Engineering manual

Heat Manager Pro Connect

PLEASE READ THIS MANUAL BEFORE ATTEMPTING TO CONNECT AND/OR SWITCHING POWER ON THE MODULES. THIS DOCUMENT CONTAINS VERY IMPORTANT INFORMATION THAT WILL PREVENT WRONG CONNECTIONS THAT CAN CAUSE DAMAGE TO THE UNITS.

Thank you for choosing "Heat Manager Pro Connect Series"

This manual should enable you to use your machine to full satisfaction.

Every effort has been made to provide you with maximum performance, ergonomics and benefits from this premium quality product.

Version History:

17-9-2010	Initial version V1.0
06-2-2014	Version 1.1 Updated for Heat Manager Connect software version 4401T V103.133
21-2-2014	Version 1.2: Pin levels added and cosmetic changes, chapter on PID control, FAQ updated
30-12-2014	Version 1.3: Updated for Heat Manager Connect software version V105.146 - CT module functionality for guarding element currents added - New menu structure documented (small changes)

TABLE OF CONTENTS

READ THIS FIRST

Explanation of symbols

The following signs have been used throughout this manual to draw your attention.

Hint: Useful hints for ease of operation.
Printed in Blue.

Info: Information you should know to fully understand your system and benefit from its properties. Printed in green.

Warning: Read these important messages before executing the desired operation.
Printed in red.

Warning: Read these important messages before executing the desired operation.
Printed in red.

Welding Thermocouples

Do not weld thermocouples while connected to the system! This may damage the system.

Touchscreen introduction

Your machine has been equipped with a “Human Machine Interface” or HMI or -more popular called-: A touch screen.
If you are familiar with touch screen operation, found nowadays on modern cell phones, navigation systems, informational displays etc. you may want to skip this section. If however, this is the first time you are using a touch screen, please keep in mind that in contradiction with older fashioned operating panels utilizing mechanical buttons, lamps and displays, both the displays and images on a touch screen can be interactive too, meaning they will react on a touch by your finger. The interface on the touch screen is optimized for ergonomic operation. In practice this means that all objects are positioned and sized such, that they can be touched easily with your finger without the need for a stylus or precise positioning. A soft tipped stylus can be used if preferred, but is normally not required for proper operation.

Touching objects on a touch screen can be compared with a mouse-click on a computer screen. Based on the shown graphical user interface and your finger’s position on the screen, the system can determine what action it should take when an object is touched.

To prevent accidental, unwanted actions some objects may require a prolonged touch, meaning you should keep your fingers pressed longer on a certain object (like a button or display) to invoke the required action.

Example : The RUN/PROG button to start the programmer on the operation screen requires a prolonged touch for about 1 sec.

Touchscreen maintenance

IMPORTANT - READ THIS FIRST
Never operate a machine until you have fully understood it’s safe working conditions and operating principles.
Never operate the machine unless you are authorized to do so

NORMAL EVERY DAY USAGE

Your touch screen utilizes a sensitive touch mechanism. The technique used provides reliable operation, even when the screen is modestly covered with moist and dirt. It also allows the wear of rubber gloves. And even under these conditions it should normally react already on a **gentle touch**.

Some buttons may require a prolonged touch to prevent unwanted actions.

If the touch screen fails to respond, ask yourself first whether you have applied a valid command. If in doubt, you could check the responsiveness of the touch screen by using other commands.

Each valid command will invoke a short beep, confirming the reception of the touch. However, whether or not the actual action is performed depends also on other conditions

Avoid applying excessive force on the touch screen and never use sharp or hard objects (e.g. nails, tools, kitchenware or a pencil) to operate it !
In either case you might damage the screen and void your warranty.

Touchscreen cleaning

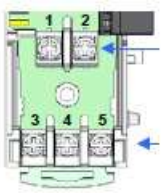
Your touch screen is provided with a durable front sheet which is water, oil and fat resistant. The best way to clean the front sheet is with a soft, lukewarm and mildly moist cloth.
Special, disposable front cover protection sheets that will reinforce and protect your touch screen, are available through your dealer.

Never use solvents (e.g. thinner, tri, turpentine) hot water, soda, abrasives or other aggressive matter for cleaning.

1. CONNECT TIO/DIO/CT MODULES

This part describes how to connect all signals to the TIO and, if present, DIO and CT modules.

1.1 Power and communication signals



Please remove the left-most TIO from the backplane. You can also remove the cabling protection cover from the connection screws.

On the first (most left) TIO module (channel 1-4) you must connect the +24VDC power supply and the RS-485 communication line (connected to **COM 2** on the touchscreen) to the backplane behind the TIO. We strongly advise a 2x2x0.25mm2 (or thicker) LiCY cable for the communications.

Please regard the polarity of the +24VDC signals!!!

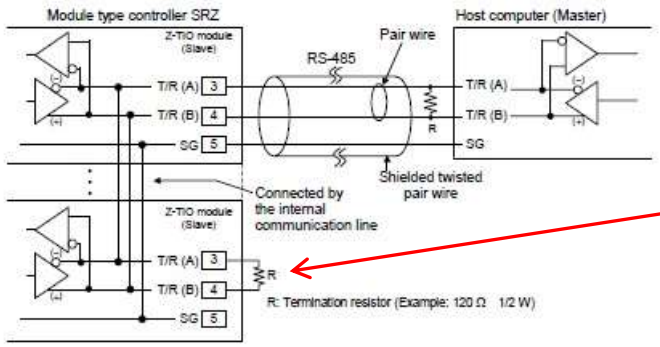
Number on the backplane	Description
1	+24VDC
2	0VDC
3	RS-485 T/R (A) brown wire
4	RS-485 T/R (B) white wire
5	RS-485 SG green wire

You don't have to connect 24VDC power and communication signals to the next TIO and DIO modules. The power supply and communication signals are internally transferred via the backplane.

We strongly advise that you *don't* use the backplane for bridging the 24VDC lines to other modules in the system. This can cause irreparable damage to the backplane and/or modules.

1.2 RS-485 communication termination resistor

To enable a reliable communication between the touchscreen and the modules, you need to add a 120 ohm termination resistor between the T/R(A) and T/R(B) line. (brown and white wire). This must be done on the **last** communication module that is connected to the communication line.



Touchscreen side **COM 2**

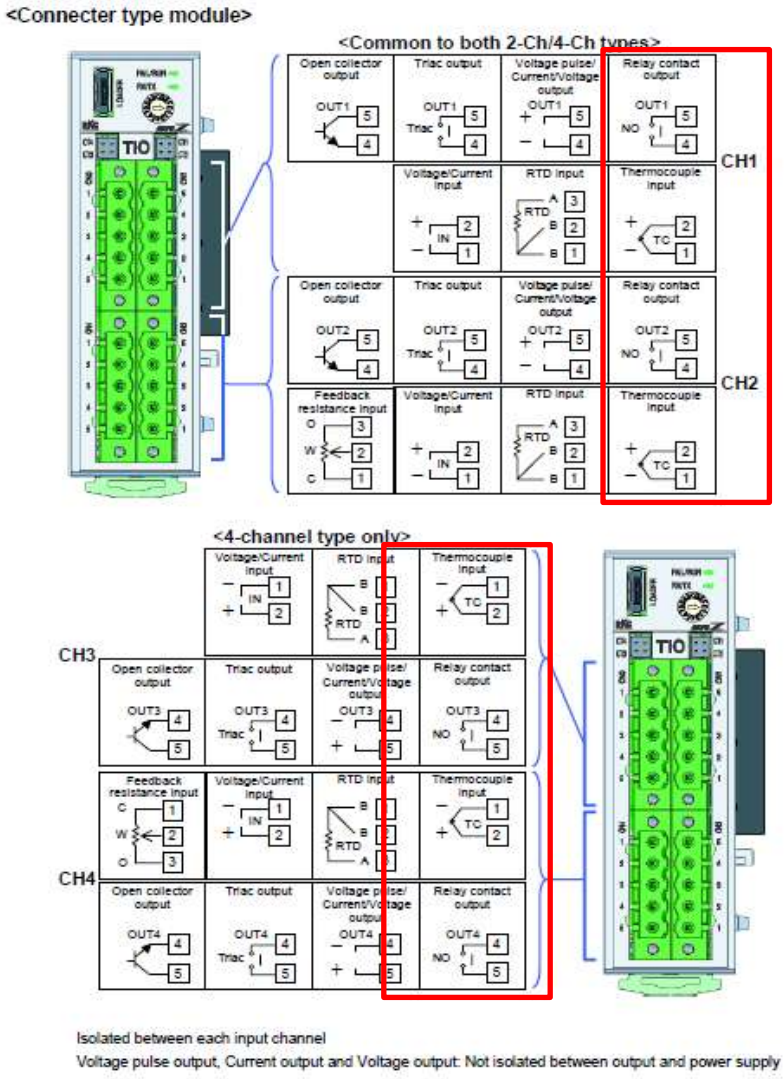
Bus termination resistor 120ohm 0.25W on the last TIO/DIO module between 3 and 4 op backplane)

Watch out with the 24VDC signals, never connect them to the RS-485 communication signals!

1.3 Temperature sensors and control relays (TIO module)

Check the diagram below, here you can see where the temperature sensors and relay contacts must be connected on the TIO module.

Right top of the TIO module is channel 1, right bottom channel 2, left top channel 3 and left bottom channel 4.



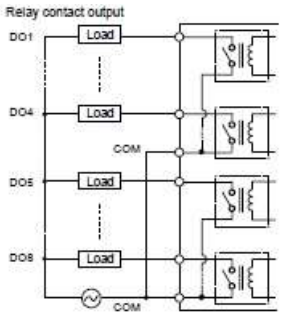
Shown here is a TIO-A module (4 channels, so 4 green connectors). When you have a 6 channel Heat Manager the second module consists of a so-called TIO-B (only 2 connectors on the right side)

The connection numbers of channel 1 and 2 (right side of the TIO module) are increasing from bottom to the top . For the channels 3 and 4 the numbers of the connectors are decreasing when looking from bottom to the top.
Watch very carefully before connecting and check this with the side connection diagram on the side of the TIO.

1.4 Digital outputs (DIO module)

This part of the manual describes the signals on the DIO digital output module.

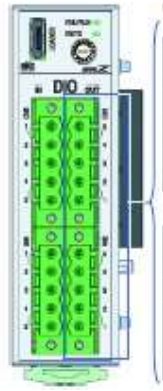
The digital outputs on the DIO modules are fitted with potential free dry contacts. These contacts are divided in two groups, group 1: DO1-4 and group 2: DO5-8. Each group has 1 central common line.



Here you see the principle-schematic diagram. You need to connect the common (COM) line for each group. Example: when you want to switch 230VAC AC signals with output DO1-8 you need to connect both COM lines and connect them to 1 side of the AC-power supply. The output signals of the DIO module go to the A1 control-point of the 230Vac power relay you want to switch. The A2 side of the control-point of the relay goes to the other side of the 230VAC.

Other example, when you want to switch DO1-4 with 24VDC and 230VAC with DO5-8 you need to connect the COM line of DO1-4 to +24VDC and the COM line of DO5-8 to 230VAC.

The outputs of the DIO modules are coded as follows:



Relay contact output/
Open collector output *

CN1

Pin No.	Description
5	COM
4	DO1
3	DO2
2	DO3
1	DO4

CN2

Pin No.	Description
5	COM
4	DO5
3	DO6
2	DO7
1	DO8

The digital outputs are on the right-hand side of the DIO module.
Right-top you find DO1-4 and right-bottom DO5-8.
To the left side of the module are the digital inputs.

The connection numbers of digital output channels 1 to 8 (right side of the TIO module) are increasing from bottom to the top (CN1&CN2) .
For the digital input channels 1 to 8 the numbers of the connectors are decreasing when looking from bottom to the top.
Watch very carefully before connecting and check this with the side connection diagram on the side of the DIO.

Heat Manager channel number	Function
1	D01: Temperature inside band channel 1
2	D02: Temperature inside band channel 2
3	D03: Temperature inside band channel 3
4	D04: Temperature inside band channel 4
5	D05: Temperature inside band channel 5
6	D06: Temperature inside band channel 6
1-6	D07: Temperatures of channel 1-6 inside band
1-6	D08: TC-break or polarity alarm on channel 1-6

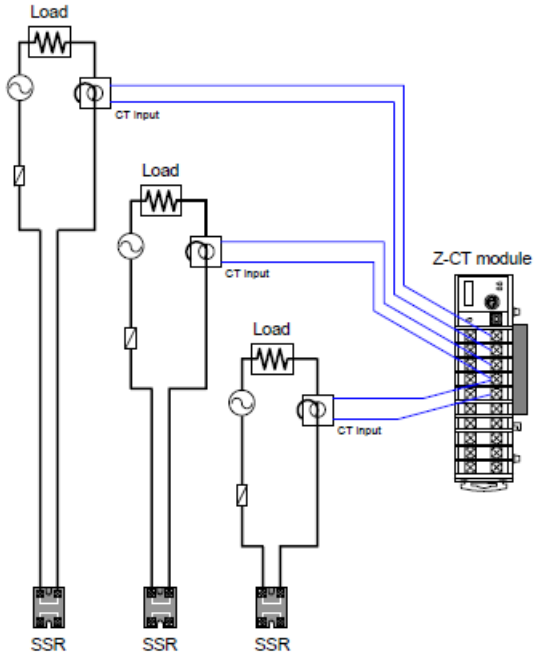
Please note that for each digital output signal you can select whether the signal is active high or low. This can be set in the advanced system settings of the Heat Manager.

1.5 Current measurement inputs (CT module)

This part of the manual describes the signals on the CT current measurement module. This module can monitor the actual current that is flowing through the heating element and can detect the following situations:

- Short circuit in heating element
- Heater break in heating element (current below nominal value)
- Maximum current in heating element (for overcurrent protection

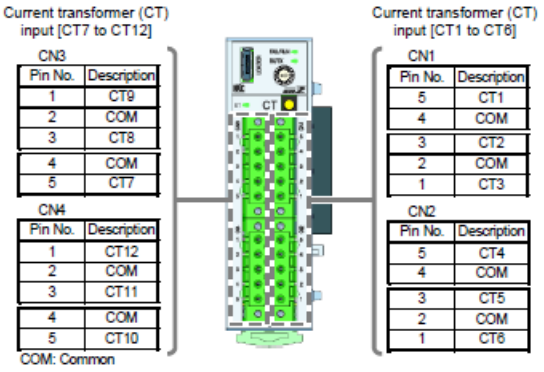
The actual current measurement is done with so-called current-transformers that are also available from CasCade.



In this example you see that every current is looped through a CT but in a normal situation you don't need to loop it. **Only feed 1 cable through the hole of the CT.** In this example a terminal type Z-CT is shown but most customers use the connector type (see below).

Warning: **make sure that the connections of the CTs are very tight! Otherwise high-voltages across the Z-CT module can occur that can damage this module.**

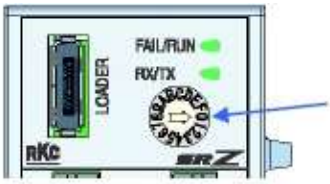
The input connections are configured on the modules in the following way (currently only channel(s) CT1-6 are used):



For channel 2&3 and 5&6 only 1 common is used. There 2 wires of 2 separate CTs are connected together to the same terminal. This is normal and not a problem.

The address switch should be set to 0 (actual Modbus address is 33).

2. SET HARDWARE CONFIGURATION OF TIO/DIO/CT MODULES



The rotating switches on the modules must be set as follows (from left to right):

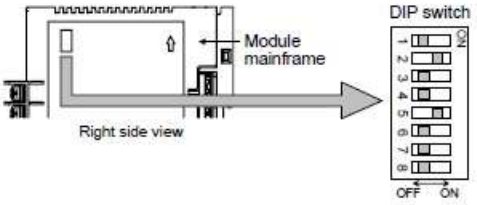
Module	TIO-1	TIO-2	TIO-3	DIO-4	DIO-5	CT-6
Address that must be set on the rotating switch	0	1	2	0	1	0
Modbus communication address	1	2	3	17	18	33

The TIO/DIO/CT modules only accept the new setting after a power cycle

On the side of the TIO/DIO/CT modules you will find a small dipswitch with 8 switches, this must be set to the same setting for each module: 38400 bps, 8-bit, no parity, 1 stop-bit and Modbus protocol.

Use a very small watch-makers screw-driver to change these settings, since these very small switches are easily damaged

Below you see the factory default setting:



(The above figure is for the terminal type. However, the switch positions are the same for the connector type.)

1	2	Communication speed
OFF	OFF	4800 bps
ON	OFF	9600 bps
OFF	ON	19200 bps
ON	ON	38400 bps

Factory set value: 19200 bps

3	4	5	Data bit configuration
OFF	OFF	OFF	Data 7-bit, without parity, Stop 1-bit *
ON	OFF	OFF	Don't set this one
OFF	ON	OFF	Data 7-bit, Even parity, Stop 1-bit *
ON	ON	OFF	Data 7-bit, Odd parity, Stop 1-bit *
OFF	OFF	ON	Data 8-bit, without parity, Stop 1-bit
ON	OFF	ON	Don't set this one
OFF	ON	ON	Data 8-bit, Even parity, Stop 1-bit
ON	ON	ON	Data 8-bit, Odd parity, Stop 1-bit

* When the Modbus communication protocol is selected, this setting becomes invalid.
Factory set value: Data 8-bit, without parity, Stop 1-bit

6	Protocol
OFF	RKC communication
ON	Modbus

Factory set value: RKC communication

- Switch No. 7 and 8 must be always OFF. Do not set to ON.
- When two or more modules are connected on the same communication line, the DIP switch settings of all modules must be the same.

In the table below you see the **needed** settings for the Heat Manager. You must adjust these settings for **all TIO, DIO and CT modules**. These settings are all the same for all these modules.

Dipswitch Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Position	on	on	off	off	on	on	off	off

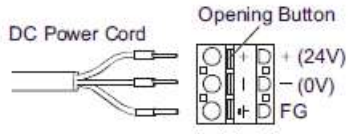
The TIO/DIO modules only accept the new setting after a power cycle

3. CONNECT TOUCHSCREEN

3.1 Power supply connector

The touchscreen must be supplied with 24VDC. This must be connected to the power supply connector of the touchscreen.

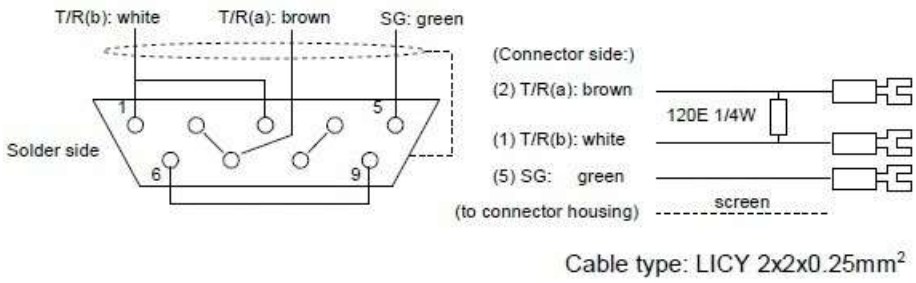
Please regard the polarity of the +24VDC signals!!!



The FG (functional ground) must also be connected to the central PE (protective earth) connection of the unit. This can prevent damage to the touchscreen in case of an electrostatic discharge.

3.2 RS-485 communication connector

Connect the RS-485 communication port (**COM2** on the touchscreen) with the 9-pole sub-D plug (female) with the first TIO module.



To the left you see the 9 pole connector on the side of the touchscreen. To the right you see the part of the cable that must be connected to the first TIO.

Note that on the TIO module, you connect:

Brown wire to	T/R(A)	3
White wire to	T/R(B)	4
Green wire to	SG	5

The 120ohm bus-termination resistor must be connected between the T/R(A) and T/R(B) communication lines on **the last module in the communication line**, between T/R(A):3 and T/R(B):4.

When using a 6 channel Heat Manager configuration with 1 4-channel TIO and 1 2-channel TIO, you need to connect the communication cable to the first leftmost TIO (with rotating switch set to 0) and the bus-termination resistor to the rightmost TIO (with rotating switch set to 1).

When using 3 TIO modules and 1 DIO module, you must connect the communication cable to the first leftmost TIO (with rotating switch set to 0) and the bus-termination resistor to the rightmost DIO module (last module on the communication line).

Connect the screen of the cable to the housing of the 9-pole Sub-D plug.

For a GP4201TW/4301TW and 4401T touchscreen you need to make the following internal connections inside the 9-pole sub-D plug (female) that will be connected to the COM2 port on the touchscreen:

Connect point 1 to 3
Connect point 2 to 7
Connect point 4 to 8
Connect point 6 to 9

Watch very carefully when making these interconnections on the 9-pole sub-D plug!

4. STARTING FOR THE FIRST TIME

When the Heat Manager starts it will first try to communicate with the first and second TIO modules (so they must be connected properly). When this test fails an error screen will appear with advice on how to check the problem:

Here is some advice on what to check when this screen appears:

Check the rotating switch with the TIO address. The left is for the first TIO (channels 1-4) and must be 0 (internally converted to Modbus address 1).
The right one is for the second TIO (channel 5-6 or 5-8 respectively, depending on Heat Manager type) and must be 1 (internally converted to Modbus address 2).
The third TIO (channel 9-12) must be 2 (internally converted to Modbus address 3).

Watch out: when using external signaling modules (DIO modules), the first DIO module must ALSO have the rotating switch set to address 0 (internally converted to Modbus address 17). The second DIO module must have address 1 (internally converted to Modbus address 18).

The current measurement modules (CT modules) must have its rotary switch set to 0 (internally converted to Modbus address 33).

Also check the small dip-switches on the side of the TIO, DIO and CT modules (you have to remove them from the DIN-rail to check, otherwise you cannot see them).
Put them in the configuration shown above (this is for setting the communication speed to 38400bps, no parity, 8 data-bits, 1 stop-bit and Modbus communication protocol).

When all these settings are correct you need to check the wiring from the COM2 communication port of the touchscreen to the TIO module. It sometimes helps to swap the A and B line (see bottom of TIO module backplane).

Make sure there is 24VDC present on the TIO modules. You can check this by looking at the green FAIL/RUN light on the TIO/DIO/CT module: this should be continuously on.

Also check if a 120 ohm resistor is present between the A and B communication line on the LAST module in the communication line. Otherwise communication errors are possible.

Check the green led indicators on the TIO modules (Rx/Tx), they must flash green. The FAIL/RUN light on the TIO modules must be continuously on.

Check that the internal wire bridges inside the 9-pole sub-D plug (female) that will be connected to the COM2 port on the touchscreen are present. This is necessary for 4401T/4301TW/4201TW touchscreens.

You need to power-cycle the Heat Manager to recover from this error

5. INITIAL SETUP

Language setup
After the system detects your initial startup you will be asked to choose the setup language. Note that this is the language used for setting up the Heat Manager. This is not the language that the user will see, we will set that up later on during the setup process.

You can select the desired language by pressing on the corresponding flag. Your selection will be highlighted after doing so. Press EXECUTE to continue the initial setup and confirm your selection.

End user license agreement
After setting up the language the "End user license agreement" will be displayed. Press the up and down buttons to scroll through the license.

After reading the agreement you can press the "Yes, I agree" button to agree with the content of the license.

You cannot continue the initial setup without agreeing to the "end user license agreement". Contact CasCade if you have any questions about the license agreement.

The NEXT button will be highlighted as soon as you have agreed with the license. Press the NEXT button to continue the initial setup.

Edit system information.
After agreeing to the "End user license agreement" you can enter the system information.
You can fill in the identification, serial- and order numbers.

Press <<EDIT HERE>> next to the corresponding field to edit its value. The keyboard will now appear allowing you to enter the desired data. Repeat this action for all 3 fields.

If this is your first time using the built in keyboard read the keyboard information in the "Common" section of this manual to understand its functions.

Adjust date and time
You can set the correct date and time by pressing the corresponding button. Keep in mind that the date is arranged according to the international standard which is "year / month / day". The time is displayed according to the 24hr time notation.

Press the corresponding digit to show the keyboard. The keyboard allows you to edit its value only when the filled in value fits within the allowed range. The allowed range will be shown on the keyboard.
Note that this date and time can always be changed later.

Choose setup type
Press the USE WIZARD button in the Choose setup type screen. The button will start flashing as soon as it has been selected. Now press next to start configuring your system (the other option "load FR USB" is not implemented yet in the software).

Select user language
Start by selecting the language which you want your operators to use. This works in the same way as selecting the setup language. Your selected language will start flashing. Press NEXT to continue your configuration. The user language can always be changed later. Please note that the French translation is not implemented yet.

Select number of channels
You will be asked to select the number of channels that your Heat Managers has.
Note that you cannot choose a 12 channel setup when you do not have a 12 channel configuration using 3 Z-TIO-A modules. Currently you have a 6 channel version consisting of 1 TIO-A and 1 TIO-B module or 12 channel version, consisting of 3 TIO-A modules.

Press the desired configuration. Your selection will start to flash. Press NEXT to confirm your selection.

Temperature unit selection
You can select the preferred temperature unit. Note that the unit selection can always be changed later on. Press NEXT after you have made a selection.
When using Celsius the Heat Manager works with 1 decimal behind the comma. In Fahrenheit mode the Heat Manager works in whole degrees without a number behind the comma.

Select input type
Select thermocouple type K or S.
Select TC-K 1200°C when using RKC-TIO modules (default setting).
Select TC-K 800°C when using a single board RKC-B400 module (special version with limited functionality).

Select restart type
Select "HOT" if you want the system to resume where it left off when a power failure occurs.
Select "COLD" if you want all channels to stop when a power failure occurs. This setting can always be changed later in the system settings.

Preload profiles
Insert the USB stick with the default profile database file on it. This file F00001.BIN is a binary file (supplied by CasCade and for backup reasons present in de FILE directory on the SD/CF card).
Put this F00001.BIN file on an empty USB-stick in the directory FILE (make the directory if it does not exist). The Heat Manager expects that the file is in this directory.
After the USB stick has been inserted you can try to load it by pushing the continue button.
You can skip this step at this stage, but need to perform it before actually starting a profile in the Heat Manager (in both the advanced and easy mode).

Select options (first screen)
Select the options that are available for your Heat Manager:

Modem connected:	GPRS modem for LogOnline present
THV Thyristor units:	6 RKC thyristor units used for driving the heating outputs
Recorder comms:	Communication with a Chino AL/H4000 recorder (start/stop etc.)
Advanced mode:	Work with 100 recipes and the 16-step profile editor. When not selected the Heat Manager works in so-called easy mode (only 1 profile in channel with ramp up/soak and ramp down step)

Select options (second screen)

Customer specific screens: when selected, a customer logo is shown at startup for a short time before the Heat Manager continues. The logo is also shown in the info-menu. These logos are present on the SD/CF card.
Logo_start.jpg (620x372 pixels) for startup and
Logo_info.jpg (635x283) for the info screen.
You can change the logos yourself and put them on the internal SD/CF card (you can remove it from the underside of the touchscreen)
When you don't select this option the normal startup with CasCade logo is shown. Make sure the new file sizes don't exceed the original size, so first size down the pictures you want to use.

External Signal Module: This option is for selecting if the extra output relay unit for controlling the welding light is present in the system.
Select 01-06 if the channel 1-6 DIO output module is present,
Select 07-12 if the channel 7-12 DIO output module is present.

Current sensor module channel 01-06:
This option must be selected when an extra Z-CT module for monitoring the heating element currents is connected.

When selecting the external signal module for channel 07-12 both DIO modules must be present in the system. When you only use 1 DIO module for channel 01-06: only select external signal module channel 01-06. It is not possible to only use a DIO module for channel 07-12, channel 01-06 –has- to be present in this case.

When al data is correctly filled in you can confirm this by pressing the “YES, STORE” button. Your configuration will now be saved.

After this you can reboot the system. If you still have doubts you can push re-init to perform the whole setup from the start.

After rebooting the first time the Heat Manager will check if the TIO temperature controller modules are configured correctly. If they are configured correctly the system will show various startup screens, including the customer specific logo (when selected) and continue to the main menu.

If the Heat Manager detects TIO modules that are not configured, the following screen will appear:

Now press the SETUP button and all modules will be re-configured by the Heat Manager. The screen below will appear when this procedure starts.

DIO digital output external signaling modules and CT current sensor modules must be manually re-initialized after replacement. There is no configuration detection. Do this with the SETTINGS – SYSTEM – RE – INIT procedure and perform the TIO INIT (see the corresponding chapter in this manual on how to get to that screen). This can be done later, if desired.

The touchscreen tries to communicate with the first TIO module, when this is successful the following screen will appear (when not successful an error message will be displayed):

The Heat Manager will now configure the temperature controllers (TIO modules) and all other optional IO (selected in the setup). This takes a few minutes to complete since hundreds and hundreds of parameters need to be set in the temperature control modules.

After all has been finished correctly the following screen will appear:

You can now reboot the system. After rebooting the system will try to communicate with the TIO modules and check their configuration. When that was successful the Heat Manager will try to communicate with all the other connected devices. When a communication error occurs an error screen will appear, if not, the system will show various startup screens (incl. your logo, when selected) and continue to the main menu.

6. ENGINEERING SETTINGS AND PREFERENCES

This screen shows an overview of the settings menu screen. To enter this menu press SETTINGS in the main menu screen. The RECORDER CFG, LIMIT SET and MODEM menu-items are covered in the User Manual, please consult that manual for those settings.

Note that the LIMIT SET button is only visible when you have DIO external signaling modules connected, the MODEM button is visible when the external GPRS modem is connected.
The CURRENT SET button is visible when during the setup the THVA1 thyristor modules or the Z-CT current sense module have been selected.

6.1 Controller configuration

This screen is for tuning the PID settings. Only change this when you have experience with adjusting these settings, otherwise an unstable temperature control can occur.

First select the controller channel you want to change, since they are all the same, we will select channel 1 as an example.

Here you can tune the PID settings. For most situations the default settings are ok, these are:
Prop. Band: 11.0°C
Int. action: 180sec
Der. Action: 20sec
Cycle time: 10.0sec
Dig. Filter: 15.0sec

When the programmer is in a soak segment you can push the AUTOTUNE button: the system will try to determine the PID settings by executing an automated calibration procedure.
Only perform this operation when you have experience with setting these values.

The COPY TO ALL button copies the PID settings for this channel to all other channels.
The DEFAULT button sets the PID settings back to the settings above.

6.2 Current Set

Press SETTINGS – Current Set to the correct settings for the current limits and heater break alarms. You must also select which channel you wish to set. After selecting the right channel the following screen will appear when a CT module has been selected:

With this screen you can set the desired nominal current for the heating element that is connected to this channel.
The current setting is displayed above the buttons.
Keep the desired current button pressed for 1 second and the HeatManager will write the desired current to the module.

[COPY TO ALL]: Write the selected settings to all 6 current monitoring channels.
[CURRENT SET]: Select another channel for current setting (1-6]
[MAIN MENU] : Return to the main menu

6.3 Change system settings

6.3.1 Changing input type

Enter the system settings input type menu by pressing SETTINGS → SYSTEM. Here you can change the settings on the INPUT TYPE tab.

The temperature unit selection can only be changed, when all channels in the Heat Manager are in stopped state

Unit selection:
You can change the temperature unit by pressing the down arrow next to the label: the temperature unit can be set in Celsius or Fahrenheit.
Select the preferred temperature unit by pressing the desired setting. Your selection will be highlighted in white.
Press the OK button *for a few seconds* to confirm your choice (this is to prevent accidental changes).
The Heat Manager will now start re-configuring the temperature control modules, please be patient and follow the instructions on the screen.

Action at TC break or polarity error
You can select whether the programmer needs to continue with the profile when an open thermocouple is detected. By default this setting is set to "continue". You can also change this into "hold". In this situation the programmer will remain at the same temperature set value and step time until all thermocouples of the programmer group are not in burnout state.

Polarity error when sensor below
The Heat Manager will detect a polarity error warning when a process value drops below this temperature. The default setting is -50 degrees.

6.3.2 Change general settings

Enter the system settings menu by pressing SETTINGS → SYSTEM. You can change the general settings on the GENERAL tab.

Restart type
With restart type you can select whether the Heat Manager can automatically re-start all channels when the power on the Heat Manager returns after a power failure. When you select "hot" the Heat Managers automatically restarts the running channels and continues with the set values where the power failed. When the power was off for a long time, you need to restart the Heat Manager because the temperatures have dropped way below this set value.
When you select "cold" the Heat Manager will automatically stop when the power returns: an operator intervention is now necessary to restart the channels: they will then start at the actual process value of the programmer.

Operation language (only visible here when external signaling modules are selected)
With operation language you can switch the language of the Heat Manger between English, German and Dutch (French language is not implemented yet). You don't need to restart the system.

Batch info at start
When batch info at start is enabled the Heat Manager demands that you enter the batch information when you start the first channel (so this occurs only when all channels had been previously off). Starting other channels after this will not ask the batch info again.

Operation Mode
The operation mode selects the way the heating profile is edited on the Heat Manager.
There are two modes, the advanced mode and the easy mode.

In the advanced mode you can use a profile-database of 100 profiles, each consisting of 16 steps, in the Heat Manager. The profile editor assists you while editing each step in the profile.

In the easy mode there can be only 1 profile running in channel 1 that consists only of a ramp up, soak segment and a cool down segment.

Please note that the operation mode can only be changed when all channels are in stopped state.

Be sure to set a correct new channel configuration and (when necessary) profile setting after changing from easy mode to advanced mode (and vice versa).

When you switch from advanced to easy mode, the default profile is loaded. This profile is:
ramp up to 600°C at 150°C per hour,
soak for 1 hour and 5 minutes,
ramp down to 300°C at 150°C/hour,
after set value reach 300°C: all channels off. Cooling down in a natural way

This default profile is also loaded when a channel set is performed in the easy mode

6.3.3 Change date and time

Enter the date & time menu by pressing SETTINGS → SYSTEM. Here you can change the system date and time settings by pressing the "DATE & TIME" tab (3rd from the left).
You can change the values by pressing on them and entering the new desired setting.

Note that the date format is *Year/Month/Day.*
Note that the time format is *Hour/Minutes/Seconds.*

6.3.4 Change security settings

You can change the systems security settings in in the security menu. This menu can be accessed by pressing SETTINGS -> SYSTEM. Press the SECURITY tab (4th from the left) to show the security menu.

The PIN code system is only active in the advanced mode. In the easy mode you are always automatically logged on

There are 4 levels of access within the Heat Manager. These access levels are described below:

Level:	PIN:	Description:	Limits:
1	1111	Used for operators that are only allowed to start and stop channels	Cannot change control type, heating profile and system configurations
2	2222	Used for operators that are also allowed to change heating profiles	Cannot change control configuration and system settings
3	3333	For experienced operators	Cannot change system security settings
4	4444	Administrator	None

The PIN code of the 4 access levels can be changed by pressing the corresponding PIN. The PIN always has to be 4 digits (0000 to 9999). Note that the PIN of one access level cannot be the same as any of the other 3.

PIN code lock

When having filled in an incorrect PIN X amount of times the system will be blocked for a X amount of time. The time the system is disabled can be set using the “PIN disable timer”. The PIN disable timer is the amount of seconds that the system will be blocked.

The maximum amount of PIN attempts can be set by pressing “Max. PIN attempts”. The maximum amount of PIN entries can be set from 1 to 9.

A login session will expire after an X amount of time when the system is not in use. The time before expiring can be set using the “Expire Timer” option. The entered value is measured in seconds (10 to 9999).

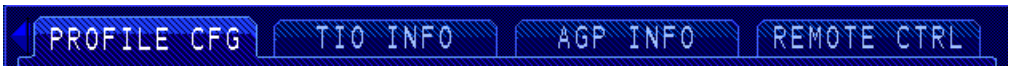
Always write down the changed PIN codes, otherwise you cannot access the Heat Manager anymore. In case of emergency you can perform a new setup from the advanced system settings. The PIN codes will then be reset to their original values

When you log on many times with the wrong PIN-code, the screen appears locked. In case of emergency you can enter unlock code 3712. The PIN code will now reset to 0000. Log in with the reset PIN code of 0000 and enter the new desired PIN codes in the SYSTEM SETTING PIN code setup screen.

6.4 Advanced system settings

Hardware configuration settings can be re-configured in the "Advanced Settings" menu. This menu is accessed from the SYSTEM SETTINGS menu in the following way.
Enter the SYSTEM SETTINGS menu by pressing SETTINGS → SYSTEM.
Now go to the "Security" tab (*4th from the left*). Note that an arrow has appeared on the right-top of the screen.

Press the arrow to enter the next screen with the advanced system settings.
Here you will see the following tabs: PROFILE CFG, TIO INFO, AGP INFO and REMOTE CTRL.



6.4.1 PROFILE CFG

On this screen you can set different settings with regard to the programmers.

Pref. prog method
When creating a heating profile the step configuration screen will always start with a ramp-display (degrees per hour). You can switch this function to time by selecting time as the "Preferred Program Method". Press OK to confirm the preferred method.

Start profile from
When creating a profile you can choose to either start from the ambient temperature or from zero degrees. Use the "Start Profile From" to select your desired method. Press OK to confirm.

Action @ profile end
Action at profile end sets the action that needs to be performed when the profile is finished. You can either choose to "stop control"; all channels will be switched off and the process cools down in a natural way.

You can also select cont. control, in this case the temperature set value of the programmed profile will remain on the last value and the channels will not be switched off.

6.4.2 TIO INFO

This screen shows the actual temperatures that are currently on the 6 channels (or 12, when selected) channels.
This can be used for calibration purposes.

[CAL] When you press this button, the current time and date will be stored inside the Heat Manager as a reference to when it was last calibrated.
Keep this button pressed for 3 seconds to activate.

[MAX]/[TEMP]: Toggle between actual temperature and maximum temperature overview. The maximum temperature screen shows the highest temperatures ever measured inside the TIO module. These values cannot be reset.

6.4.3 AGP INFO

Batt condition
This screen shows the actual condition of the internal non-volatile memory backup-battery that is used for storing the parameters/recipe/setup and recording buffer of the Heat Manager.
A green light means that the battery is ok, red means that there is a fault with this battery. Contact your supplier when this happens.

TIO x comms ok
When the light is green the communication between the touchscreen and the TIO module is ok.

Number of samples left to trigger buffer almost full warning
When the buffer that is used for sampling is below this amount you will get a pre-warning, the sampling however, keeps on running until not sampling positions in the buffer is left. You then get an alarm that prompts you to store the measurements and clear the buffer.

Editor/Firmware
Here you can see the software versions used in the Heat Manager.

SYSTEM platform
This shows the hardware version of the touchscreen.

OFFLINE

If you set the touchscreen to offline, all control and communications between the touchscreen and the TIO/DIO control modules will be stopped and will remain on the last received set values.
The TIO modules however keep on controlling the temperatures on the last received set value.
Proceed with care!

Push this button to enter the offline mode (keep it pressed for a few seconds).

6.4.4 REMOTE CTRL

This screen is used when an external heater control is used. It shows the Modbus TCP status addresses for external control. These values can be accessed via the Modbus-TCP interface protocol that is mapped on the ethernet interface of the HeatManager.

6.4.5 THV SETTINGS (when present)

This screen shows the actual status of communication with the RKC THV A1 thyristor modules used for controlling the heating elements. These modules are controlled via a Modbus-TCP to RS485 convertor. The units itself work with a Modbus-RTU (serial protocol).

6.4.6 RECORDER (when present)

This screen shows the actual status of the Chino AL/AH 4000 recorder communication and its settings. This recorder communicates with the Heat Manager via a Modbus-TCP connection.

6.4.7 DIO 1 (when present)

This screen shows the actual status of the DIO digital outputs for channels 1-6. A total of 8 digital outputs are used.

For each digital output you can select if it is active high or low (output relay activated or not when temperature inside band). If you push the output type text behind the corresponding channel the output action will be inverted from the current situation

6.4.8 DIO 2 (when present)

This screen shows the actual status of the DIO digital outputs for channels 7-12.

For each digital output you can select if it is active high or low (output relay activated or not when temperature inside band). If you push the output type text behind the corresponding channel the output action will be inverted from the current situation

6.4.9 Z-CT SET (when present)

This screen can be used to set the various nominal heating element current settings and select alarming options.

In box 1, 2 and 3 you can set the nominal current settings that are used in the CURRENT SET menu option of the SETTINGS.

Off by current alarm: Put a mark here when you want to switch the channel with a current alarm off. **Note: this only works with a channel in Fixed SV mode, in Programmer mode the channel keeps on running but an visible and audible alarm is given.**

Block HBA and MELT alarm:

Put a mark here if you only want the CT module to react to maximum current alarms.

[ADV]/[SIM]: Toggle between the advanced settings overview and the simplified overview.

When you switch to the advanced view the following screen will appear:

These settings are for experienced users. Consult the supplier if you want to make changes here.

6.4.10 RE-INIT

Only execute this procedure when you are familiar with the setup procedure of the Heat Manager. Otherwise possible damage to the system and/or a dangerous situation can occur.

Be sure to store the actual heating profiles on the USB-stick before executing this function. During the setup the Heat Manager needs to read this file from the USB-stick. Go to the PROFILE-SET menu to store this file to the USB-stick.

RUN SETUP: ONLY PROCEED WHEN YOU HAVE AN USB STICK WITH THE \FILE\F00001.BIN DEFAULT PROFILES FILE STORED TO IT

RUN SETUP
Use this option to select a new configuration without initializing the control system module (TIOs/DIOs). Press the button for more than one second to invoke the initial setup process (this is to prevent accidental pushing on this button).
Read the "Initial Setup" chapter to help you guide through the initial setup process.

TIO INIT
Select the TIO INIT option to only initialize the control system modules (TIOs/DIOs) and select a new configuration. A new setup will not be performed. Only the settings in the modules will be set correctly

Remarks: You an only execute these functions when all the channels in the Heat Manager are in the stopped state.

You can use this setting if you replaced a TIO, DIO or CT module and want to write the correct settings to it.

In case of emergency the default heating profile F00001.BIN file resides on the SD/CF-Card.
It can be copied manually from the SD/CF-Card location \FILE\F00001.BIN to the USB-Device (also in the same directory) with the File Manager from the HISTORY menu.

After that you can load the default profile file in the PROFILE SET menu. Select LOAD FR USB for this and follow the instructions on the screen.

Push EDIT in the PROFILE SET menu to verify if the loading procedure went correctly. If the list contains:
TEST (or another name)
TEST (or another name)
Program 3 (EMPTY) (or another name) etc.
The loading procedure went correctly. If the screen appears empty: try again.

7. NETWORK SETTINGS

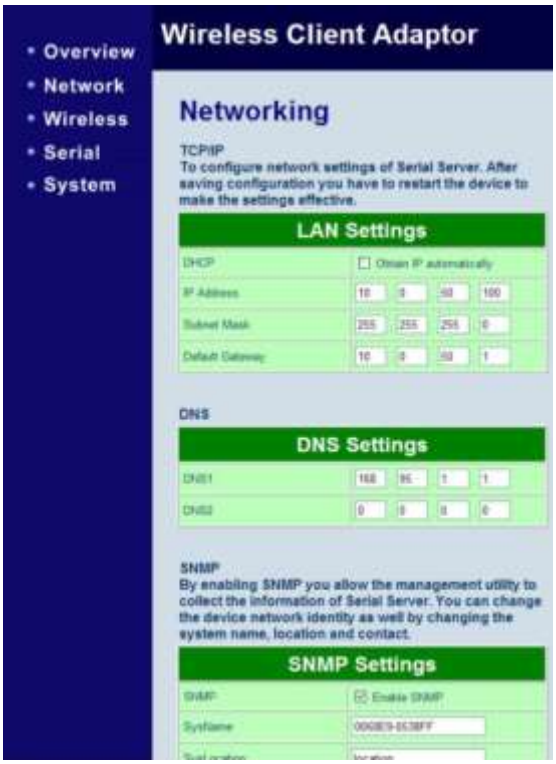
7.1 Setup PC-W in Ad-Hoc Wi-Fi configuration (when present)

Use the following steps to configure a so-called Ad-Hoc configuration with your PC-W Wireless module.

Configure the network settings of your PC-W module
In order to connect to the PC-Ws built in web interface you must make sure that your computers IP is in the same range as the module. The modules default IP address is 10.0.50.100.
If you cannot connect to the PC-W using this address press the reset button to restore its default settings.
The RESET button is located on the front of the module next to the Ethernet port. The button needs to be pressed using a paperclip.

To start configuring the module, type its IP address into your PC's web browser to open the web interface. Click on "Network" in the main menu on the left to open up the network settings.

This screen will look as follows:



Configure the PC-W using the following settings:

LAN Settings
IP-Address: *10.0.50.100*
Subnet Mask: *255.255.255.0*
Default Gateway: *10.0.50.1*

Save the settings after having filled in all the values.

Warning: note that after you saved your settings with another IP address, the module can no longer be approached at the default IP addresses 10.0.50.100

Configure the Wireless settings of your PC-W module
Open up the Wireless Settings by clicking on "Wireless" in the main menu on the left. The screen will look as follows:

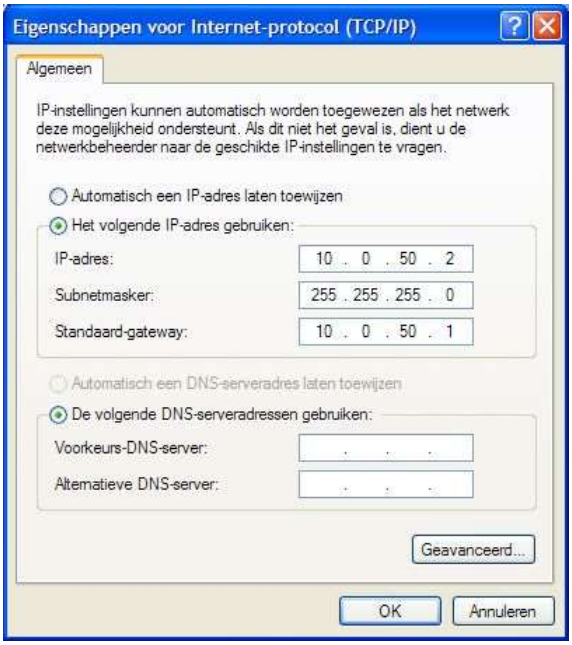
Configure the Wireless connection by using the following settings.

Roaming Threshold:	Normal
SSID:	HMPConnect1
Topology:	Ad-Hoc Mode
Wireless Band Mode:	G Only
TxRate:	Auto
Channel:	1
Authentication:	Open
Encryption:	WEP
WEP Key1:	ASCII , 128bits , heatmanager01

Press "Save Settings & Connect" to finish setting up the Wireless Connection on the PC-W module.

7.2 Setup your PC for connection with the PC-W (when present)

Open up the start menu and click “Configuration screen” → “Network Connections". Here you will see “Wireless Network Connection”. Right click on this Icon and select “Properties” to open up the TCP/IP settings screen”. The TCP/IP screen will look as follows:



Configure the Wireless connection on your pc by using the following settings.

Use the following IP Address
IP-address: *10.0.50.2*
Subnet mask: *255.255.255.0*
Default gateway: *10.0.50.1*

Click on “OK” to confirm the new configuration.

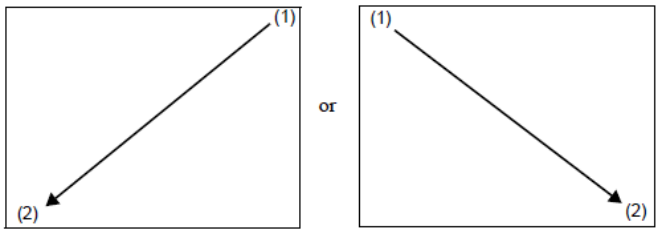
Test your wireless connection to the PC-W module. You can connect to the PC-W by using WEP password you entered in the PC-W module. The password is “heatmanager01”.

With some PCs it is necessary to fully restart it with a power down/up to make use of the new IP settings.

7.3 Assigning an IP address to the touchscreen

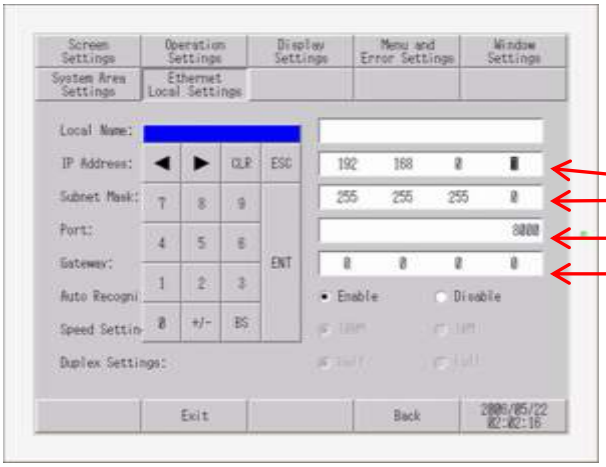
The touchscreen settings can be changed during operation by entering the touchscreen offline mode.

This can be done by either pressing the upper right then the bottom left corner, or the upper left and then bottom right corner. Note that you need to push –inside- the black rectangle, but just on the edges of the corners. You need to push in a rapid "click-click way", with finger (2) just after the finger that pushes (1). You must not push both fingers together, but –just- after another.



The menu bar will now appear on the bottom or top of the screen: **now immediately stop pushing, or it disappears again**. Press the "Offline" button to enter the System menu.

Go to the Touchscreen mode and touch "Main Unit Settings". Now press "Ethernet Local Settings": this will show the IP configuration screen.
Press on the corresponding fields to bring up the keyboard and fill in the desired values.



Configure your touchscreen by using the following settings:

IP-Address: *10.0.50.102*
Subnet Mask: *255.255.255.0*
Port: *8000*
Gateway: *10.0.50.1*

Your new settings will automatically be saved when you press enter.

Now press "Exit" to terminate the offline mode and restart the touchscreen, the touchscreen can now be accessed at the IP address that is entered.

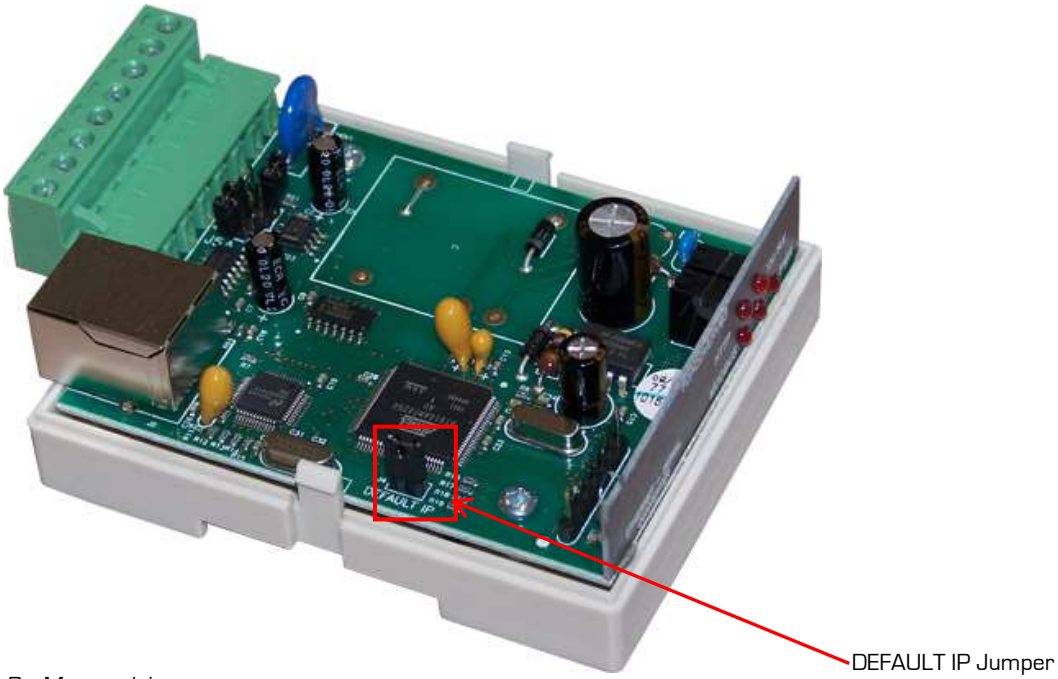
Please make sure that you don't set the same IP addresses inside a network, this will cause IP conflicts and the communication will not work.

7.4 Setting up the ProMux ethernet to RS232/485 convertor for communication with RKC THV-A1 thyristor modules (when present)

Enter the Promus web interface by typing the following URL into your browser: *http://10.0.50.101/ip.htm*.

If you cannot approach the module with this URL it is recommended that you reset it to its default settings. You can do this by opening the module (push in the two clips on the side) and removing the default IP jumper.

Turn the module on and off again and place the jumper back. The module now has its default settings back, including its default IP address.



ProMux module

Now you can approach the module with the following URL: *http://169.254.11.111/ip.htm*.
After doing so the "Serial/Ethernet converter & Modbus Gateway" screen will open up.

Make sure that you set our pc in the same IP range (169.254.11.xx), otherwise you cannot reach the module with your pc. You must write down the original IP address of your PC, before changing it, because you need to set IT back to the original values after setting up the module.

Module IP: *10.0.50.101*
Gateway: *10.0.50.1*
Subnet Mask: *255.255.255.0*

Server IP: *10.0.50.102*
(Server IP has the same IP address as the touch-screen)

8. COMMON FUNCTIONS

8.1 Built in QWERTY keyboard

While using the Heat Manager Connect you will be asked to fill in all sorts of information. This can be done by making use of the built in touch-keyboard. The keyboard is as displayed below. You will notice that the keyboard makes use of the standard "QWERTY" layout. The things you must know to make correct use of the keyboard are:

- Your written text will be displayed in the "input field" at the top of the screen.
- You can change the layout from "QWERTY" to "numeric" and vice versa by pressing the "**123 :#+**" / "**ABC**" button at the left bottom of the keyboard.
- Use the "BS" and "CLR" buttons to clear parts of the inserted text.
- Close the keyboard by pressing "**ESC**" at the left bottom of the screen
- Move the cursor by pressing the "Left" and "Right" arrow buttons at the right bottom of the keyboard.
- Confirm your entry by pressing "ENTER"

8.2 Numeric keyboard

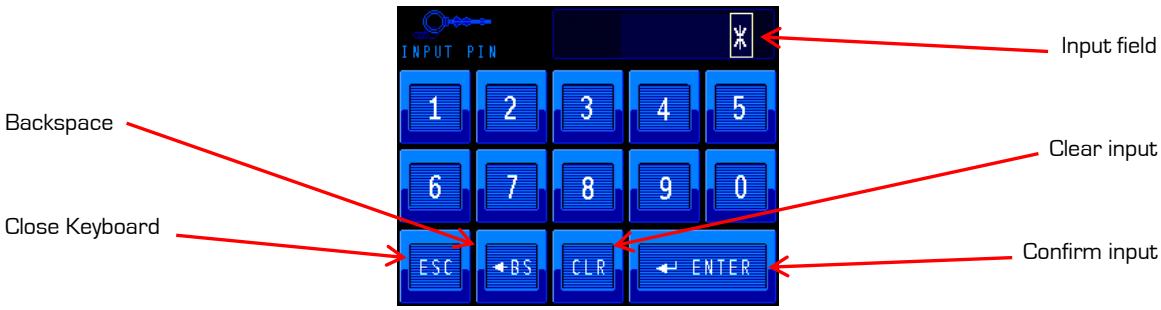
You make use of the numeric keyboard when editing heating profiles. The functions of this keyboard are be explained below.

The minimal and maximal values that can be entered will be displayed at the top of the keyboard. Values that do not fall in this range will not be accepted by the system (you hear a few beeps).

- Use the number buttons to fill in the Input field.
- Use the "**BS**" and "**CLR**" buttons to clear areas of the input field.
- You can close the Keyboard by pressing the "**ESC**" button.
- Confirm your entered data by pressing the "**ENTER**" button.

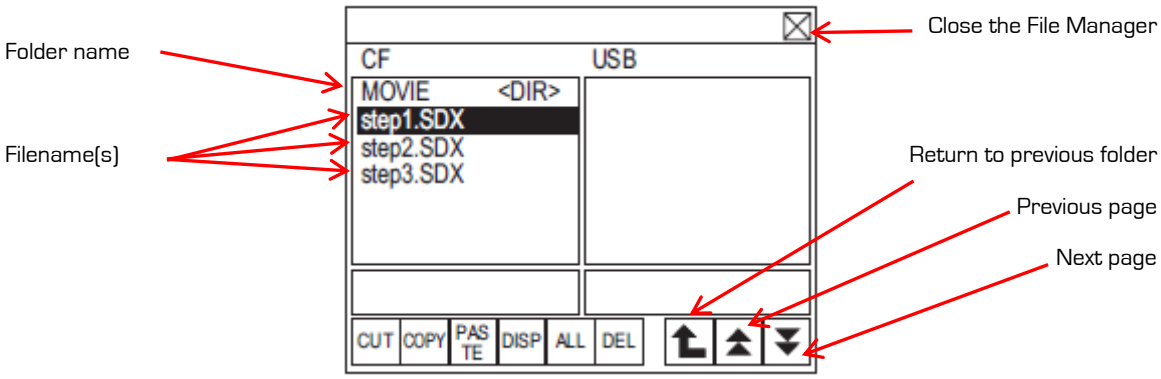
8.3 Login keyboard

After pressing the LOGIN button the login keyboard will appear. The login keyboard works in the same way as the numeric keyboard. The only difference is that the input field will cover up your input with "* * * *" for safety reasons. Your login code is a 4 digit number.



8.4 Using the built in file manager

You use the built in file manager to transfer files from the SD/CF card to the USB device (and vice-versa).
The left part of the file manager will show you the files that are on the SD/CF card where the right part of the browser will show you the files from the USB device.



[DEL] : Deletes the selected file or folder.
[COPY] : Selects al the files in the displayed folder.
[DISP] : Displays the files in the selected folder.
[PASTE] : Pastes the file that was cut or copied.
[ALL] : Copies the selected file or folder.
[DEL] : Cuts the selected file or folder.

Transferring data from the internal SD/CF card to USB stick.
Use the following steps to copy files from the CF Card to the USB stick (or vice-versa) using the file manager.
First make sure that your USB stick is connected to the Heat Manager and push on the [SD< - >USB] button.

Select the files you wish to transfer from the left column of the file manager. The files you have selected will be highlighted in "white". Entire directories can also be selected.

Directories are shown with <DIR> next to the folder name. You can either choose to copy the files or cut the files. Press CUT or COPY. The USB section will now be highlighted in yellow. Select the directory in which you want the files to be stored. Now press PASTE to copy the files. Close the file manager by pressing the X button on the top right. The files are now copied and the USB stick and it can be removed.

Do not disconnect the USB device until you have closed down the file manager

Always check if your CSV files can correctly be opened on the PC before removing these files from the internal SD/CF card of the Heat Manager.

9. PID CONTROL

The default settings for the PID controllers in the Heat Manager have been determined by performing a lot of tests in actual real-life process situations. When you keep the ratio between heating power and work piece mass the same you can use the same settings for most process conditions.

PID control can be considered as the intelligence or "brain" of the controller. The same is when you are driving a car on the highway and wish to control the speed at 100 km/hr. Because of varying road conditions (different tarmac, driving up- or downhill) it is necessary to increase and decrease throttle to hold the desired speed. You will also notice that your foot automatically does this.
Try to concentrate more on what you are actually doing, and you will notice that it is actually quite impressive on how the brain executes this apparently easy task. Your brain is now acting as some kind of very high level adaptive PID controller.

9.1 A bit of history

In the past century, when automation became more and more important in industry, mathematicians and engineers tried to find a way to integrate this knowledge into an automated system.

PID controllers date back to the 1890s governor design. PID controllers were subsequently developed in automatic ship steering. One of the earliest examples of a PID-type controller was developed by Elmer Sperry in 1911, while the first published theoretical analysis of a PID controller was by Russian American engineer Nicolas Minorsky in 1922. Minorsky was designing automatic steering systems for the US Navy, and based his analysis on observations of a helmsman.
Observing that the helmsman controlled the ship not only based on the current error, but also on past error and current rate of change. This was then made mathematical by Minorsky. His goal was stability, not general control, which significantly simplified the problem. While proportional control provides stability against small disturbances, it was insufficient for dealing with a steady disturbance, notably a stiff gale (due to droop), which required adding the integral term. Finally, the derivative term was added to improve control.

Trials were carried out on the USS New Mexico, with the controller controlling the angular velocity (not angle) of the rudder. PI control yielded sustained yaw (angular error) of ±2°, while adding D yielded yaw of ±1/6°, better than most helmsmen could achieve.

The Navy ultimately did not adopt the system, due to resistance by personnel. Similar work was carried out and published by several others in the 1930s.

In the early history of automatic process control the PID controller was implemented as a mechanical device. These mechanical controllers used a lever, spring and a mass and were often energized by compressed air. These pneumatic controllers were once the industry standard. Later on the first electronic analog PID controllers were made with tube-amplifiers.

After the invention of the solid-state transistor things were progressing into analog solid state PID controllers and later, with digital IC technology, the first truly digital controllers were invented that make very advanced adaptable PID controllers possible under quickly varying process conditions.

9.2 From theory to practice

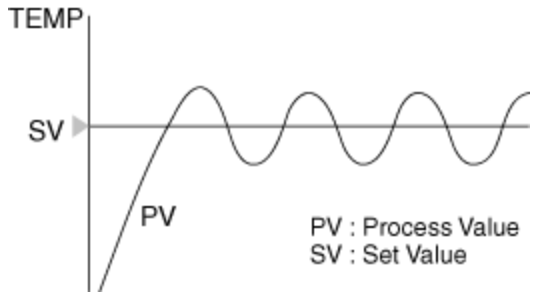
In order to fully understand a PID controller, an extensive and thorough mathematical knowledge of Laplace and Z-domain transformations is necessary. That goes too far for this manual.

We therefore take a more practical approach and try to describe a PID controller in common language that almost everybody can understand.

To make things easier we will start out with a very simple on/off controller, think of the old thermostat that was used in the past to control the temperature in a room (the modern types used nowadays are almost all PID controlled).

9.2.1 ON/OFF control action

ON/OFF temperature control is the simplest and least expensive form of control available. The output signal from a controller is either FULLY ON or FULLY OFF depending on the direction of the deviation between the set value and process value.
The figure below shows the characteristics of an ON/OFF control action:



The ON/OFF control action takes place if any deviation from the set value occurs.

This action responds quickly, but is sensitive to input noise which causes chattering (ON/OFF switching at short intervals). Therefore, in actual use, the ON/OFF temperature control action has some hysteresis which is named dead band or control sensitivity. This prevents the quick chattering around the set value when the process value is very near.

9.2.2. Proportional action

P stands for proportional action and is a multiplication factor of the deviation between actual set value and process value. Proportional action control is also referred to as P or gain in some control systems.

With the proportional action, the controlled process no longer switches as a direct result of the deviation between set value and process value but controls this *proportional* to this deviation.

The proportional action control is active within a user-definable zone around the set value, called the proportional band (Pb). When the process value (PV) enters the proportional band, the output becomes gradually smaller and the process value stabilizes somewhere within the proportional band.

In the Heat Manager you set the proportional band in *degrees*, but beware that there are other brands of systems that set this value in a percentage of the measurement span.

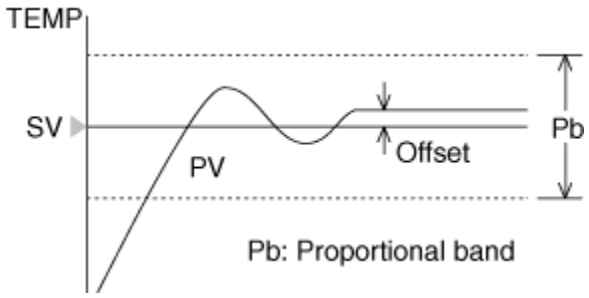
Proper adjustment of the proportional band will result in smooth control. However, it is very seldom, that the actual process value stabilizes exactly on the set value, and it usually becomes stable with some deviation from the set value, called offset.

A high P value gives the control system a large band of modulation, the major disadvantage is that the reaction to the deviation can be quite slow.

A too low P value, however gives an oscillating system where the process value continuously over- and undershoots the set value. We call that "hunting", the controller hunts to reach the set value,

Visualize this by thinking of the gas pedal in a car (with automatic transmission): a high P value is a gas pedal where you can push it very far in so you can control in an accurate way, but need to push it far in and out to reach the speed that you want.
A low P value however is a gas pedal that has a very small travel, but controls the speed of the motor from idle to maximum rev with only a small push on the pedal. It is clear that this situation makes it also difficult to reach the speed you want: you over- and undershoot the speed all the time: more like a classic on/off control.

The "trick" is to reach the correct value where the oscillation is very low, but with a quick enough responsiveness to deviations. Large slow systems that react slowly to deviations generally need a higher P action than small quick systems.



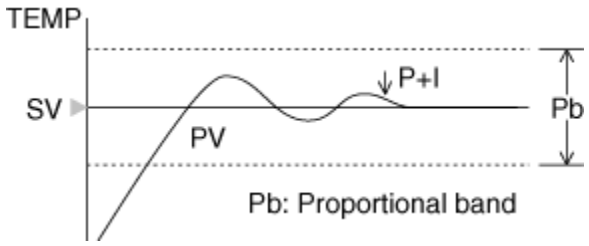
Note: Setting the P action to 0 will result in on/off control action. This will result in relatively large over- and undershoots.

9.2.3 Integral action

I stands for integral action. It takes a summation of the deviations between set value and process value from the past into account. This action is necessary for removing the small offset error that remains between set value and process value when only a P action would be used.

The integral control action is also referred to as reset. The degree of integral action is expressed as an integral time in seconds. The purpose of the integral action is to automatically compensate for any steady state offset that is inherent with a controller that only works with a proportional action.

The integral action moves or resets the proportional band up or down depending on the offset. The integral time of the controller is adjustable and determines how fast the proportional band is moved.



A too high setting of the integral action will result in a very slowly reacting process with big over- and undershoots.

A too low setting of the integral action will result in a control system that can never reach the set value exactly. There will remain a small offset error and the desired set value is not reached.

The trick here is also to reach the setting that more or less corresponds to the actual inertia of the system under control.

Now we go back to the speed control of our car with the gas pedal. When you push in the gas pedal fully it takes some time to rev up the engine and speed up. Also when you let go of the pedal it takes some time to let the engine rev down. This is mainly because of mechanical inertia inside the engine. The weight of the car itself is also very important: a big heavy truck takes much more time to speed up then a small compact car.

In a laboratory, on rollers, we determine the speed of the car as a function of the gas pedal position: this can now be considered as the P-action.

This situation does not correspond to a real road situation where you have wind and different kinds of tarmac.

To compensate for this the gas pedal needs to be pushed in a bit more (or less) depending on the situation. This last action can be considered as the integral action: it fine tunes the actual gas pedal setting, but in a very slow way, otherwise we overshoot the desired speed.

9.2.4 Differential action

The D stands for differential (or sometimes called: derivative) action. This takes the rate of change per time unit of a deviation between set value and process value into account.

Differential action temperature control is also referred to as rate. The degree of differential action is expressed by the differential time in seconds.

The controller measures the rate of the temperature increase per time unit and moves the proportional band to minimize overshoot. The output change is directly proportional to the rate of change in the process value (PV) per time unit.

Theoretically speaking a heating process is a pure integrator and can be controlled by using only a P and I action (most slow processes are). Practice however shows that a small amount of D action can improve accuracy and especially responsiveness to changing external circumstances just a bit further.

A D-action is often used in positioning systems (servo applications) where quick movements are performed. A D-action is also important in a tunnel furnace where the product load differs from time to time (sometimes no product feed), here the D-action is used to prevent over- or undershoot under various process load conditions that change more quickly than the integral time of the process itself.

A too high D action will result in a very unstable process with large over- and undershoots.

A too low D action will result in a system that does not respond quick enough (too late) to varying process conditions. This will also result in an unstable system with over- and undershoots.

9.2.5 Cycle time

Another important setting in a PID controller is its cycle time. This time is the time span used by the controller to calculate how long a relay should be on or off.

Here is an example: we have a mechanical relay that is driving a heating element and the cycle time is set to 15 seconds.
When the controller output is 100% the relay will be continuously activated. When the process value goes a bit over the set value the controller starts to react to this by *modulating* the controller output back to a lower value, e.g. 50%.
When the output is 50%, and the cycle time is 15 seconds, the relay will be on for 7.5 seconds, then switch off for 7.5 seconds, switch back on for 7.5 seconds, etc. etc. etc.

When the controller output is only 10% the relay will be switched on for 0.1 x 15 = 1.5 seconds and then remain off for 15 – 1.5 = 13.5 seconds.

The problem is that we introduce some kind of *lag time* into the system. Of course it would be a good idea to set this cycle time as low as possible, because then the controller can react more quickly to varying process conditions. The major disadvantage is then, that the *mechanical* relay has to switch very quickly on and off. This will damage the contacts of the mechanical relay too quickly and wear them out too fast.
As a *compromise* the cycle time has been set to 15 seconds for this purpose.

When you make use of thyristor modules or solid state relays the cycle time can be set at the lowest possible value (0.1s) since these modules don't have mechanical contacts. The controller output can directly drive the modules proportionally which will result in a quick response to varying process conditions and a more stable and accurate process control.

9.3 Work step-by-step and-by-one

When you adjust a PID controller by hand, a lot of experience and, as the Germans say: “fingerspitzen gefuehl” is necessary. We consider this manual adjustment procedure more like an art than a science.

It is very important that you have a graphic overview of the process values so you can see if your modifications give improvements (or not, then you need to move in the other direction).

It is always best to first start by setting the I and D factors to 0 and only use the P-action.
When you roughly “feel” how the process reacts to a step like change of the set value, you can try the addition of the I action to get the process value exactly on the set value.

Later on you add the D action to improve responsiveness.

After that, you start changing the P, I or D values one by one. Try doubling them, or halving them, and see how the process reacts to it. This procedure must be re-done until you are satisfied with the new settings.

When you see a process value that is slowly oscillating with a small amplitude and long period towards the desired set value you are on the right track with these settings.

We know from practice that the D action should be roughly 25% of the I action. Certainly not more.

9.4 Auto tuning

It is also possible to make use of the auto tuning feature in the Heat Manager. This is only possible when the controller is in a soak/dwell segment and the set value does not change over time.

After enabling this feature the controller will perform a few test-cycles where it automatically tries to determine the PID settings based on so-called step-wise changes of the set value.

After changing the controller output to maximum (or minimum) monitors the physical behavior of the process value and determines the settings based on oscillation amplitude and period.

After performing many tests with various control systems, Ziegler and Nichols, derived formulas on how to convert the results of these tests into PID settings as a starting-point before actual fine tuning can take place.

It sometimes takes a while before the system actually determines the new values during this auto tuning cycle. Please be patient and wait until you see the newly determined values appear. This can take some minutes and depends on how quickly the process reacts to the controller.

If the controller was not able to determine the new values it will leave the PID settings on the values before the start of the auto tuning procedure.

Watch out: these calculated PID values are only a rough indication of the actual perfect PID settings and –can- result in an unstable process, so keep in mind that manual fine tuning is often necessary.

Important: only perform auto tuning when the process reached a stable state (controller output and process value more or less stable). The set value must also be stable, so this is only possible in a soak segment and not in a ramp up/down segment.

Warning: Never execute an auto tuning procedure when the process conditions are not stable. The software algorithm *assumes* that all external factors with regard to the process are not changing while performing this operation.

Please remember, that a manually tuned controller almost always outperforms a controller that was set with auto tuning. Auto tuning is more or less a rough indication if you need some “direction” on where to start.

9.5 Write down the newly determined PID values!

It is very important, that you write down the newly determined PID values so you don’t lose these painstakingly difficult to determine values.

A software upgrade, re-init procedure or controller module re-init (necessary after a replacement) will restore the PID values back to their default values as programmed in the software of the Heat Manager.

9.6 Common pitfalls

A system that is oscillating around its set value, or reacting too slow to process variations, is almost always caused by a PID controller that needs fine-tuning.

Beware when it takes many minutes of time for a process value to change after step-wise change of the set value. This is caused by a so-called dead-time in the process and is very difficult to overcome with PID settings in 1 PID loop alone.

The most common solutions for these kind of process issues are:
Measure more directly the actual product process value (bring sensor nearer to product).
Make use of a so-called cascaded control system where we make use of a master-slave PID loop where the slave loop controls the heating to the process (with its separate sensor near the heater as process value input). The set value for the slave comes from output of the master PID controller that measures the actual desired process value of the product.

When you change a P-action, you also influence the I and D action responses in some kind of way.
The same goes when you change the I or D action, everything is connected together more or less.
Don't start to move down in spiraling circles and change only 1 parameter at a time and verify very well if this improves the situation or not.

A good idea is to always write down carefully what you are doing, so you begin to see a "pattern" in your workflow and take a few steps back, if desired.

Don't set the D action too high, since this very easily results in an unstable process control. Use this only for fine tuning after you set the P and I factors correctly.

When you change an action you need to wait for the process to respond to the new situation. This can take many minutes and depends on the inertia of the process. Watch the recorder output of the process value to determine if it stabilizes or not.

Generally speaking it is important to keep the ratio between heating power versus mass of the system the same, after determining the correct PID settings for your system. You can then use the same settings for different situations.

9.7 More information

Consult the internet on more information about this, there is an excellent Wikipedia page with much more information on this subject.
See: http://en.wikipedia.org/wiki/PID_controller

Parts of this description comes from the website of RKC instruments,
See: http://www.rkcinst.co.jp/english/control_01.htm

10. FREQUENTLY ASKED QUESTIONS

10.1 I selected by mistake an extra TIO/DIO module in the setup and now the system continuously gives a communication error, how to get out of this hang-up?

When the communication error screen shows up, push for 1 second on the round indicator (middle below in the screen): with this you will force a new re-init procedure. You can now de-select the extra IO modules.

10.2 I started a new setup procedure but forgot to store the actual profiles file to the USB-stick.

The default (empty) binary file with 100 empty profiles is also stored to the SD/CF card inside the touchscreen.
On the setup-screen that asks for the USB-stick with profiles you just push SKIP and finish the setup.
After that, go to the file-manager in the history menu and there you can copy the SD/CF-CARD \FILE\F00001.BIN file to the USB stick.
On the USB stick this file must also be in the \FILE\F00001.BIN directory, otherwise the Heat Manager cannot find it.
After storing this file correctly to the USB-Stick you can perform a re-load of the profiles file in the PROFILE SET menu.
Select LOAD FR USB for this and follow the instructions on the screen.
Push EDIT in the PROFILE SET menu to verify if the loading procedure went OK. If the list contains:
TEST (or another name)
TEST (or another name)
Program 3 (EMPTY, or another name) etc.
The loading procedure went correctly. If the list appears complete empty: try again.

10.3 One of my TIO or DIO modules broke down and I need to replace them, what should I do, and in what order?

- Power down the Heat Manager touchscreen and its TIO/DIO modules completely.
- Make sure you write down the exact serial numbers on the side of the module you wish to replace. E.g. Put them on a copier so you can use it for reference.
- Make sure you get a replacement type **with exactly the same letter and number combination!**
- Make sure that you set the round address switch and the small dipswitches on the side of the module exactly the same as the settings on the broken module.
- Click the new module in the system and start the Heat Manager.
- At startup, the Heat Manager will see if the TIO module needs configuration. Please note that this is only done for TIO modules, but **not** for DIO modules, you need to re-init them manually from the setup screen.
- When the Heat Manager detects a TIO module that is not configured, it will show the following screen:

This means that the Heat Manager can communicate with the TIO modules but needs to re-configure them to the correct settings.
Now press the SETUP button and all modules will be re-configured by the system. This will take a few minutes to finish.

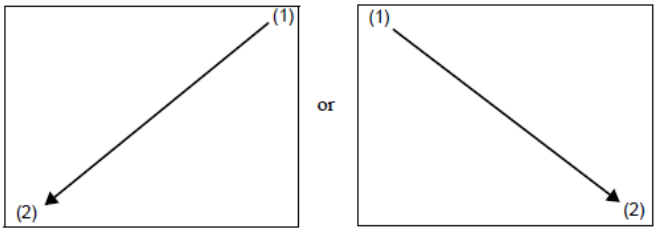
DIO digital output external signaling modules must be manually re-initialized after replacement. There is no configuration detection. Do this with the SETTINGS – SYSTEM – RE – INIT procedure and perform the TIO INIT (see the corresponding chapter in this manual on how to get to that screen).
In case of emergency you can configure the DIO modules later.

10.4 I don't know what went wrong with the setup/configuration and I wish to reset the touchscreen back to its factory defaults.

Only proceed with this procedure if you are 100% sure about this, all stored settings, heating profiles and data logging inside the touchscreen (except the stored CSV files on the SD/CF card) will be erased from the backup memory. When this procedure is executed in the wrong order a re-load of the touchscreen at the supplier may be necessary

Before executing this action, be sure to store the actual 100 heating profile database on the USB-stick in the PROFILE SET menu.

First we need to get the touchscreen in the offline mode**, this is not easy**. For this you need to be in the main menu and push the corners of the screen, but just inside the black square, intermittently. If you see a gray bar appear: **STOP, don't push anywhere anymore!** You need to push the screen intermittently (first push 1 and quickly after that 2), so don't push both fingers at the same time.



Now follow these steps after the gray bar appears, **exactly in this order:**

1. Push Offline
2. Enter system password: 15 + enter
3. Go to the right-top button "Initialization Menu"
4. Push only "Initialize Backup SRAM" (**and nothing else, otherwise a re-load at the supplier is necessary!!!)**
5. Enter system password: 15 + enter
6. Push Start
7. Push Yes (if you are sure about this)
8. Push Close
9. Push Exit
10. Push Yes

The touchscreen will now restart in the factory default state. You can now perform a clean setup. To be 100% sure, you can perform a TIO INIT from the system settings menu: the TIO/DIO modules will now be re-initialized completely to the default settings for the Heat Manager.

10.5 I changed the logo files on the SD/CF card, but the Heat Manager does not show them at startup.

It sometimes happens, that after editing the Logo_start.jpg (620x372 pixels) or the Logo_info.jpg (635x283 pixels) it is not displayed at startup, but the files are there, and the pixel sizes of these files are correct.

It is very important that you used the same JPEG compression when saving the edited file. Saving a JPEG file is just a “container”, but does not specify the compression ratio.

Make sure that the saved file has about the same size as the previous one, 30kB. When your new file is much larger, you can download the free program IRFANVIEW (google) to convert it to the correct size.

When you open your edited file in Irfanview and store it again, you can set the desired file size. Normally speaking the default options in Irfanview are correct for this.

Store the file again in Irfanview with the correct file size and compression setting can solve the problem.

11. NOTES