounts can only be accessed using the supervisor username/password, or by M Squared Lasers personnel.

Factory **–** factory level accounts are for factory set-up only, and are accessible by M Squared Lasers personnel only.

Typical factory default settings for these passwords are given in Appendix A. The User Account page of the web interface is shown in Figure 12.

5 Netbook and Software User Interface

Caution!

Caution! Please refer to your laptop manual for all precautions, safety, operating and maintenance instructions for the laptop.

The TC-4 incorporates M Squared Lasers' proprietary Instrument Control by Ethernet (ICE) web interface, which enables the operator to control temperatures using a standard web browser. The HTML/JavaScript-based web interface is embedded in the on-board memory and may be accessed by connecting the module to a personal computer via any standard RJ45 cable/ WAN/ LAN/ Internet-based Ethernet connection.

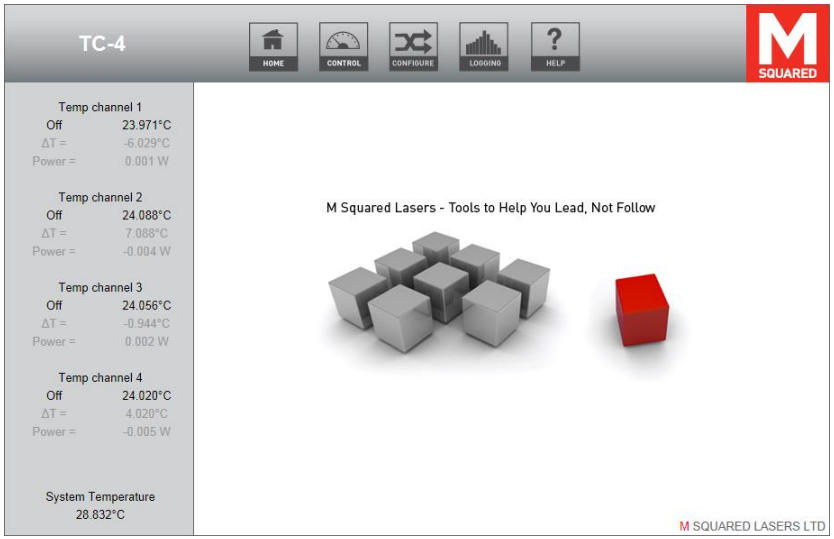


Figure 6 TC-4 web interface – Home page

The TC-4 software interface consists of a multi-page web interface (starting with the *HOME* page, Figure 6, which appears at software initialisation). Depending on the TC-4 & accessories you purchased, and your password access level and software revision, the number and content of your web interface pages may differ from those shown below.

The *HOME* page will appear when the browser has been successfully connected to the control unit. The navigation icons at the top of the *HOME* page may be used to access other web interface pages. The TC-4 is generally set up and controlled via the *CONTROL*, *CONFIGURE* and *LOGGING* pages (The *HELP* page is not currently used). A username and password will be requested on entering any page other than the home page; this password can be set to be either a user or supervisor level password by the system administrator (further details on password access levels may be found in Section 4.5). The panel on the left hand side of the *HOME* screen is used for status information, appears on several of the other web interface pages, and displays the following parameters:

<Channel Name> Off/Not Ok/Ok – Status of each temperature channel. When active, status will display 'Not Ok' if out of range of the target temperature, and 'Ok' when within range.

<Channel Name> temperature – The measured temperature of each channel.

<Channel Name> ΔT – The difference between the target and the measured temperature for each channel.

<Channel Name> Power – The power supplied to each channel driver.

System Temperature – The measured internal temperature of the ICE-BLOC.

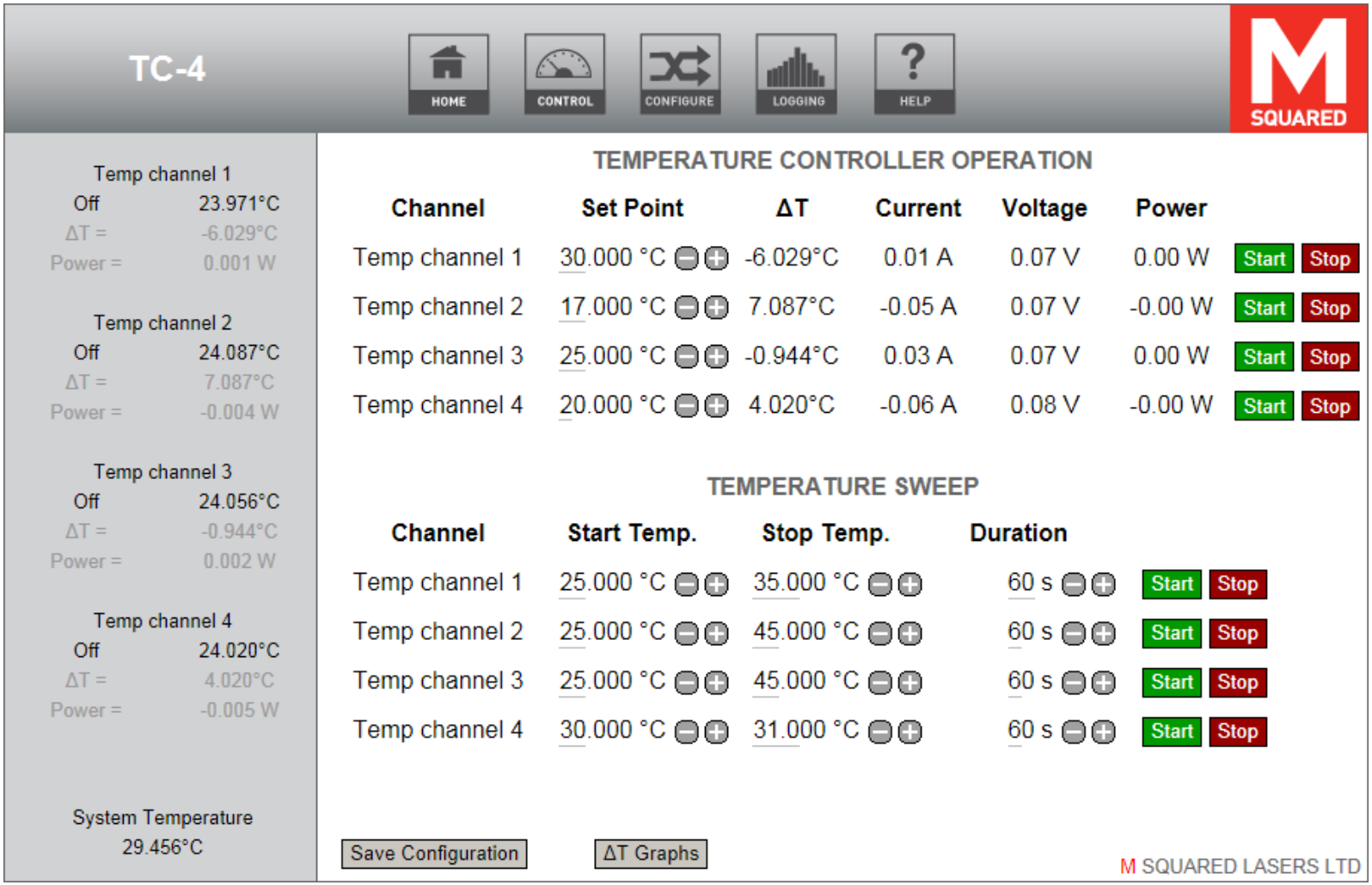


Figure 7 TC-4 web interface – Control screen page

Figure 7 shows the *Control* page of the web interface, accessed by selecting *CONTROL* from the top menu bar. This page allows the user to operate the module. Please refer to Section 6 for a more detailed description of the functions of this page and how to use them.

The *Configure* page is accessed by selecting *CONFIGURE* from the top menu bar is shown in Figure 8. This page gives the User/Supervisor access to a number of the TC-4 settings, which are shown by Figure 9 to Figure 15.

The *Clock Set* page, shown in Figure 9, allows the User to set the time and date for the system. The time and date can be set using the buttons beside each element, or *Quick Initialise* can be used to derive the time based on the laptop controller's system clock. Click *Set Clock* to confirm the new time and date.

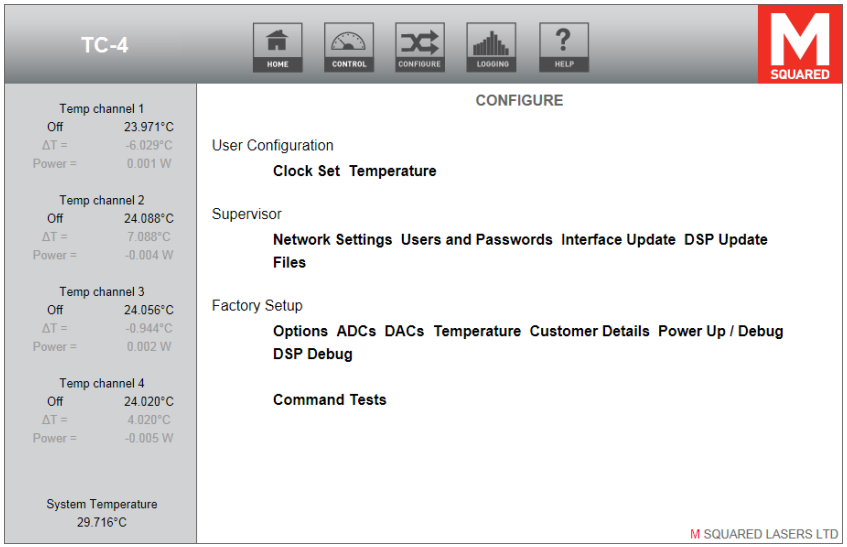


Figure 8 TC-4 web interface - System configuration page

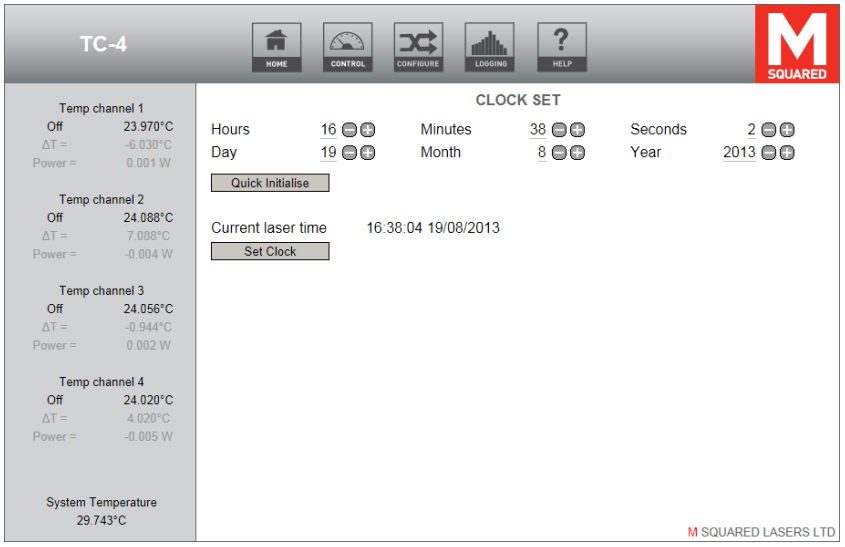


Figure 9 TC-4 web interface – Clock Set page

The *Temperature* page, shown in Figure 10, allows the User to configure the drive, sensor and control loop options for the four temperature control channels.

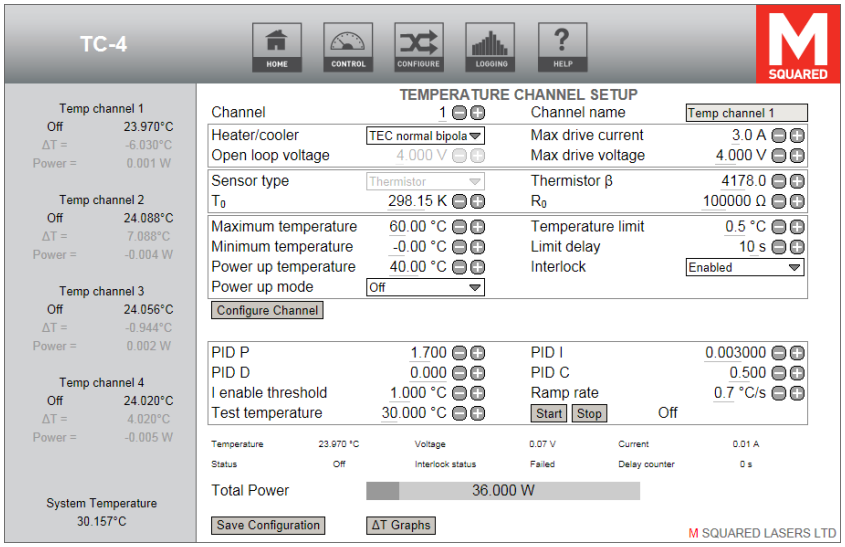


Figure 10 TC-4 web interface – Temperature Channel Setup

Channel Select channel for configuration.

Channel name Give the selected channel a descriptive name; this will appear in the status panel.

Heater/cooler Select drive type: *TEC normal bipolar*, *TEC inverted bipolar*, *Heating only*, *Cooling only* or *Open loop* (for fan drive etc.).

Max drive current
Max drive voltage Set maximum output parameters for the selected channel; for TEC applications these values are bipolar.

For low-resistance devices (e.g. thermoelectric coolers), it is advisable to set the maximum current to a safe low value. If the current output exceeds the maximum current set, the channel will shut down and a pop-up window will inform the user that an overcurrent event has occurred.

Open loop voltage Set fixed voltage for open loop drive (only available when *Open loop* selected for Heater/cooler).

Sensor Type Set sensor type. This is automatically set to *Thermistor* when *TEC*, *Heating* or *Cooling* is selected. For *Open loop*, this can be selected as *Thermistor* to show an associated temperature, or *None* to hide the associated field in the status panel.

Thermistor β, T_0, R_0 Set thermistor parameters: see thermistor datasheet for these values unless this has already been configured by M Squared Lasers. Greyed out if *None* is selected for *Open loop.*

Temperature Parameters

Maximum / Minimum temperature sets limits beyond which the channel will shut down.

Temperature limit sets a window around the set point and *Limit delay* sets a time duration window; when the measured temperature is outside the temperature limit range for the duration of the limit delay an out of range warning will appear.

Power up temperature and *mode* determine whether the channel should automatically drive the output to this temperature on power up (or if *open loop*, whether the output will enable at the selected voltage on power up).

Interlock is used to determine whether the channel's temperature out-of-range status is reported to a DD-40 ICE-BLOC (if connected) so that it can take action by shutting down one or more diode drive channels (see *Lockouts* section in DD-40 user manual).

PID Parameters

For closed loop channels, these parameters allow the supervisor to optimise the temperature control loop. A *Test temperature* setting and *Start* / *Stop* buttons are provided to allow control of the channel while optimising.

ΔT Graphs

The *ΔT Graphs* button opens a window with graphical traces of the four temperature channel errors to assist with optimisation of the PID closed loop parameters.

Total Power

The *Total Power* progress bar displays how much of the total power budget will be output according to the configuration of maximum voltages and currents set for each temperature channel.

The *Network Settings* page, shown in Figure 11, allows the Supervisor to change the IP address of the TC-4 so that it can be connected to an existing network by entering new values then clicking *Save Configuration*.

A link can also be set up with external devices that can use a command set to control and/or retrieve the status of the temperature channels (contact M Squared Lasers for details of the command set). The IP address and port number of an external controlling PC can be entered in the *Remote Interface* boxes, and can be enabled/disabled by the corresponding buttons.

Similarly, a connection with a DD-40 ICE-BLOC Diode Driver can be established by entering its IP address and port number in the *Diode Driver* boxes. When connecting to a DD-40, it is important that the device type selected is different from the type selected on the corresponding Network Settings page on the DD-40 (i.e. the types selected cannot be Server/Server or Client/Client). Setting up a link will allow the DD-40 to interrogate the TC-4 for temperature readings for each channel, as well as retrieve the status of whether the channel is within range of the temperature set-point or not.

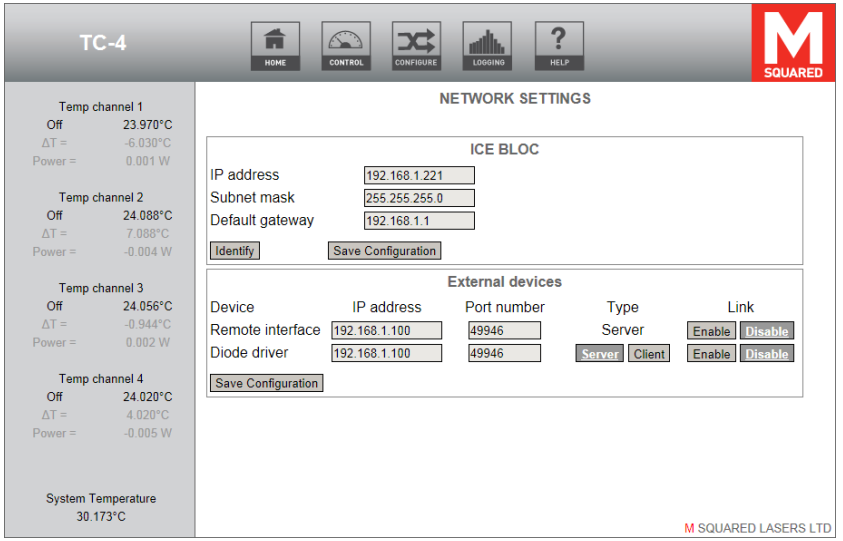


Figure 11 TC-4 web interface – Network Settings page

The *Users and Passwords* page, shown in Figure 12, allows the Supervisor to amend usernames and passwords and password timeout; changes are saved by clicking *Save Configuration*.

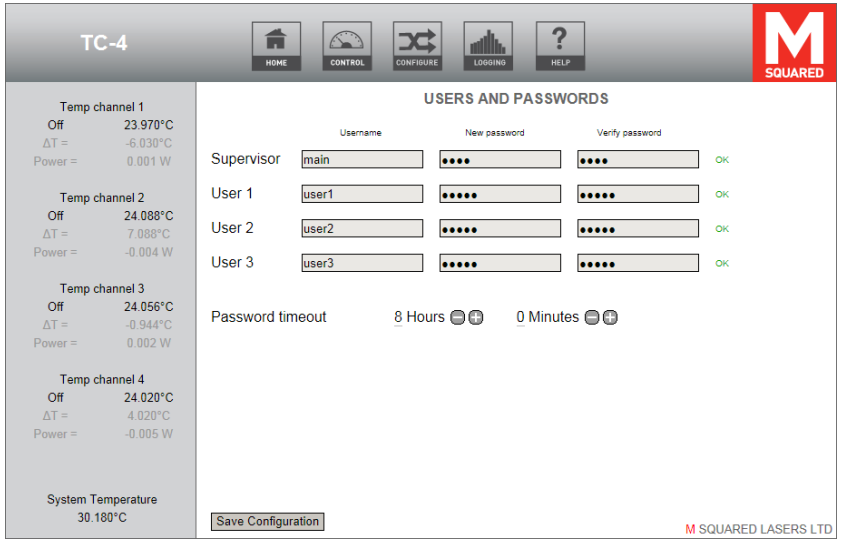


Figure 12 TC-4 web interface – User accounts setup page

The *Interface Update* page, shown in Figure 13, allows the Supervisor to update the interface firmware by selecting a file supplied by M Squared Lasers, by browsing to the file then clicking *Submit*.

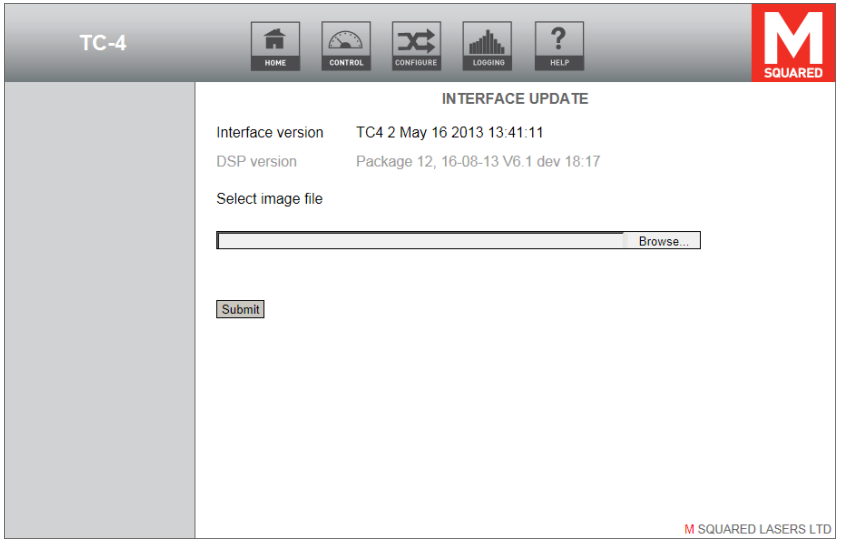


Figure 13 TC-4 web interface – Interface Update page

The *DSP Update* page, shown in Figure 14, allows the Supervisor to update the DSP by selecting a file supplied by M Squared Lasers, by browsing to the file then clicking *Submit*.

The *Files* page, shown in Figure 15, allows the Supervisor to manage files stored on the ICE-BLOC filestore. The *Factory* folder is not currently used on this system. The *Logs* folder contains any files captured during system logging if enabled. The *Sys_Restore* folder contains configuration files used for storing and retrieving a snapshot of all settings across the system, and as such has additional *Save* and *Load* buttons to allow this. Files can be added from the connected computer's hard drive by clicking *Upload File*. Files can be saved to the connected computer's hard drive by right clicking a filename (not the icon) and selecting *Save Target As…*

System restore and logging files are tab-spaced text files, and can therefore be viewed in a spreadsheet program.

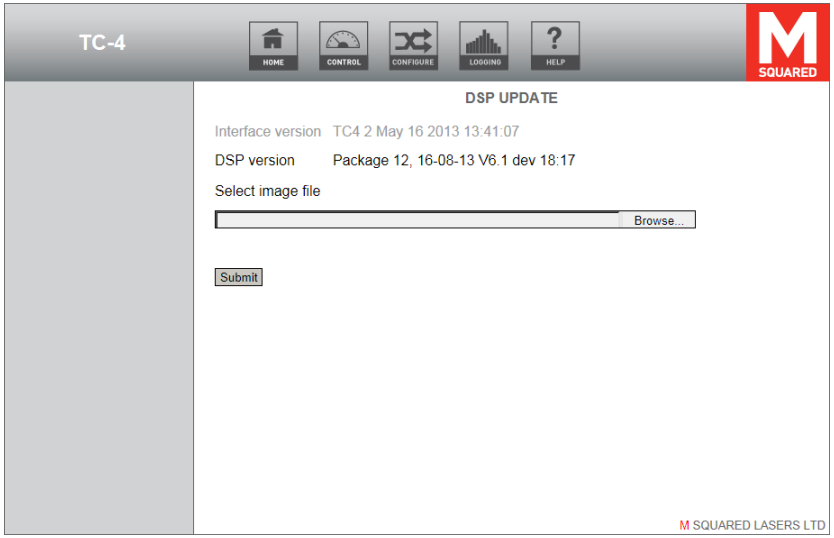


Figure 14 TC-4 web interface – DSP Update page

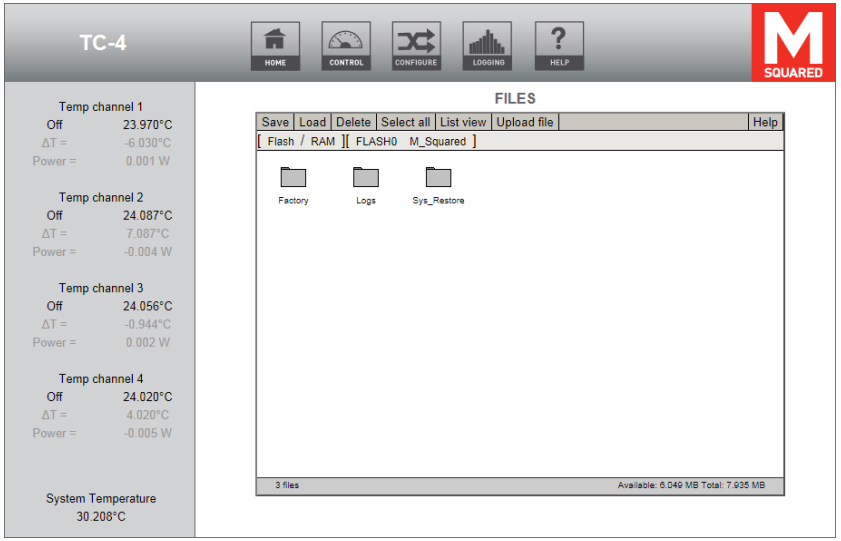


Figure 15 TC-4 web interface – Files page

The *Logging* page is shown by Figure 16, accessed by selecting *LOGGING* from the top menu bar. This page allows the user to configure logging of system parameters. Changes to logging options are saved by clicking *Save Configuration*.

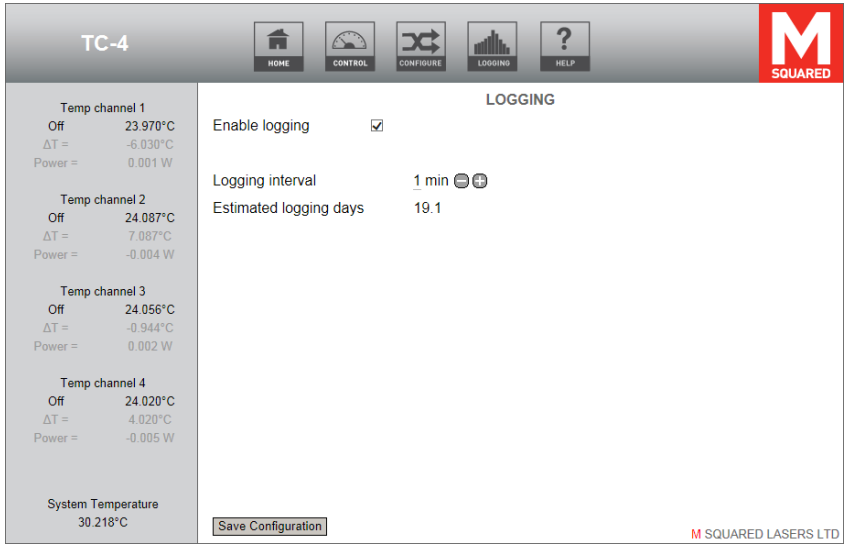


Figure 16 TC-4 web interface – Logging page

6 Operating the TC-4

Caution! Use of controls, adjustments or procedures other than those described in this manual may result in a hazard.

Before starting the module ensure that all suitable safety precautions have been taken.

6.1 Starting from Complete Power Off Condition

1. If the channels have not already been configured, ensure the coolers/heaters are disconnected from the TC-4 before powering on to protect them from possible damage.
2. Turn on the TC-4 module.
3. Turn on any other components of your system.
4. Start up the laptop computer.
5. Open the web browser by clicking on the icon on the desktop of the computer.
6. In the web browser, enter the module's IP address (given on the rear of the unit) into the browser address bar.

The user should now follow the instructions for module operation below.

6.2 Power Down

To power down the module, turn the front panel key switch to the 'Off' position.

6.3 TC-4 Operation

The following section gives a detailed description of the controls given in Figure 7.

The temperature controls for the four channels are shown in Figure 17. To alter the temperature set points, the user should select a digit of the Set Point (depending on the magnitude of the change) and either use the Temperature Adjustment buttons or use the keyboard's up/down arrow keys to increment / decrement the digit. The left/right keyboard arrow keys can also be used to change the currently selected digit. Alternatively, by selecting the most significant digit, the set point can be typed in using the keyboard numeric keys. The required channel is activated/de-activated by clicking on the corresponding *Start / Stop* button.

The current, voltage and power being driven by the channel is displayed beside the temperature difference.

If the module does not respond please refer to the troubleshooting guide in Section 7.1

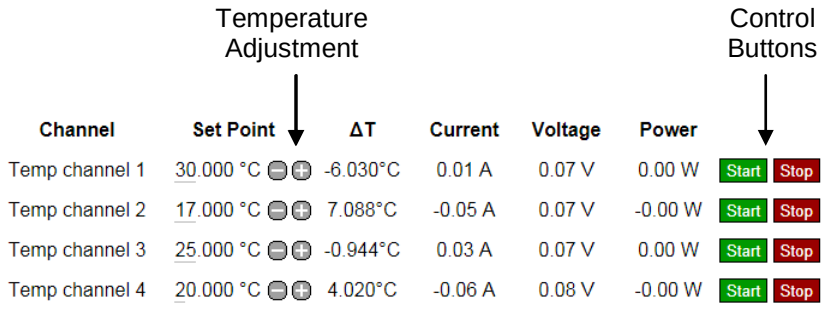


Figure 17 TC-4 web interface – Individual temperature control

As well as setting individual temperatures the TC-4 can also perform a temperature sweep on a single channel, shown in Figure 18. To perform a sweep select a channel, set the start and stop temperatures and select the duration of the sweep (in seconds). When the sweep has been configured it is enabled/disabled by pressing the *Start / Stop* buttons respectively.

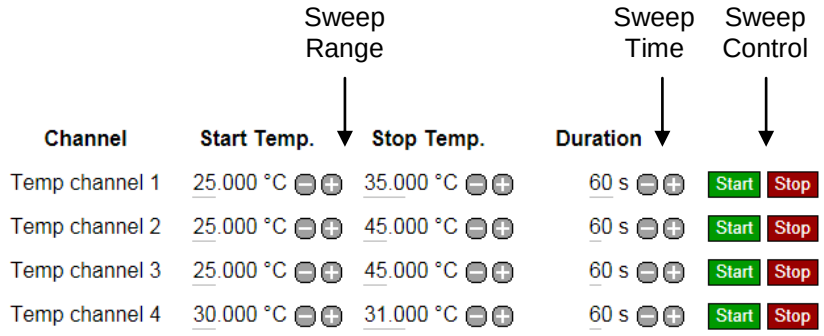


Figure 18 TC-4 web interface – Temperature sweep control

7 Maintenance & Troubleshooting

Warning! There are no user-serviceable parts inside the TC-4. Removal of any covers will void your warranty.

Warning! Please refer to all information contained in all instruction manuals associated with your system. Failure to follow all instructions in these manuals may cause safety hazards, may damage your system, and will void your warranty.

Note! If, after consulting our manuals and reviewing the tips below you find you are unable to recover the specified performance of your system, please contact M Squared Lasers or your authorised representative using the contact information in Section 8.

7.1 Troubleshooting Tips

Below is a check list to go through if the TC-4 fails when using the Control page of the web interface.

1. Are all the electrical connections made?
2. Is the Ethernet cable connected?
3. Is the TC-4 unit switched on?

If it is suspected that the IP address has been changed to something other than the address printed on the back of the unit, pressing the white button on the back panel for 5 seconds will reset the IP address to 192.168.1.222. The IP address can then be configured as required from the Network Settings page.

8 Customer Service

If you experience any difficulties with your laser system, require maintenance not described in this manual, require repairs, or if you have questions or concerns, please do not hesitate to contact M Squared Lasers Ltd or your authorised representative:

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9 Warranty

This Warranty supplements the warranty contained within the sales order specific to your purchase of this laser system. In the event of a conflict between documents, the terms and conditions of your sales order shall prevail.

This Warranty applies only to products manufactured by M Squared Lasers Ltd (hereinafter referred to as 'M Squared'.) This Warranty does not extend to any third-party accessories purchased with or used in conjunction with M Squared products, such as pump lasers or wavemeters. The warranty for all third-party accessories supplied with M Squared products is provided by the manufacturer of those products – please inquire.

The warranty period for the laser system you have purchased is for 1 year from the date of shipment, or 2000 hours of operation, whichever comes first. This Warranty extends only to the original purchaser and is not transferable. Optional extended warranty calendar periods and/or extended warranty hours for M Squared products are available for purchase – please inquire.

During the warranty period, all mechanical, electronic, and optical parts and assemblies are warranted to be free of defects in workmanship and material. Liability under this warranty is limited to repairing, replacing, or giving credit of an amount up to and including the purchase price of any equipment that proves defective during the warranty period, provided prior authorization for such return has been given by an authorised representative of M Squared. Any repairs or replacement equipment is then warranted only for the remainder of the original warranty period that is applicable to the repaired or replaced items. All exchanged parts and products replaced under this Warranty will become the property of M Squared.

This Warranty is valid only if M Squared products are assembled, installed and operated according to the instructions included with the products. This warranty is void if the product is subjected to any of the following mistreatment:

- Any deviation from the installation, operating and maintenance instructions provided with the system.
- Opening or modifying the product.
- Operation in any hostile environment outlined in the instructions.
- Any substantial mechanical shock.
- Any damage caused by static discharge (this will not occur under normal operation).
- Any damage due to operation in unclean environments.

The definition of mistreatment in its applicability to the warranty is at the reasonable discretion of M Squared.

Except as expressly set forth in the Warranty, M Squared makes no other warranties, expressed or implied, including any implied warranties of merchantability and fitness for a particular purpose.
M Squared expressly disclaims all warranties not stated in this Warranty. Any implied warranties that may be imposed by law are limited to the terms of this Warranty. Neither M Squared nor any of its affiliates shall be responsible for any incidental or consequential damages. Some jurisdictions do not allow limitations on how long an implied warranty lasts or the exclusion or limitation of incidental or consequential damages, so the above limitations or exclusions may not apply to you.

Appendix A: Additional Information

Supervisor user name: main
Supervisor user password: main

User accounts can access key, commonly needed control pages only:

User 1 name: user1
User 1 password: user1

User 2 name: user2
User 2 password: user2

User 3 name: user3
User 3 password: user3

Appendix B: Ethernet Overview

The TC-4 ICE-BLOC connects using Ethernet allowing it to be controlled and monitored using a standard web browser as well as allowing ICE-BLOCs to communicate with each other.

Every device on a network needs a unique identifying address. This is provided in different levels, the lowest of which is the Media Access Controller address (MAC). The MAC address is unique to every individual network-connected device and is comprised of six pairs of hexadecimal digits (0-F). This is set at the hardware level—often coded into memory—and is not (usually, nor intended to be) changeable by the user.

Although unique, the MAC address alone is not convenient for network administration because in a large network there could be many devices, all of which will have completely random, but unique, MAC addresses. To make it easier to manage a network and to provide some structure to it, an IP (Internet Protocol) address is superimposed on top of the MAC address. In IPv4 this is comprised of four groups of three decimal numbers in the range 0-255. An IP address is mapped onto a MAC address using the web interface of the networked device, be it a computer, printer, server or M Squared *ICE-BLOC* module. When two devices have been assigned IP addresses they can start to talk to each other over a TCP/IP network, including the Internet. The IP address becomes the externally visible address of the device on the network, rather than the MAC.

When a computer is plugged into a network, it will have a MAC address, but commonly it will not already have an IP address. Through a standard process called DHCP (Dynamic Host Configuration Protocol) the computer requests an IP address from a DHCP server, which (assuming all security requirements are met) will automatically issue an IP address to the computer, which it will keep until removed from the network for a period of time. The DHCP server keeps a record of the MAC address of every device connected and the IP address assigned to that device.

It is possible to set a fixed IP address for a computer or other network device, although this can result in the assigned name being the same as another device. This could potentially result in communications problems if a device with a fixed IP address is added to an extensive network, but using fixed IP address is not unusual practice if the device is connected directly to a PC, or is added to a small, secure and/or safety-critical network.

Note! The TC-4 ICE-BLOC module that was shipped was factory pre-configured with fixed IP addresses. This means that it can be connected and powered up without the need for a network connection.

If a PC and a network device are to be connected directly together the network rules discussed still apply. As there is no network or DHCP server between the PC and network device in this case, the PC will not be automatically assigned an IP address, so will not be able to communicate with the network device automatically. To resolve this, the PC must be given a fixed IP address if it is to control the network device.

Appendix C: PID Optimisation Procedure

The following process is used to optimise the PID parameters of each temperature channel for the specific application.

1. Before connecting anything to Temperature Channels 1-4, check the electrical parameters in the datasheet of the thermoelectric heater/resistive heater to be used. Go to the "Temperature" page under the "Configure" tab and ensure the following parameters for Channel 1 are appropriately set to the datasheet values to avoid accidental damage to the device:
    - Max Drive Current
    - Max Drive Voltage

    Click on "Configure Channel" to save the changed settings. Repeat this for temperature channels 2 to 4.

2. Click the "Stop" button on each channel and confirm that each channel is Off.

3. Connect a thermistor and thermoelectric cooler/resistive heater to a temperature channel drive. Select the appropriate temperature channel and choose the device type from the *Heater/Cooler* dropdown box.

4. Enter the following values into the PID parameters:
    - P = 1.000
    - I = 0.000
    - D = 0.000
    - C = 0.5 (this parameter is not used in optimisation)
    - I enable threshold = 1°C
    - Ramp rate = 1°C/s

5. Setting the I enable threshold setting as above means the Integral term is enabled when the error becomes less than 1°C. The I enable threshold setting holds the Integral term at zero until the error is low to avoid the Integral term winding up.

6. Once the temperature has settled, enter a Test Temperature several degrees away from the ambient temperature (typically 5°C lower for a TEC, 5°C higher for a resistive heater) and Start the channel.

7. Click on the ΔT Graphs button. Check if the error falls to within 1°C without oscillating. Use the mousewheel to zoom in on the Y-axis if necessary.

8. If the error is more than 1°C, increase the value of P. If the error oscillates or overshoots, reduce the value of P.

9. Continue iterating the changes in P while stepping the Test Temperature up and down until the error is within 1°C and does not overshoot or oscillate.
    - If the error cannot be reduced to within 1°C using the P term then increase the I enable threshold to the achievable error signal.

10. Change the I parameter to 1/100th of the final P value and repeat the iterative Test Temperature procedure. Increase I until the error oscillates then decrease it until the I value is approximately half this value. Adjust P slightly if necessary.
    - The final error is dependent on the temperature control setup, but typically falls within 1mK for small tightly coupled systems.

11. Further optimisation can be performed by setting the D parameter to 1/10th of the value of I. This speeds up the initial response of the control loop to a temperature demand. Monitor the speed at which the loop settles while adjusting D.

12. When the PID loop has been optimised, Stop the channel and set the Ramp rate to a value appropriate to the system being controlled. This sets the rate at which the system will ramp from one temperature setting to another.