MANUAL
MAGNET POWER SUPPLY
SYSTEM 9100

REV.	By	Date	Description	Pages
1.0	CSN	12.04.2010	Initial	All
2.0	CSN	18.06.2010	Chapter 2.5: Two or more SYSTEM 9100 in parallel deleted	12
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2.2	CSN	05.05.2011	Various	
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1 Introduction and specifications

1.1 General introduction

The System 9100 is a DC constant current output Power Supplies designed for applications requiring very high stability and low noise combined with reliability and ease of operation.

The System 9100 is aimed at correction magnets in ion beam applications based on Danfysik´s forty years of experience in delivering precision DC Power supplies to industrial and research laboratory users around the world.

The System 9100 is the new generation of high performance Power Converters suitable for many high current and voltage applications where size and cost are essential.

- Power range of 3 kW, 6 kW, 9 kW and 12 kW , allowing the user to select the most suitable solution
- 10ppm stability class using LEM Ultrastab high precision DCCT current transducer to control the current stability in the power supply
- Wide current range from 50 A to 200 A
- Low output ripple, internal power modules are parallel connected in pairs with a 180º phase angle, hereby reducing input and output ripple.
- Remote controlled through a serial interface “RS232/RS422/RS485”

1.2 Specifications

AC INPUT

Mains, voltage:	400 VAC, 3 phase, 47 - 63 Hz.
Control voltage:	230 VAC, 47-63 Hz.
AC voltage variation:	±10%

See page 58 for connection to AC mains connector.

DC OUTPUT

Power Range	up to 12 kW
Current:	50 A - 100 A - 150 A - 200 A versions
Voltage:	60 V
Regulation Topology:	Constant current regulation
Converter Type:	Primary switching type that operate after the Zero voltage switch-mode principle

PERFORMANCE

Warm up time (cold):	30 min.
Warm up time (stand-by):	15 min
Drift (long term 8 hours):	±10ppm
Line regulation	
± 10% slow, T > 1 min.:	±5ppm
± 1% fast, T > 3 m sec.:	±5ppm
Load regulation	
± 10% resistance change:	±5ppm
Output ripple and noise	
Voltage – peak to peak:	< 100 mV @ 0-100 kHz
Load Range	
Time Constant (L/R):	0 - 1 sec
Inductance (L):	0 - 1 H (standard)
Temperature coefficient	
Ambient 15 – 40° C:	5ppm/°C
Ambient 15 – 30° C:	1ppm/°C
Current setting resolution:	20 bit DAC
Current reproducibility:	± 10ppm
Absolute current calibration:	-0 / +400ppm

Current readback resolution:	16 bit ADC
Voltage readback resolution:	16 bit ADC
Current control range (setting range):	1 – 100%
Ramp speed (0 – 100%):	0.1 – 10 s (adjustable)*
Current loop bandwidth:	2 – 100 Hz
Voltage loop bandwidth:	>200 Hz

*Ramp speed for the bipolar version is limited in the second and fourth quadrant. See page 22.

CONTROL PANEL

Alphanumeric LCD display:

Preset output current, 6 digits	[A]
Actual output current, 5 digits	[A]
Output voltage, 2 digits	[V]
Interlock status text string	

Push buttons and LED's

OFF	[Button]/[LED]
Reset (interlock)	[Button]/[LED]
ON	[Button]/[LED]
Menu	[Button]
Out of regulation	[LED]

Remote control / interfacing

RS232 as standard (RS422 and RS485, or SPI are available on request)

The following status messages are available via the remote control interface:

ON/OFF command
Reset command
ON/OFF status
Remote status
Output current
Output voltage
Ambient temperature
Delta temperature
Internal power supply 15 V
Internal power supply 5 V
I set value
V set value

The following controls are available via the analog control interface:

Set current
Set voltage
Output current readback
Output voltage readback

Interlock status

Over voltage
Over current
Over temperature
Fan fault
Earth leakage
AC fault
Out of regulation
External interlock (ext. 1 – 4)
Summary interlock

COOLING

Water:	1 l/min @ max. Inlet temperature 35° C
Differential pressure:	1 bar
Test pressure:	15 bar

TEMPERATURE RATINGS

Operation Ambient temperature:	15 - 40° C
Storage temperature:	-20 - 70° C, non-condensing

CABINET LAY-OUT

Material:	Steel
Dimensions W x D x H:	482 mm x 550 mm x 132.5 (3U)
	19 inch rack mount
Weight	32 kg (shipping weight 35 kg)

NORMS

Immunity for industries:	EN/IEC 61000-6-2:2005
Emission for industries:	EN/IEC 61000-6-4:2007
Harmonic Emission (single phase):	EN/IEC 61000-3-2:2000
Harmonic Emission (three phase):	EN/IEC 61000-3-12:2005
Electromagnetic compatibility:	EN/IEC 61000-3-11:2000
Safety req. for electrical equipment:	EN/IEC 61010-1:2001

1.3 Warranty and warranty repair.

DANFYSIK A/S warrants that the products manufactured by us will be free from defects in material and workmanship that adversely would affect the normal functioning of the unit, for a period of 24 months from the Date of Acceptance of the Equipment.

The exemptions to this are:

a) **Parts not manufactured by DANFYSIK A/S** which are covered by the original equipment manufacturer's warranty.

b) **Repair work**, which is warranted for six (6) months from the date of shipment from the DANFYSIK works.

DANFYSIK A/S will repair or replace either on site or at the factory, at option and without charge, any equipment which proves to be defective within its warranty period.

In the case of warranty, DANFYSIK A/S will pay or reimburse lowest freight rate (two-way) of any item returned to DANFYSIK or our designated agent/representative, provided that prior written authorisation for such return has been given by DANFYSIK A/S.

This warranty shall not apply to any equipment, which has become defective or unworkable due to mishandling, improper maintenance, incorrect use, radiation damage or any other circumstance not generally acceptable for equipment of a similar type.

On standard products, DANFYSIK A/S reserves the right to make changes in design without incurring any obligation to modify previously manufactured units.

The foregoing is the full extent of this warranty, and no other warranty is expressed or implied. In no event shall Danfysik be liable for special damages arising from the delivery, late delivery or use of the equipment.

If any fault develops, the following steps should be taken.

Notify DANFYSIK A/S, giving full details of the problems, and include Model-Type and Serial number.

On receipt of these information, DANFYSIK A/S will give you either service information or instructions for shipping.

All shipments of DANFYSIK equipment should be made according to our instructions and shipped in the original or a similar container.

For smaller parts a carton will be sufficient, if the parts are wrapped in ESD bags and surrounded with at least 10 centimetres of shock absorbing material.

2 Unpacking and installation

2.1 Receiving the goods

The Shipping container and the Power Supply should be thoroughly inspected for signs of obvious physical damage immediately upon receipt.
All materials in the container should be checked against the enclosed packing list.
DANFYSIK A/S will not be responsible for shortages against the packing list unless notified immediately.

2.2 Instructions for unpacking

The Power Supply is shipped in reinforced cardboard.

If the equipment is damaged in any way, a claim should be filed with the shipping agent, and a full report of the damage should be forwarded to DANFYSIK A/S or our local agent/-representative immediately.
Upon receipt of this report, you will be issued instructions for the repair, replacement or return shipment.
Please include the Model no, Type no, Serial no, and Order no for the Power Supply on any communication with DANFYSIK A/S or our representative.

2.3 Installation requirements

During installation of the Power Supply, local rules and regulations for electric power supplies should be respected and the following conditions and installations should be available.

* A normal, dust free room with humidity not above 80 % and a room temperature within 15 to 40 centigrade.

* Three-phase Mains voltage switched and fused, + neutral and protective earth.

* Ground connection according to the local authority regulation and the requirements for the equipment.

* If applicable, cooling water supply at a temperature within 15 to 35 centigrade.
  Differential pressure: Min. 1 bar.
  Max. inlet pressure: 12 bar.

  Please see specification sheet chapter 1.2 in this manual for actual figures for this power supply.

* For cooling of our power supplies and magnets we recommend the use of demineralised water or pure water with an electrical conductivity of less than 10µS/cm. This reduces the electrolytic corrosion to a minimum.

  Adding pure ethylene glycol to cooling water with no other additives should not affect the electrolytic corrosion. However, it will reduce the thermal conductivity of the coolant. A percentage of 40% glycol reduces the conductivity by approximate 30%. We would recommend not using more than 25% corresponding to an approximate reduction of thermal conductivity of 17%. It may be necessary to increase the water flow in the power supply.

No other additives should be used.

During operation, the conductivity of the coolant should be checked regularly. A few days operation with water of poor quality can cause more corrosion damage than during several years' operation with good quality water.

2.4 Installation

Before and during installation of the Power Supply, the following points should be checked / carried out.

* Check that the main voltage and frequency matches to the specified and labelled requirements.

* Check that screw connections from the output terminals are tightened.

* Check that all screws on D-sub connectors are tightened.

* If the magnet is provided with a thermal breaker connect the contacts to external interlocks and +24 VGND (Ground for +24 V)

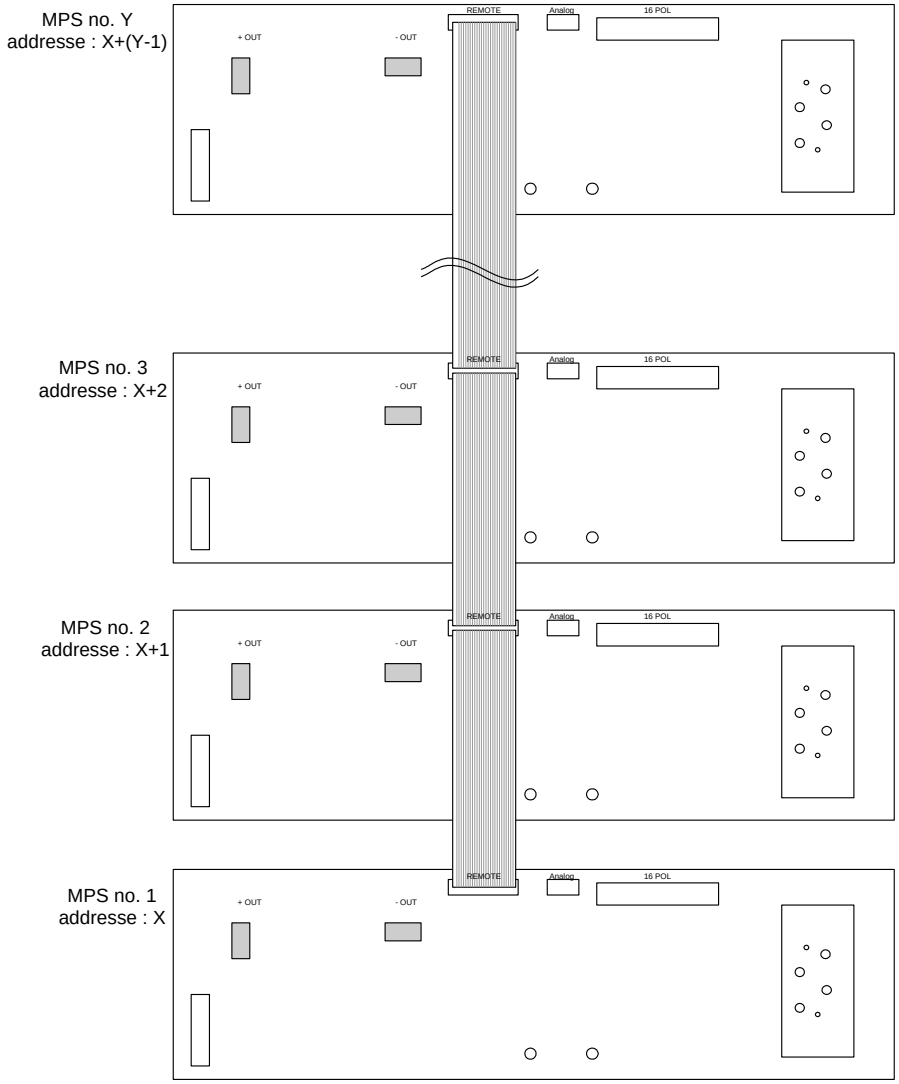
* Unused external interlocks shall be connected to +24V ground (Ground for +24 V pin 12, X112 or to pin 11 +24V_Ext_GND if +24V_Ext, pin X8 is used for interlock supply)

2.5 RS422 or RS485 Multidrop configuration

Up to 32 SYSTEM 9100 units can be connected in a RS422 or RS485 multidrop configuration.

It is also possible to run a Master/Slave configuration within a multidrop system. To set up the Master/Slave configuration, see chapter 2.5.

- Connect parallel cables to all masters at the port REMOTE.
- Address all the masters so each unit has a unique address. *See chapter 3.3.1 for setup address in local and remote mode.*



Example of multidrop configuration

About the termination of RS422 or RS45, *see chapter 3.3.3 "Termination using RS422 or RS485"*

3 Operating instructions

This chapter outlines the procedure and precautions for the operation in local and in remote control mode.
It identifies and describes the controls and indicators on the M-Panel Graphical.
Also the programming of the remote lines is described.
Instructions for initial remote line set up are given in chapter 3.3.

3.1 Switching on

When precautions have been checked in accordance with chapter 2.3 and 2.4, the power supply can be switched on.

Immediately after the Power Supply is switched on, a start up screen appears on the M-Panel and displays which control module is connected and makes a self test and scans for a text table has been downloaded or not.
After approximately 5sec., the panel is ready for use. The remote line is ready for use after approximately 3 sec.

Make sure that the time between switching the control power - OFF and - ON again is at least 5 sec. to ensure a correct cold start (initialization of the Power Supply).

- Select LOCAL CONTROL mode at the CMD-menu. "LOC" text appears in the display (1).
  To turn the power supply ON for the first time, it is recommended to activate it in the LOCAL CONTROL mode as this is the easiest way to get started.

- If any Interlocks are set, push the "Reset" button (8).
  Remove the faults if the Interlocks are not reset.

- Set the desired output current by use of the SET-menu.

- Switch the Main power "ON" (3).

- The READY LED (6) illuminates, when the output current is equal to the preset value within a given accuracy typically +/-200ppm.

- Switch the main power "OFF" (5).

3.2 Operating with the Manual Control Panel

The MANUAL CONTROL PANEL (M-Panel Graphical) is an interface module that are used with several Danfysik Magnet Power Supplies including SYSTEM 9100.

The SYSTEM 9100 comes with a M-panel as standard. It can however also be delivered with a display board. This has two 5 digit 7 segment displays for voltage and current. LED indicators for POWER ON, FAULT and READY. With this display board, the System 9100 can be operated remotely from a PC, or by connecting an M-panel to the local port situated on the back side of the system 9100. The M-panel can be connected and disconnected from the Power Supply without affecting the power supply operation. Communication between the Power Supply and the M-Panel is by a serial link, and may be physically located at the Power Supply or up to 400 meters away from it.

3.2.1 Main power ON / OFF and interlock RESET

The basic function on the M-panel is to turn the power supply ON / OFF and to RESET pending interlocks. All controlled from a single button. For further information about the button locations, see chapter 3.2.3 Front Panel Control.

Setting the output current is done through one of the pull down menus described in the next chapter.

When the power supply is ON the LED in the button area will illuminate.
When the power supply is OFF the LED in the button area will illuminate.
If an interlock is present the LED inside the RESET button will illuminate.
Pressing the RESET button will clear the interlocks that are not due anymore.

Hint: If an interlock is present, it will also be represented on the display at the lower right corner.
Hint: The color of the LEDs can be reprogrammed to illuminate green, red or "orange".

3.2.2 Using the Manual Panel Menus

This chapter shortly describes the use of the M-Panel Graphical. The menus themselves will be described later.

The user interface of the M-Panel Graphical is based upon pull down menus. To display the menus simply press the MENU button (if not already standing in the Menu window).

To prevent unnecessary hiding of the main display (set current, output current and voltage) the pull down menus are always displayed left aligned. In other words, it is the menu bar that rolls over the pull down region.

With visible menu bar, activating the "◂" or "▸" arrow buttons the menu bar always displaying the selected pull down menu at the left side will rotate. At the bottom right is a help text, showing what the selected pull down menu group is used for. To select one of the lower menu items the "▴" or "▾" arrow buttons must be used. Also here a help text at the bottom right of the display will tell what the selected menu will do. If a menu has a sub menu it will be shown with a right arrow to the right of the menu text. This sub menu can be accessed by pressing the right "▸" arrow. Having found the desired menu it can be entered by pressing the "↵" Enter key (The selected menu is shown inversed). If the chosen menu has a parameter to be edited a pop up window will be shown with the parameter (as the set current menu), if the menu only contains data to be shown a pop up window will be displayed with the data (as in the Interlock menus) or if the menu is a command (as the REMote or the LOCal) then the task will be executed immediately and the cursor will stay at its position. A pop up window is exited by pressing the "↵" Enter key again.

The above in short, one can say: The menu bar is entered with the MENU key end exited again with the MENU key (back to default window). A pop up window is entered with the "↵" Enter key and exited again with the "↵" Enter key. Just like parentheses in equations.

As usual any rule has exceptions and these are:

- If there is no need for parameters after activating the "↩" button "Stand alone menu" there is no need to press the "↩" button again. [One " ↩" equals "( )"]
- Pressing the MENU button while editing a parameter will abort the operation. [Regret the operation as an "ESC"]
- Remotely changing the command status to Remote will automatically abort any local operation.

Hint: To ease the use, the "↩" Enter key may be used instead of one of the arrow keys in some situations- i.e. if the action is given anyway. Eg. Standing on the top of a menu the "↩" will do the same as the "▾" key or when standing in a menu containing a sub menu the "↩" will do the same as the "▸" key. (Interferes a bit the mathematical parentheses idea; but is fast to use in some cases)

Hint: Pressing the MENU key the first displayed menu will either be the SET or the INTL menu. The last one if at least one interlock is present. This minimizes the number of buttons to be pressed to "MENU", "▾" , "↩" for setting the output current or the same key sequence to se the active internal interlocks. Actually the three lowest vertical keys pressed from bottom up.

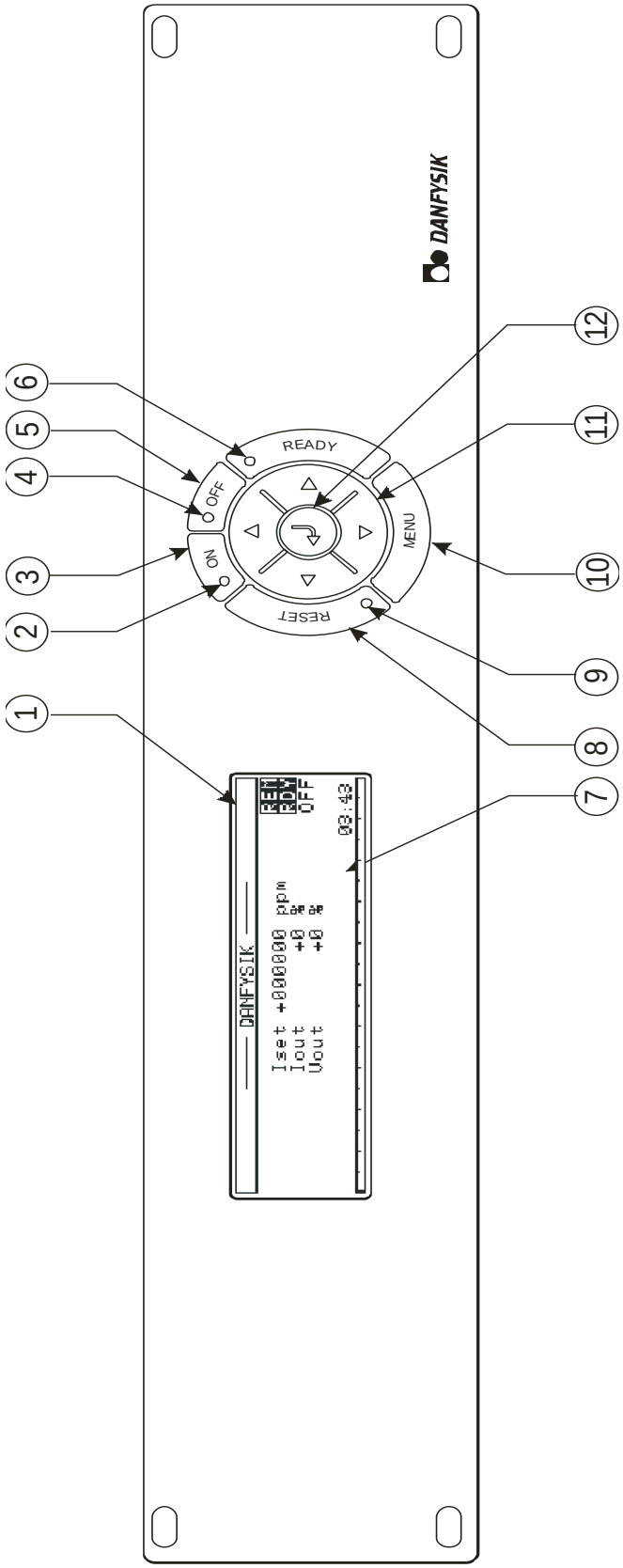
Changing a parameter is done with the arrow keys. (See also the help text at the bottom right of the display). A cursor, shown as the digit inverse, marks the digit to be manipulated. Pressing the "Enter" key ends the editing.

Hint: Holding either the "▴" or the "▾" keys pressed when editing a number the auto increment function will start.

If no menus have been used within 5 minutes, then the display will automatically be switched back to the opening window aborting any current operation (security reason).

3.2.3 Front panel controls.

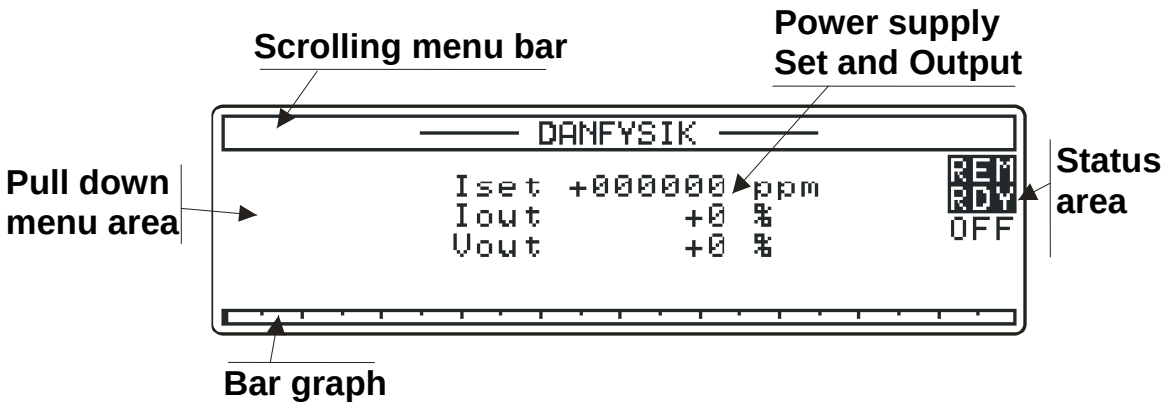
1. Graphic display 240*64
2. Main power is "ON" LED.
3. Main power "ON" push button.
4. Main power is "OFF" LED.
5. Main power "OFF" push button.
6. READY LED indicates when the actual output current is within a predefined limit.
7. Control Power "ON". Back light is lit.
8. Interlock "RESET" push button.
9. Sum Interlock LED.
10. MENU - Enter / Exit pull down menus.
11. Navigation keys. ・ ・ ・ ・
12. ENTER - Enter / Exit parameter change.



3.2.4 The Display

The display is a multi purpose graphic window to the user. The window can be divided into three groups:

Default window:
The default window is shown below. If the Operator Control Panel is unused for 5 minutes, the Operator Control Panel will automatically enter this state. This is for security reason. Escaping from any menu back to this default window can be performed by pressing the "MENU" button again. Any ongoing operation will be cancelled.



Scrolling menu bar

The upper part of the display is normally used for displaying the viable top menus. In the default window, "------ DANFYSIK ------" will be displayed. It is called "scrolling menu bar" because contrary to normal Windows © pull down menus it is the top menus that scrolls with the "▸" "◂" buttons.

Pull down menu area

The pulls down menus are always shown in this area. If a pull down menu has sub menus they will advance to the right. The second submenu will overwrite the " Set and Output" area.

Power supply Set and Output

Upper line displays the output current setting with six digits. After a cold start it displays "SET 000000 ppm". When full output current is set, it displays "Iset 999999 ppm", which is to be read as 99.9999 % of full scale. If required a setting in Ampere with six digits and a decimal point can be adapted. This will be set at Danfysik during test or by Danfysik service personnel.

The middle line display the actual output current with two digits. E.g. "Iout 54 %" means that the current is 54 % of full scale. This reading is made by the internal 8 Bit bipolar ADC. If a more accurate read out is required, the Control module can be added with a 16 Bit ADC. The current will then be automatically displayed by six digits where the last digit always will be zero. That is with five significant digits. E.g. "Iout 346340 ppm" means that the current is 34.634 % of full scale. If required an output reading in Ampere with two or five digits can be adapted. This will be set at Danfysik during test or by Danfysik service personnel.

The lower line displays the actual output voltage with two digits. E.g. "Vout 45 %" means that the current is 45 % of full scale. This reading is made by the internal 8 Bit bipolar ADC. If required an output reading in Volt with two digits can be adapted. This will be set at Danfysik during test or by Danfysik service personnel.

Bar Graph

The bar graph is an analog representation of the actual output current. The output current is 100 % when the bar-graph is full. The minor tics are for 5% steps and the major tics for 10%. Each pixel represents therefore 0.5%.

Status area

The status area shows for a quick view the present control status of the power supply These are:

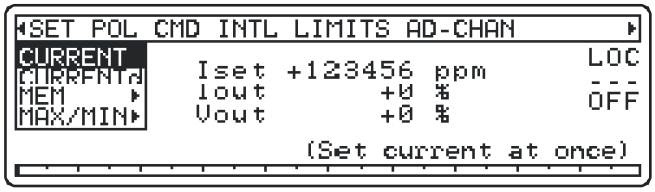
- Control mode. LOCal or REMote Remote is shown inversed.
- Regulation status. ReaDY or not Ready is shown inversed and not ready as three bars.
- Main power. ON or OFF. OFF is shown inversed.
- The controlling address in a multi drop configuration. Blank if not enabled

Information area

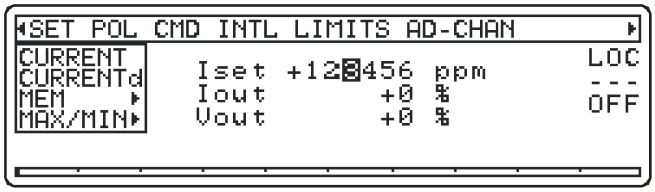
The bottom right corner of the display is used for displaying other information. These are:

- The time taken from the SMD Control module is shown if nothing else is to be displayed.
- INTERLOCK present if an interlock is pending. (In default window)
- STATUS present if a particular Status is pending, normally 1 transistor fault.
- Help text on the menus.

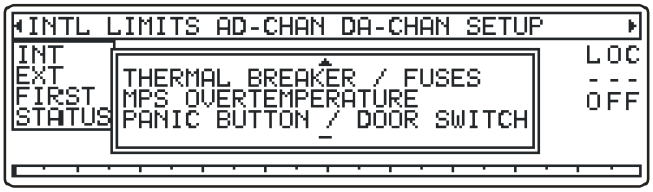
Menu Window:
Pressing the MENU button the Menu window will appear. The picture to the right shows the opening window if no interlock is present and after the "▾" button is pressed once.



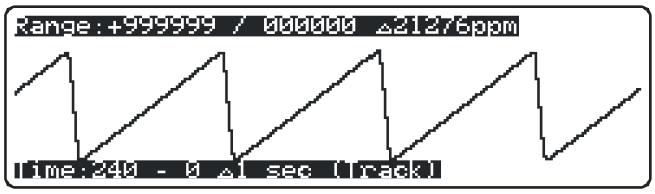
Editing Window:
If a value needs editing a cursor, shown as an inverted character, will occur somewhere in the value. Somewhere because the cursor can remember its last used position. Move the cursor to the desired position and change its value with the "▴" or "▾" keys. Holding the keys pressed will initiate an auto increment / decrement operation.



Pop Up Window:
The picture to the right shows a pop up window displaying many interlocks. The bar at the bottom indicates that there is no further information downwards, and the arrow at the top indicates that pressing the "▴" button will display the above listed interlocks. If a pop up window contains values to be set, the line to be changed will be displayed inversed (cursor over the line). Use the "▸" "◂" buttons to change the value. "▴" & "▾" scrolls between the lines. (Eg. LED Color setup menu).



History Window:
The history window can be seen as an oscilloscope screen with auto scaling.
The picture to the right shows an example history window set to absolute scale with visible scale units. The △ indicates one pixel unit.



3.2.5 Control Menus

The table below lists the standard menus. (Horizontal pop up layout)

Scroll menu	Sub menu 1	Sub menu 2	Sub menu 3	Comment
SET				Setting of output current
	CURRENT			Set output current immediately
	CURRENT d_{elayed}			Set output current after ・
	MEM			Memory function
		RCL	Reg 0 ・ 9	Recalls one memory
		STO	Reg 0 ・ 9	Stores to a memory
	MAX/MIN			Set current to one end.
		0%		Set current to zero
		100%		Set current to max
CMD				Control Command line
	REM			Set to Remote Control
	LOC			Set to Local control
	ADR			Select a multidrop address
INTL				Display Interlocks / Status
	INT			Internal Interlocks
		CROWBAR OFF DC OVERCURRENT (OCP) DC OVERVOLTAGE (OVP) 15VP OK PHASE FAILURE EARTH LEAKAGE FAILURE FAN MPS OVERTEMPERATURE		★・ See also the list below the tables.
	EXT			External interlocks
		EXTERNAL INTERLOCK 0 EXTERNAL INTERLOCK 1 EXTERNAL INTERLOCK 2 EXTERNAL INTERLOCK 3		
POL				Change output polarity
	POS +			Set polarity to +
	NEG -			Set polarity to -
	+<>-			Invert output polarity

Scroll menu	**Sub menu 1**	**Sub menu 2**	**Sub menu 3**	**Comment**
LIMITS				Value limitations
	I SET			Current value limitations
		POS		Positive limit
		NEG		Negative limit
AD-CHAN				
	CHN 0-8			A/D Channels 0 to 8
		Output current Field Input Vout Internal +15V Internal -15V Internal +5V Delta Temperature I Set Value Optional Iout 16 bit resolution		Output current 3 significant digits Hall-probe required. Output Voltage 0 - 120% Internal control voltage Internal control voltage Internal control voltage Delta temperature inside regulated area Output setting current Output current 5 significant digits
	CHN 9-17			A/D Channels 9 to 18
		Iout Not Used Output current for display Output voltage for display Not Used Not Used Not Used Not Used Iset value		Output current for bar graph Output current for display, in ampere Output voltage for display, in voltage Output setting current
DA-CHAN				Setting of D/A Channels
SETUP				Sets working conditions
	BAUD			Operator Control Panel Baud rate setting
		1200, 2400, 9600, 19200, 38400 57600 76800 115200		Communication may be lost when changing the baud rate.
	COLOUR			LED Color
		Interlock PSU ready Power ON Power OFF		Set to RED, GREEN or “YELLOW”
	SOUND			Buzzer ON or OFF
	DEFAULT			Set to factory default
	OPTION			
		ADR		Multidrop Address enable
HISTORY				
	OPEN LOG			Se chapter for further information.

3.2.6 Current setting

The output current may be set immediately as a potentiometer “SET CURRENT” or first preset and thereafter accepted with the Enter ” ↵” button “SET CURRENT”.
Setting the output current choose the “SET CURRENT” menu, position the cursor above the digit to alter and adjust the digit with the “▾” or “▴” button.

When the output current is within a predefined limit of the set value the "READY" LED will turn ON.

It is also possible to set the output current to a predefined value, either using the storage registers (STO, RCL in the MEM menu), to maximum current (=100%) or to zero (=0%).

The maximum allowed set value can be limited through the LIMITS menu. This separates for the positive and the negative set values. That is, if it is not possible to adjust the current above a certain value, then check the limits.

The storage and the limit registers are saved within the M-Panel and can therefore not be used in remote control. When using multidrop configuration e.g. all power supplies will share the same limit.

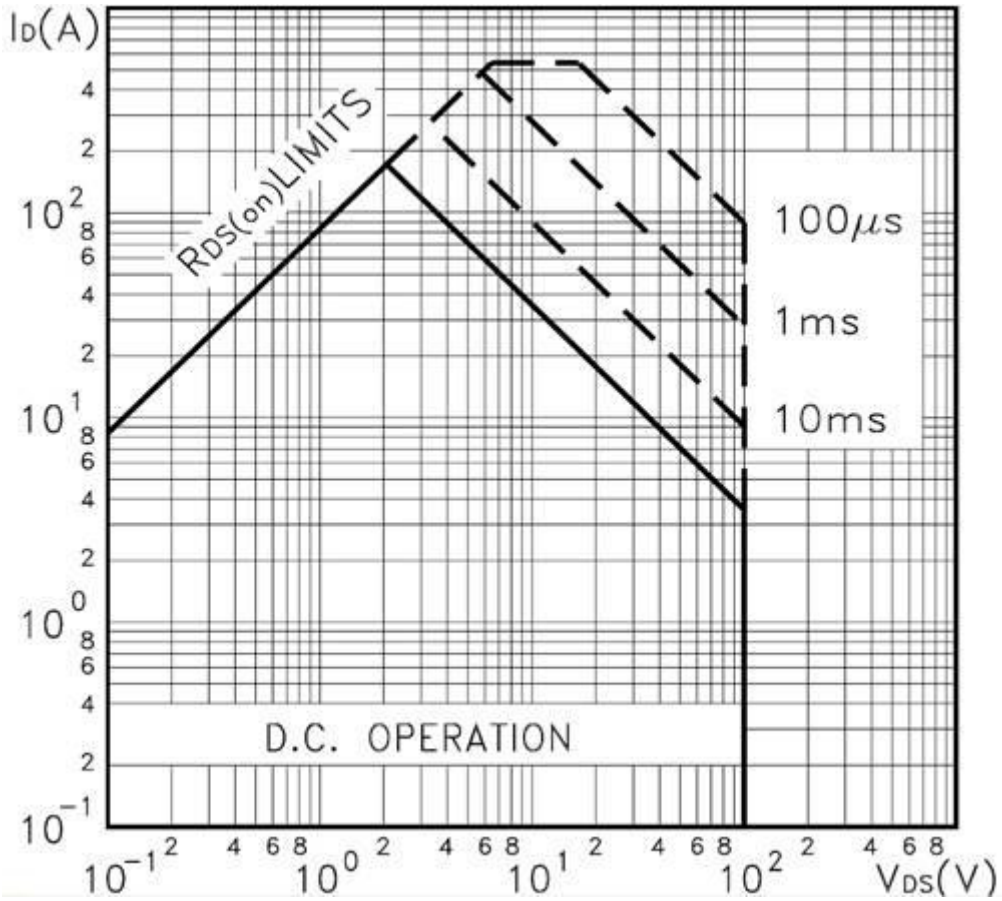
3.2.7 Polarity reversal

If a polarity reversal switch is installed, a sign will be shown in front of the set value. (+ is NOT reversed).
A polarity reversal procedure can be initiated either through the “POL” menu or simply by putting the cursor above the sign in the “SET CURRENT” menu and changing the sign with either the “▾” or “▴” button.

Please be aware that the system 9100 power supply is designed to work mainly in the first and third quadrant, i.e. either positive output voltage *and* current or negative output voltage *and* current. Working in the second or fourth quadrant is limited to the safe operating area of the polarity switch transistors. The safe operating area of these transistors can be seen in the picture on the next page. The Vds voltage on the horizontal axis is the drain to source voltage of the transistors and is equal to the output voltage in the second and fourth quadrant. The Id on the vertical axis is the drain current of the transistors. There are two transistors in parallel so the actual allowed output current is equal to twice the drain current indicated on the graph.

The graph should be interpreted as follows:
If the output voltage of the 9100 during ramping down the current in an inductive load becomes negative, say -10V, the current in one transistor must not exceed approx. 35 A i.e. the output current must not exceed 70A.
The curves used in this example are the solid lines which should be used for DC operation.

The ramp time of the system 9100 bipolar version has been factory set to 3 sec., i.e. ramping down from 150A to 0 takes 3 seconds, and from 0 to -150A also 3 seconds. Other ramp times can be set by the user, see software manual for detailed description, but this must only be done if the safe operating area is not exceeded. A lower ramp time i.e. ramping the current down faster in an inductive load gives a higher negative voltage on the output (second quadrant operation) and therefore the output current must be smaller so that the safe operating area is not exceeded.


ID(A)
RDS(on)LIMITS
100μs
1ms
10ms
D.C. OPERATION
VDS(V)

3.3 Operating by RS 232, RS422 or RS 485 I/O

The Control-Module uses standard serial interfaces compatible with many computers, PC and terminals.

Two data communication lines are available:

- A REMOTE LINE, with either RS232, RS422 or RS485 communication.

- A LOCAL LINE, with either RS422 or RS 485 communication.

The two channels are galvanic isolated from all other internal voltages through opto couplers but are supplied from the same voltage source.

3.3.1 Setting up the MPS via display board

The set up of the MPS is done by two dip switches SW3 and SW4 together with the push button S4 (SETUP), or through SW commands. Please refer to the "ESC" commands in the SW appendix chapter for further information.

The two dip switches are configured as a multi function port, which will be validated by the CPU upon pressing the button S4.

The four levers on SW3 instruct what parameters to set up, and the eight levers on SW4 delivers the actual parameters for this set up.

The parameters are first acknowledged after pressing the SETUP switch S4.

The SW3 switch position can also be seen as a binary number. The following table to the right shows the SW3 number position and which parameters it controls.

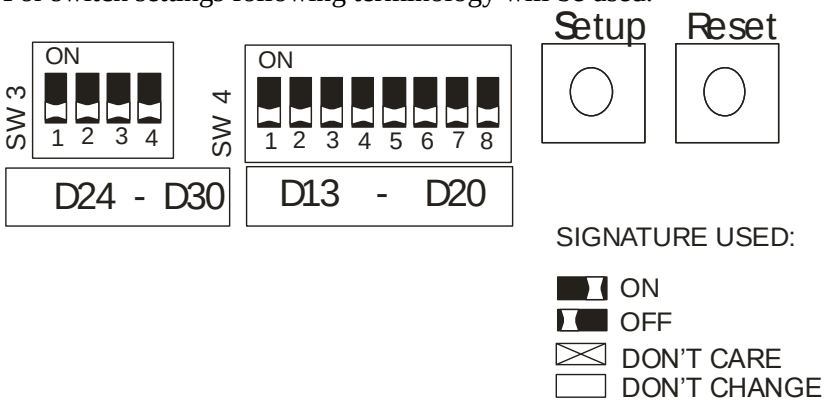
Leaving all levers in the OFF position will disable the SETUP switch and enable Interlock status mode. 8 LEDs will illuminate and indicate which interlocks have occurred. Therefore please leave all dip switches in the OFF position as default.

If the one of the set up modes are selected, the yellow LED D24 below switch SW3 will illuminate and indicate that set up port is activated. The eight red LEDs, D13-D20 below switch SW4 will show the present parameter of selected mode. Changing SW4 has no effect, first after pressing S4 SETUP the red LEDs (D13 to D20) will take the same indication as SW4.

SW3 position Number	Parameter
0 {0000}	Interlock Status Mode
1 {0001}	REM_UART_SETUP
2 {0010}	REM_LINE_SETUP
3 {0011}	REM_ADR_SETUP
4 {0100}	LOC_UART_SETUP
5 {0101}	LOC_LINE_SETUP
6 {0110}	LOC_ADR_SETUP
7 {0111}	COLDBOOT_SETUP
8 {1000}	AUX_SETUP
9 {1001}	NOT USED
10 {1010}	NOT USED
11 {1011}	NOT USED
12 {1100}	POLARITY_DELAY_PULSE
13 {1101}	NOT USED
14 {1110}	AD_AUTO_SCALE
15 {1111}	DA_AUTO_SCALE

Be aware when changing the Baud rates. Wrong setting may cause communication loss. Modifying a baud rate with the HW switches or through the appropriate SW command, will first take effect after a reset. At the remote line, use command ESC<CPURESET to make a reset.

For switch settings following terminology will be used.



SETUP

Interlock LED indications (Mode 0)

red LED								
LED 13	LED 14	LED 15	LED 16	LED 17	LED 18	LED 19	LED 20	Status
OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	NO interlocks
ON								Overvoltage
	ON							Overcurrent
		ON						Phase failure
			ON					Fault UV/Temp
				ON				Ground Leak
					ON			Fan
						ON		External interlock 1&2
							ON	External interlock 3&4

If all interlocks occur, all 8 red LEDs will illuminate.

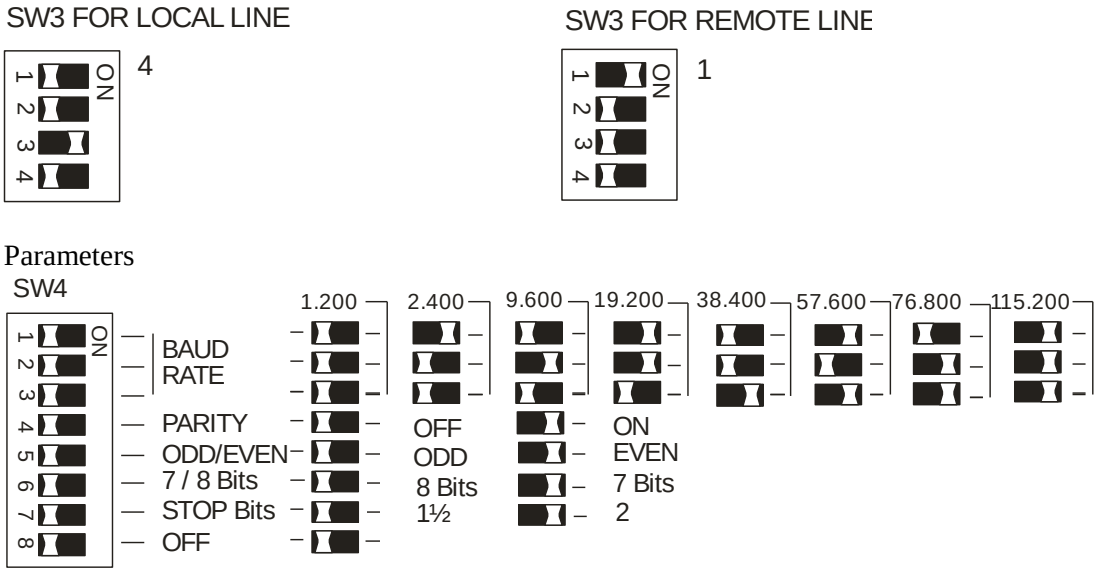
When the interlocks are removed, the interlock LED indications can be reset by pressing the RESET button on the display board which means that the red LEDs turn off.

UART HW SET UP **(Esc<BAUD)**

In the "UART HW SETUP" mode the baud rate and associated parameters for the serial lines can be set.

SW3 indicates witch line to set up.

Hint: Selecting SW3 will immediately display the present setting on the red LEDs below SW4.



Default setting after "COLD BOOT"

Local Line: 9600Baud, No party, 8 Bits, 2 Stop bits

Remote Line: 115200Baud, No party, 8 Bits, 1 Stop bits

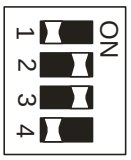
ADDRESS LINE SET UP **(Esc<ADR)**

When using the RS422 or RS485 standard for the serial communication Remote or Local, it is possible to attach a specific address to the line for multi drop connection.

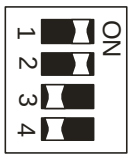
The LOCAL line addressing can be used for controlling more power supplies through one Operator Control Panel. (SW nr. 4 in the OPERATOR CONTROL PANEL must be ON). Grounding problems has to be taken into consideration to avoid communication problems due to noise and high differential voltages that may jam the input signals.

The REMOTE line addressing can be used for controlling more power supplies through one serial line (one PC). Grounding problems has to be taken into consideration to avoid communication problems due to noise and high differential voltages that may jam the input signals.

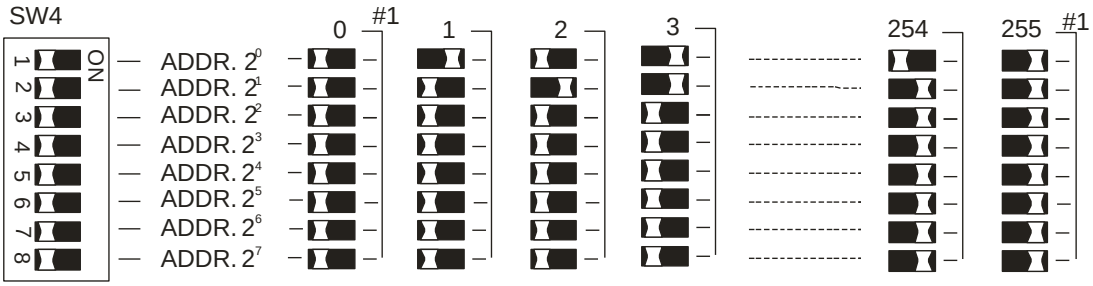
SW3 FOR LOCAL LINE



SW3 FOR REMOTE LINE



Parameters



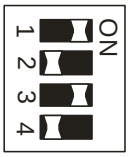
#1: Selecting address 0 or 255 equals allways addressed channel.

Default setting after “COLD BOOT”

Local Line:	Address 0
Remote Line:	Address 0

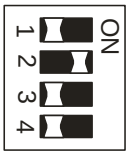
LINE FUNCTION PROTOCOL SETUP **(Esc<LINE)**

SW3 FOR LOCAL LINE



5

SW3 FOR REMOTE LINE

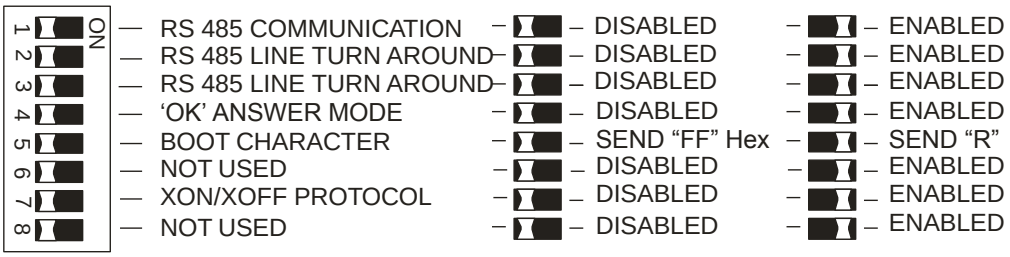


2

The “LINE FUNCTION PROTOCOL SETUP” is for setting up serial line protocols.

Parameters:

SW4



Default setting after “COLD BOOT”

Remote Line:	RS485 Communication:	Disabled
(=0)	RS485 Line turn around time:	Disabled Line turn around set bit 0
	RS485 Line turn around time:	Disabled Line turn around set bit 1
	OK Answer mode:	Disabled
	BOOT character:	"FF" / "R"
	NU	Disabled
	XON/XOFF Protocol:	Disabled
	NU	Disabled
Local Line:	RS485 Communication:	Disabled
(=1)	RS485 Line turn around time:	Disabled Line turn around set bit 0
	RS485 Line turn around time:	Disabled Line turn around set bit 1
	OK Answer mode:	Disabled
	BOOT character:	"FF" / "R"
	NU	Disabled
	XON/XOFF Protocol:	Disabled
	NU	Disabled

Line turn around set bit:

2, 3:	0, 0	Delay = 0
2, 3:	1, 0	Delay = 1ms approx.
2, 3:	0, 1	Delay = 2ms approx.
2, 3:	1, 1	Delay = 3ms approx.

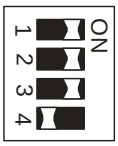
The line turn around time setting includes RS422 as well.

COLD BOOT SETUP **(Esc<COLDBOOT)**

After power up or reset the power supply can wake up in different control conditions. The switch settings shown below describe the possible Wake up conditions.

Parameters:

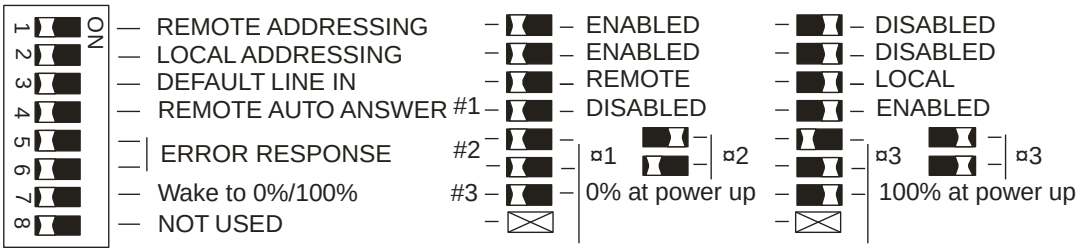
SW3 FOR COLD BOOT INITIAL SETUP



7

Default setting after “COLD BOOT”

SW4



¤1: “?”-BELL, Without further information.
¤2: “?”-BELL, Followed by error in code.
¤3: “?”-BELL, Followed by error in text.

#1: Local line is allways in auto answer mode.
#2: Using ACK/NACK protocol with or without error code will overide this setting.
#3: Default is 0% output current at power up. [From SW version SCS109]

Remote addressing:	Disabled
Local addressing:	Disabled
Default line in:	Local
Remote Auto answer:	Disabled
Error response:	“?”-BELL only
Wake up output current:	0%

AUX SETUP **(Esc<AUX)**

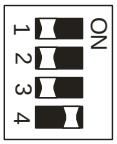
Special options can be initiated with the auxiliary switch set up 1.

Setting of bit 16 and 17 is intended for Offset DAC use. That is a 16 bit setting between 88 and 96% (Bit16=0 & BIT 17=1) or between 92% and 100% output current (Bit16=1 & BIT 17=1).

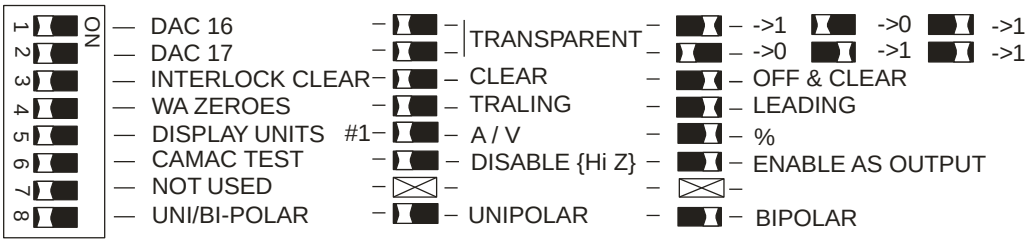
For linear DAC settings please set bit 16 & 17 to transparent mode.

Using the “WA” command a leading zeroes or trailing zeroes input format can be chosen.
- For leading zeroes: “WA 123" equals “WA 000123"
- For trailing zeroes: “WA 123" equals “WA 123000"

SW3 FOR AUXILIARY SETUP 1



SW4



#1 AD Scaling factor must be set accordingly.

Parameters:
Default setting after “COLD BOOT”

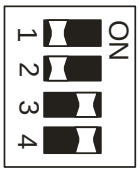
DAC 16 & 17:	Transparent
Interlock clear:	OFF & CLEAR resets interlocks
“WA” Zeroes:	WA command uses trailing zeroes.
( ):	UNIPOLAR

Notice that UNI/BI-polar is a read-only parameter and cannot be changed by dip switch setting nor by software. The mode is detected automatically.

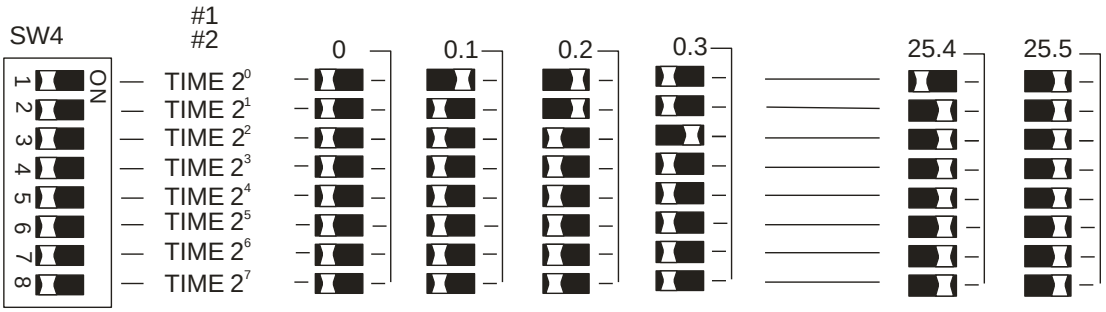
POLARITY DELAY TIME SETUP **(Esc<POLDELAY)**

A time delay can be inserted between the OFF state and the activation of the polarity change over switch. The range of the time delay can be set from 0 to 25.5 seconds, (in steep of 100ms) this for letting the rest energy in the magnet to decay.
The time delay is only inserted, if the power supply was ON before invoking the POL +/- command. That is, when just changing the polarity in the power OFF mode, no time delay will be inserted.

SW3 FOR POLDELAY



12



#1: Time is in 0.1 sec steps.
#2: Zero defaults to no delay

Parameters:

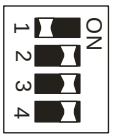
Default setting after “COLD BOOT”

No polarity delay.

AD AUTO ADJUSTMENT (Gain & Offset) **(Esc<ADSET)**

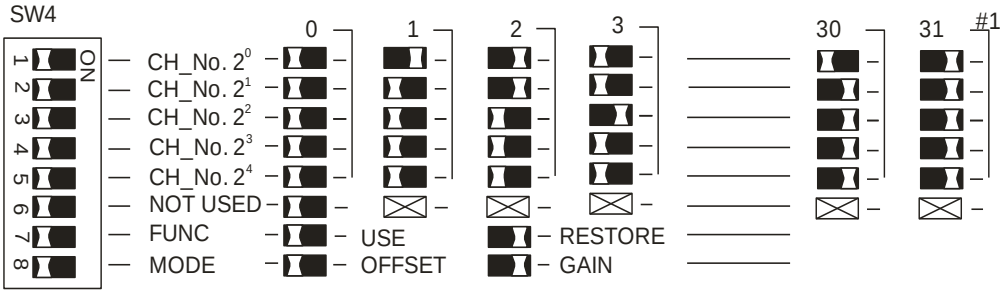
The scaling factors for the AD channels can automatically be adjusted with this setting.

SW3 FOR ADSET



14

Parameters



#1: Not all channels are implemented.

OFFSET adjustment

The OFFSET adjustment can automatically be executed if the value lies between 0 and 255 of the AD channel resolution.
To activate the automatic OFFSET adjustment following steps must be preformed:

- Select SW3 as above. “setting number14"
- Select the desired channel number “lever 1 to 5" on SW4
- Set lever 8 on SW4 to OFF (The LEDs will display the present Offset value)
- Ensure that the AD input signal is set to zero. Grounded or turned OFF in any way.
- Press the Setup Button
- To restore the Offset value to default factory setting (Zero), please set lever 7 to one before pressing the Setup Button.

CHANNEL	VALUE	CHANNEL	VALUE
0	Output current	1	Field input
2	Output Voltage	3	Internal +15V sup.
4	Internal -15V sup.	5	Internal +5V sup.
6	Delta Temperature	7	I set value
8	Optional Iout (16 Bit)	9	Iout (16 Bit)(Crtl panel).
10	Not used	11	Output current for display
12	Output voltage for display	13	Not used
14	Not used	15	Not used
16	Internal +5Vana.	17	I set value
18	Spare		

GAIN adjustment

The GAIN adjustment can automatically adjust the scaling factor of the selected channel to only nines. That is e.g. 99999 for the 16 bit output current reading. This adjustment is only useful for the output current and voltage read back (CH0, CH2, CH8, CH11 and CH12) Please do not use this feature if the output reading is in Volts and Amps and for not applicable channels.
To auto adjust to a specific value, please use the “Esc”ADSET command.

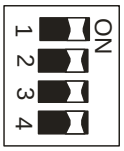
To activate the automatic GAIN adjustment following steps must be preformed:

- Select SW3 as above. “setting number14"
- Select the desired channel number “lever 1 to 5" on SW4
- Set lever 8 on SW4 to ON
- Ensure that the AD input signal is set to 100%
- Press the Setup Button
- To restore the Gain value to default factory setting, please set lever 7 to one before pressing the Setup Button.

DA AUTO ADJUSTMENT (Gain & Offset) **(Esc<DASET)**

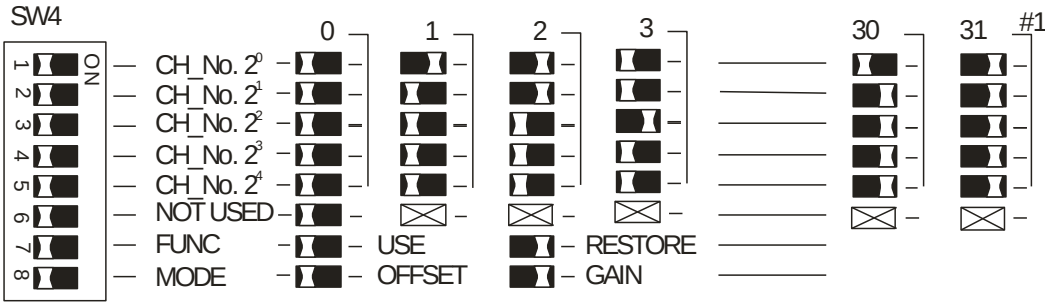
The scaling factors for the DA channels can automatically be adjusted with this setting. This feature is specially designed for “non calibrated”

SW3 FOR ADSET



15

Parameters



#1: Not all channels are implemented.

OFFSET adjustment.
The OFFSET adjustment can automatically be executed if the value lies between 0 and 255.
To activate the automatic OFFSET adjustment following steps must be preformed:

- Select SW3 as above. “setting number15"
- Select the desired channel number “leaver 1 to 5" on SW4
- Set lever 8 on SW4 to OFF and leaver 7 to OFF (The SW1 LED’s will display the present Offset value)
- Set the AD channel value (WA for “DA 0") to a value that gives a zero output.
- Press the Setup Button. A given “DA 0 0" or “WA 0” will now produce a zero output at the DA channel. Due to the unipolar operation of the DAC’s only positive offset values can be added.
- To restore the Offset value to default factory setting (Zero), please set lever 7 to one before pressing the Setup Button.

GAIN adjustment.

The GAIN adjustment can automatically adjust the scaling factor of the selected channel to only nines. That is eg. 999999 for the WA command.
To auto adjust to a specific value, please use the “Esc”DASET command. (DAC setting in Amps)

To activate the automatic GAIN adjustment following steps must be preformed:

- Select SW3 as above. “setting number15"
- Select the desired channel number “lever 1 to 5" on SW4
- Set on SW4 lever 8 to ON and lever 7 to OFF.
- Set the output signal to 100% with the DA or the WA command
- Press the Setup Button.
- To restore the Gain value to default factory setting, please set lever 7 to one before

pressing the Setup Button.

CHANNEL		VALUE	DA channel spec.	Equal to
0	Output current	16 bit	WA range as default	
1	Not used			
2	Not used			
3	Not used			
4	Output voltage	16 bit		

3.3.2 Data communication

The SYSTEM 9100 uses the standard serial interface RS 232 which is compatible with many computers and terminals. Beside RS232, SYSTEM 9100 supports RS422 and RS485.

The connectors for the serial interface ports "REMOTE CONTROL" and "LOCAL CONTROL" are found at the back of the power supply.
Pin description for RS232 and RS422 for the connector DB25S at the back of the power supply is as follow.

REMOTE CONTROL DB25		
	RS422/RS485	RS232
Pin No.	Signal	Signal
2		TX
3		RX
7	RETURN	RETURN
9	TX_REM	
10	/TX_REM	
11	RX_REM	
12	/RX_REM	
13	Vcc	Vcc

LOCAL CONTROL DB9	
RS422/RS485	
Pin No.	Signal
2	/TX_LOC
3	TX_LOC
4	/RX_LOC
5	RX_LOC
6-7	+15V
8-9	-15V

Rx : Signals received by the Control Module from its host.
Tx : Signals transmitted by the Control Module to its host.

NOTE! The selection between RS232, RS422 and RS485 is selected through solder straps on the Control Board.

Serial interface in REMOTE mode	Strap	REMOTE CONTROL DB25
RS232	ST330 : Close ST 324 : Open ST 325 : Open	Pin 2 TX Pin 3 RX
2-Wire RS485	ST324 : Close ST325 : Open ST330 : Open	Pin 9 TX_REM Pin 11 RX_REM
4-Wire RS422/RS485	ST325 : Close ST324 : Open ST330 : Open	Pin 9 TX_REM Pin 10 /TX_REM Pin 11 RX_REM Pin 12 /RX_REM

Serial interface in LOCAL mode	Strap	LOCAL CONTROL DB9
2-Wire RS485	ST334 : Close ST339 : Open	Pin 3 TX_REM Pin 5 RX_REM
4-Wire RS422/RS485	ST339 : Close ST334 : Open	Pin 3 TX_REM Pin 2 /TX_REM Pin 5 RX_REM Pin 4 /RX_REM

The default serial setting is:
8 BIT DATA, NO PARITY AND 1 STOPBIT and baud rate 115200.

The communication is done by transmitting characters in ASCII code terminated by CARRIAGE RETURN.
The termination characters from the Power Supply are CARRIAGE RETURN and LINE FEED.

An ERROR message includes a "?BELL". (Bell = ASCII 7.)
NOTE! None of the serial lines has control signals.

3.3.3 Termination using RS 422m or RS 485

As standard there is no termination resistors connected inside the M-panel. An external termination resistor of 100 Ohm must therefore be added at the end of the communication cable or the internal 100 Ohm resistor must be enabled (short-circuiting strap ST2). This applies for both the local and the remote line.
The external resistor is preferable.

Hint. This resistor can be placed inside the last DB 25 plug for the remote line and the DB9 plug for the Local line.

When using the RS 485 or the RS 422 line in the multi drop configuration, it is very important during an address transfer to leave the lines at the "SPACE" state when tri stated. That is when the line is not driven by any transmitters at all. The "SPACE" state can be utilized by adding 1K Ohm resistors to +5 V(non inverting) and GND (inverting) on both the transmit and the receive lines. The control module can provide this by short circuiting ST318-ST321 and ST326-ST329 for the remote line and ST335-ST338 and ST340-ST343 for the local line (use a thin soldering iron). The 1K resistors increase the noise immunity eliminating noise to be treated as commands thereby flawing the first character after being addressed.

NOTE! None of the two serial lines have control signals (hand checking). Use the XON/XOFF protocol if necessary.

3.3.4 Programming

The power supply communication protocol is built upon plain ASCII characters where each command or reply is delimited by a "Carriage Return" <CR> character. However replies have a “Line Feed” <LF> character added before the <CR> for a friendlier display when using a terminal. <LF> characters on commands will be ignored.

Hint. Actually the protocol allows full control of the power supply from a "dumb" terminal. In case of a service- debug- situation a terminal can be used to tap the communication transfer by a simple parallel connection.

Hint: When debugging, the "ERRT" command enables error messages to be given as a read able text.

More commands may be transmitted in a chain but each single command must be trailed individually with the delimiter character <CR>. The power supply is able to execute up to 200 commands a second depending of the complexity of each command.

Ps. Issuing short commands faster than the time to transmit the answer e.g. “S1" will overload the internal transmit buffer regardless of the selected baud rate.

All commands can be divided into three sections.

a) Directive commands. Eg. the "N" command that turns the power supply ON
b) Status commands. Eg. the "S1" that returns the power supply status

Status commands delivers always a reply whereas directive- and setup- commands only responds with an error message if the command couldn’t be understood or if the given parameters are incorrect. It is possible to set the power supply to always generate an answer; this feature is very useful when using RS485 protocol.

Hint. When using the "Always Answer" mode a re-transmission of the last given command can be performed if no answer or an error message is received. The System 9100 respond time is around 5ms after receiving the last bit of the termination character.

Answer scheme if set to “Always Answer” mode.

c)	Directive commands.	Answer: - No answer - ERROR message - OK if set to always answer mode (ab SW ver. SCY 2.xx)
d)	Status commands . Answer:	- Data - ERROR message
e)	Set up commands. Answer:	- No answer - ERROR message - OK if set to always answer mode (ab SW ver. SCY 2.xx)

Below is an example written in BASIC on how to turn ON the power supply and read the status without and with acceptance answer:

Turning the power supply ON and reading/evaluating the status with always answer disabled.

```
LPRINT "N"+CHR$(13)              :REM Turns the power supply on
LPRINT "S1"                      :REM Issues the status command
LINPUT S1$                       :REM Read the MPS reply
IF LEFT$(S1$,1) = CHR$(?)        :REM Is it an error message reply?
 GOTO ERROR_HANDLING             :REM Yes then go to error module
ENDIF
J=1
DO                               :REM evaluate status reply
 IF MID$(S1$,J,1)="!"
  GOSUB STATUS(J)_ACTIVE         :REM set this status bit active
 ELSE
  GOSUB STATUS(J)_ACTIVE         :REM set this status bit inactive
 ENDIF
 J=J+1
UNTIL J=24
```

Turning the power supply ON with always answer enabled

```
J=0 :ERROR$=”“
DO
 J=J+1                           :REM Counter for maximum attempts
 LPRINT "N"+CHR$(13)                   :REM Turns the power supply on
 LINPUT RE$                      :REM Read the MPS reply with 0.1 Sec. time out
 IF LEFT$(RE$,1) = CHR$(?)       :REM Is it an error reply?
  ERROR$=RE$                     :REM Mark the error code
 ELSEIF RE$=”OK”                 :REM Is it a good reply
  BRAKE                          :REM then exit DO loop
 ELSEIF J=6                      :REM Try only six times
  IF LEFT$(ERROR$,1) = CHR$(?)   :REM Was it error reply?
   GOTO ERROR_HANDLING           :REM Yes then go to error module
  ELSEIF
   GOTO NO_COMMUNICATION         :REM Yes then go to “No answer” error module
  ENDIF
 ENDIF
UNTIL -1                         :REM loop endless
```

Ps. An ERROR message includes a "?BELL". (Bell = ASCII 7.)

3.3.5 Software Profile Programming

SYSTEM 9100 is delivered with the software ramp profile option.
With the ramp profile SW it is possible to down load and run a predefined ramp sequence that the output current must follow. The ramp sequence can be programmed in two quite different methods.
A- Arbitrary point method; B- Equal timeslot method.

Arbitrary point method and Equal timeslot method are both available, but only one method can be used at a time.

The examples below are shown for a unipolar power supply. For bipolar supplies, the output current may also be set as negative.

3.3.6 Arbitrary point ramp profile method

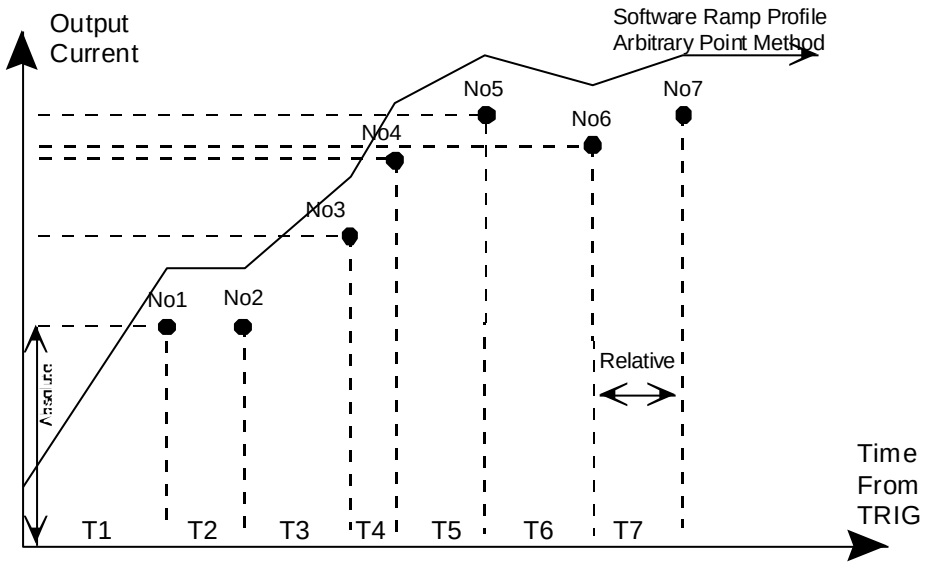
With the ”Arbitrary point method” it is possible to download up to fifteen independent points each generating a ramp line (through interpolation). This profile must be stored in one of the 15 available stacks.
Each ramp point consists of a stack number, a starting point (current set value, normally the previous end point), an end point (current set value) and a time value for reaching the given end point.

E.g. **Command:** WSA' sp' stack, start, stop, time 'cr'

To use the arbitrary point method at least the following steps must be preformed:
- Clear the stack “CSS [parameter]”,- Program the stack “WSA [parameter]”,- Set the speed “SPEED [parameter]”, -Set the attenuator “MULT [parameter]”, -Start the stack “TS [parameter]”, -Read the status of the running stack “S2".

Please refer to the software manual about “SW2 Ramp Profile Commands” for full instructions.

The figure shows an example of one ramp profile stack. (Ps. not all 15 points need to be programmed empty, entries will be ignored.)



The SW will after the start (Trig) command update the output current every 1.25ms in the FAST and in the SLOW mode (Step Time). This enables us to calculate the stair case size (interpolating step size) according to the formulae below:

$$\frac{(START-END)*(StepTime)}{\Delta t} = Step.Size$$

Where “START” and “END” are the set values in ppm. The “Step Time” is 1.25ms. , Δt in seconds and the “Step. Size” will come out as ppm value.

In-between the 1.25ms step time a second HW interpolation counter will update the set value for every 78µs (fast ramp times) to about 78µs (slow ramp times).

Starting the ramp is done with the trig command “TS (stack no.)”.

If synchronization to an eternal event is required, it is possible to arm the ramp sequence first with the synchronization command “SYNC (stack no.), [trigger delay]”. A hardware signal on the trigger input X9 pin 1&2 (10 to 24V) or a TS command will start the sequence. If a trig delay is entered, the sequence will first start after the delay time has elapsed.

If more power supplies have to be synchronized, one of the supplies has to be appointed as master. Connecting the master trig output X9 pin 3&4 to the other supplies trig input will start the other supplies when the master is triggered. A maximum skew of 5µs between the supplies may be expected. (an external 15V auxiliary supply is needed, as the trig output is an open collector and the trig input is an optocoupler input.)

3.3.7 Equal time slot ramp profile method

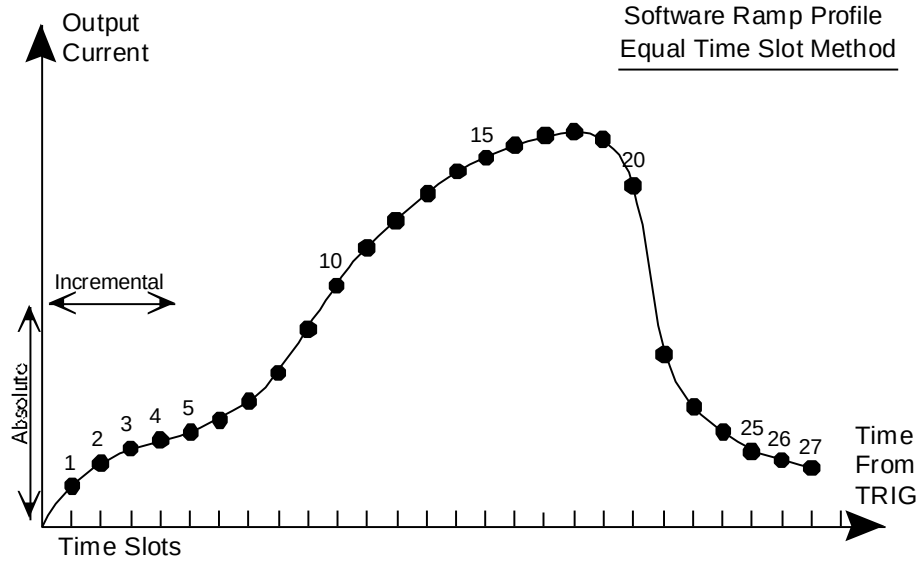
With the ”Equal time slot method” it is possible to download up to 1000 current set values and a single time slot value, that will be used for all set values. Only one stack is available.
This profile method is especially useable for faster and more accurate curves fitting profiles e.g. as a function generator.

To use the Equal time slot method at least the following steps must be preformed:
- Clear and set the stack “RAMPSET [parameter]”,- Program the stack “R [parameter]”, -Start the stack “RAMP [parameter]”, -Read the status of the running stack “RAMP".

PS. A difference in the value parameters setting comparing to the “Arbitrary point method” is, that all values must be given as a floating point number scaled to “1.000000". That is; 1.25ms must be entered as 0.00125 and 19.54% output current as 0.1954.

Please refer to the Software manual about Ramp Profile Commands for full instructions.

The figure below shows an example of one ramp profile stack. (Ps. not all 1000 points need to be programmed empty entries will be ignored.)



The time slot must be given as a multiple of 1.25ms. Between 1.25ms to 1 second. Any value in-between will automatically be rounded according to formula:

{time slot}=frac({time}/0.00125)*0.00125

The SW will after the start command update the output current every 1.25ms. By means of interpolation regardless of the programmed time slot value:

The ramp can be set up to run as a single shot “RAMP R”, auto iteratively (auto loop) “RAMP RL” or HW triggered auto armed “RAMP TW”. For a full documentation on controlling the “Equal time slot method” please refers to the software manual about Ramp Profile Commands.

If synchronization to an external event is required, it is possible to arm the ramp sequence first with the synchronization command “RAMP T”. A hardware signal on the trigger input X9 pin 1&2 (10 to 24V) or a “RAMP R” command will start the sequence.

If more power supplies have to be synchronized, one of the supplies has to be appointed as master. Connecting the master trig output X9 pin 3&4 to the other supplies trig input will start the other supplies when the master is triggered. A maximum skew of 1.25ms between the supplies may be expected. (an external 15V auxiliary supply is needed, as the trig output is an open collector and the trig input is an optocoupler input.)

3.3.8 Auto Slew Rate Ramp Profile method.

With the”Auto Slew Rate Ramp Profile Method” an automatic ramp profile will be generated and executed when issuing a new current set point. In other words, this feature acts like a software driven slew rate controller.

Two shapes can be preselected. A cosines and a square shape. Which shape is selected, is given by the Aux2 setting bit 4. 0 = Cosines & 1 = Square

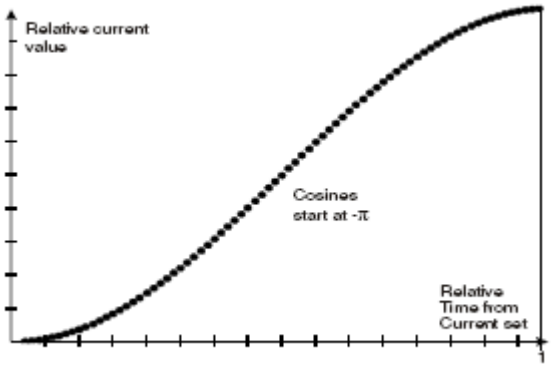
Example: If the power supply is at 10% output current, the slew rate is set to 1 second (‘esc’<slopetime 1.1) and a set command “da 0.600000" is given the power supply will start at 10% and run to 60% within ½ a second with the selected shape.

The positive and negative slew rate value can be set individually. Please refer to the SW manual describing the “‘esc’< slopetime ‘val1',’val2'” for further information.

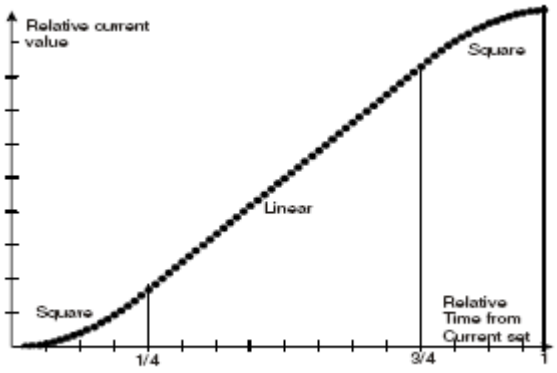
The two ramp profile shapes has both its benefit and draw backs. The cosines shape is smooth all the way but has a higher di/dt in the middle and results in a sinus output voltage shape on an inductive load whereas the square shape in a trapezoidal output voltage

The ramp profile consist of 80 points with HW interpolated points in-between. Each of the 80 points has a distance of 2.5 ms. In-between. Profiles with shorter distances than 200ms (80*2.5ms) are achieved by omitting points. Eg. a ramp time of 20ms will only consist of 8 points thereby resulting in a more coarse profile.

The figures below shows the shape of the two ramp profiles.



Cosines ramp shape



Quadratic ramp shape

The time slot must be given as a multiple of 1.25ms. Between 1.25ms to 1 second. Any value in-between will automatically be rounded according to formulae:

{time slot}=frac({time}/0.00125)*0.00125

The ramp profile can be stopped either with a "STOP" command or when the power supply is turned OFF.
The state of the ramp profile can be read through the "RR" command.

3.3.9 SW limits

The limits of the "Arbitrary point method" ramp profile SW are:

- The set value must be given in ppm units
- The time between two points can be between 0.2 to 65535 seconds.
- Maximum numbers of stacks: = 15
- Maximum number of lines in a stack: = 15

The limits of the "Equal time slot method" ramp profile SW are:

- The set value must be given in a floating point representation normalized to 1.000000.
- The time slot may be between 0.0125 to 1 second given in a floating point representation normalized to 1.0000.
- Maximum numbers of stacks = 1
- Maximum number of time slots in a stack = 1000

The limits of the "Auto Slew Rate method" ramp profile SW are:

- Maximum positive slew rate time = 10 sec,
- Maximum negative slew rate time = 10 sec,
- Minimum positive slew rate time = 5m sec,
- Minimum negative slew rate time = 5m sec,
- Number of points = 80 with a minimum interval of 2.5ms

SW Commands

Following are the commands for the standard software listed in alphabetic order.
Please see the SW appendix 1 for detail explanation of every command.

STANDARD COMMANDS. Summary

AD X	Read value from an ADC channel.
ADR	Read the address of the MPS.
ADR XXX	Write an address to a MPS.
ANACTRL	MPS Control by analog Set.
ASW	Enters Answer mode
CMD	Read current control mode.
CMDSTATE	Read current control state.
CPUCTRL	MPS Control by CPU DAC.
DA X,XXXXXX	Writes a value to an Digital to Analog converter. (Alternative to the WA command.)
ERRC	Coded error message.
ERRT	Text string error message.
F	Main Power OFF
LALL	Listen ALL.
LOC	Change to Local Control
LOCK	Lock the MPS in Local Control.
N	Main Power ON
NASW	No answer mode.
NERR	No error message
PO	Polarity status
PO +/-	Change to Normal polarity
POLOOL	Polarity Output Off Limit.
PRINT	Reads internal user information about the MPS.
RA	Read the set value.
REM	Change to remote control.
RLOCK	Remote line only
RR	Read Ramp speed.
RS	Reset interlocks.
S1	Read the internal status.
S1H	Read internal status in HEX format
S1FIRST	Read the interlock first catch status.
S1FIRSTH in HEX format	Read the interlock first catch status
S3	Read the internal extended status.
S3H	Read internal extended status in HEX format
TD	Test DAC
TYPE	AD type in use
UNLOCK	Unlock the MPS
VER	Reads the software version
WA XXXXXX	Writes a value to a Digital to Analog converter. (Preferred new command:DA 0)
WR	Write Ramp speed

X is a number from 0 to 9 and Commands in quotation marks are optional

Following are the SET UP commands for the standard software listed in alphabetic order.
Please be aware that some of these commands should only be used with caution.
See the SW appendix for detail explanation on every command.

'esc' SET UP COMMANDS. Summary

ESC<AD	Configures the AD converter attaining and routing (Output reading adjustment or output reading in % or Amps)
ESC<ADR	Configures the communication address setting (in RS422 mode).
ESC<ADSET	Auto Configures the scaling "gain" and Offset for an AD converter channel.
ESC<AUX	Configures the special options
ESC<BAUD	Configures the Baud rate for the serial lines.
ESC<COLDBOOT	Configures the power up state (Wake up position)
ESC<CPURESET	Hardware reset / CPU reset
ESC<DA	Configures the Digital to Analog converters. (Slew rate setting in A/sec or set value in Amps)
ESC<DASET	Auto Configures the scaling (gain) and Offset for a DA converter channel.
ESC<LINE	Configures the protocol for the serial lines.
ESC<POLDELAY	Configures the delay between off and polarity switch change

Following are the commands for the software driven "RAMP PROFILE" listed in alphabetic order. Please see the SW manual for parameter formats and further detail description.
These commands are optionally available.

SW RAMP PROFILE COMMANDS "Arbitrary point method". Summary

CONT	Continue sequence operation
CSS	Clear sequence stack and pointers.
FAST	Fast sequence timing
HALT	Halt sequence operation
MULT	Reads the multiplying factor for the DAC scaling
MULT X	Writes a multiplying factor for the DAC scaling
RRSP	Reset read sequence pointer
RSA	Read sequence and auto increment
RSP	Read sequence position
RWSP XX	Reset write pointer
S2	Read sequence status
SLOW	Slow sequence timing
SPEED	Read sequence timing
STOP	Stop sequence executing
SYNC	Synchronization of sequence
TS	Trig sequence
WSA	Write sequence and auto increment
WSP	Write Sequence position

SW RAMP PROFILE COMMANDS "Equal Time slot method". Summary

R Write data to the stack.

RAMP [RSHTN],[LWB]
Control the stack operation

RAMPSET Time,Multiplicant, [LWN],C
Configure the ramp operation

3.4 Operating in analog mode

The SYSTEM 9100 can operate in analog mode and can be set either by software or hardware via jumpers.

Software:
For enabling analog mode by software no jumpers must be set on J502 and J503.
The jumpers are located on control module PCB 91376.

The software command ANACTRL puts the MPS in analog mode.
Likewise, the command CPUCTRL sets the MPS in CPU control mode.

The ANACTRL command switches the I Set Value between analog control and I Set Value from CPU control board DAC. ANACTRL change the I Set Value into analog control.
For more information about the command ANACTRL, refer to software manual for SYSTEM 9100.

Hardware:
For enabling analog mode by hardware some jumpers need to be set.
The jumpers are located on control module PCB 91376

Jumper configuration: J502 in position 1 and 2
J503 in position 1 and 2

In order for controlling and monitoring the different analog modes, several pins are available for these uses. The connector X108, back on the MPS, is dedicated for analog controlling and monitoring. For detail pin description, see chapter 4.1.2.

The table below shows the analog modes and the pins for a specific mode.

Analog mode	Connector X108
Analog I set point: 0-10 V	pin 16 and pin 23
Analog I monitoring: 0-10 V	pin 7 and pin 25
Analog I set point read back 0-10V	pin 10 and pin 25
Analog V set point: 0-10 V	pin 15 and pin 20
Analog V monitoring: 0-10 V	pin 19 and pin 24
Analog V set point read back: 0-10 V	pin 9 and pin 24
ON/OFF control 12 V galvanic isolated	pin 14 and pin 2

3.4.1 Standard interface / Parallel interface

The analog mode can be set up to operate in two different modes, standard or parallel. Default mode is standard.
Table below shows input/output connections of the two modes and straps settings for selecting standard or parallel mode. Notice that you need to cut some straps and likewise to solder some straps for changing to parallel mode. The straps are located near the D-SUB25 on bottom side of the PCB.

D-Sub 25 X108 (backplane)	**Standard Mode**	Straps (standard)		**Parallel Mode**	Straps (parallel)
1	Spare	-		Sum Interlock *	ST801=close
2	ISO RTN	-		ISO RTN	-
3	Spare	-		ON/OFF status, low=ON *	ST803=close
4	Spare	-		/Ready status Low=Ready *	ST804=close
5	ON	ST817=close ST805=open		Sum Ext interlock *	ST817=open ST805=close
6	COM (GNDD)	ST818=close ST806=open		Earth leak status	ST818=open ST806=close
7	I-MON	ST819=close ST807=open		Overcurrent status	ST819=open ST807=close
8	RTN AUX (GNDA)	ST821=close ST809=open		GND (Parallel)	ST821=open ST809=close
9	V-set Readback	ST823=close ST811=open		/OFF control	ST823=open ST811=close
10	I-set Readback	ST825=close ST813=open		RESET control	ST825=open ST813=close
11	I-set Parallel	-		I-set Parallel	-
12	V-set serial	-		V-set serial	-
13	GNDA	-		GNDA	-
14	ISO TTL/CMOS	-		ISO TTL/CMOS	-
15	VP 10V	ST815=close ST802=open		LOC/REM status Low=LOC *	ST815=open ST802=close
16	IP 10V	-		SOLL-WERT & SOLL-WERT sense	-
17	Fault relay	-		Fault relay	-
18	Fault relay	-		Fault relay	-
19	V-MON	-		V-MON	-
20	VP RTN	ST820=close ST808=open		Phase fail status *	ST820=open ST808=close
21	+15V AUX	ST822=close ST819=open		GND (parallel)	ST822=open ST819=close
22	-15V AUX	ST824=close ST812=open		ON control	ST824=close ST812=open
23	IP RTN	-		SOLL-WERT GND & SOLL-WERT sense GND	-
24	V-MON RTN	-		V-MON RTN	-
25	I-MON RTN	-		I-MON RTN	-

* Open Collector output

4 Theory of operations

4.1 Introduction

The following chapter describes in short the main components/blocks of the SYSTEM 9100.
An overview of the SYSTEM 9100 architecture can be found on next page.
Furthermore an interface specification i.e. an overview of the possible connections will be listed with description of every single pin and its use.
Technical description

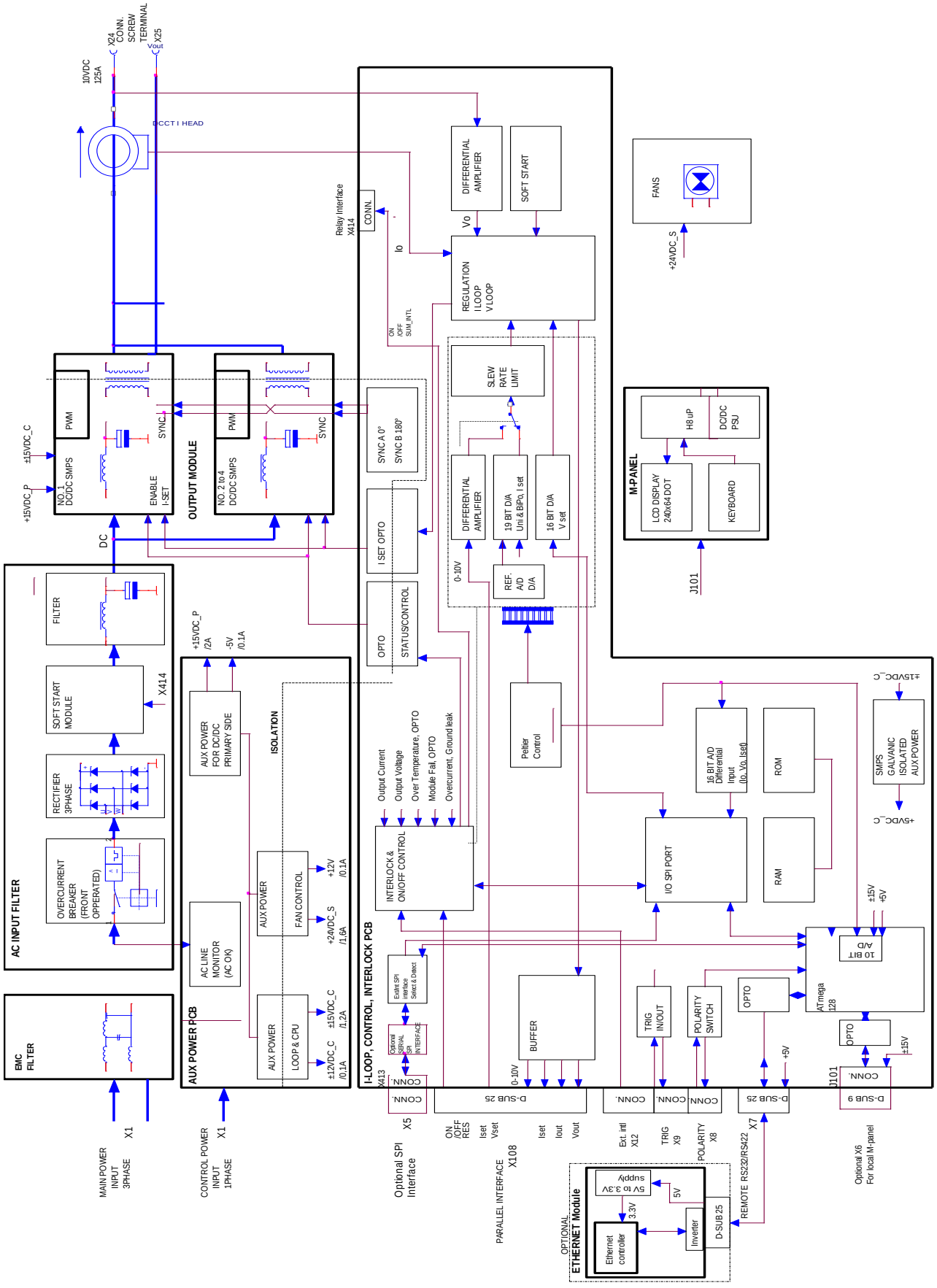
The power supply modular system is mounted in a 19" rack. The dimension of the rack is 3U high and 600mm deep.
This allows for quick replacement of all modules and print circuit boards in Magnet Power Supply. Thus this reduces service-time and total down time.

The System 9100 is a full bridge phase modulated, zero voltage-switching converter, which offers several benefits compared with traditional hard-switching technology.

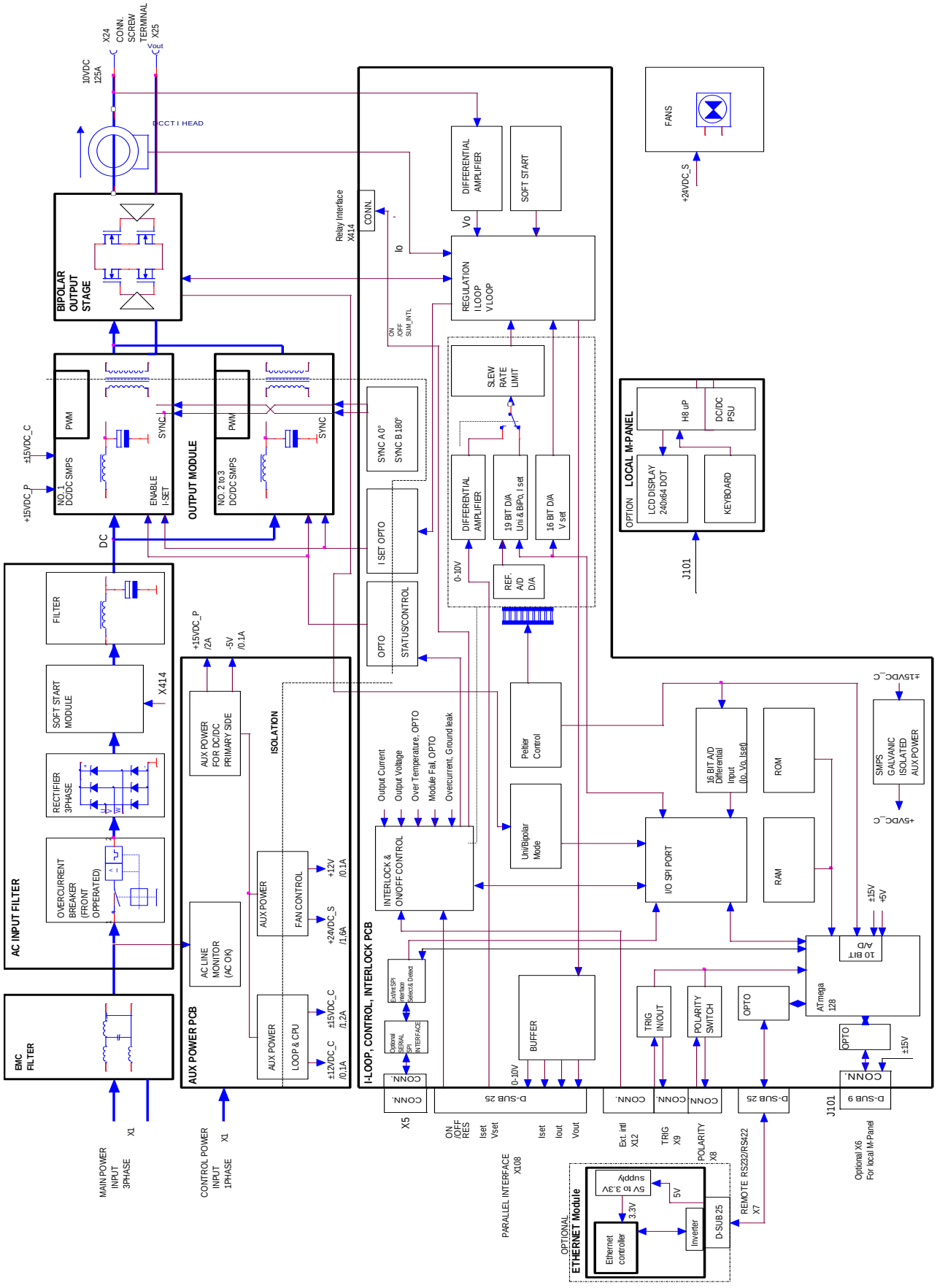
Figures below are block diagrams of the SYSTEM 9100 unipolar and bipolar type. There are 11 blocks and each block will be described in short.

-EMI filter.
-Diode module
-Soft start module
-AC input filter module.
-Output modules (1 to 4 modules depending of max output current)
-Aux power supply, PCB.
-I-loop, CPU control, interlock, PCB.
-DCCT transducer.
-Display module.
-Local control M-panel.
-Bipolar output stage (Bipolar only)

Unipolar block diagram:



Bipolar block diagram:



4.2 M-Panel

The M-panel is the user interface for reading current, voltage, status and making settings to the MPS. The display has a resolution of 240*64.
The display board is built upon a micro-processor IC2, which communicate to the control module via RS422 interface.

4.3 I-Loop, Control, Interlock PCB

The control board contains DAC for the set value, ADC for the read back, Peltier control, DC/DC converter, serial interface, loop control, interlock and the controlling micro-processor with external memory.

4.3.1 Micro-processor

The micro-processor is the intelligent part of the system. It consists of the micro-processor U212, a CPLD U213, external static memory (SRAM) U214 and 3-8 decoder U211.
The micro-processor is of the type ATMEGA128 from Atmel and the CPLD is an AFT1502 from Atmel.

The CPU runs at 14.7456 MHz, controlled from the crystal Y202.
The micro-processor has built-in "Watchdog" circuit and will reset the CPU, if it for some reason stops refreshing the watchdog.

As memory it uses its internal FLASH EEPROM for bootstrap loader and U214 with 1Mbit capacity for the PGM storage. The PLD chip U213 generates the lower address lines as well as the chip select signal for the SRAM. U211 74HCT138 3-8 decoder provides chip select signal for DAC, ADC, interlocks, external status and display board.

4.3.2 DAC Circuit

The DAC circuit converts the serial digital set value to a voltage reference.

The circuit is built around U701, U702 and U705. U701 and U702 is connected to perform a 20 bit DAC used for setting the current, 19 bit plus sign while U705 is used for setting the output voltage in the voltage mode.
The DAC circuit delivers an output voltage proportional to the digital input value.
The Digital to Analogue Converter sets the output current level in local/remote mode.

4.3.3 ADC Control

Different voltages are monitored by means of the Analogue to Digital converter U706. The measured values and their resolution are shown in the table below.
The 2.5V reference voltage for the ADC converter comes from U707.

VALUE	BIT RESOLUTION
Output current	16
Current Setting	16
Output Voltage	16
Field measure	16

For monitoring of power supplies +15V, -15V, +5V and Peltier control output voltage, the internal ADC of the CPU U212 is used. The bit resolution of the internal ADC is 10 bit.

4.3.4 Voltage reference

The voltage reference circuit is constructed around U707 “MAX6325” which delivers 2.5V high precision voltage to the ADC “U706”.
U704 is the 10 V high precision voltage reference for the DACs U701, U702 and U705.

4.3.5 DC/DC Converter

A small buck switch regulator U101 converts the +15 V to +5 V for the digital circuits.
The buck switching regulator is an LT1765 from Linear Technology.

The linear regulator LM78L05 U709, regulates +15 V to +5 V for the analogue circuits.

For supplying of RS232/422/485 interface, transformer drivers for isolated serial interface and low-dropout voltage regulator are used. Transformer drivers have references U102 and U104 for remote and local line respectively. Low-dropout voltage regulators have reference U103 and U105 for remote and local line respectively.

4.3.6 Serial Interface

The SYSTEM 9100 supports the serial communication standards RS232, RS422 and RS485. The default setting is RS422.
The serial communication circuit consists of U321, U326, U328, U329, and U334. This circuit is fully galvanic isolated from other circuits in the supply but not between each other.

The connectors “REMOTE CONTROL” “LOCAL CONTROL” are the serial interface ports on remote and local line respectively. Please refer to chapter 3.3.2 about pin description for these serial line connectors.

The selection between the RS232, RS422 and RS485 mode is done through straps located on the Control Module. Please refer to chapter 3.3.2 for these strap settings.

4.3.7 Current & Voltage loop

In this block, internal and external set current and voltage are preformed and are built around A501, A508, A 513 and A514B. Detection of current/voltage mode consists of A511A. Summation of the current and voltage of more units in parallel is also preformed in this block. The circuit consists of A504A and A504B.

4.3.8 Control

The output voltage and current are monitored by this block. A801B monitors the output current and A801A the output voltage while readback of the set output current and set voltage is monitored by A802B and A802A respectively.

4.3.9 Soft start

The soft start circuit enables the Power Amplifier to smoothly ramp up the output current. This circuit has nothing to do with the normal ramp time controller in the regulation circuit, but ensures only a proper start of the Power Amplifier.

The circuit is build around A509.

When the "main power signal" switches on the integrator output ramps slowly up until D510 is reversed. It takes about 3 seconds to ramp to max output.

Soft Start pulls down the current limit signal via D510. Slowly this voltage increase and finally the D510 are reversed.

4.3.10 Interlock

Internal interlock except fan UV detection and status signals are connected directly without galvanic isolation. External and fan UV detection interlock are galvanic isolation with optocoupler.

The latched interlock information can be seen from the LED’s, on the local control panel, on the display board and is activated in the Digital interface.

Each interlock is individually connected to a SR latch. Every time an edge transition is detected it will be latched in a SR latch. The first one though will be latched on arrival of the delayed sum interlock.
On arriving of the first interlock, the SR latch will store this interlock.

This circuit consists of the integrated circuits U609, U611, U613 and U614.

4.3.11 Peltier Control

The temperature inside the temperature regulated area is regulated by Peltier control circuit. The temperature difference ΔT from the defined constant temperature inside this area is measured and generated a voltage to the CPUs ADC for monitoring.
This circuit consists of thermistor RT901, A901, A903, A904, U902 and U903.

4.4 EMC filter

An EMC filter provides three-phase filtering to attenuate conducted interferences at low and high frequency noise generated from the switch mode power supply inside the magnet power supply.

4.5 AC input filter module

The main function of this module is to filter noisy AC signals, overcurrent protecting and rectify the AC signals to DC signals.

4.5.1 Overcurrent breaker

An overcurrent breaker Q1 functions as power switch for the power supply and fuse/ overcurrent breaker.

4.5.2 Rectifier 3 phase

The AC line rectifier is built with three one-phase rectifier D1, D3, D4 which functions as a three-phase full-bridge rectifier rated for 35A.

4.5.3 Soft Start Module

The soft start module is build around PTC resistors R1, R2, R3 and R4. These limits the inrush current that charges the capacitors.
When the control module signals “Relay_ON”, pin 1 on X2, the relay K2 switches witch makes relay K1 to switch and thus the PTC resistors gets shorted.

4.5.4 Capacitor and DC link filter

The DC link filter consists of a choke L1 with choke L2 in parallel and a bulk electrolyte capacitor bank C1, C2, C3, C4, C7, C8. The filter circuit is able to filter 300Hz as well as high frequency noises.

4.6 Output module

This block is the power stage where the output current is generated.

4.6.1 Output and filter

In order to ensure a stable output current some capacitors (C9, C11, C12 and C13) and a choke (Lcom) are placed at the output stage.

4.6.2 Transformer

The ferrite power transformer T2 is wound on an ETD 59 coil form and is designed with minimum creepage of 8 mm from primary to secondary windings.
Three layer of high temperature isolation material is applied between primary and secondary windings.
Resistive loses and loses from high frequency skin depth effects are reduced to a minimum by use of 0.1 mm isolated copper foil in the primary and the secondary windings and interleaving the windings.

4.6.3 PWM controller

The PWM controller module is built around U2, a phase shift PWM controller from Unitrode. 4 PWM signals (A OUT, B out, C out and D OUT) is wired to the output module where the output current is generated.

4.7 Aux power supply

The aux power supply module delivers the supply voltages for control board and other modules connected to it. The different supply voltages are for CPU, fans, digital and analog circuits as these don't operate at same supply voltage.

4.7.1 AC line monitor

The AC input line is monitored and the system will go in fault mode in case of malfunction at the AC line.
Monitoring of the AC line is built around Q1, Q2, Q3 which measure the voltage across the three-phase line input and send an error signal via U1, U4 and U7 to the 'AC Line OK' which is connected to the I-loop control board.

4.7.2 Aux power loop & CPU

This circuit regulates different voltages for supplying of the microprocessor CPU and the I-loop control board.
The different voltage supplies are regulated by U5 and U12 and a transformer T2.
Available supply voltages are +15 Vdc, -15 Vdc, +12 Vdc and +5 Vdc.

4.7.3 Aux power FAN

The fan and will go on if the MPS is power on and off if the MPS is off controlled by the signal FAN CONTROL.

4.7.4 Aux power primary

Supply voltages -5 V and +20 V is generated by U3 and T1 respectively.

4.8 DCCT transducer

DCCT current transducer measures the output current and controls the current stability in the power supply. The output signal from the device is a current (2000 times less than the output current). The current generates a voltage of approximately 1 V across a burden resistor when the output current is 200 A.
The 1 V signal developed across the burden resistor R519 on the control module, is measured by A501B coupled as a differential amplifier and scaled to give 1 V output for an output current of 200 A.

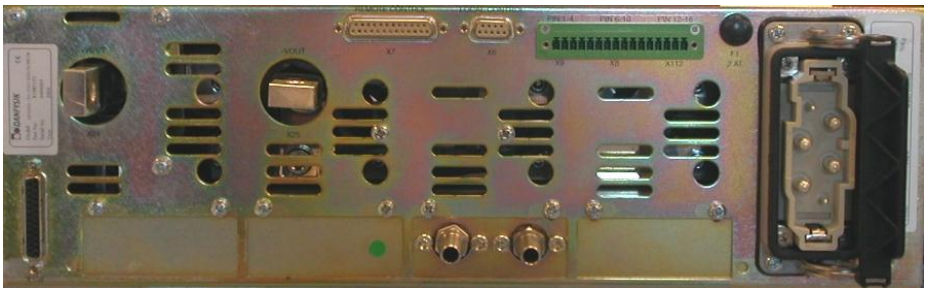
4.9 Bipolar output stage (H-Brigde)

The bipolar power supply can be achieved by using the standard unipolar system as the power platform added with an analogue bipolar output stage. It consists of a loop control and two output H-bridge stages. The system will be able to deliver a bipolar output current Io also around zero. The output MOSFET amplifier is therefore designed to work in two modes, linear and saturated. As long as the control voltage signal Vpwr < Vmin, the output amplifier works in linear mode and when Vpwr>Vmin the output works in saturated mode.
When the bipolar output stage is connected to the control module, a bipolar mode signal is generated to switch the control module working on the bipolar mode.
The control loop circuit is constructed around A1, A2, A3, A4 and A5.
The one half of the linear analogue output stage will be build around Q5, Q6, Q2 and Q12. The corresponding one half of H-bridge interface circuit is constructed around MOSFET Q1, Q2, Q3 and Q4.

5 System 9100 Interface specification:

System 9100 has following external connection:

- Analog interface X108, D-sub 25 pole female
- REMOTE control Interface, D-sub 25 pole female
- LOCAL control interface, D-sub 9 pole female
- AC main input, 3 phase, Neutral and Earth and AC Control input
- Voltage output (+) X24, (-) X25
- MPS Status, 16-pol connector
- External trig (for use with Ramp), 16-pol connector
- External interlocks and polarity switch, 16-pol connector
- Connector for water cooling
- Fuse 2 A



AC Mains connector X1:

The power connector for 400VAC main and 230VAC control input

Pin no:	Name	I/O	Description & Specification
1	NU		
2	400 VAC		3-phase AC main input, L1
3	400 VAC		3-phase AC main input, L2
4	400 VAC		3-phase AC main input, L3
11	230 VAC		Control input, Phase
12	230 VAC		Control input, Neutral
Clips *			Earth

*Two spring clips at the top and bottom of the connect

The power connector for 208VAC main and control input

Pin no:	Name	I/O	Description & Specification
1	NU		
2	208 VAC		3-phase AC main input, L1
3	208 VAC		3-phase AC main input, L2
4	208 VAC		3-phase AC main input, L3
11	208 VAC		Control input, L1
12	208 VAC		Control input, L2
Clips *			Earth

*Two spring clips at the top and bottom of the connect

Output X24 and X25

Pin no:	Name	I/O	Description & Specification
X24		O	Positive polarity
X25		O	Negative polarity

Analog X108 (D-SUB 25 Pole):

Analog status and analog set value interface.

All analog 0 to ±10V max

Pin no:	Name	I/O	Description & Specification
1	Spare / SUM_INTL	O	Open collector,High = Interlocks
2	ISO_RTN		Return line for pin 14
3	Spare / ON/OFF	O	Open collector, Low = ON, High = OFF
4	Spare / READY	O	Open collector, Low = READY, High = NOT READY
5	ON / SUM_EXT_INTL	I/O	Power ON chain. All parallel units will go OFF if one unit drops out. Sum external interlock status, Open Collector
6	COM	O	GNDD / Earth Leak Interlock, Open collector
7	I MON	O	Output current monitoring. Voltage representation of the supply output current.
8	RTN AUX/ GND	O	GNDA Return line / GND
9	V-SET READBACK / OFF	O/I	Readback of the output set voltage / OFF Control signal (Low=OFF)
10	I-SET READBACK / RESET	O/I	Readback of the output set current / RESET Control Signal (High=RESET)
11	I-SET PARALLEL	O	Current set output for parallel connected slave units (I-SET READBACK after slewrate limiter and soft-start circuit)
12	V-SET SERIEL	O	Voltage loop set value from current loop
13	GNDA		Analog GND
14	STDBY_ISO	I	12V signal to turn converter
15	VP 10V / LOC/REM	I/O	Analog external voltage set point / Local/Remote status (Low=LOC), Open col.
16	IP 10V	I	Analog external current set point
17	FAULT RELAY	O	Fault relay, closed = OK
18	FAULT RELAY	O	Fault relay, closed = OK
19	V MON	O	Output voltage monitoring. Voltage representation of the supply output current.
20	VP RTN / PHASE_FAIL	O	Return line for VP pin 15 / Phase failure interlock, Open Collector
21	+15V AUX / GND	O	+15V auxiliary output / GND
22	-15V AUX / ON	O/I	-15V auxiliary output / ON Control Signal, active High
23	IP RTN	I	Return line for IP pin 16
24	V-MON RTN		Return line for V MON pin 19
25	I-MON RTN		Return line for I MON pin 7

SPI – Iset DAC interface X5 (HDMI 19- Pole) (Optionally):

Optionally Interface for direct communication with the output current setting 20-Bit SPI DAC.

Pin no.:	Name:	I/O:	Description:
1	SDI -	I	Serial Data In -
2	SDI Shield		Serial Data In Shield (GND)
3	SDI +	I	Serial Data In +
4	SDO -	O	Serial Data Out -
5	SDO Shield		Serial Data Out Shield (GND)
6	SDO +	O	Serial Data Out +
7	Select 1 -	I	Select 1 -
8	Select 1 Shield		Select 1 Shield (GND)
9	Select 1 +	I	Select 1 +
10	SCK -	I	Serial Clock -
11	SCK Shield		Serial Clock Shield (GND)
12	SCK +	I	Serial Clock +
13	(NU)		This line is connected to TP1.3. If a jumper is connected between TP1.2 and TP1.3, these lines can be used for “board connected” -detection.
14	PWR_On	O	This line is pulled low when power is applied to the FPGA.
15	Select 2 -	I	Select 2 -
16	Select 2 +	I	Select 2 +

17	GND	I	GND
18	5V	I	+5V supply input.
19	(NU)		This line is connected to TP1.2. If a jumper is connected between TP1.2 and TP1.3, these lines can be used for “board connected” -detection.

LOCAL CONTROL X6 (D-SUB 9 Pole):

Local, RS422, RS485 DB9 serial line Interface

Pin no:	Name	I/O	Description & Specification
2	Tx Low	O	RS422/485 Transmitter negative line
3	Tx High	O	RS422/485 Transmitter positive line
4	Rx Low	I	RS422/485 Receiver negative line
5	Rx High	I	RS422/485 Receiver positive line
6-7	+15V	O	+15VDC
8-9	-15V	O	-15VDC

REMOTE CONTROL X7 (D-SUB 25 Pole):

Remote, RS232, RS422, RS485 DB25 serial line Interface

Pin no:	Name	I/O	Description & Specification
2	Tx	O	RS232 Transmitter line
3	Rx	I	RS232 Receiver line
7	RETURN	I/O	Return line for RS232
9	Tx High	O	RS422/485 Transmitter positive line
10	Tx Low	O	RS422/485 Transmitter negative line
11	Rx High	I	RS422/485 Receiver positive line
12	Rx Low	I	RS422/485 Receiver negative line
13	VCC	O	Supply voltage +5VDC

Connector X9 (pin 1-4) X8 (pin 6-10) X112 (pin 12-16):

16-pol connector for SYNC, POLARITY, INTERLOCKS and 24V DC supply:

Pin no:	Name	I/O	Description & Specification
1	SYNC+O	O	Open collector output up to 24V/100mA. Active in minimum 2.5ms when a ramp profile has been triggered.
2	SYNC-O	O	Return line for SYNC +O
3	SYNC-I	I	Return wire for pin 4
4	SYNC+I	I	Applying a 15 to 25 V signal between pin 3 and 4 will start the SW ramp profile if armed.
5	+24V_ EXT	O	+24V
6	POL_NORM		
7	POL_INV		
8	POL_GND		
9	POLSHIFT		
10	POL+24V		
11	+24V_EXT_GND		Return for +24V_EXT
12	+24V Input	I	Supply input for external interlocks.
13	EXT INTERLOCK 3	I	Optically isolated input. Pull to +24V ground to disable.
14	EXT INTERLOCK 2	I	Optically isolated input. Pull to+24V ground to disable.
15	EXT INTERLOCK 1	I	Optically isolated input. Pull to +24V ground to disable.
16	EXT INTERLOCK 0	I	Optically isolated input. Pull to +24V ground to disable.

Fuseholder F1:

Fuse for control power

Pin no:	Name	I/O	Description & Specification
F1		Fuse for control power (2A/250V)	

6 Maintenance

6.1 Introduction

Servicing DANFYSIK Magnet Power Supply should be attempted only by trained and qualified personal.

Dangerous voltages capable of causing loss of life are present inside this power supply. Use extreme caution when accessing, handling, testing and adjusting.

6.2 Preventive maintenance

In normal operating environment, perform the following tasks at one year intervals.:

- Clean all fan protection grilles.
- Vacuum the openings in the cabinet and all heat sinks mounted on printed circuit boards to ensure a normal flow of cooling air.
- Check that screw connections from the output terminals are tightened.

In dusty or dirty environments the above-mentioned points should be performed more often.

- Inspect visually the power supply for components that have been overheated or other suspicious sign.

In high radiation environment, performances of following tasks are recommended at one year intervals:

- Replace all ICs mounted in sockets on the printed circuit boards.
- Printed circuit boards with ICs mounted without sockets should be replaced.

6.3 Adjustment and calibration

This power supply does not need any regular adjustment or calibration.

7 Trouble shooting

The syntax for trouble shooting hints:

WILL NOT GIVE MAIN POWER ON:

- Check for interlocks.
- Check connections to main contactor:

PHASE FAIL INTERLOCK:

- Check all phases.
- Check AC main power voltage.

MPS OVER TEMPERATURE INTERLOCK:

- Check ambient temperature:
  - > Temperature higher than 40 °C: Ambient temperature must come down.

MAGNET TEMPERATURE INTERLOCK:

- Check connections to magnet.

RACK FAN FAULT INTERLOCK:

- Check airflow switch in Rack:
  - > Failure in thermal breaker.