MINAC Systems
Mobile Induction Heating Equipment

USER MANUAL

MINAC 25/40, 50/80
MINAC 25 Twin

Version MCCC 2.2.1

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CONTENTS

1 INTRODUCTION

This manual provides step-by-step operation instructions for the MINAC standard 25/40 and 50/80 systems and MINAC 25 Twin systems. It also contains safety information and instructions, and some simple corrective measures.

The operation instructions must be read thoroughly before the equipment is used. Using these instructions, MINAC operators should be able to undertake correct and safe operation. However, only qualified personnel should carry out general trouble-shooting and maintenance tasks.

Figure 1. MINAC Standard 25/40 Induction Heater.

Figure 2.

MINAC Standard 50/80 Induction Heater with HHT 400S.

2 SAFETY INSTRUCTIONS, PRECAUTIONS AND HAZARDS

2.1 General

Safety instructions, including important information concerning the risks associated with specific operations and recommendations on suitable precautions, are found throughout the handbook where appropriate. The safety instructions are divided into the two categories *Warnings* and *Cautions*:

WARNING!

Warning statements identify conditions or practices that could result in injury or loss of life.

CAUTION!

Caution statements identify conditions or practices that could result in damage to equipment and surroundings.

Safety precautions must be observed during all phases of operation and maintenance. Failure to comply with these precautions, or with specific WARNINGS and CAUTIONS given elsewhere in this handbook, is a violation of the safety standards of the design, manufacture and intended use of the equipment.

All personnel operating, maintaining or working in close proximity to the equipment MUST thoroughly read, understand and obey the safety instructions that apply to this equipment given by EFD Induction a.s. Only properly trained personnel who are familiar with the technical handbook should be permitted to open the covers for servicing this equipment.

WARNING!

Comply with all safety instructions. Failure to do so can result in serious personal injury or damage to equipment and surroundings.

Please note the following:

- To avoid personal injury, do not remove the equipment's covers or panels. Do not, under any circumstances, operate the equipment without the covers and panels properly installed.
- Switch off the equipment's power supply when it is not in use, and always retract the mains plug prior to repair or maintenance.
- Always comply with all safety measures when handling electrical equipment, including any national or international regulation.

2.2 Electric Shocks

WARNING!

Electrical shocks can result in personal injury or loss of life.

To avoid the risk of an electric shock, **DO NOT**:

- **open** the equipment covers during operation
- **cut or damage** the HF cable to the HHT
- **touch** the induction coil or coil adapter terminals after the power is turned on
- **open** the equipment covers during service without retracting the mains plug in order to isolate the equipment from the main power supply.

WARNING!

Always retract the main-power plug before opening the main fuse box.

2.3 Heated Objects

WARNING!

Heated objects can cause fire or burns.

The principle of induction heating is based on an alternating current flowing through a coil and thereby generating a magnetic field that varies in magnitude with the current. If an electrically conductive material is placed inside the coil, eddy currents will be induced in the material. Due to the resistance of the material, heat is developed in the region of the material through which the eddy currents flow. Induction heating equipment can heat electrically conductive materials to a very high temperature in a short time.

To prevent the danger of fire or burns, **DO NOT**:

- **come in direct contact** with heated objects before they have cooled
- **wear or have** metal objects about your body while operating, maintaining or being in the presence of the inductance equipment when it is in use
- **use or keep** any combustible materials near the work area or heated objects.

2.4 Electromagnetic Fields

WARNING!

Electromagnetic fields can be a health risk.

All induction heating equipment produces electromagnetic fields that are concentrated inside the coils. The field's strength depends on the current's strength and the number of turns in the coil. The field's strength decreases with the square of the distance from the coil.

To avoid hazards to personal health:

- Anyone with an implant, regardless of type, should consult a physician about the effects of high-frequency electromagnetic fields on the implants. This also applies to pregnant women.

- Persons with pacemakers, heart valves or metal pins, plates or other bone joining devices, should avoid exposure to induction coils or areas with strong magnetic fields if they have not consulted their physician beforehand.

- In general, all personnel should take great care not to come too close to the induction coil when the equipment is in operation.

3 RESTRICTIONS IN USE

Only use the MINAC solely for its intended purposes under safe conditions and in proper surroundings. Take great care when using the equipment. Heat only electrical conductive materials. The presence of combustible materials involves a risk of fire.

The MINAC systems provide the following output power limitations for continuous use and intermittent duty:

Equipment	Continuous use	Intermittent duty
MINAC 25, 25 Twin	25 kW	40 kW
MINAC 50/80	50 kW	80 kW

The maximum output powers are attainable only with low Q - magnetic steel. The maximum duty factor is 0.5 and the maximum cycle time is 10 minutes. This means that during a selected cycle, the unit can run at maximum output power only half of the time (to a maximum of five minutes).

4 CONNECTING AND USING THE COIL

1. Make a good electrical contact between the coil and the HHT terminals — be sure that the contact surfaces on both the coil and the HHT terminals are free of dirt and oxides. If necessary, clean the surfaces with fine emery paper.
2. Be sure that the O-rings for the cooling water seals are free of any dirt or damage.
3. When fitting the coil to the HHT terminals, maintain a parallel gap between the coil and the HHT to avoid a short circuit.
4. Use only brass termination nuts on the HHT. Nuts of any other material are not allowed. Torque the nuts to 9 Nm for 125S, and 14 Nm for HHT 240S and HHT 400.
5. Once the flow of cooling water has been opened, hold the HHT so that the coil points upwards. This prevents air bubbles from being trapped inside the transformer, causing local overheating of areas which are not in contact with the cooling water.
6. Prevent short circuits in the coil during operation by avoiding contact between the coil and the workpiece. If contact is difficult to avoid, coat the coil with an aluminum oxide (avoid oxide on the contact surface). This will reduce the risk of short circuits. Coils supplied by EFD Induction a.s are already coated with an aluminum oxide.

CAUTION!

The HHT is a vulnerable part of the equipment and therefore must be handled with care.

CAUTION!

TEST RUN: When changing the induction coil or heating new materials, run tests to check the equipment settings.

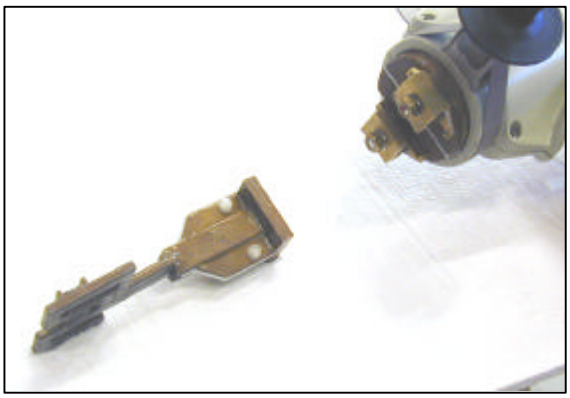

Figure 3. Separate HHT and Coil

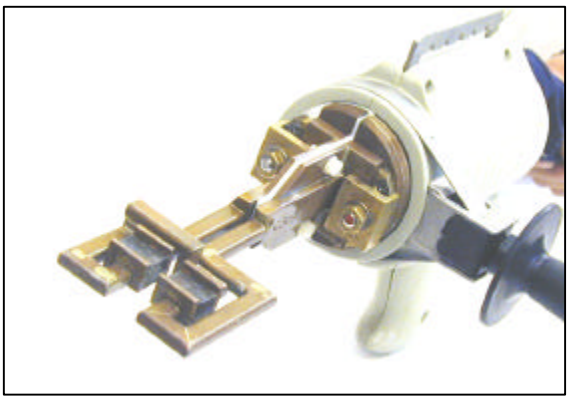

Figure 4. Coil connected to HHT

5 MAN-MACHINE INTERFACE

5.1 Display and Keyboard

The display and keyboard together form the frequency converter's Man-Machine Interface (MMI) and are located on the operating panel. A number of different menus are available to the operator.

The starting point for access to these menus is the Main Menu (menu 1), which gives an overview of the menus available.

Six of the menus are active. This means that the operator can enter different variables/options such as control mode, time, sequence, setpoint, water shut-off, extended operating range etc. These settings can be entered only in the “power off” mode.

Four passive menus provide operational information. The operator can switch between the different menus by using the function keys on the keyboard. If the unit is a Twin model, it has one extra passive menu accessible to give information for both outputs at the same time.

Additionally, there are two menus for the PIN code.

A. Display Sections:

The top row of the screen is divided into three areas. The left area displays the menu identifier number, the center area displays the menu name, and the right area indicates the returning key. When the PIN code is active, a “padlock” symbol is displayed in the upper right corner.

The center part of the screen shows the contents of the selected menu. This display can show a bar graph of relevant internal analog signals, timer or sequence data or operator selectable values. The menu displays also contain explanatory text for the different displays.

The bottom line or footer message shows operational and alarm messages from the left.

If the unit is a Twin model, a square in the lower right corner shows which one of the two outputs is displayed on the screen.

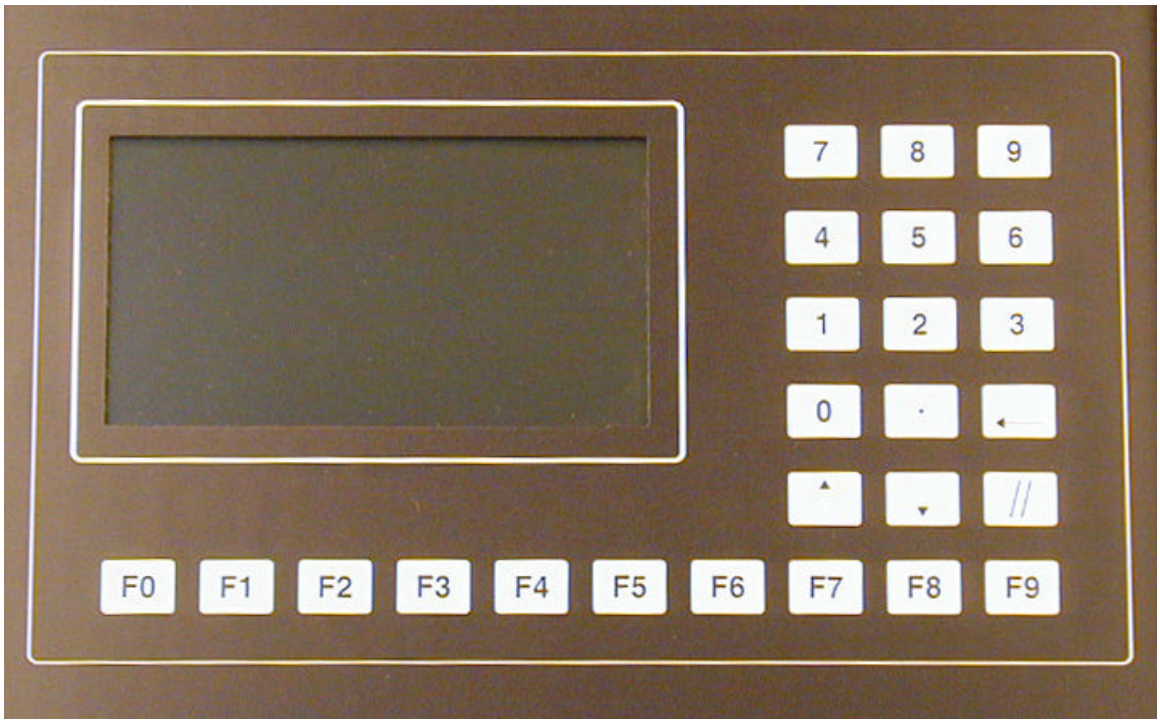

Figure 5. Display and Keyboard.

Table 1. Keyboard Keys and Functions

Key	Function
Ten function keys, F0-F9	For selecting different functions. F9: For returning to the previous menu.
Number keys, 0-9	For typing numbers.
Enter key, ↵	For entering typed numbers
Arrow keys, ⇑ ⇓	To adjust the output reference and for use where a function comprises more than one line.
Clear key, //	Clears typed numbers if the enter key has not yet been pressed.

B. Operating Switches and Indicators

Below the display/ keyboard section of the MMI there is a section of operating switches and indicators. These switches and indicators function as the operating devices during normal operation.

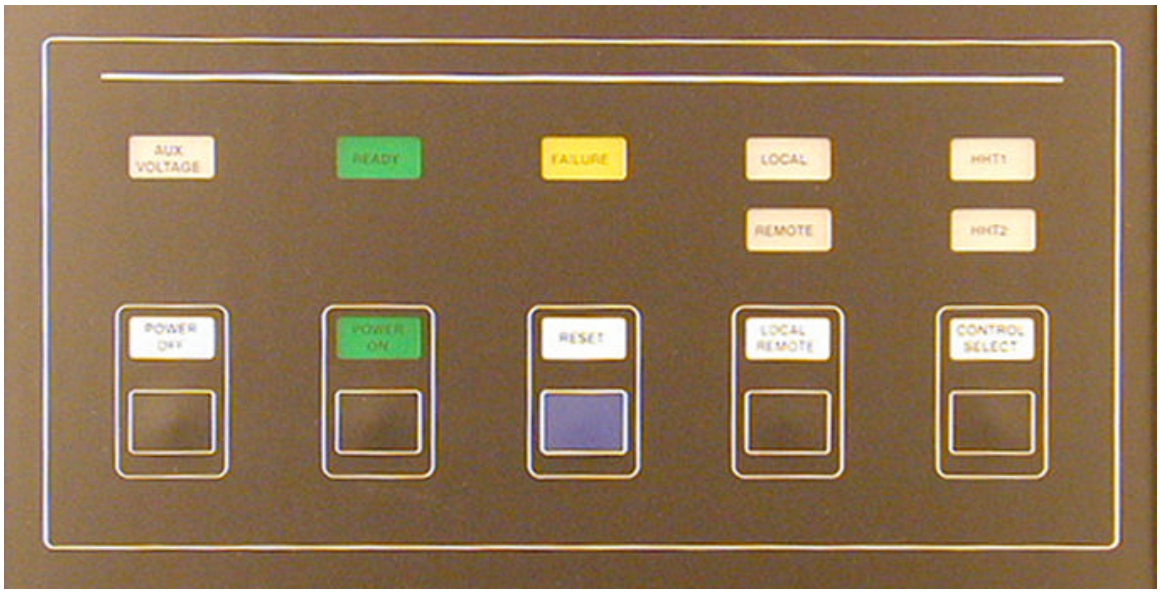

Figure 6. Switches and Indicators

Table 2. Switches and Indicators, and Functions

Key	Type	Function
AUX Voltage	indicator	Indicates that the voltage for the auxiliary circuits is on.
Ready	indicator	Indicates that the MINAC system is ready for use.
Failure	indicator	Indicates that some fault condition is present. This will block the power-on function until the alarm system is reset.
Local/ Remote	indicator	Show if the unit is to be controlled from the operating panel or via the external control plugs.
Power off	switch	Switches the output power off.
Power on	switch	Switches the output power on. This button has an indicating light that is lit when the output power is on.
Reset	switch	Resets the alarm system when a fault condition is no longer present.
Loc./ rem.	switch	Toggles the operation mode of the unit.
HHT1	indicator	Indicates that the operating panel keys are valid for HHT1 output.
HHT2 (Twin units only)	indicator	Indicates that the operating panel keys are valid for HHT2 output.
Control Select (Twin units only)	switch	Allows the operator to switch between HHT1 and HHT2. The HHT selected is the one operated by the operating panel and the one displayed on the MMI display.

5.1.1 Footer Messages

Each screen shown on the display contains a footer field where the following information is displayed (with priority as indicated):

1. Alarm messages.
2. Indications/limitations when the power is on.
3. Messages during normal operation.

Remove the alarm messages by eliminating the cause of the alarm and pressing the RESET button on the operating panel.

Table 3. Alarm Messages and Causes

Alarm	Cause
Emergency Stop	Emergency Stop has been activated on externally connected equipment.
DC Voltage Too Low	The voltage across the rectifier is too low (the DC voltage is measured directly). Check the supply voltage.
DC Voltage Too High	The voltage across the rectifier is too high (the DC voltage is measured directly). Check the supply voltage.
Power Supply Alarm	Fault in the power supply to the electronics.
Power On By Start-up Alarm	A "Power on" device has been activated when the converter was turned on. Check the button on the HHT handle.
External fault	User defined event/failure has taken place.
Over-current driver alarm	Transistor current too high or driver circuit failure.
Capacitive alarm	AC current is too capacitive or a short circuit has occurred in the output circuit.
AC over-current alarm	Over-current in the output circuit was detected.
DC over-voltage detected	DC over voltage peak was detected.
Inductive alarm	AC current is too inductive.
Ground fault detected	Circuitry shorted to ground.
Water flow low	Water flow in the cooling circuit too low
Over temp. inlet water	Cooling water inlet temperature too high
Over temp. inverter	Inverter heat sink temperature too high
DC over-current alarm	DC over-current was detected.
Low frequency alarm	Output circuit resonance frequency below limit
High frequency alarm	Output circuit resonance frequency above limit
Switch mode supply alarm	Problem on the SMPS card.
Fuse fan alarm	Internal cooling fan broken.
System reset by WatchDog Timeout	The unit has been restarted automatically by the micro controller due to an internal failure in software or hardware
Main contactor off	The main contactor is not energized.

For further descriptions of the various causes and actions, refer to Paragraph 6.7, ”Disturbance of Operation and Corrective Measures.”

Indications/Limitations during Power On

The purpose of these limitations is to achieve an optimal combination of maximum output power and sufficient overload protection of the equipment.

- Low frequency current limit
  The voltage across the transformer has reached a preset maximum level for the current load and frequency level, preventing further increases in output power.
- High frequency current limit
  The output current (going through the transistors) has reached a preset maximum level for the current load and frequency level, preventing further increases in output power.
- Maximum AC Current Limit
  The output current has reached a preset maximum level, preventing further increases in output power.
- Maximum DC Power Limit
  The DC power has reached a preset maximum level, preventing further increases in output power.
- Output reduced by EOR
  The extended operating range (EOR) function has reduced the output to a secure level for the current cooling water flow and temperature, preventing further increases in output power.

Messages During Normal Operation

- Ready
  The unit is ready for operation. Operate a POWER ON device.
- Power On
  The output power is turned on.
- DC Power
  DC power is the current mode of operation.
- AC Current
  AC current is the current mode of operation.
- Timer Active
  The timer function is active.
- Sequence Active
  The sequence function is active.

- Extended Operating Range Activated

  The Extended operating range function has been activated, enabling the unit to operate outside the normal ratings for cooling water flow and temperature. This message flashes, alternating with the rest of the ‘Messages during normal operation’.

- Water tank level low warning

  A connected sensor in an optional cooling water tank has detected low level. Please refill water tank, and check for leaks in water cooling system. This message flashes, alternating with the rest of the ‘Messages during normal operation’.

5.2 Menus

The Main Menu consists of the following sub-menus:

F0	Activate menu	{ menu 2 }
F1	Setpoint menu	{ menu 3 }
F2	Timer menu	{ menu 7 }
F3	Sequence/ Energy menu	{ menu 4 }
F4	Display Values	{ menu 24 }
F5	Display Timer/Sequence	{ menu 23 }
F6	Display Twin Values	{ menu 36 } (visible only in Twin units)
F7	Status info	{ menu 29 }

When the frequency converter is turned on, the system automatically enters menu 24, "Display Values". If the Timer or Sequence functions are enabled, menu 23, “Display Timer/Sequence” is entered instead. In Twin units, menu 36, “Display Twin Values” can be selected to view information of both outputs. One of these menus is selected as the opening menu to facilitate operation once all settings have been entered. The operator does not need to use the keyboard to obtain information on the operational values during the heating process. Pressing F9 shows the Main Menu.

5.2.1 Activate Menu (menu 2)

This menu enables the operator to choose control functions. To make a choice, the operator presses the keys in front of the given options. "Sequence" and "Timer" are mutually exclusive functions. Pressing F4 calls up the PIN Code Menu. Press F5 to shift the menu through the possible languages until the desired language is present.

F0	Sequence	<ACTIVE/OFF>

F1	Timer	<ACTIVE/OFF>
F2	Water auto shut-off	<ACTIVE/OFF>
F3	Energy supervision	<ACTIVE/OFF>
F4	PIN code	<ACTIVE/OFF>
F5	Language	Change to next available language
F6	Extended Operating Range	<ACTIVE/OFF>
F8[1]	Select Ext.interface	<Hardwired/Fieldbus1>

Return to the Main Menu by pressing F9.

5.2.2 PIN Code Menu (menu 26)

This menu provides a security option for the system through the entry of a Personal Identification Number (PIN). The PIN Code Menu will automatically be called up when the operator tries to enable/disable the PIN code function in menu 2 (Activate Menu). This ensures that only authorized personnel can enable/disable this function. The PIN Code Menu is also called up automatically if the operator tries to change converter settings when the PIN code function is set at ACTIVE. This prevents unauthorized personnel from reprogramming functions/settings in the menus.

Once the PIN code is entered, the operator can change any settings without re-entering the PIN code each time. After 5 minutes of inactivity on the keyboard, the PIN code protection is reactivated. A picture of a lock, in the upper right corner of the display, indicates that the PIN code protection is active.

When the PIN code is entered (and accepted) the program returns to the previous menu.

Give PIN code:		<0-9999>
F0	Change PIN code	{new menu 27}

The PIN Code Menu also contains a "Change PIN code" sub-menu. Press F0 to call up this menu. Return to the previous menu by pressing F9.

Default PIN Code

The default PIN code on a new converter is the number 0, and can be changed in the Change PIN Code Menu. On twin versions the PIN code is identical for the two outputs.

[1] The ‘F8’ selection is only visible if the unit is equipped with double external interfaces (optional).

5.2.3 Change PIN code Menu (menu 27)

This menu allows the operator to change the PIN code.

First enter the old PIN code and then enter the new PIN code twice:

Give old PIN code:	<0-9999>
Give new PIN code:	<0-9999>
Retype new PIN code:	<0-9999>

Return to the previous menu by pressing F9.

5.2.4 Setpoint Menu (menu 3)

This menu is used to select the mode of operation (type of regulation). Only one of the first three modes in the list can be activated at a time (mutually exclusive functions). In addition, this menu contains a function for selecting the setpoint source and signal type to/ from the external control.

F0	AC Current	<ACTIVE/OFF>
F1	DC Power	<ACTIVE/OFF>
F2	Temperature	<ACTIVE/OFF>
F3	Setpoint source	<LOC/EXT/HHT/DEFAULT>
F6	Ext. signal select	<DC power/AC current/DC voltage/Frequency/Temperature>
F7	Ext. setpoint signal type	<0-10V/0-20mA/4-20mA>
F8	Ext. feedback signal type	<0-10V/0-20mA/4-20mA >

Return to the Main Menu by pressing F9.

Setpoint source

The four options given in function F3 "Setpoint source" have the following definitions:

LOC	Setpoint from the control panel “up” and “down” arrows.
EXT	Setpoint from an external device.
HHT	Setpoint from the HHT setpoint control.
DEFAULT	Setpoint from the source where the power-on command is detected.

If HHT handle is not equipped with a power control device make sure not to select HHT as Setpoint source as this will result in zero setpoint value.

5.2.5 Timer Menu (menu 7)

This menu enables the operator to program the timer.

F0	Time Unit	<0.1 s/1 s/0.1 m/1 m/0.1 h>
	Time	<0-999>

Select the time unit by pressing the F0 key. Use the down arrow key ⇓ to go to the "Time" line. Enter the number of seconds (s)/ minutes (m)/ hours (h) using the number keys followed by the enter-key ↵. Return to the Main Menu by pressing F9.

5.2.6 Sequence Menu (menu 4)

This menu enables operators to set up eight different programs, each composed of ten different segments. Type, time unit, time and target setpoint must be defined for each segment.

F0	Program no	<0-7>
F1	Segment no	<0-9>
F2	Type	<Step/Ramp>
F3	Time unit	<0.1 s/1 s/0.1 m/1 m/0.1 h>
	Time	<0-999>
	Target setpoint	<0-100%> or <0-250°C>[2]
		100% corresponds to <kW / A / C>
F4	Energy menu	{ menu 08}

To select a program number, segment number, segment type and time unit, press the relevant function key until the requested number/option is displayed. To set time and target setpoint, use the arrow keys, type in the requested number and press the enter key (s = seconds, m = minutes and h =hours). Return to the Main Menu by pressing F9. The Sequence Menu also contains two sub-menus. Press F4 to call up the "Energy" menu and F5 to call up the “Event output menu”.

Segment Type

The two segment types are STEP and RAMP. While a step runs at a steady level determined by the target setpoint, a ramp increases/decreases to the level determined by the target setpoint from the setpoint level given in the previous segment. If a ramp is the first segment in a sequence, it always starts at zero.

[2] If Temperature mode of operation is selected, this entry is in degrees Celsius, or else in percent.

Table for Registering Program Settings

Mode of Operation: AC current / DC power / Temperature

Program No:

Segment no.	Segment type	Segment duration	Target setpoint
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			

Example of a Sequence

Figure 7 illustrates a heating sequence, while Table 1 shows the sequence parameters. The example on the next page shows how to program this sequence.

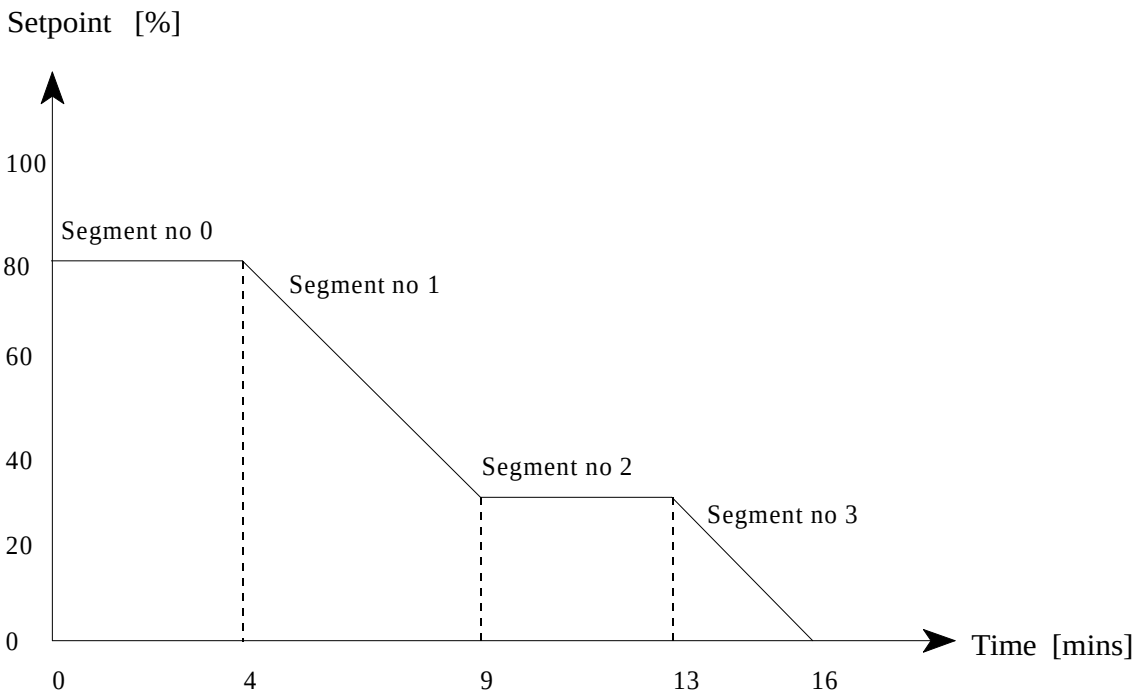

Figure 7. Sequence A

Table 4. Sequence A

Program No: 2

Segment no.	Segment type	Segment duration	Target setpoint
0	Step	4 min.	80%
1	Ramp	5 min.	30%
2	Step	4 min.	30%
3	Ramp	3 min.	0%

Programming example

1. SELECT SEQUENCE MENU
   Press F3 when in the Main Menu.
2. SELECT PROGRAM NUMBER
   Press F0 until the number 2 is displayed.
3. SELECT SEGMENT NO 0
   Press F1 and the number 0 is displayed.
4. SELECT SEGMENT TYPE
   Press F2 if "STEP" is not already set as the segment type.
5. SELECT TIME UNIT
   Press F3 until "1 m" is displayed.
6. ENTER NUMBER OF TIME UNITS
   Enter the number 4.
   <4> and <↵>
7. SET TARGET SETPOINT
   Move the cursor down a line by pressing the down arrow key and enter the number 80.
   <↓>, <80> and <↵>
8. SELECT SEGMENT NO 1
   Press F1 and the number 1 will be displayed.
9. SELECT SEGMENT TYPE
   Press F2 if "RAMP" is not already set as the segment type.
10. SELECT TIME UNIT
    Press F3 until "1 m" is displayed.
11. ENTER NUMBER OF TIME UNITS
    Enter the number 5.
    <5> and <↵>
12. SET TARGET SETPOINT
    Move the cursor down a line by pressing the down arrow key and enter the number 30.
    <↓>, <30> and <↵>
13. SELECT SEGMENT NO 2
    Press F1 and the number 2 is displayed.

14. SELECT SEGMENT TYPE
    Press F2 if "STEP" is not already set as the segment type.

15. SELECT TIME UNIT
    Press F3 until "1 m" is displayed.

16. ENTER NUMBER OF TIME UNITS
    Enter the number 4.
    <4> and <↵>

17. SET TARGET SETPOINT
    Move the cursor down a line by pressing the down arrow key and enter the number 30.
    <↓>, <30> and <↵>.

18. SELECT SEGMENT NO 3
    Press F1 and the number 3 is displayed.

19. SELECT SEGMENT TYPE
    Press F2 if "RAMP" is not already set as the segment type.

20. SELECT TIME UNIT
    Press F3 until "1 m" is displayed.

21. ENTER NUMBER OF TIME UNITS
    Enter the number 3.
    <3> and <↵>

22. SET TARGET SETPOINT
    Move the cursor down a line by pressing the down arrow key and enter the number 0.
    <↓>, <0> and <↵>

23. PROGRAMMING SEGMENT NO 4-9
    This heating sequence (Sequence A) consists of just four segments. This means that the remaining six segments in the program must be set to zero duration. Proceed as follows:

    a) Select segment no (4-9).
    b) Move the cursor to the "Time" line by using the down arrow key, ↓.
    c) Enter the number 0, <0> and <↵>.

The sequence is now programmed and ready to run, provided that the "SEQUENCE" function in the Activate Menu (menu 2) is activated.

5.2.7 Energy Menu (menu 8)

This menu enables the operator to see how much energy was used in the last sequence, both overall and for each segment. It is possible to store the total energy value (one value per program) and state an allowed energy deviation value (as a percentage) for comparison against later sequences. The energy check result is shown on the last line.

F0	Program no	<0-7>
F1	Segment no	<0-9>
F2	Store total energy	
	Allowed energy deviation	<0-100%>
	Segment energy (kJ)	
	Total energy (kJ)	
	Stored total energy (kJ)	
	Energy check result	<LOW/OK/HIGH>

- To select the program and segment numbers, press F0 and F1, respectively, until the desired number is displayed.
- To store the total energy value, press F2.
- To set the allowed energy deviation value, enter the desired value and press the enter key.

Return to the Main Menu by pressing F9.

Energy Supervision

The purpose of the energy supervision function is to detect changes in the heating process when running the sequence function[3]. A change in the heating process is often caused by changes in the coil position relative to the workpiece or changes in the workpiece itself (preheating, changes in mass/shape). Fault situations such as short circuits in the coil can also cause changes in the heating process.

To make use of the energy supervision function, do not run the converter in the DC power mode. In the DC power mode, the converter itself compensates for any changes in the heating process.

Total energy is the amount of energy used by the equipment during the last program run. This value can be used as a reference by the energy supervision function for later runs. When used as a reference, the allowed percentage deviation value (±) must be entered into the program memory. Before using this energy supervision function, install the converter properly and establish a perfect sequence program.

[3] To calculate the exact amount of energy transferred to the workpiece, subtract the losses in the inverter, output circuit and coil.

In some cases when using temperature mode of operation, it is preferred to disable energy count below a certain temperature to minimize the influence on the total energy caused by variance in the work piece start temperature. This function has to be configured by EFD personnel.

5.2.8 Event output menu (menu 30)

In this menu a specific event can be configured to trigger an output during a sequence program run. Each of the eight sequence programs can be configured separately. Two types of events can trigger the output: 'Temperature reached' or 'Segment output'. They are mutually exclusive for each program number. The menu is dynamic so that if no event is selected for the current program number only the three first lines in the menu are visible.

F0	Program no	<0-7>
F1	Temperature reached	<ACTIVE/OFF>
F2	Segment output	<ACTIVE/OFF>

'Temperature reached' can only be used in equipment fitted with temperature sensing equipment and when running a sequence in temperature mode of operation. When Temperature reached is activated the following lines appear:

Temp. reached 1 level	(C)	< 0-250 >
Temp. reached 2 level	(C)	< 0-250 >
100% corresponds to:	(C)	< 250 >

The two Temp. reached levels can be set by the operator to a temperature between 0 and the temperature sensors maximum value (in this case 250 °C). When the temperature at the sensor is above the set 'Temp reached level,' the corresponding Event output (1 or 2) is high; otherwise it is low. The Event outputs are available only when using a fieldbus as external interface.

When Segment output is activated, the following lines appear:

F3	Segment no	<0-9>
F4	Event output 1	<LOW/HIGH>
F5	Event output 2	<LOW/HIGH >

The 'Segment output' function makes it possible to specify the Event outputs levels (Low or High) for each segment in a sequence program. The Event outputs are available only when using a fieldbus as external interface.

Typical use of the event outputs is to synchronize an outside operation with a heating event.

5.2.9 Display Values (menu 24)

This menu provides information on normal operational values. It displays a continuous graphical presentation of AC current and DC power. The programmed setpoint is marked on the bar graph representing the selected mode of operation. The AC current frequency is indicated on the right upper side of the AC current bar graph. Return to the Main Menu by pressing F9. The Display Values Menu also contains a "Display All Values" sub-menu. Press F0 to call up this menu.

5.2.10 Display All Values (menu 19)

This menu shows all normal operational values in the form of bar graphs. These values are AC current, DC power, DC voltage and DC current. The bar graph representing the value selected as the mode of operation is marked with the setpoint value. Return to the previous menu by pressing F9.

5.2.11 Display Timer/Sequence (menu 23)

This menu provides a continuous graphical presentation of the current sequence or timer function (time is given as a relative value). Only one of these functions is shown since they are mutually exclusive. This menu also shows the bar graph representing the value selected as the mode of operation (AC current or DC power). The setpoint is marked on the bar graph. If energy supervision is activated, a “smiley” will show whether the energy check result is OK or not.

OK: ☺ LOW/HIGH: ☹

Return to the Main Menu by pressing F9.

5.2.12 Display Twin Values (menu 36) (Only Twin units)

This menu provides information on operational values of both outputs in Twin units. The menu is split horizontally into two parts, with the upper part showing information related to output 1 and the lower part correspondingly to output 2. Each part displays a graphical presentation of AC current and DC power, and indicates the setpoint and AC current frequency. A footer message, of the type found in the other menus, is at the bottoms of both the upper and lower parts. The output number is displayed to the right of each footer message. Return to the Main Menu by pressing F9.

5.2.13 Status menu F7 (menu 29)

This menu displays the following parameters.

- Water flow (dl/min)
- Water temperature (°C)
- Output current frequency (kHz)
- Up to 6 active alarms, if any.

Return to the Main Menu by pressing F9.

6 OPERATION

WARNING!

To avoid personal injury, do not open the equipment's covers or panels. Under any circumstances, do not operate the equipment without the covers and panels properly installed.

6.1 Before Starting

1. Place the induction heating unit in its working position.

2. Fit a suitable induction coil to the hand held transformer; refer to paragraph 4.

CAUTION!

CORRECT VOLTAGE: Make sure that the supply voltage matches the specifications.

WARNING!

PROTECTIVE GROUNDING: To avoid electric shocks, make sure the protective grounding conductor for the main power cable is connected to ground.

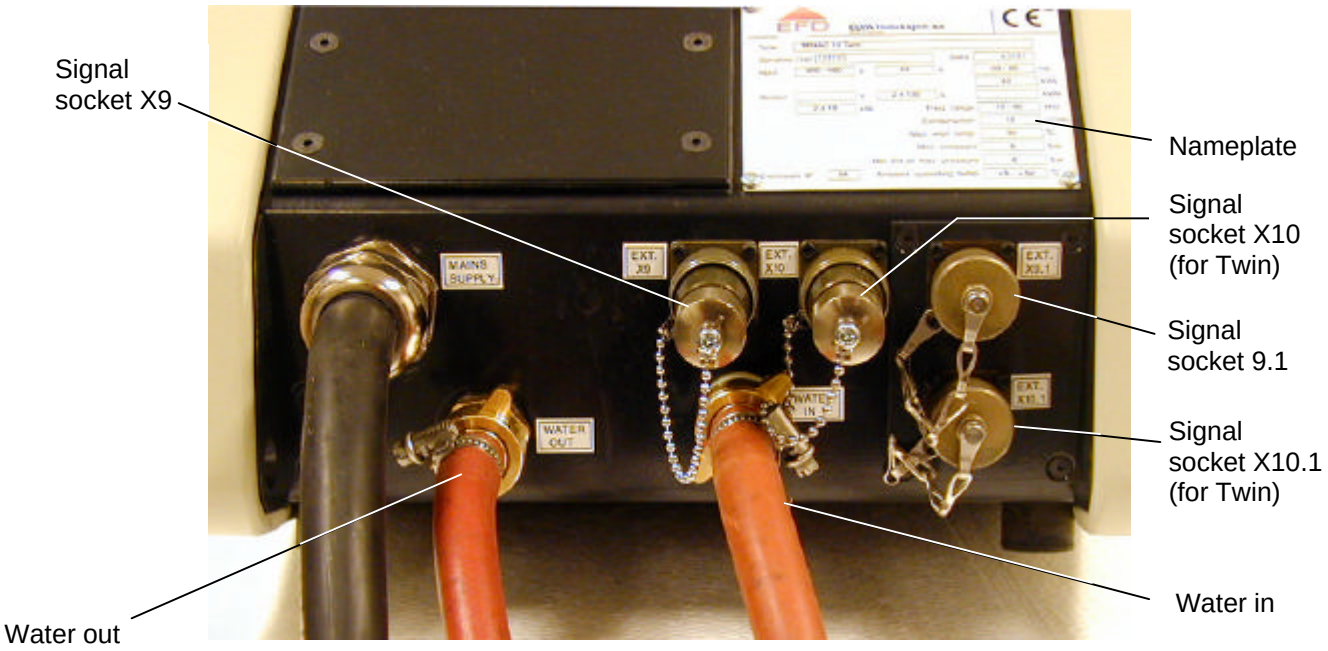

Figure 8. Supply input/output panel on rear of cabinet.

3. According to IEC 60204-1, paragraph 5.3.2, the plug on the main supply cable is known as the “supply disconnecting device.” To comply with this regulation the unit must be connected to the main power supply by means of this plug-socket combination.

   Before connecting the main power cable, make sure that the supply voltage matches the specifications on the nameplate on the back of the cabinet.

4. See figure 8. Fit the cooling water supply to the inlet and outlet water tailpieces. Make sure that the water supply is connected to the inlet and the water return to the outlet.

5. Check that the cooling water circuit is ready for use (pumps turned on, external valves open, etc.) and that the inlet water temperature is below 35°C/95°F.

6. See figure 8. If the external control unit (ECU) is in use, connect it to the signal plug socket(s), X9 and/or X9.1, at the rear of the converter. For Twin versions, the signal plug sockets for HHT 2 are X10 and/or X10.1.

7. When using an ECU, make sure that the LOCAL/REMOTE selector is in the correct position, i.e., at REMOTE. Otherwise, it should be positioned at LOCAL.

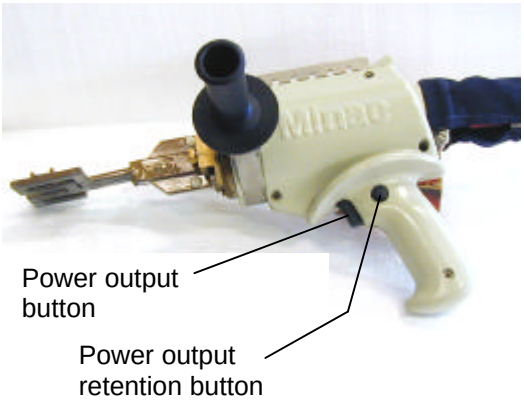

Figure 9. HHT 240S, power output and retention buttons

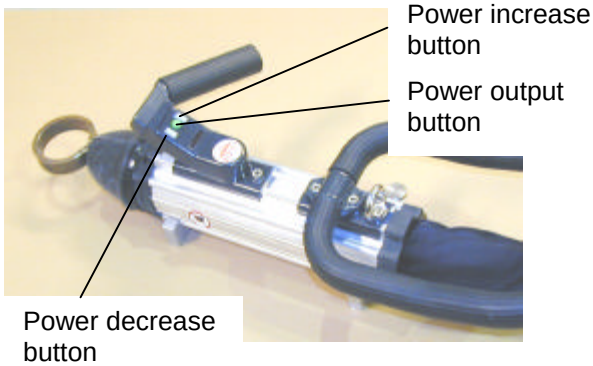

Figure 10. HHT 400S, power output, increase and decrease buttons

8. See figure 9/10. Be sure that the power output button on the HHT handle is not stuck in the POWER ON position. This also applies to ECU switches and buttons.

9. If possible, the operator should have a workstation from which he/she can observe the workpiece, the induction coil and the front of the converter and/or the ECU.

6.2 Start

6.2.1 Main switch

Figure 11. MINAC 25/40 and 50/80 cabinet front, main switch

1. See figure 11. At the front bottom of the cabinet, turn on the converter's main switch.

2. See figure 6. The following lamps and LEDs should light:
   - AUX VOLTAGE lamp on the operating panel
   - READY or FAILURE lamp
   - LOCAL lamp
   - HHT 1 lamp

   The display on the Man-Machine Interface (MMI) briefly shows a presentation screen followed by the Display Values Menu. This menu provides a graphic presentation of the operational values during the heating process.

6.2.2 Programming the MMI

If the MMI is already programmed and no editing is needed, go to paragraph 6.2.3. Otherwise, return to the MMI main menu by pressing F9 and perform the necessary programming/editing.

1. Choose Control Functions (Activate Menu); there are seven types of control functions:

- Sequence
- Timer
- Water Auto Shut-off
- Energy Supervision
- PIN Code
- Language
- Extended Operating Range

The sequence and timer functions are mutually exclusive. For further information about the control functions, refer to paragraphs 5.2.1 and 6.3.2.

a. Go to the Activate Menu (F0 in the Main Menu).

b. Activate the desired control functions by pressing the keys in front of the various options (sequence and timer are mutually exclusive functions).

c. Return to the Main Menu (press F9).

2. Choose Mode of Operation (Setpoint Menu)

There are three modes of operation: AC current, DC power and Temperature (mutually exclusive functions). The selected mode of operation regulates the output power determined by a given setpoint. For further information about modes of operation and the reference setpoint, refer to paragraphs 5.2.4 and 6.3.3. Temperature operation requires additional temperature measuring equipment.

a. Go to the Setpoint Menu (F1 in the Main Menu).

b. Choose the mode of operation.

c. Return to the Main Menu (press F9).

6.2.3 Power on

1. Setpoint Source

The setpoint source is determined in the Setpoint Menu (menu 3). Function F3 "Setpoint source" gives the following options:

LOC Setpoint from the “up” and “down” arrow buttons on the control panel.

EXT Setpoint from an ECU or other external device.

HHT Setpoint from the setpoint control on the HHT handle if available.

DEFAULT Setpoint from the source where power on command was detected.

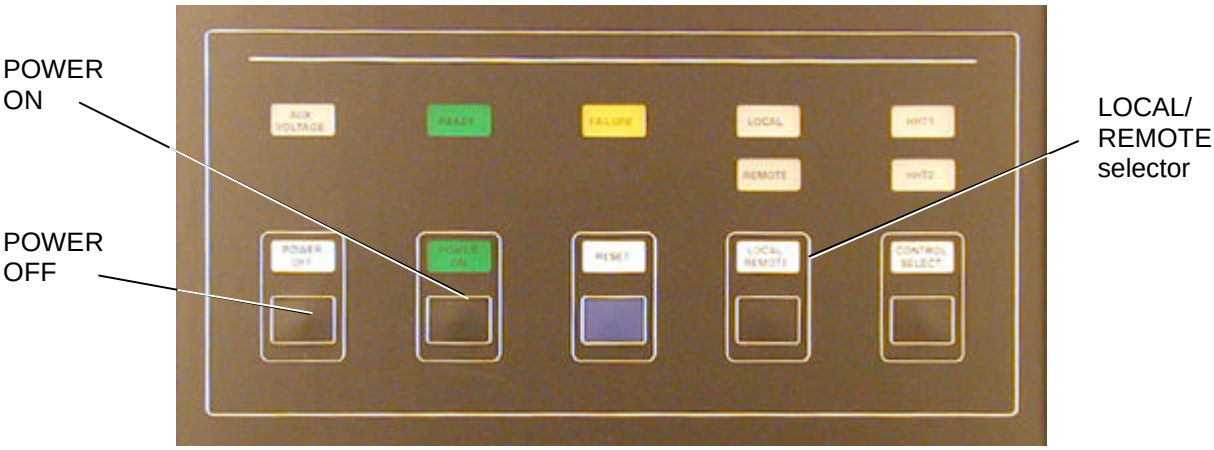

Figure 12. Switches and Indicators panel, POWER ON/OFF buttons

2. Local Control from Operating Panel

The LOCAL/REMOTE selector must be set to LOCAL when the MINAC is operated from the operating panel only.

Turn the output power on and off with the POWER ON/POWER OFF buttons.

Unless the sequence function is activated, set the output level from the control panel with the “up” and “down” arrows.

Setpoint source: LOC, EXT, HHT or DEFAULT.

When the timer function is active, the output power will be on until either a preset time has elapsed or the POWER OFF button is pressed.

If the sequence function is activated, the function will start each time the POWER ON button is pressed. Set the output power level in the sequence program—refer to paragraph 5.2.6. To interrupt the function, press the POWER OFF button.

3. Control from the HHT

Control of the output power with the button on the HHT handle is independent of the LOCAL/REMOTE switch position. Turn the output power on by continually pressing the button.

If the HHT in use has a gun grip control handle, the handle is equipped with a trigger type push button with an LED. The LED indicates output power on. When the push button is activated, the output power will be switched on. By pressing the trigger switch further, the output level of the variable selected as the mode of operation is adjusted by the travel of the trigger switch.

When the timer/sequence is activated in the Activate menu, it runs (with power on) as long as the green button on the HHT is depressed and until the selected time has expired. The HHT green button must be released before a new

timer/sequence can be started. **Setpoint source: LOC, EXT, HHT or DEFAULT.**

4. **External Control**

Different types of ECUs can be used to operate the frequency converter. The start-up sequence will vary depending on the type of ECU used. Make sure that the LOCAL/REMOTE selector is in the REMOTE position. **Setpoint source: LOC, EXT, HHT or DEFAULT.**

4a. **Foot Controller/ foot switch**

The unit can be equipped with a foot controller or a foot switch. The LOCAL/ REMOTE selector must be in the REMOTE position when operating the MINAC from a foot controller/switch. Turn on the output power by operating the pedal. Increase the level of output power by pressing the pedal gradually if using a foot controller (0-100% control range). **Setpoint source: EXT or DEFAULT for foot controller / LOC for foot switch**.

6.2.4 Alarms during start-up

If any alarm is activated during the start-up sequence, an alarm message will pop up in the footer area of the display. If an alarm is activated, find the cause of the alarm and remove it (refer to paragraphs 5.1.1 and 6.7). Press the RESET button to reset the FAILURE lamp.

WARNING!

Do not remove the equipment's covers or panels. Refer trouble-shooting to qualified personnel.

6.3 Normal Operation

WARNING!

PACEMAKERS: Anyone wearing a pacemaker may be at risk when in the vicinity of the induction heater's coil section. There is a risk that the electromagnetic fields produced by the induction heating unit may interfere with the performance of the pacemaker.

WARNING!

RISK OF BURNS: Avoid wearing materials that conduct electricity close to the body. Energize the coil only when it is in the vicinity of the workpiece.

6.3.1 Operational Information

During normal operation, select one of the MMI information screens:

- Display Values (menu 24)
- Display All Values (menu 19)
- Display Timer/Sequence (menu 23)
- Display Twin Values (menu 36) (Twin units only)

Refer to paragraphs 5.2.9, 5.2.10, 5.2.11 and 5.2.12. These menus provide continuous information about current operating conditions, e.g., output power, voltages and current values. The output frequency is displayed in the F7 Status information, and in the “Display Values” and “Display Twin Values”.

Regardless of which menu is selected, each screen contains a footer displaying alarms, indications/limitations and operational messages. The various messages are described in paragraph 5.1.1.

6.3.2 Control Functions

Sequence

The sequence function enables the operator to run specific heating sequences. Eight different sequences can be programmed in the Sequence Menu (menu 4); refer to paragraph 5.2.6. If the sequence function is activated, the sequence (program no.) selected in the Sequence Menu will start each time a POWER ON signal is given. Note that in remote control, the sequence program to be started is selected via the external interface.

Timer

The timer function enables the operator to run the unit at a specific time interval. The duration of the interval is selected in the Timer Menu (menu 7); refer to paragraph 5.2.5. If the timer function is activated, the time interval starts each time a POWER ON signal is given. This means that the output power is on from the moment a POWER ON signal is given until the time interval has elapsed.

Water Auto Shut-off

Activating the "Water auto shut-off" function automatically closes the water flow 20 seconds after the output power is turned off. This cuts down on water consumption. To turn the power on again, press the POWER ON button and hold it for a minimum of 1.6 seconds until the output power comes on. The reason for this time delay is to make sure that the water is flowing before any heat develops.

NOTE:

When the cooling water temperature is low at the same time as the ambient temperature is high, activate the "Water auto shut-off" function in the Activate Menu to avoid condensation on pipes, etc., inside the unit.

Energy Supervision

The energy supervision function enables the operator to detect changes in the heating process when running the sequence function. Once a perfect sequence program has been established, store the total energy value of the run and enter an allowed percentage energy deviation value. The energy consumption of the following runs (of the same program no.) will be compared with the stored value. If the current value is within the allowed deviation, “OK” or a ☺ is shown in the Display Sequence/Timer Menu. If it is not within the allowed deviation, “LOW/HIGH” or a ☹ is shown.

For further information, refer to paragraph 5.2.7. The energy supervision function is activated/deactivated in the Activate Menu.

PIN Code

The PIN code function provides a security option for system programming. The function is described in paragraph 5.2.2.

Extended Operating Range

The extended operating range (EOR) function enables the unit to operate outside the normal ratings for cooling water flow and temperature. When this function is activated, the output is reduced/limited, according to the water’s cooling capacity, if necessary to protect the unit. The alarm level for low water flow is reduced and the alarm level for over temperature is increased[4].

If this function is activated, a footer message flashes, alternating with the normal message. If output power is reduced/limited by this function ‘Output reduced by EOR’ is shown in the footer message. For further information, refer to paragraph 5.1.1. The EOR function is activated/deactivated in the Activate Menu.

NOTE:

The EOR function must be used with great care. Because the output power can vary with variations in the cooling water supply, repeatability can not be guaranteed.

Select Ext. interface (optional)

This function is only available on units specially equipped with both hardwired external plug and a fieldbus connection. By setting this function to ‘Hardwired’ all external control input to the unit must come from the hardwired external plug. By setting it to ‘Fieldbus 1’ all external control input to the unit must come from the fieldbus connection. Both external connections will however provide information out regardless of the selected function.

[4] Refer to specifications for details on water flow alarm level and over temperature alarm level when EOR is activated, as this is equipment dependent.

6.3.3 Output Power

There are the following maximum output powers available for continuous use and intermittent duty:

Equipment	Continuous use	Intermittent duty
MINAC 25/40, 25/40 Twin	25	40
MINAC 50/80	50	80

The maximum output powers are attainable only with low Q - magnetic steel.

The output power can be regulated by using the following three different parameters (modes of operation):

AC current Using the current to regulate the output power is recommended for heating processes with varying impedance as a constant current produces constant induction. Typical application: hardening.

DC power DC power regulation is recommended for heating processes where the load is constant (constant impedance) or in general where heat absorption varies as a function of the heating temperature. This mode of operation is generally chosen when the equipment is used in a production line.

Temperature Temperature mode can be used in special applications where a temperature sensor is installed at the workpiece. This also requires optional temperature input connector.

In local operation, the setpoint can be either entered as a percent value in a sequence program or adjusted by using the “up” and “down” arrows.

NOTE:

As long as a POWER ON signal is given, the output power will never be zero, although the reference setpoint may be set to zero. There will be a small current in the coil because the frequency converter's regulation system needs some current feedback to function.

6.3.4 Distance to Workpiece

The efficiency of the coil decreases as the distance to the workpiece increases. The best results are obtained where the distance between coil and workpiece is 1-3 mm. Practical reasons, such as the shape of the workpiece, may require a larger air gap between the coil and the workpiece, although this may reduce efficiency.

6.4 Normal Stop

1. Turn the output power off by pressing the POWER OFF button on the operating panel or an equivalent actuator on the ECU, or by releasing the button on the HHT handle.

2. Turn off the main disconnector.

3. When the MINAC is turned off, a built-in magnetic valve closes the water flow to the converter. Any external inlet/outlet water valves should be closed when the equipment is left unsupervised for a time (some hours).

NOTE:

If the equipment is to be kept or transported in areas where there is a risk of low temperatures and damage from freezing, drain the cooling system. Set the MAIN switch to the ON position and deactivate the “auto water shut off” system before supplying compressed air to the water inlet tailpiece (refer to 6.3.2). Keep the outlet tailpiece open — Do not use a snap-action valve.

6.5 Emergency Stop

If an Emergency Stop input is generated while an ECU is used, the alarm message “Stop” appears on the footer display. See 5.1.1 The power output of the MINAC is switched off and all power-on functions of the MINAC are blocked.

To perform local emergency switching off, simply turn off the main disconnector on the MINAC’s operating panel.

6.6 Restart after Emergency Stop Command.

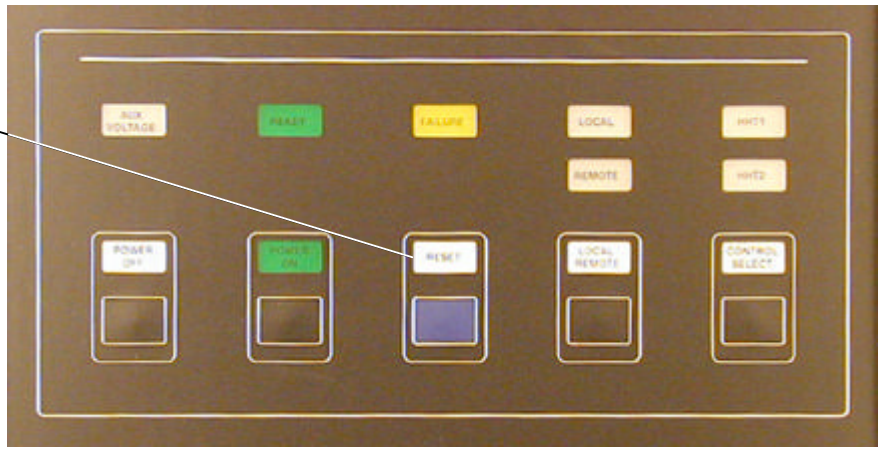

Figure 13. Switches and Indicators panel, RESET button

To restart after an Emergency Stop caused by an ECU, release the emergency stop from the ECU and press the “RESET” button on the operating panel. The unit will be ready to receive a new power-on command.

To restart after a local Emergency switching off, follow the normal start procedure. Refer to paragraph 6.2.

WARNING!

DANGER WHEN RESTARTING: To avoid repeating a dangerous situation, do not restart the equipment before finding the reason for activation of the External Stop Command/emergency off switch and correcting the cause.

6.7 Disturbance of Operation and Corrective Measures

Every operational failure results in an interruption of the output power. The FAILURE lamp on the operating panel and an alarm message in the MMI display indicate the fault. Before restarting the converter, find the reason for the alarm and eliminate the possible cause(s).

WARNING!

Do not open the equipment's covers or panels during operation. Refer trouble shooting to qualified personnel.

EFD personnel or qualified on-site maintenance personnel normally should take corrective actions. However, the operator may handle the alarm situations set out below. If these actions do not restore normal operation, the operator must record the error message and contact the on-site maintenance personnel, EFD Service Department or the nearest EFD representative. Whenever possible, the operator should manually record the relevant operational data as this information may be of help in further fault finding. This data will include current, voltage, power and frequency readings at the time of the fault or just before the fault occurred.

All fault-finding and corrective actions by on-site maintenance personnel should normally be performed with the main disconnector turned off. Always comply with all safety measures when handling electrical equipment, including any national or international regulations.

WARNING!

HIGH VOLTAGE: The unit must never be left unsupervised when the power supply is turned on and protective covers are removed. Such conditions involve a risk to life and equipment.

The following operational failures are indicated by alarm messages on the MMI display, and the FAILURE lamp on the operating panel. The failures, probable causes and corrective actions are listed below.

Operational Failures

Alarm	Probable Cause	Corrective Action
Switch mode power supply alarm Indicates a problem on the SMPS card. On twin units this alarm will stop both outputs	– A missing phase. – Main fuse break. – Broken fuse(s) in the internal switch mode power supply – Faulty switch mode power supply.	1. Make sure that the supply voltage consists of all three phases. 2. Check the main fuses 1F1, 1F2, 1F3. 3. Only qualified personnel shall repair a failure on the internal electronic circuits.
Power Supply Alarm Indicates a problem on the power supply unit. On twin units this alarm will stop both outputs	– Error in external connected equipment, if any. – Error on the internal power supply or other internal electronic circuits.	1. Remove externally connected equipment, and reset the alarm. 2. Only qualified personnel shall repair a failure on the internal electronic circuits.
AC over-current alarm	– AC over-current can be caused by a short circuit in high-power modules CAP, CON or HHT, including cables. Most common is a short circuit in the induction coil or its terminals. – It may also be an error on the internal power supply or other internal electronic circuits.	1. Check that the coil is within the system performance. 2. Inspect the above mentioned systems for short circuits. 3. Only qualified personnel shall repair a failure on the internal electronic circuits.
Low frequency alarm **High frequency alarm**	Too low or too high frequency is most commonly caused by an incorrectly designed induction coil. The coil may have too large or too small an area, or it may be short-circuited. Operation at full load with a very low frequency (7-8 kHz) may also be the cause. It may also be an error on the internal power supply or other internal electronic circuits.	1. Check that the coil is within the system performance. 2. Inspect the above mentioned systems for short circuits. 3. Only qualified personnel shall repair a failure on the internal electronic circuits.

Alarm	Probable Cause	Corrective Action
Over-current driver alarm Indicates an over-current in the inverter.	Possibly caused by a short in the output circuit, or a malfunctioning transistor. If the alarm can not be reset, there is a malfunctioning transistor. It may also be an error on the internal power supply or other internal electronic circuits.	1. Check for short circuits in the induction coil and its terminals. Make sure that the workpiece does not short-circuit the coil during operation. 2. Only qualified personnel shall repair a failure on the internal electronic circuits.
Inductive Indicates too inductive an AC current	An error in the internal frequency control system.	1. Only qualified personnel shall repair a failure on the internal electronic circuits.
Capacitive Indicates too capacitive an AC current, or a short in the output circuit.	An error in the internal frequency control system. Short circuit in the induction coil or terminals	1. Make sure that there are no short circuits in the induction coil or its terminals. (Please note that both the coil and the terminals must be kept clean to avoid the risk of short circuits). 2. Only qualified personnel shall repair a failure on the internal electronic circuits.
Over temperature Inlet water Indicates that the temperature of the cooling water is too high. On twin units this alarm will stop both outputs	– The inlet temperature of the cooling water is too high. – It may be an error on the internal power supply or other internal electronic circuits.	1. Make sure that the inlet cooling water temperature is below 35°C/95°F. If the temperature has been too high, it might take some time before the "Over-temp Water" alarm can be reset. Let the water flow through the converter. (the "Auto Water Shut-off" control function must not be activated). If the EOR function is active see paragraph 5.3.2 2. Any failure on the internal electronic circuits has to be repaired by qualified personnel.

Alarm	Probable Cause	Corrective Action
Water flow low Indicates insufficient water flow through the cooling circuit.	– Insufficient water flow through the converter module heat sink. – Clogged water filter in water inlet terminal – Insufficient water flow through the HHT. – Insufficient water flow through the induction coil.	1. Check that external manual valves and solenoid valves are open. 2. Make sure that cooling water supply to the frequency converter is adequate, i.e., 4 bar/58 psi differential pressure minimum, 3/4" inlet hose minimum, and minimum water flow. (See nameplate) 3. Clean the inlet water filter. There is access to this filter on the outside. Unscrew the hose tail for the water inlet, retract the filter and clean with compressed air. 4. Make sure that the heating coil allows for enough water flow. Redesign the coil if necessary. 5. If the EOR function is active, see paragraph 5.3.2
External Fault Customer-defined alarm (e.g., external interlock alarm, external water flow alarm, etc)		
Emergency Stop command Indicates that the emergency stop has been activated.	The emergency stop command has been activated externally on an external control unit.	1. Before restarting the unit after an emergency stop command, find the reason for the activation of the emergency stop function. 2. To reset the emergency stop command function, reestablish the emergency stop command signal on the ext. plug. 3. Press the RESET button to make the unit ready for use.
DC Voltage too low The DC voltage on the rectifier is too low.	– The main voltage is too low. – One phase is missing. – There was a temporary drop in the main voltage.	1. Check that the main voltage is within the limit. 2. Make sure that the supply voltage consists of all three phases.
DC Voltage too high On twin units these alarms will stop both outputs	– The main voltage is too high – There was a temporary high main voltage	3. Check that the main voltage is within the limit.

Alarm	Probable Cause	Corrective Action
Power on by startup	There was a “Power on command” detected by the control system during startup.	Release any stuck power-on buttons, and press the RESET button to make the unit ready for use.
DC Over-voltage detected On twin units this alarm will stop both outputs	There was a high voltage peak on the DC capacitor.	
Ground fault detected On twin units this alarm will stop both outputs	– The induction coil was grounded. – The HHT had an internal flash over – Internal circuits are shorted to ground.	1. Check the main voltage supply for noise peaks from other equipment connected to the same line. 2. Make sure that the induction coil is not connected to ground during heating. 3. Have the HHT replaced by qualified personnel. 4. Any failure on the internal electronic circuits must be repaired by qualified personnel.
Fuse Fan Indicates current limiter for the internal cooling fans is active. On twin units this alarm will stop both outputs	Broken fan motor.	Any failure on the internal electronic circuits has to be repaired by qualified personnel.
System reset by Watch Dog Timeout On twin units, this alarm is activated in both outputs.	For safety reasons, the micro controller is reset automatically if a software or hardware condition stops it from operation. The unit will be restored as after a startup. After such a reset, this alarm will be active.	1. Press the RESET button to make the unit ready for use. 2. Any failure on the internal electronic circuits must be repaired by qualified personnel only.
Overtemp Inverter Indicates too high temperature at the inverter heat sink . On twin units this alarm will stop both outputs	Clogged water channels in inverter. Damaged transistors in inverter. Electronics fault.	1. Press the RESET button to make the unit ready for use if possible. 2. Inspect water flow in inverter. 3. Any failure on the internal electronic circuits has to be repaired by qualified personnel.

Alarm	Probable Cause	Corrective Action
Main contactor off On twin units this alarm will stop both outputs	The main contactor is not energized because Emergency stop is activated	Refer to the emergency stop alarm
— **No lights on control panel** Indicates lack of electronics' power supply.	Electronics' power supply failure.	Refer to Power supply alarm