Design report for the
JLAB SHMS MAGNET DC POWER SUPPLIES

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1 INTRODUCTION

This design report describes the design of the DC power supplies required for the Super High Momentum Spectrometer (SHMS) which is being built at JLAB.

The power supplies are designed to provide stabilized DC current into the SHMS superconducting magnets.

In the following, the power supplies are described as one - unless otherwise noted. Where the differences are described, the power supplies will be referred to as Item no. 001-005.

1.1 Applicable Documents

AD[1] JLAB RFP/Solicitation no.: JSA-09-R280029, Rev. 1

AD[2] JLAB Technical Specification: 67185-SPEC-00001

AD[3] Danfysik quotation, ref. 500973, dated January 8th 2010

AD[4] Danfysik System 8500 SW appendix, standard commands: ApSccSW1h

AD[5] Control Crate Schematic DWG 92130A

AD[6] Main Schematic DWG 92131A

1.2 Abbreviations and Definitions

DCCT	DC Current Transducer
DF	Danfysik A/S
JLAB	Jefferson Lab
MPS	Magnet Power Supply
NC	Normally Closed contact
NO	Normally Open contact
TBD	To Be Defined
W,D,H,	Width, Depth, Height

Live parts Parts that carry voltages greater than 48V (DC or AC_{RMS})

2 MPS DATA

This table sums up the specifications for the power supplies and the calculated data for power, cooling, etc.

Table 1

Ref.	Parameter	Requirement:	Comments	
1	**Input**			
1.1	Line Voltage	3 x 480V + EARTH	±10%	
1.2	Line Current	115A 92A	For Item no. 001 For Item no. 002-005	
1.3	Input Frequency	50Hz / 60Hz		
1.4	Rectifier	12 Pulse		
1.5				
1.6				
2	**Output**			
2.1	Output Voltage	±6V		
2.2	Output Current	5000A 4000A	For Item no. 001 For Item no. 002-005	
2.3	Operating Range	5% to 100%		
2.4	Absolute accuracy	-0 / +100ppm		
2.5	Stability 30 Min 8 Hours	 < ± 5ppm < ± 10ppm	With following fluctuations: ±10% Mains ±5% Load ±10°C Water ±10°C Air	
2.6	Slew rate / Ramp rate	±5 A/s	Limited by the specified output voltage	
2.7	PARD	5mV + 0.01% Vout		

Ref.	Parameter	Requirement:	Comments	
3	**Protection**			
3.1	Interlocks that turns power supply OFF	Phase failure Prim. over-curr. Doors/Emerg. Stop Ground Fault Reg Mod Failure Output over-curr.	±10% & Rotation 125% Open/Pushed >100mA Internal: Set from 10%-110% trip DCCT: 120% trip Separate: 110% trip	
3.2	Interlocks that turns power supply OFF and opens dump switch (Fast Ramp down)	Quench Detected Water flow Over temp.	Integrated quench detector < TBD l/min	
3.3	Dump circuit	60mΩ, 300kJ x 1/hr 75mΩ, 1MJ x 1/hr 75mΩ, 10MJ x 1/hr 75mΩ, 17MJ x 1/hr	For Item no. 001 For Item no. 002 For Item no. 003-004 For Item no. 005	
4	**Interface**			
4.1	RS232 / RS422	Remote control	DF protocol, 1.2-115.2kBaud	
4.2	Current setting resolution Digital	4ppm	An 18bit or 20bit DAC will be implemented	
4.3	Output Current Read Back Digital	16 bit plus sign	1 second sample time RS232 connection	
4.4	Output Current Read Back Analogue from DCCT #1	10V	+10V = 100%	
4.5	NMR field stabilization	1μT lock in	±20mA → TBD correction	
4.6	Front Panel Control	Yes	M-Panel connection.	

Ref.	Parameter	Requirement:	Comments	
5	**Cooling**			
5.1	Cooling (Air)	5-38 °C		
5.2	Cooling (Water)	15-35 °C		
5.3	Pressure, nominal	250 psi	±10 psi	
5.4	Test pressure	400 psi	1 min	
5.5	Cooling water flow	190 l/min 150 l/min	Item no. 001 Item no. 002-005 Estimated	
6	**Mechanical**			
6.1	Cabinet size (WxDxH)	120 x 31.4 x 70,8" 96.3 x 31.4 x 70,8"	Item no. 001 Item no. 002-005	
6.2	Main power input	Separate enclosure		
6.3	Control I/O	Bottom of cabinet		
6.4	Cooling water I/O	Bottom of cabinet		
6.5	Current output	Top of cabinet		
6.6	Weight	TBD		
7	**Misc.**			
7.1	Ground Isolation	> 1MΩ	Dry, ground detection opened	

3 MPS DESIGN

The MPS design is based on the standard Danfysik System 8500 concept type 854. 854 indicates a linear output stage.

The power supply description is based on the following block division. That is: Input converter, Output converter and Control electronics as shown here:

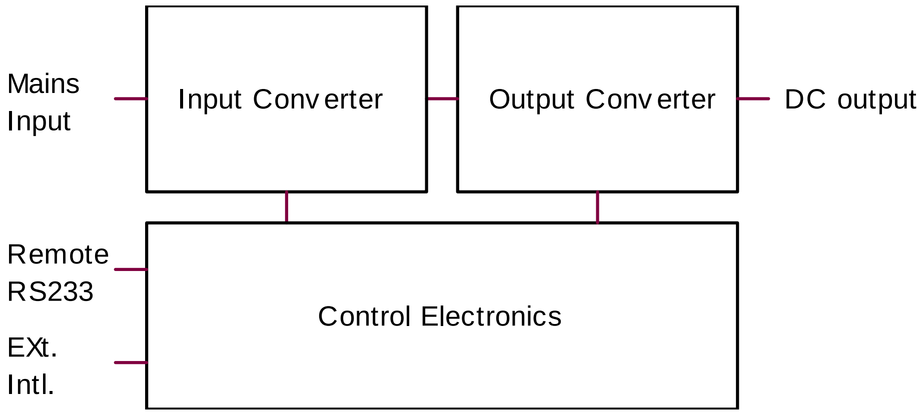


Figure 1 MPS main block division

Each block will be described separately, and the construction of the power supply will be divided into modules accordingly.

3.1 Schematics

Preliminary detailed schematics can found here:

- 92130A.pdf Control Crate Schematic
- 92131A.pdf Main Schematic

3.2 Input Converter

The main task of the input converter is to convert the input power to a raw DC voltage ready to use by the output converter. To do so it has to perform following sub tasks:

The main AC input supply is passed to the main transformer through an isolating switch and a contactor which turns on the power in two steps to minimize the inrush current.

The AC voltage on the secondary side of the transformer is converted to a DC voltage through a 12-pulse diode rectifier (two parallel 6-pulse rectifiers with interface transformer) and thereafter filtered in an L-C low-pass filter. This ensures a good power factor and low current harmonics drawn from the line.

For safety an emergency stop button on the front of the main cabinet is provided. This button removes the control power to the input converter, thereby turning the main power off directly. The power to the control electronics will not be affected by the emergency stop button, enabling the message to be sent to the upper level control system.

The input converter includes all the parts between the three phase input and the rectified DC output rail. Its interfaces are therefore: Mains input, Control power to the main cabinet, Control signals to/from the control electronics and Raw DC output.

Figure 2 below shows the block schematic of the input converter:

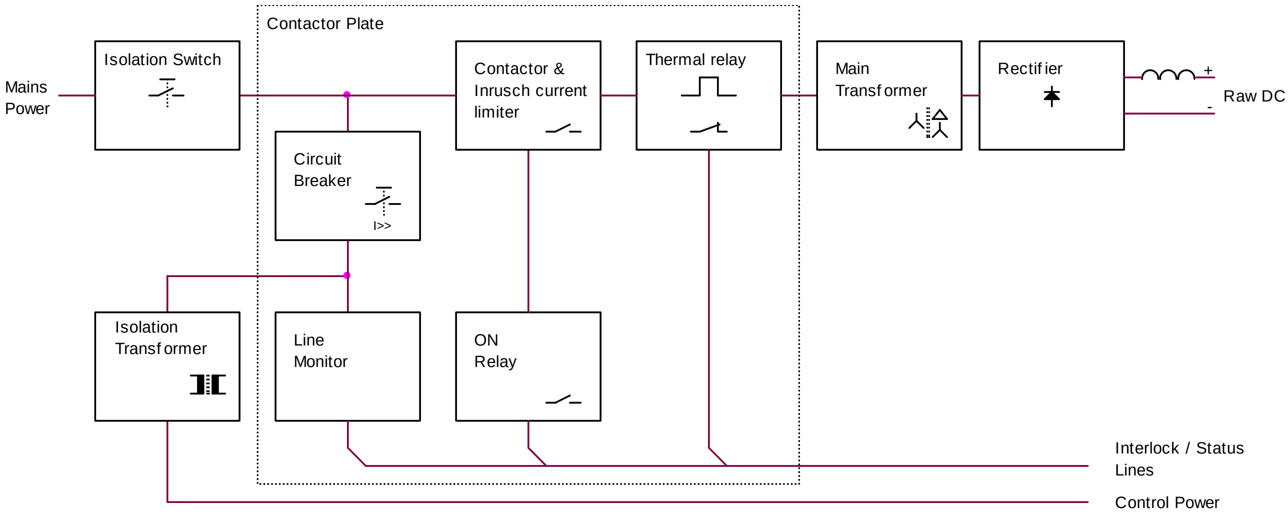


Figure 2

The individual blocks are described further below:

3.2.1 Manually operated Mains Isolation Switch

The switch will be a Kraus & Naimer switch type C125-A202-620E mounted in a separate enclosure, this to ensure a completely voltage-free main enclosure when the switch is off. (Catalog and picture attached.) The switch is rated for 150A of load, and the largest power supply (Item no. 001) will draw 115A worst case.

3.2.2 Main Contactor and soft-start

The main contactors will be as follows:

	Item no. 001	**Item no. 002-005**
Contactor type	AEG/(GE) LS110K	AEG/(GE) LS90K
Rated power	132kW @ 500V	110kW @ 500V
Required power rating	96kW	77kW

See datasheet in appendix.

Soft start resistors are used to limit the inrush current when main power is turned on. The current will be limited to ≤ the nominal input current.

The following resistors will be used:

	Item no. 001	**Item no. 002-005**
Resistor	2 x 4R8/300W in parallel	2 x 6R8/200W in parallel
Limiting current to:	480V / (2 x 4R8 / 2) = 100A	480V / (2 x 6R8 / 2) = 71A

The soft start contactors will be as follows:

	Item no. 001	**Item no. 002-005**
Contactor type	AEG/(GE) LS45K	AEG/(GE) LS30K
AC-1 rating	140A	110A

3.2.3 Thermal relay

To protect the primary wiring from overload, a thermal overload relay is employed. The thermal relay will be adjusted to trip at 120% of nominal current.

The relays will be as follows:

	Item no. 001	**Item no. 002-005**
Thermal relay type	AEG/(GE) B90K	AEG/(GE) B90K
Adjustable range	110-140A	110-140A

3.2.4 Phase relay

A phase relay will perform the line monitoring to ensure the presence of all three phase and correct phase voltage.

As line monitoring relay the type CROUZET MVU 208-480V 50/60HZ will be used

3.2.5 Main transformer for line isolation and level adaption

The main transformer will be custom made by Elhand in Poland. The transformer will be water cooled to reduce the physical size, and to minimize the heat dissipation to air. The following will be specified:

	Item no. 001	**Item no. 002-005**
Primary voltage	3 x 480V	3 x 480V
Secondary voltage	#1: 3 x 12.5V star #2: 3 x 12.5V delta	#1: 3 x 12.5V star #2: 3 x 12.5V delta
Nominal power rating	96KVA	77KVA
Misc.	Electrostatic shielding between prim. and sec. Internal thermal switch for thermal overload protection	Electrostatic shielding between prim. and sec. Internal thermal switch for thermal overload protection

3.2.6 Rectifier block for AC to DC conversion

Calculations for the rectifier bridges:

Item no. 001

Parameters for power components					
Order no.500973			Date:	04-02-2011 20:15	
Parameter description		Variable		Results	
Rectifier:					
6 or 12 pulse rectification				12	Pulse
Bridge Configuration (**S**=Seriel, **P**=Parallel, **I**=Interface transformer)				I	Bridge
Diode or **Thy**ristor rectification bridge				Di	Rectifier
I rectifier RMS				1452,5	A
I rectifier MEAN				833,3	A
P rectifier (Result for 1 bridge)				6250	W
Type: {Eupec or International-Rectifier}	Eupec	3	*	DZ950N12K	

Eupec **D970N** or similar will be used. (Datasheet attached.)

Item no. 002-005

Parameters for power components					
Order no.500973			Date:	04-02-2011 20:17	
Parameter description		Variable		Results	
Rectifier:					
6 or 12 pulse rectification				12	Pulse
Bridge Configuration (**S**=Seriel, **P**=Parallel, **I**=Interface transformer)				I	Bridge
Diode or **Thy**ristor rectification bridge				Di	Rectifier
I rectifier RMS				1162,0	A
I rectifier MEAN				666,7	A
P rectifier (Result for 1 bridge)				5000	W
Type: {Eupec or International-Rectifier}	Eupec	3	*	DZ950N12K	

Eupec **D650N** or similar will be used. (Datasheet attached.)

Stacked, press-pack diodes with double-side cooling are foreseen. Exact make and model is TBD.

3.2.7 Isolation transformer

An Isolation transformer will provide control power for the main cabinet (for fans, contactors and other auxiliary supplies), transformed down from the 480V mains input. The Isolation transformer will be naturally air cooled.

3.3 Output Converter

The main task of the output converter is to regulate the raw DC from the input converter to the correct voltage - set by the regulation loop.

The regulation itself is based on a linear transistor bank ensuring high bandwidth and low noise.

If control of the transistor bank is lost, a string of free-wheel diodes take over the current.

A high accuracy/high stability LEM/Danfysik DCCT system measures the output current and provides feedback to the regulation loop.

A polarity reversal switch enables the power supply to deliver both positive and negative currents.

A dump switch and dump resistor is provided so that, in case of a quench, the magnet energy can be extracted faster that the free-wheeling diodes would allow.
Figure 3 describes the output converter in its major sub-blocks:

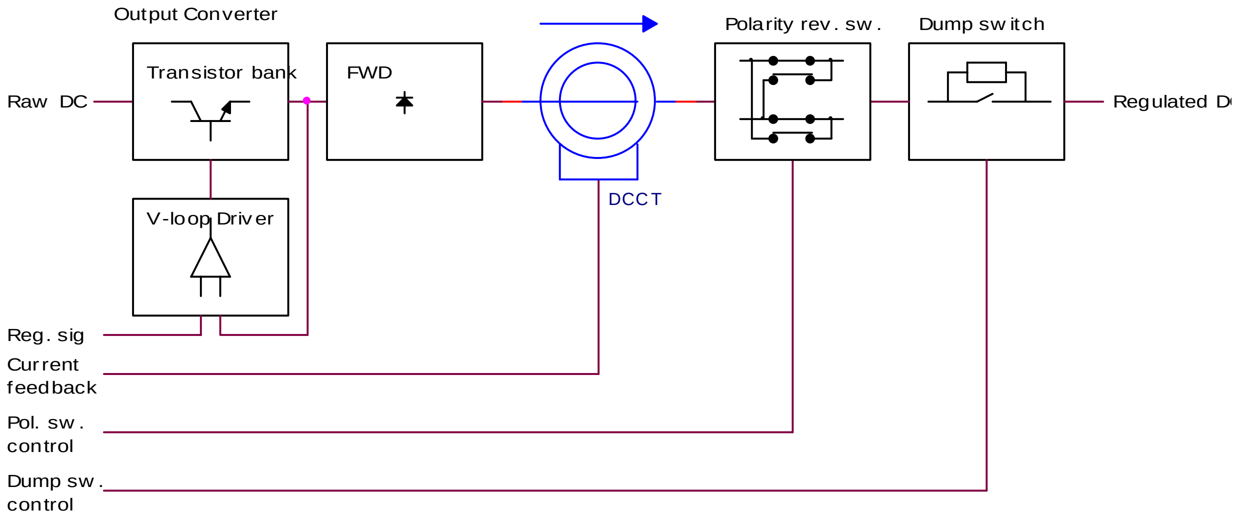


Figure 3

3.3.1 Transistor bank

The transistor bank will be made up of a number of water-cooled sub-banks, each consisting of 36 parallel MJL21194 transistors (datasheet attached).

The following calculations assume worst-case conditions for the transistors, that is +100% output current, -100% output voltage (full power delivered back from load), 45°C water (including 10°C temp. rise) and +10% voltage from the mains. It is also included, that the transistor bank shall have to be functional even with 5% defective transistors.

Item no. 001

Power in trans-bank at max.					107,66	kW
Power in trans-bank at 100%					107,66	kW
Maximum transistor errors in %		5	%	>=	82	Trans
Current through each transistor	But max	5,4	A		3,22	A
Qty. of transistors pr. bank	(New TO 247 Bank)	34	Pcs.		34	Pcs.
T j max. For transistor		130	°C		130	°C
R junction to water		1,2	C/W			
Qty. of heatsinks with transistors		0			**48**	Pcs.
Power dissipated in each transistor					69,44	W
T j (worse case)		1			128,33	°C

48 transistor banks (1728 transistors) will be used in total. These will take up 2½ "door frame" of space in the cabinet.

Item no. 002-005

Power in trans-bank at max.					86,13	kW
Power in trans-bank at 100%					86,13	kW
Maximum transistor errors in %		5	%	>=	65	Trans
Current through each transistor	But max	5,4	A		3,26	A
Qty. of transistors pr. bank	(New TO 247 Bank)	34	Pcs.		34	Pcs.
T j max. For transistor		130	°C		130	°C
R junction to water		1,2	C/W			
Qty. of heatsinks with transistors		0			**38**	Pcs.
Power dissipated in each transistor					70,17	W
T j (worse case)		1			129,21	°C

38 transistor banks (1728 transistors) will be used in total. These will take up 2 "door frames" of space in the cabinet.

Under normal operation, the junction temperature of the transistors will remain well below 100°C.

3.3.2 V-loop Driver

The transistor output stage is controlled and driven by a driver module placed directly on the transistor bank. The driver module gets a voltage set-point from the Regulation module and it incorporates a high-bandwidth (several kHz) voltage loop (V-loop) ensuring good attenuation of ripple and fluctuations at the output of the rectifiers. The interface to/from the Regulation module is galvanically isolated on the V-loop driver module for safety and to eliminate ground loops.

The V-loop driver module contains the following functions:

- Galvanic isolation of interface to/from Regulation module (voltage set-point from, status, etc.)
- High-bandwidth voltage loop amplifiers
- Output driver stage to drive the output stage transistor bank
- Voltage read-back for monitoring
- Voltage supplies

3.3.3 Polarity reversal switch

The power supply will incorporate an automatic, motorized polarity switch.

Please refer to paragraph 2.6 in Appendix A for details on the sequence of a polarity switch.

Exact make and model of the polarity switch is TBD.

3.3.4 Dump circuit

The dump circuit will be made up of:

- an electrically operated DC circuit breaker capable of breaking the full current, and
- a dump resistor limiting the voltage to approx. 300V when breaking at full current.

The resistor will be capable of dissipating the full energy of the load once pr. hour. The resistor will be stainless steel or cast iron. It is suggested to place the resistor on top of the main cabinet. This will keep the generated heat away from the rest of the power supply, and it will facilitate easy forced cooling from below. *This is to be discussed.*

To protect the load and the power supply, the breaker will be opened:

- in case of a detected quench,
- if the power supply has and over-temperature-/flow-fault, or
- if power is lost.

Exact make and model of circuit breaker/dump switch and dump resistor is TBD.

3.4 Control Electronics

The control electronics is based on standard Danfysik modules, and will be built into a 3U high 19" rack mountable crate with integrated local control panel (M-panel). The crate has forced air cooling (front to back), and all modules can be accessed from the top of the crate (when lid is removed).

The crate can be placed up to 20m/60' from the main power supply enclosure.

Figure 4 below shows the block schematic. Each main module is described in the following sub chapters.

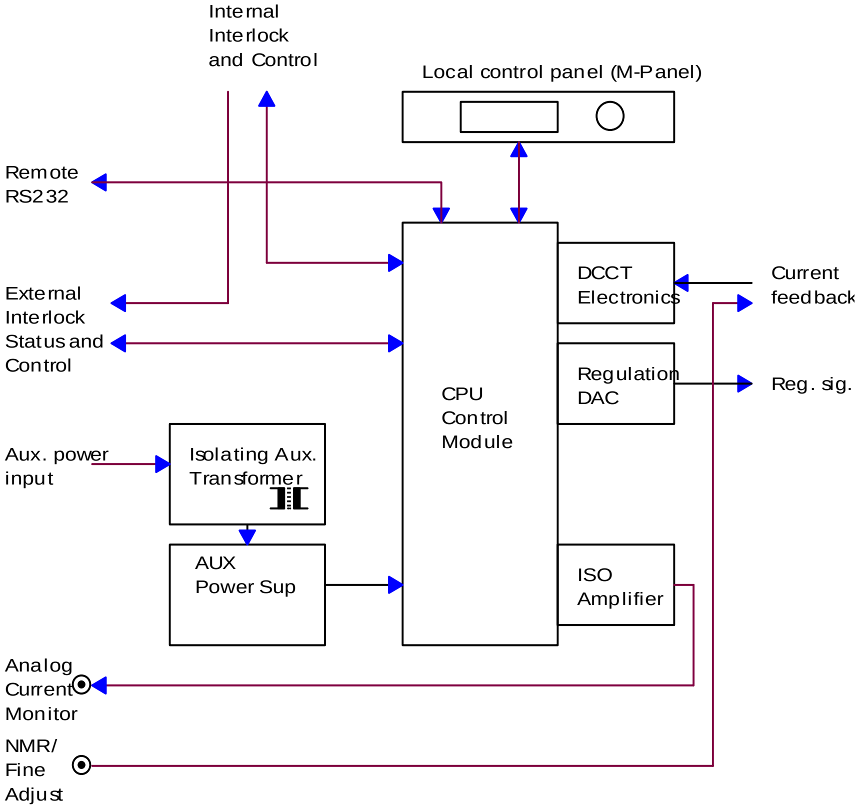


Figure 4

3.4.1 Control module

The Control Module will be the same as for the standard system 8500 power supply range.

The task of the Control Module is to control the power supply. In short, these functions are:

- communication with the Local control panel,
- communication with a host PC over the remote line,
- turning the power supply ON and OFF,
- setting the output current value (DAC control).
- monitoring of different analog signals and
- interlock process and evaluation

A microprocessor takes care of the above mentioned functions. However, all interlock signals are hard-wired and are not dependant of the microprocessor.

3.4.2 Local Control Panel

The local control panel is the operator control panel for operation in local mode. Through this, it is possible to turn the power supply ON/OFF, set output current, read actual output current and voltage, read and reset pending interlocks, read status messages, etc.

Please refer to Appendix 2 for further detail on controlling the power supply using the local control panel.

3.4.3 DCCT electronics module

The DCCT electronics module drives the DCCT and delivers a current proportional to the MPS output current measured by the DCCT head. This module is calibrated with the DCCT to give exactly 1A with a 100% output current. (100% is selected by a DCCT programming plug).

The module contains the following main functions:

- power output amplifier
- zero flux detector
- interlock circuit (trips at approx. 120% or if DCCT control fails due to missing supply or connection)
- voltage supply

3.4.4 DAC Module

The main task of the DAC Module is to create the set point for the power supply output current. It also compares this set point to the actual current and amplifies the difference to provide an amplified error-signal for the regulation module.

To do this, the DAC module contains the following functions:

- Precision voltage reference
- DAC (20 Bit) for digital set value
- Burden resistor for actual output current measurement
- Summing amplifier

The above is mounted in a temperature stabilized faraday cage for best stability and noise immunity. The DAC module implements the "outer loop" for ppm stabilization.

3.4.5 Regulation module

The Regulation module implements the "inner loop" for load linearization and ripple cancellation. It may also contain a HW slew-rate controller that provides smooth, adjustable/programmable ramping at a fixed dI/dt. The Regulation module controls the output converter through an appropriate interface – in this case the V-loop driver module. The Regulation module also acts as an interface for read back of voltage and other status/interlock signals from the output converter.

The regulation module contains the following functions:

- Loop amplifiers for "inner loop"
- Adjustable/programmable slew-rate controller (option)
- Power-down/soft-start clamp circuit
- Interface to output converter
- "Ready" detection
- Over current detection
- Over load detection

3.5 Protection scheme

A number of interlocks will be implemented to protect personnel, power supply and load.
Any interlock will put the MPS in the OFF state. All interlocks will be latched and will require an active reset command to be cleared.

3.5.1 Personnel protection

No *live* parts will be accessible without the use of tools. All doors covering *live* parts will be equipped with door switches. Opening a door will trip and interlock the MPS.
For complete isolation, a disconnect switch will be mounted in a separate box, leaving the main cabinet free from *live* parts when disconnected.
An emergency stop push-button will be placed on the front side of the main cabinet. One switch on the emergency stop will interlock the MPS via the control system, and another switch on the emergency stop will be wired in series with the coil of the main contactor (releasing main power directly).
A ground fault (earth leakage) detector will be implemented, interlocking the MPS if more than 100mA of the output current flows to ground. This circuit will tie the output (+ or -) to ground through a sensing resistance of 10Ω.

3.5.2 Power supply protection

A phase-control-relay will monitor the three-phase mains to ensure the presence of all three phases and correct voltage. This relay will interlock the MPS if a phase is missing or if incorrect voltage is connected.
The power supply will incorporate several levels of over-current protection:
On the primary side of the main transformer, a thermal overload relay will trip to protect the transformer and wiring in case of an overload of the primary.

On the output side, the MPS will incorporate four levels of over-current protection:

1. By remote control, the digital output current set-point ("DA 0") can be clamped to stay within an arbitrary window (please refer to the "ESC<DASET" command paragraph on page 48 in ApSccSW1h for further detain on this SW clamp).
2. An analog over-current interlock with user-adjustable trip-level will be provided on the control crate. This circuit senses on the current measured by the main DCCT (also used by the loop).
3. A 110% current safety interlock using a separate DCCT will be implemented. Foreseen current transducer supplier: LEM (exact type is TBD)
4. Inherent 120% current interlock (implemented in the DCCT electronics, see paragraph "DCCT electronics module" above)

The transistor bank will be protected against excess power dissipation by a circuit monitoring voltage across and current through it.
All power devises (transformers, inductors, semiconductors, etc.) will be monitored by thermal switches – interlocking the MPS if the temperature rises above safe level for the individual devises.
Flow switches will monitor the cooling water flow of each parallel water path, and interlock the power supply if the flow drops below the critical rate for the individual path.
At thermal overload or insufficient flow of cooling water, the power supply will also release the dump-switches to ensure a fast ramp-down of the output current.

3.5.3 Load protection

The load will be protected against over-current and -voltage by the circuits protecting the power supply against the same.

Besides that, a four dual-channel quench detector is included. The quench detector will have an adjustable threshold of 2mV-2V, and initiate the release of the dump-switches in case of a quench.

Due to the low end of this adjustment range (2mV), it is suggested to place the quench detector circuit as close to the load as possible (i.e. in the main cabinet of the MPS). *This is to be discussed.*

3.6 Water supply

The water inlet and outlet will be common for one supply, that is, distribution for different internal users is a part of the cabinet design.

The cooling water will arrive from below and connected to internal fittings at the bottom inside of the cabinet.

1" pipe threaded connection is foreseen. Danfysik will provide mating fittings where applicable.

3.7 Mechanical layout

Preliminary cabinet layout for Item no. 002-005:

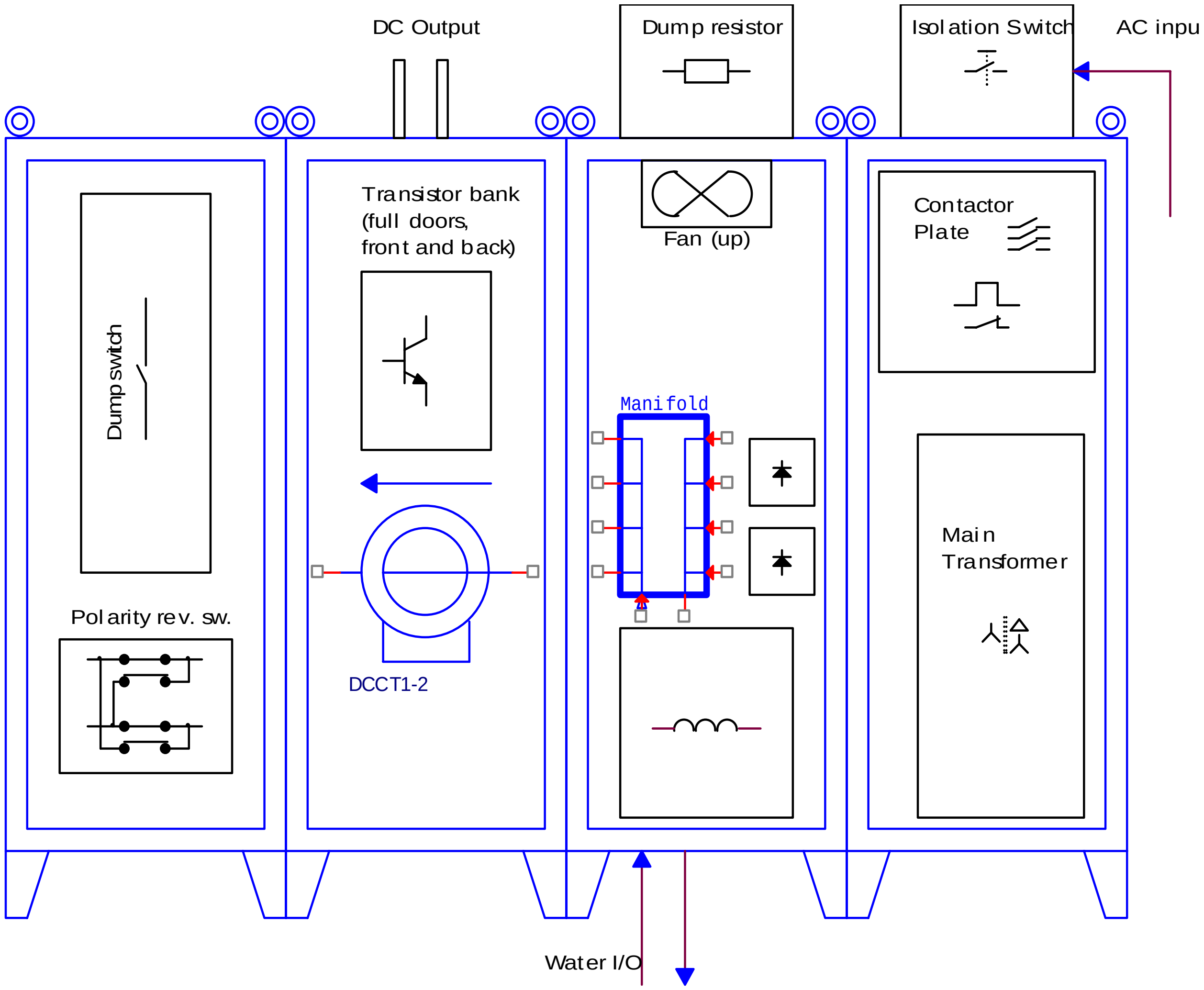


Figure 5

3.8 Test

The power supply will be tested on resistive load only. This will be done at:

- full current/full voltage, and
- full current/reduced voltage

Stability measurement will be performed in both modes.

APPENDIX A

Appendix A describes the control electronic module through a function description and how to use.
This appendix is added for interest and deeper knowledge of the system 8500 only.

1 CONTROL MODULE

The task of the Control Module is to control and supervise the different functions within the power supply. That is:

- Turning the power supply ON and OFF
- Communication with the "Front panel" module
- External serial link
- Parallel user interface
- Monitoring different analog signals
- Setting the output current
- Setting other DAC values if applicable

For these tasks it also acts as a motherboard link for other modules.

The Control Module can be divided in following functions:

- µ-Processor.
- Real time Clock
- Serial Communication. RS232/RS422/RS485
- Parallel Communication. (Connected to the SPI interface)
- Interlock control.
- DAC control. Current setting and internal ramp profile interpolation
- ADC control. Analog measurements.
- Setting up the board parameters.
- Internal Ramp profile HW interpolation and synchronization.
- Water Flow measurement
- Motherboard .

1.1 µ-Processor:

A micro processor of the type Hitachi H8 with built in A/D channels, serial interface and some I/O bits running at 14 MHz takes care of the above mentioned functions.

A "Watchdog" circuit, which will reset the CPU if it for some reason stops refreshing the watchdog once a second.

The CPU can be manually reset with switch S1.

1.2 Real time clock:

The control module is equipped with a real time clock circuit. This clock circuit is used to catch the exact time spot for the first arriving interlock after the last issued interlock reset.

The clock can be set through SW commands. To keep the clock synchronized with local time, it is recommended to set the time at least every week. The clock is not designed for high accuracy time keeping.

A lithium Cell of 3V type CR2450 ensures that the clock will continue running without the control power. A red LED located beside the cell indicates if the battery needs to be replaced (normally after 5 years).

1.3 Serial Communication:

The communication between the control module and the outside world can be performed through serial links or a parallel interface. There are two serial communication ports implemented.

A) RS422/485 intended for the local manual panel called the M-PANEL
B) RS232/RS422/485 intended for Remote control.

All serial communication lines are galvanically isolated from the micro processor by means of opto couplers. The communication settings can be assigned either through dip switches or through software.

Switching between RS422, RS232 and RS485 line operation is done by straps. See schematic for more detailed information.

1.4 Parallel Communication:

The power supply can also be remotely controlled via the parallel interface available through plug P3.

Although controlled by the parallel interface, serial status readings are still possible, but many of the advanced features, as the first catch interlock register, Analog measurements or the real time clock, are not available from the parallel port due to line limitations.

- Control lines:	ON, OFF, RESET, INV polarity (Active high pulses)
- Current setting digital:	20 bit digital current set.
- Current setting Analog:	Must be connected directly to the regulation module.
- Status lines Digital:	Interlocks and status
- Status lines Analog:	Actual current, Output voltage and Pass bank voltage if applicable.
- Water Flow measurement:	

1.5 Interlock, status and ON/OFF control:

External interlock and status signals are optically isolated from the electronics. The opto couplers are driven from an isolated 24 Volt supply, with a current of 24 mA which ensures a good contact self cleaning.

Internal interlock and status signals are connected directly without galvanic isolation.
Inputs that are configured as interlock are hard wired (OR'ed) to the OFF circuit through diodes. Soldered straps in series with the diodes decide if the signal has to be treated as interlock or status. If the signal also has to be latched and incorporated within the first catch register, it can be programmed with the "Esc"INTERLOCK command. Please see the SW appendix for further information on this.

A delay-line ensures that an interlock signal is only accepted, if it stays high for longer than approx. 100ms. This in order to eliminate false, noise-generated interlocks. The output of the delay-line will turn off the opto coupler that controls the main contactor. The sum interlock signal is also connected to the LED D6 for a latched interlock indication.

Each interlock is individually connected. Every edge transition is detected and latched in an internal register.

On arrival of the first interlock, a mirror of the interlock and status register is stored in a first catch register along with the time of occurrence. These values can be read locally or from the remote serial line with the commands "S1FIRST" and "S1TIME".

1.6 DAC control:

The DAC control block produces the bits to the Digital to Analog Converter located in the regulation module, which sets the output current level.

In the parallel operating mode, the DAC bits are monitored for display purposes only.

1.7 Control module Analog measurements:

Different signals, such as internal supply voltages and DAC-BOX delta temperatures as well external values such as output current and voltages, are monitored by means of Analog to Digital converters.
The following analog signals are monitored:

LOGICAL CHANNEL	PHYSICAL CHANNEL	VALUE	BIT RESOLUTION
0	IC34/CH0	Output current	11 + sign
1	IC34/CH3	Tesla (+1V)	11 + sign
2	IC34/CH2	Output Voltage	11 + sign
3	IC16/CH1	Internal +15V sup.	10
4	IC16/CH2	IInternal -15V sup.	10
5	IC16/CH3	Internal +5V sup.	10
6	IC34/CH1	Delta temperature	11 + sign
7	IC34/CH5	Trans. Bank Vce	11 + sign
8	Piggy Board/CH0	Optional Iout (16 Bit)	16 + sign
9		Mirror of logical channel 0	
10		Mirror of logical channel 8	
11	IC34/CH6	Iout Optional	11 + sign
12	IC34/CH4	Vout Optional	11 + sign
13	FPGA	Water flow	8
14	IC34/CH7	Free on plug P29 (±1V)	11 + sign
15	IC16/CH0	Free on plug P19 (10V)	10

The measurements are available on both the local control panel and the serial remote line.

Adjustment and calibration of the AD channels are mainly performed by changing the ADC scale factor through SW for each channel. Only the VCE reading and the Iout Off-set value can be trimmed through potentiometers.

1.8 Motherboard:

The control module contains the control and monitoring circuits for the MPS. In addition it is used as motherboard for the following modules:

- DCCT module
- Regulation module
- Parallel interface module
- Isolation module for external monitoring of the output current and voltages (0 -> 10V)

1.9 Water Flow measurement:

A Water flow sensor giving pulses proportional to the flow rate can be attached.

The trip level is adjustable through Pot1. JX4 enables the circuit.

The flow pulses are also connected to the FPGA, which converts the frequency to a pseudo analog signal available on logical AD channel 13.

1.10 LED indications on the board:

Most of the status signals indicated on the remote lines can also be read from light-emitting diodes. Most of these LEDs are software controlled and are therefore only valid if the µP works.

1.11 Setting up the board parameters:

Setting up the board is done by two dip switches SW1 and SW2 along with the push button S2 (SETUP), or through SW commands. Please refer to the "ESC" commands in the SW appendix chapter for further information.

1.12 Data communication.

The pin numbers on the D-SUB Female 25-pin connector tells which type of communication is used RS 232C, RS 422 or RS 485.

The direction used in the tables below is:

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

RS 232C	DB 25 S.	RS 422	DB 25 S.	RS 485	DB 25 S.
Pin No.	Signal.	Pin No.	Signal	Pin No.	Signal
2	Tx.	7	GND.	7	GND.
3	Rx.	9	Tx high.	9	Tx/Rx high.
7	RETURN.	10	Tx low.	10	Tx/Rx low.
		11	Rx high.		
				12	Rx low.

NOTE! The selection between RS 232, RS 422 and RS 485 is selected through jumpers on the Control module.

1.13 Termination using RS 422 or RS 485.

There is no termination resistor mounted inside the control module. An external termination resistor of 100 Ohm must therefore be added at the end of the communication cable. This is applicable for both lines.

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 +5V(non inverting) and GND (inverting) on both the transmit and the receive lines. The control module can provide this. The 1K resistors increase also the noise immunity.

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

1.14 Programming.

The power supply communication protocol is build upon plain ASCII characters where each command or reply is delimited by a "Cartridge 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 readable text.

All commands can be divided into three sections.

a) Directive commands. E.g. the "N" command that turns the power supply ON
b) Status commands. E.g. the "S1" that returns the power supply status
c) Set up commands. E.g. the "ESC"<PPULS 5 that sets the ON pulse to 0.5 seconds.

Status commands always deliver a reply, whereas directive- and setup- commands only respond 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 (See 'esc'LINE setup).

Hint. When using the "Always Answer" mode a retransmission of the last given command can be performed if no answer or an error message is received. The System 8500 respond time is around 5ms after receiving the last bit of the termination character.

Answer scheme if set to "Always Answer" mode.

d)	Directive commands.	Answer:	- No answer
			- ERROR message
			- OK if set to always answer mode (ab SW ver. SCS110)
e)	Status commands .	Answer:	- Data
			- ERROR message
f)	Set up commands.	Answer:	- No answer
			- ERROR message
			- OK if set to always answer mode (ab SW ver. SCS110)

1.15 SW Commands.

Following are the commands for the standard software listed in alphabetic order.

STANDARD COMMANDS. summary

AD X	Read value from an ADC channel.
ADR	Read the address of the MPS.
ADR XXX	Write an address to an MPS.
ASW	Enters answer mode.
CLOCK	Reads the current time
CLOCK XX,XX,XX,XX,XX,XXXX	Sets the clock.
CMD	Read current control mode.
CMDSTATE	Read current control state.
DA x,xx	Writes a value to a Digital to Analog converter. (Alternative W(x) or WA command.)
ERRC	Coded error message.
ERRT	Text string error message.
F	Main Power OFF.
F1	Auxiliary-1 output line OFF.
"F2"	Auxiliary-2 output line OFF.
GOFF	Global OFF Same as N1 command
IEEE	Used to set IEEE interface communication if present
ID	User configurable identification text field
LALL	Listen ALL.
LOC	Change to local Control.
LOCK	Lock the MPS in local Control.
N	Main Power ON.
N1	Auxiliary-1 output line ON.
"N2"	Auxiliary-2 output line ON.
NASW	No answer mode.
NERR	No error message.
PO	Polarity status.
PO +/-	Change to Normal polarity.
PRINT	Reads internal user information about the MPS
R(x)	Read slew DAC 1 or 2
R3	Read slew DAC 1 absolute
RA	Read the set value. (Preferred new command: "DA, 0")
REM	Change to remote control.
RLOCK	Remote line only
RS	Reset interlocks.
S1	Read the internal status.
S1H	Read internal status in HEX format
S3	Read the internal extended status.
S3H	Read internal extended status in HEX format
S1FIRST	Read the interlock first catch status.
SFIRSTH	Read the interlock first catch status in HEX format
S1TIME	Read the time when the first interlock occurred.
SOFF	Slow OFF Off command followed by an WA 000000
TD	Test DAC function
TYPE	AD type in use
UNLOCK	Unlock the MPS
VER	Reads the software version
W(x)	Write slew DAC 1 or 2
W3	Write slew DAC 1 absolute
WA XXXXXX	Write a set value (Set output current). (Preferred new command: "DA 0,xxxxxx")

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

Following are the set up commands in alphabetic order.
Please see the SW appendix 1 for parameter formats and further detail explanation.

Esc SET UP COMMANDS. summary

Esc<AD	Configures the AD converter scaling 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<AUX2	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	Resets the CPU.
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<ID	Sets User configurable identification text field
Esc<INTERLOCK	Configures which input that has to be latched. Other inputs will act as status inputs.
Esc<LINE	Configures the protocol for the serial lines.
Esc<POLDELAY	Polarity change over delay time (in OFF).
Esc<PPULS	Configures the ON pulse with.
Esc<PPULS1	Auxiliary line ON pulse with.
Esc<SLOPETIME	Auto SW slew rate function

Following are the commands for the software driven "RAMP PROFILE" listed in alphabetic order. These commands are optionally available.

SW RAMP PROFILE COMMANDS for "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 DAC scaling
MULT	Writes a multiplying factor for 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

X is a number from 0 to 9

SW RAMP PROFILE COMMANDS for "Equal time slot method". summary

R value	Writes data to the stack.
RAMP	[RSLT],[LWB] Controls the stack operation.
RAMPSET	Time,Multiplicant,TrDly [LWN],C Configures the ramp operation.

1.16 Operating by RS 232c or RS 422 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 RS 232C, RS422 or RS 485 communication.
- A LOCAL LINE, with either RS 232C, RS422 or RS 485 communication.

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

1.17 Setting up the MPS

The set up of the MPS is done by two dip switches SW1 & SW2 along with a push button (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 setup button.

Leaving all levers in the OFF position will disable the SETUP switch, and thereby any unforeseen setup modification (parking position). Therefore, please leave all dip switches in the OFF position as default.

If one of the setup modes are selected, the yellow LED to the left of the switch will light up indicating, that the setup port is activated. The eight green LEDs to the left of SW1 will show the present parameter of selected mode. Changing SW1 has no immediate effect. Only when pressing setup button, the setup is saved and the green LEDs take the same indication as SW1.

S2 position Number	Parameter
0 {0000}	Parking position
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}	COLD_BOOT_SETUP
8 {1000}	AUX_SETUP_1
9 {1001}	POWER_ON_PULSE
10 {1010}	AUXILIARY_1_ON_PULSE
11 {1011}	AUXILIARY_2_ON_PULSE
12 {1100}	POLARITY_DELAY_PULSE
13 {1101}	AUX_SETUP 2
14 {1110}	AD_AUTO_SCALE
15 {1111}	DA_AUTO_SCALE

2 CONTROLLING THE MPS FROM THE LOCAL MANUAL PANEL

2.1 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.

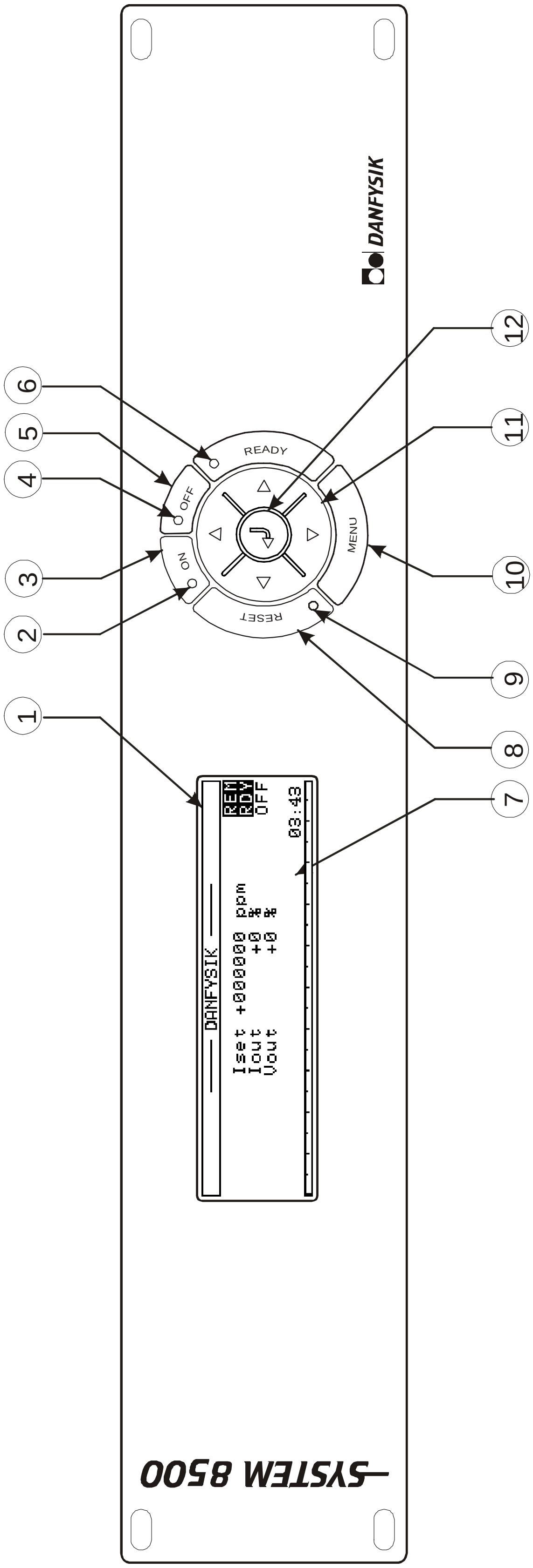
Changing a parameter is done with the arrow keys. (See also the help text at the bottom right of the display). A cursor, shown as the digit inverse, marks the digit to be manipulated. Pressing the "Enter" key ends the editing.

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).

2.2 Front panel controls

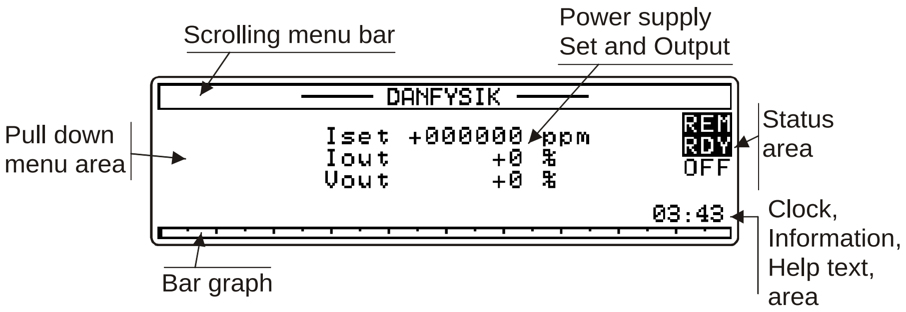
1. Graphic display 240*64
2. Main power is "ON" LED.
3. Main power "ON" push button.
4. Main power is "OFF" LED.
5. Main power "OFF" push button.
6. READY LED indicates when the actual output current is within a predefined limit.
7. Control Power "ON". Back light is lit.
8. Interlock "RESET" push button.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



2.3 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 M-Panel is unused for 5 minutes, the M-Panel will automatically enter this state, this 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 display 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 analogue 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

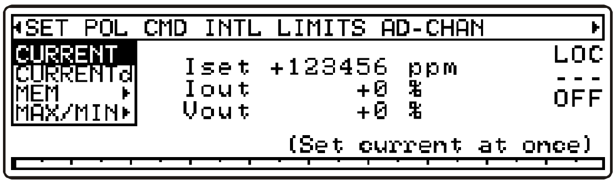
Information area.

The bottom right corner of the display is used for various 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.

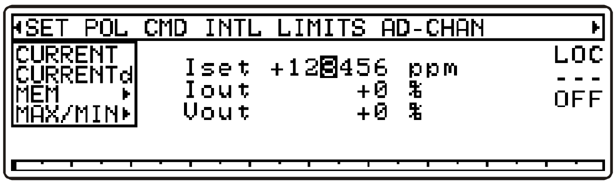
Menu Window:

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.



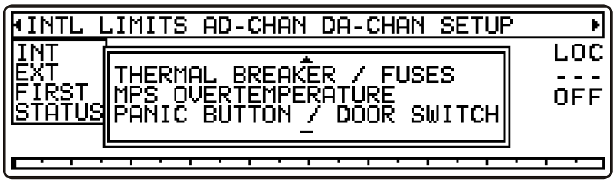
Editing Window:

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.



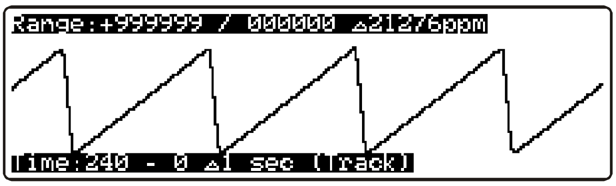
Pop Up Window:

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 Colour 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.



2.4 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
		SPARE INTERLOCK DC OVERCURRENT (OCP) DC OVERLOAD REGULATION MODULE FAILURE PREREGULATOR FAILURE PHASE FAILURE MPS WATERFLOW FAILURE EARTH LEAKAGE FAILURE THERMAL BREAKER / FUSES MPS OVERTEMPERATURE PANIC BUTTON / DOOR SWITCH DC OVERLOAD		* See also the list below the tables.
	EXT			External interlocks
		MAGNET WATER FLOW FAILURE MAGNET OVER TEMPERATURE		
	FIRST	Same list as for INT		First occurred Interlock
	STATUS			Status bits
		REGULATION TR. <>0", ONE TRANSISTOR FAULT BATTERY LOW STATUS OF TP9=0 POLARITY SW. INHIBIT TP8=0		* See also the spare list below the tables.
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
		Iout 8 bit resolution Magnet Field Vout Internal +15V Internal -15V Internal +5V Delta Temp Passbank drop Iout 16 bit resolution		Output Current 0-120% Optional Hall-probe required. Output Voltage 0 - 120% Internal control voltage Internal control voltage Internal control voltage DAC deviation temperature ±7.5°C Transistor bank voltage drop 0-120V Output current 5 significant digits
	CHN 9-15			A/D Channels 9 to 15
		Iout bar graph 1 Iout bar graph 2 Iout optional Vout optional Water flow Free from plug P29 Free from plug P19		Internal use Internal use From CAMAC line From CAMAC line Rotary sensor required
DA-CHAN				Setting of D/A Channels
	Slew-Rate			Set slew rate
SETUP				Sets working conditions
	BAUD			M-Panel Baud rate setting
		1200, 2400, 9600, 19200,	- 38400 - 57600 - 76800 - 115200	Communication may be lost when changing the baud rate.
	COLOUR			LED Colour
		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
		SLEW-R		Slew Rate setting enable
HISTORY				
	OPEN LOG			Se chapter for further information.

◇ Interlocks and status may differ from the one listed above dependent on customer request. The system 8500 enables interlock to be added or moved between status and interlocks or renamed. Below are some of the spare status information that may occur. Normally if used they will be renamed to reflect the desired information.

S1_24 NOT_USED"	SPARE 3	S1_6 NOT USED
GENERAL 2	SPARE 4	S3_13_NOT_USED
OPT.EXT.2	SPARE 1	S3_14_NOT_USED
OPT.EXT.3	SPARE 2 S1_4 NOT USED	S3_15_NOT_USED
OPT.EXT.4	S1_5 NOT USED	S3_16_NOT_USED

2.5 Current setting

The output current can be set immediately like a potentiometer menu "SET CURRENT" or first accepted with the " ☐" button menu "SET CURRENTd".
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 separately for positive and negative set values. That is; if it is not possible to adjust the current above a certain value, please check the limit settings.

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

2.6 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.
For bipolar power supplies the set value will just change its sign, but for unipolar supplies equipped with a polarity reversal motor driven switch the following sequence is initiated.

- The DAC is set to zero.
- When the current **is** zero, the Main Power is switched OFF.
- The switch motor is activated to reverse the polarity.
- When the switch is in correct position, the DAC will be set back to the original value and the Main Power will be switched ON again.
- The output current will increase until it reaches the same or the new value again.

If the Main Power is OFF the above sequence is initiated but the Main Power is not switched ON.

2.7 Local / Remote control

When the Power Supply is in LOCal control, "LOC" is shown on the right side of the display. In REMote control "REM"is shown inversed on the right side of the display.

If LOCAL CONTROL has been required by the Control Panel, the Power Supply **is locked** in local Control mode, and Remote Control cannot be requested by the remote line.
If LOCAL CONTROL has been initiated the Remote line, the Power Supply **is not locked** in local Control.

The control mode can be changed from the CMD menu.

In REMOTE CONTROL mode all commands are ignored, and "ILLEGAL COMMAND" is displayed. All status information will still be displayed.

2.8 Interlock reading

Status and Interlocks messages are found under the INTL menu. For a better over view the messages are divided into four categories:

- INTernal. Internal Interlocks. Interlocks generated from faults inside the cabinet.
- EXTernal External Interlocks. Interlocks generated from faults outside the cabinet.
- FIRST First occurred interlock. In case of several interlocks coming fast after each other, the first one will be caught together with the occurred time (If the watch is not set right the present time is showed too. It is then possible to calculate the exact interlock time). (Only amiable with SMD control modules)

STATUS All status messages are located behind this menu.

For further information, please see the menu tables.
Interlock names may be renamed. This is performed at Danfysik during factory test or by Danfysik service personnel.

2.9 A/D Channels

Along with the output current and voltage, many other analogue values are monitored. These can be seen under the AD-CHAN menu. Please refer to the menu tables and the AD software command for further information.
Analogue cannel names and units may be renamed and rescaled. This is performed at Danfysik during factory test or by Danfysik service personnel.

2.10 D/A Channels

Extra values to be set are performed under the DA-CHAN menu. At the moment, only the slew rate value is implemented. This menu sets a hardware controlled slew rate value if enabled and the power supply is equipped with this feature. (Enabled through the SETUP menu.)
When equipped with the slew rate function, the interpretation of the slew rate value varies from supply to supply. Please refer to the regulation module description chapter for the actual interpretation.

2.11 SETUP of M-Panel

The working condition of the M-Panel is set through the SETUP menu. Normally all settings are preset during factory test and should **not** be altered. However, in case of a spare part replacement, changes to the default settings may be required.

Four submenus are available:

- BAUD	Sets the M-Panel communication speed. (Normally 9600 baud)
- COLOUR	LED color. RED, GREEN or "Yellow"
- SOUND	Enable or disable the artificial click sound when a button is pressed.
- DEFAULT	Restores all setting to default settings.
- OPTION	Enables or disables the slew rate setting and the multidrop address facility.

Ps. Interlock names and or AD/DA channel scales, units and names might also been changed. If so, this will be shown in the upstart screen as a pop up window with the text "Using download text table" else the text "Using default text table" will be shown. Text and scale conversions are performed at Danfysik during factory test or by Danfysik service personnel.

2.12 History window

The history window can be seen as an oscilloscope picture of the output current. The data is taken for the internal 8 or 16 bit ADC.

Ps. As the ADC's only are used for monitoring, not temperature compensated and have Hower resolution, the recorded traces **CANNOT** be used as an indication of the power supply stability. The History function should only be taken as an indication.

The picture (output current trace) can be shown in two modes Absolute and dynamic scale. In absolute scale the window will always have 0% at the bottom (-100% for bipolar supplies) and 100% at the top. The dynamic scale is automatically scaled for best pixel resolution. One pixel equals the ADC resolution or less to display the total trace current variation. The scale text indicates the actual chosen resolution for the current and the time.

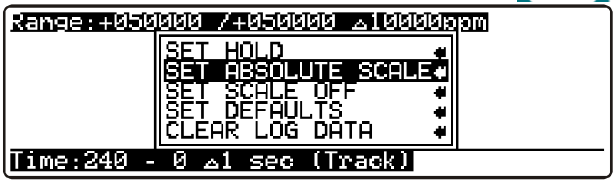
Output current values are sampled every second and stored in a log buffer. The log-buffer content is displayed via a viewport. The oldest samples are to the left and the newest samples are to the right. The view on the log-buffer can be moved backward or forward in time with the left-right arrows.

The size of the viewport can be increased or decreased with the up-down arrows to show more or less log-buffer samples at a time.
The maximum is 30 log-buffer samples per pixel (= 1 minute per pixel = total view of 2 hours).
The minimum is 1 log-buffer sample per pixel (= 1 second per pixel = total view of 4 minutes).
If the sample values differs within a time frame represented by one pixel column, then the sample values are displayed as a vertical pixel bar.

In tracking mode the viewport is automatically moved to the left when new samples are added to the log buffer, so the newest sample always become visible. When the log buffer is full the oldest sample is skipped when new samples are added to the buffer.

The log-buffer sample at the right edge of the viewport is used as anchor when the viewport size is changed with the up/down arrows. When tracking mode is enabled this corresponds to use of present time as anchor.

It is possible to hold the sampling to stop the scrolling. This gives a more understandable zoom operation. Pressing the MENU button inside the History window will not escape the operation, but will reveal a pop up option window. This shown in the right picture.



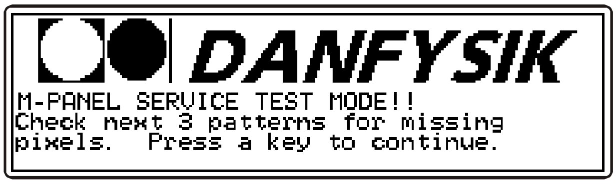
History sub menus:

- SET HOLD/TRACKING	Stops or enables sampling.
- SET ABSOLUTE/DYNAMIC SCALE	Display mode to absolute or dynamic mode
- SET SCALE ON/OFF	Removes or enables scale information.
- SET DEFAULTS	Restore to default display
- CLEAR LOG DATA	Starts a new sampling

Hint: The " ←" character to the right indicates that pressing the Enter key will set the inversed shown item.

2.13 Self test

The M-Panel graphical has a built in self test program. It can be invoked by holding three buttons down at the same time as applying the supply voltage. The picture to the right shows the opening window.



Follow the screen information and see if every thing works fine.
First the visual interface will be tested LCD & LED. Upon each new pattern on the LCD screen and a new LED is lit and a small beep will be heard. After the visual interface test the next to come is the serial line and the buttons. This requires some help from the user. If the LCD contrast is poor, it can be adjusted with a screwdriver from the back. (Through the round hole)

PS. When the screen ask to connect the RX and TX line, please then just continue.
The test software is designed to have the TX looped back to the RX in the serial line. Connected to a Control module this is however not the case. Therefore this will result in error messages when testing the keys. These error messages should be accepted as good working condition as the key pressed was accepted, the SW transmitted the key code but the control module could not understand this code and answered with the error message that hopefully was received well by the M-Panel.

The picture to the right shows the end test window after some keys have been pressed. The receive window indicates that the M-Panel is connected to a Control module, else the text will be the same on both sides.