LV Powersupply
HEC Note 137

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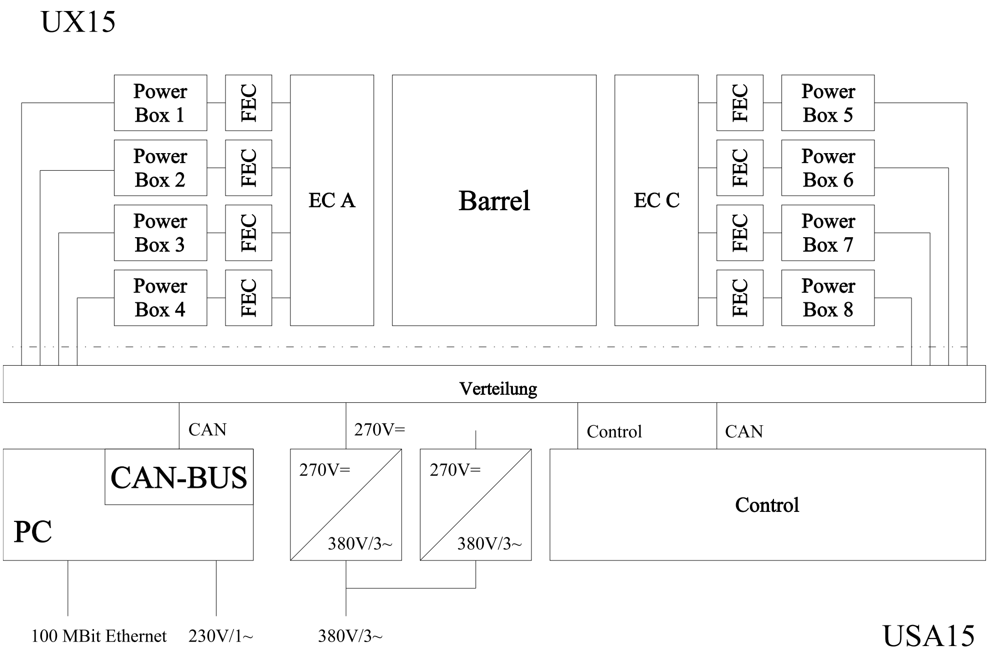
Contents

Chapter 1

Overview



1.1 Requirements

The design of the powersupply for the preamplifiers of the HEC(Hadronic Endcap Calorimeter) are discussed. The HEC calorimeter is part of the ATLAS detector at CERN. It consist of two endcaps. Each endcap has 160 PSB‘s (Preamplifier and Summing Board). The total sum is 320 PSB‘s.
Voltages for a PSB are:

- 7.0V (7.2V at the output of the Low Voltage - Powerbox)
- 3.0V (3.2V at the output of the LV-PB)
- -1.5V (-1.6V at the output of the LV-PB)

For the Powersupply it is important to know, that there are different types of PSB Boards.
The maximum currents per PSB are:

- I(7.0V)= 0.50 A
- I(3.0V)= 0.19 A
- I(-1.5V)= 0.09 A

1.2 Realization

The system consist of different parts.

- 1. converter from 380V/3∼ to 270V DC
- 2. conversion of the 270V DC in to the three middle Voltages (10V/6V/-4V).
- 3. conversion of the middle voltages to the three output voltages.

1.2.1 Location at detector:

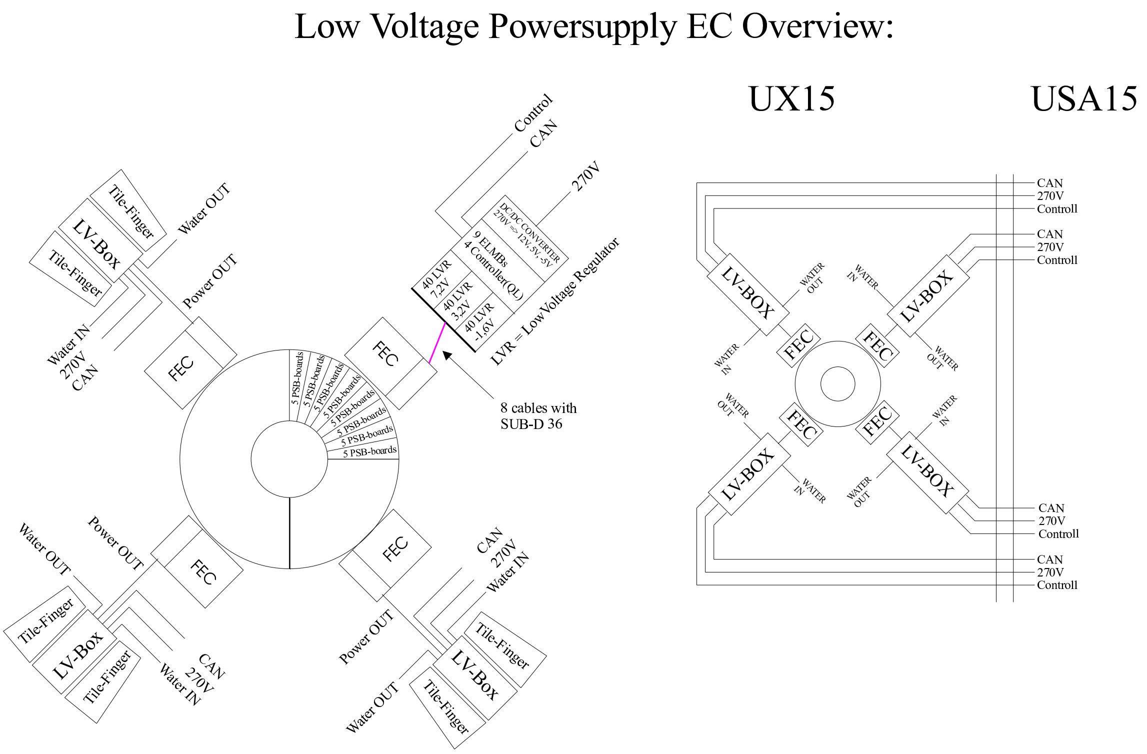


Figure 1.1: Low Voltage Power supply EC overview

The components are at the following locations:

USA15	Conversion of the 380V/3∼ Voltage to 270V DC.
TILE-Finger-Region -	HEC-Low-Voltage-Powersupply-Box Conversion of the 270V DC to the three middle Voltages. Last Conversion of the middle voltages to the output voltages.
FEC(Frond end Crate)	In the Front End Crate are two one inch wide connected to the related feedthrough. The two boards are without active electronic components.
Cryostat	In the cryostat is the calorimeter with the PSB boards.

Control and monitor requirement:

- All output channels can be switched on and off separately. one channel consist of three Voltages.
- It is possible to measure the current and voltage of each channel and output separately.
- The control and monitoring of the Power Box is done with the SCADA Software PVSS2 from ETM (Austria).

Realization for higher safety requirements:

- For each middle Voltage are two DC/DC Converter in the Low-Voltage-Powersupply-Box.
- Additional interfaces for the control of the powerbox.

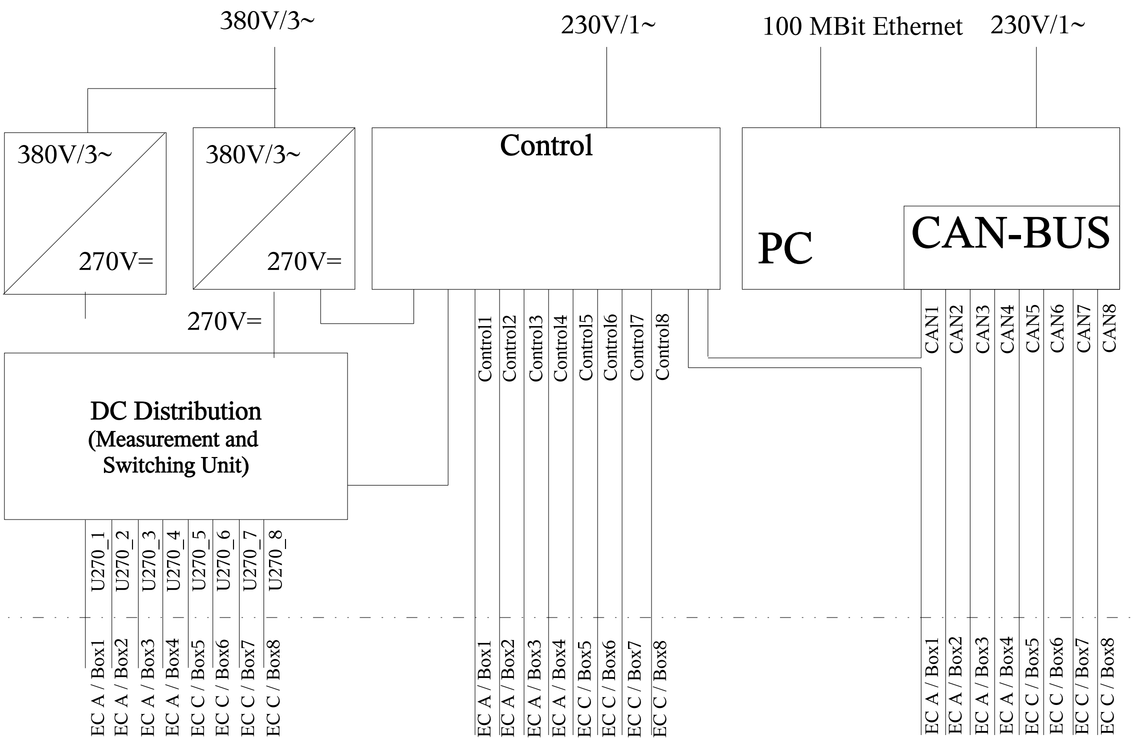
Device overview:

	ELMBs	QL-Chips	PSB boards	Voltage Regulators	
				positive	negative
Low Voltage Supply System for 2 EC	72	32	320	712	320
1 EC(with 4 Quadrants)	36	16	160	356	160
1 Quadrant (power box)	9	4	40	89*	40
1 Wedge(power supply channel	1	0.5	5	10	5
1 channel				2	1

Chapter 2

USA15

In USA15 is the crate with the PC, the 270V Powersupply, the 270V distribution and the manual control.



2.0.2 PC with CAN cards

For the control of the power supply we need a PC with two Kvasar CAN-Cards. The control will work with the SCADA software PVSS2 from ETM. The two CAN-Cards supporting 8 CAN-Buses. May be we will use a serial interface to the manual control interface at USA15.

2.0.3 270V power supply

Which safety devices are necessary. Do we need a ground shortcut detection , like for IT nets?

2.0.4 CAN power supply

The CAN-Bus has no galvanic connection, for this reason the CAN-Bus needs his own power supply. Each CAN node needs 20 mA, with 72 CAN-nodes we need a power supply for 2.0A(calculated 1.440 mA). Each Box has a CAN supply load of 180 mA(9*20 mA).

2.0.5 Possibility of ELMB Digital part power supply

The problem with the Power supply from the USA15 crate is, that we have a ground connection from USA15 to the digital part of the ELMB, but it has the same ground as the low voltage regulators. In consequence we have a direct connection from USA15 to the PSB boards in the HEC-End Cap.

2.0.6 270V distribution

The 270V distribution gives the ability to switch on and off the power boxes separately. If one power box has a short cut at the input we are able to switch of this power box. If we have an isolation problem in the power box,it will be switched off.

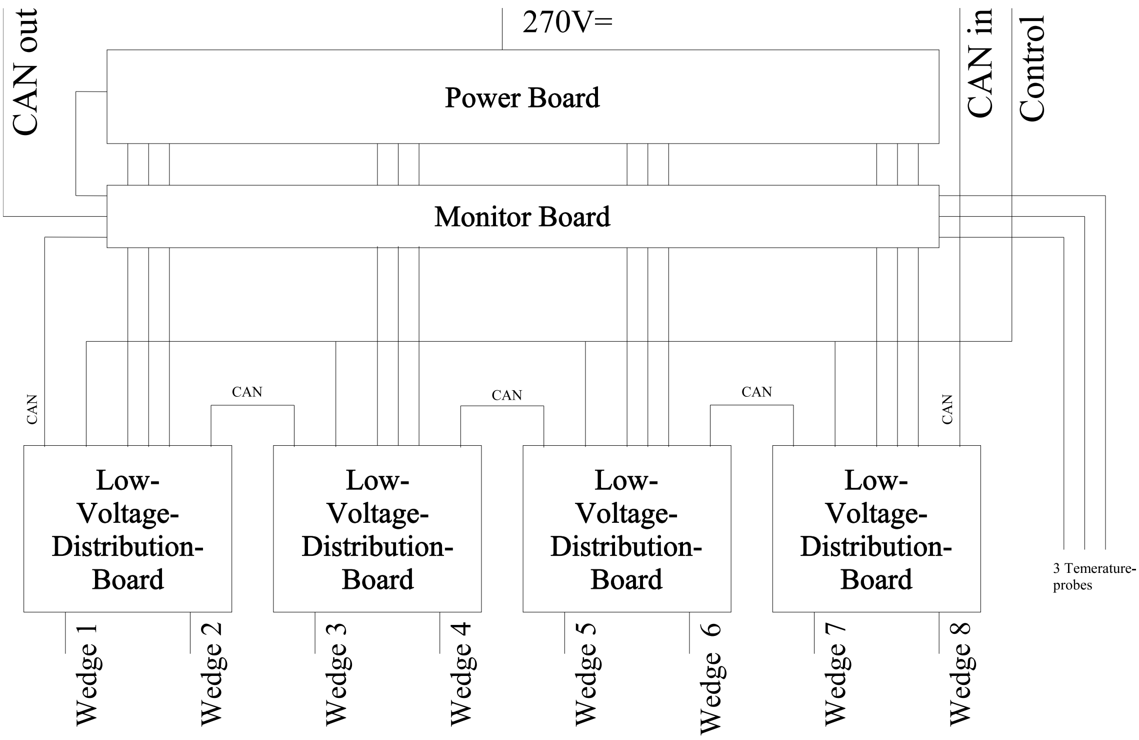
2.0.7 Control Unit

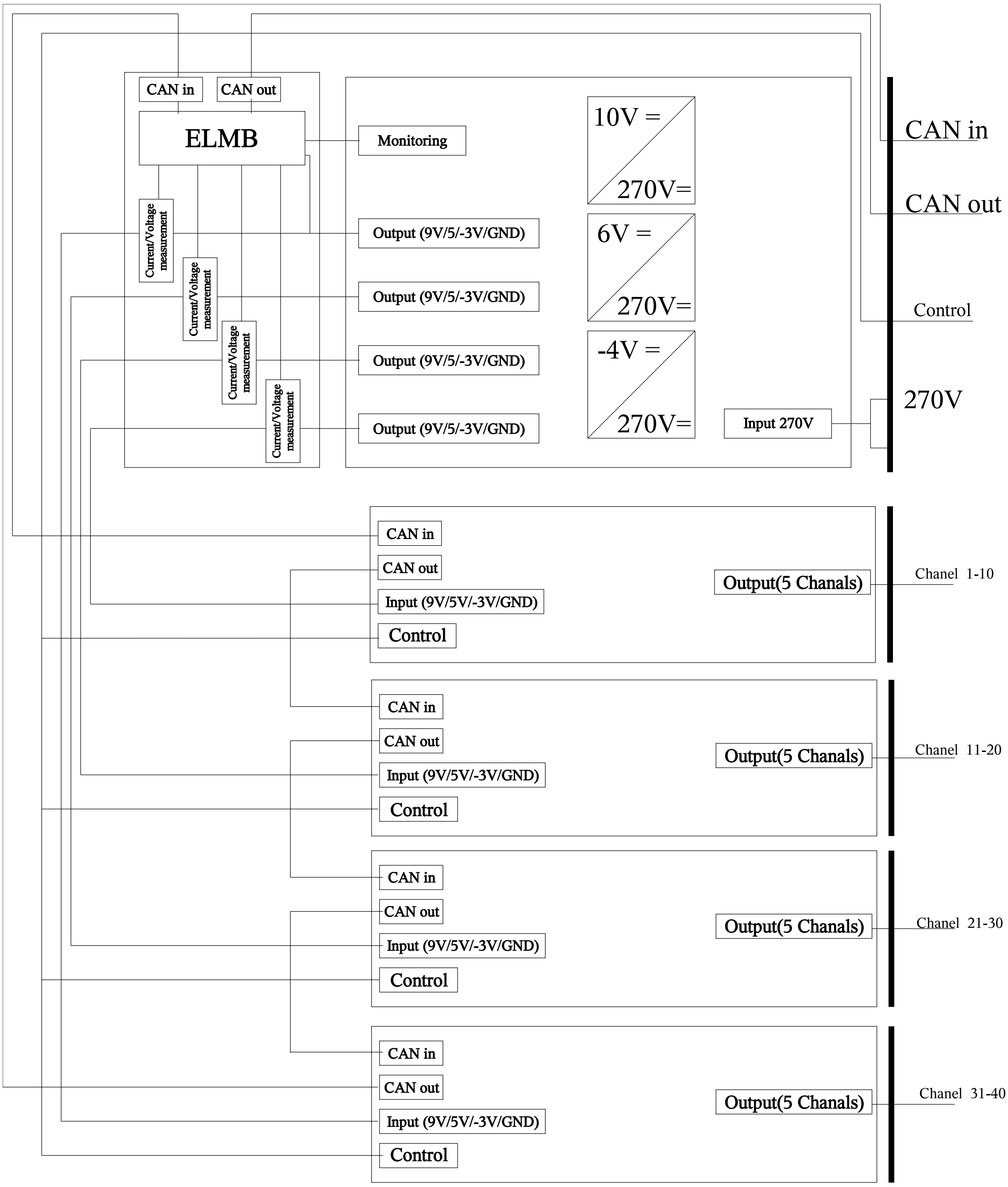
The Control Unit gives us the ability to control the power box in the moment when the CAN-bus isn't working. This is the emergency option to control the power box. The control should work with a serial protocol.

Chapter 3

Power Box

The Power Box consists of 2 layers. The first layer are the converters from 270V DC to the different middle voltages. The Low Voltage Regulators are converting the middle Voltages to the output voltages. The Low Voltage Regulators can be switched on and off from the controller chip. The controller chip switches all three Voltages of one channel at once. It gets the status information from each Low Voltage Regulator. This status information shows if there is a over current. The Controller has an interface to the CAN-Bus node (ELMB). The three Voltages and Currents for each PSB Board can be measured separately. Each Box provides the powersupply for 40 PSB Boards. Each PSB Board can be switched on and off separately.





3.1 Power Board

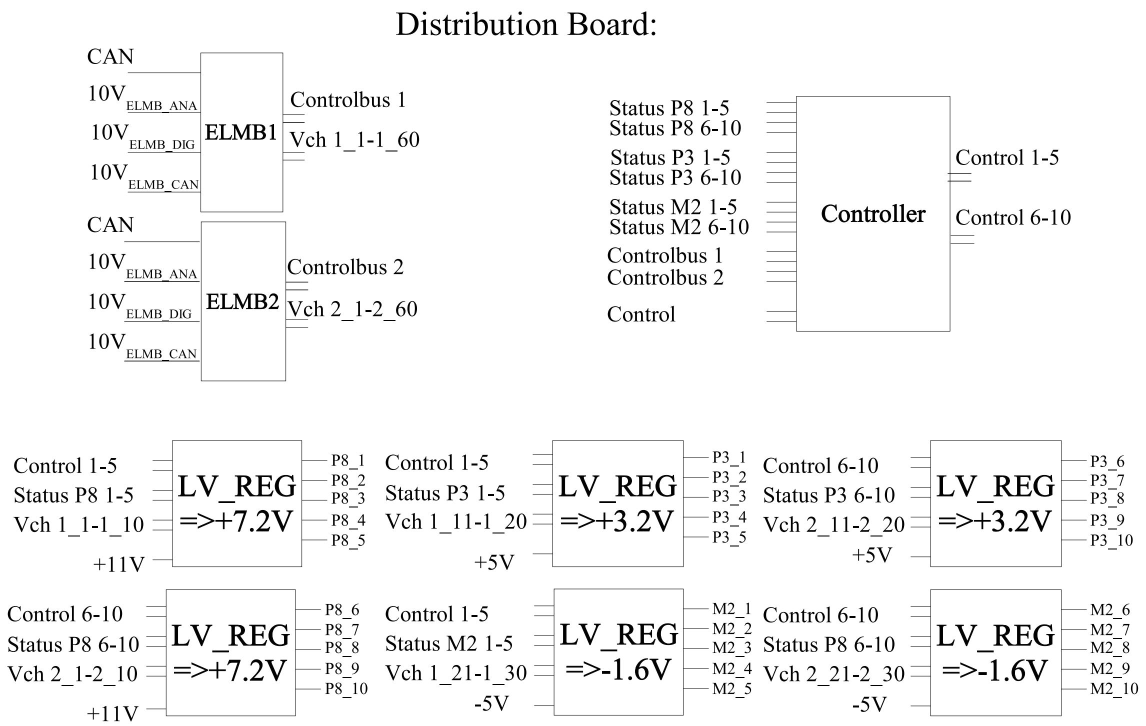
The Power Board converts the 270 Volt DC to the three middle Voltages. The board consists of the DC/DC converter and has a n+1 safety, witch means that one device per Voltage output can be destroyed and the output channel will still work.

3.2 Distribution Board

The Distribution Board consists of two ELMB‘s, one Low Voltage Controller(Quicklogic chip QL3012-2PF144C), 80 positive Low Voltage Regulators and 40 negative Low Voltage Regulators. The ELMB‘s have an interface to the Low Voltage Controller.

3.2.1 Input voltages, CAN, Control

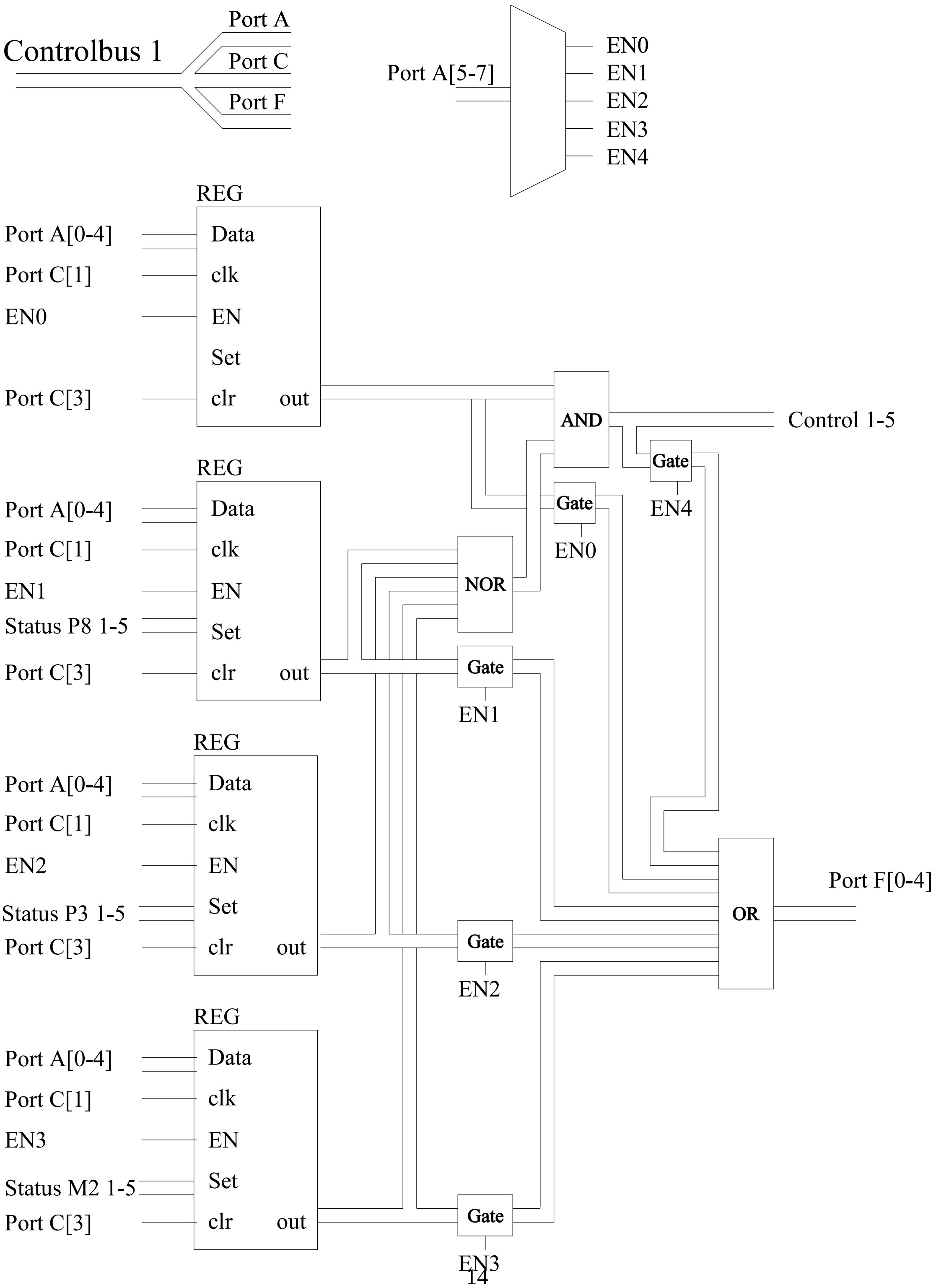
For the Low Voltage Regulators and the power supply of the ELMB and QuickLogic Chip we need three input Voltages: 10V, 6V and -4V.



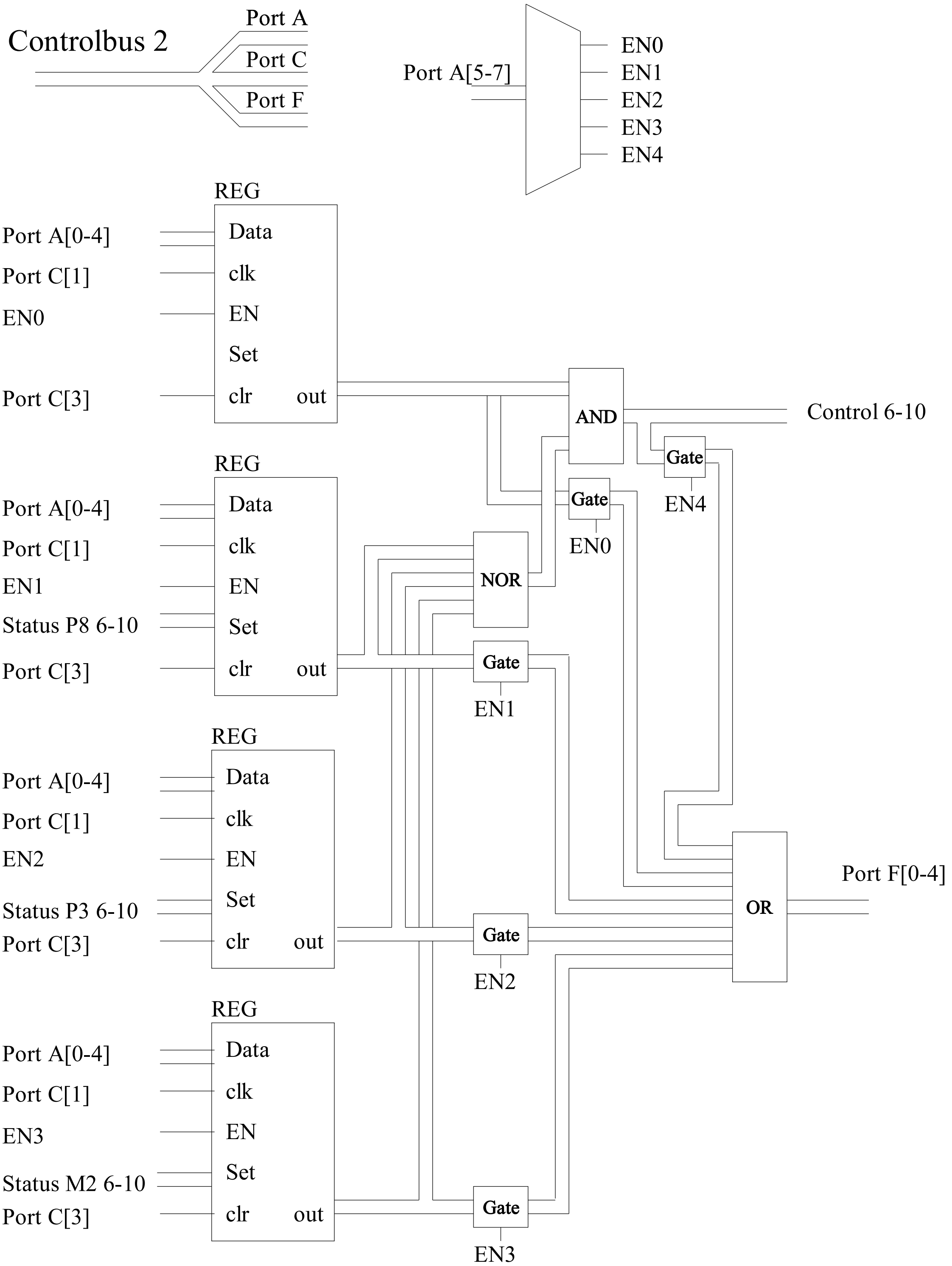
3.2.2 Low Voltage Controller

The controller chip is a FPGA from Quicklogic. It will be programmed in antifuse technologies. The type name is QL 3012 2 PF 144C. The chip has to be radiation hard. The current design is described with an schematic entry. For the second prototype the design will be modified.

Controller (1/2):



Controller (2/2):



Overview

- Control Bus
  - Port A (input)
  - Port C (input)
    - *
  - Port F (output)
- Status input from the Low Voltage Regulators
  - Status plus 7.2 Volt(OC8L)
  - Status plus 3.2 Volt(OC4L)
  - Status minus 1.6 Volt(OC2L)
- Control output to the Low Voltage Regulators
  - Control output plus 7.2 Volt
  - Control output plus 3.2 Volt
  - Control output minus 1.6 Volt

Interface from the ELMB(Control Bus)

The controller can be accessed from ELMB1 and ELMB2. The access is via the control bus. The control bus consists of an address, a data write, a data read and a control bus.
5 bit data write bus (Port A 0-4) Bit 0 to Bit 4 - Data Bus for the four registers

3 bit address bus (Port A 5-7)
Bit 5 to Bit 7 - Address Bus for the selection of the Registers.
The selection is for read and write access.

5 bit control bus (Port C 0-4)
Bit 0 to Bit 4 - Control Bus

Bit 0 - CLEAR , resets only the addressed register.
Bit 1 - CLOCK , clock for the selected register.
the value of the Data Bus is only registered
after a signal change from low to high.
Bit 2 - SET , Sets all five bits of the selected register
Bit 3 - PCLR , resets all four registers
Bit 4 -

5 bit data read bus (port F 0-4)
Bit 0 to Bit 4 , read back Bus
with this Bus one reads back the value of the
selected register.

3 bit error message bus (port F 5-7)

Serial Interface

Protocol of the serial data transfer from USA 15(Crate)
to the Power Box.

One Package:

| r/w | aaaa | ddddd | ccccc |

r/w = if ’1’ read, else write
a = address (4 Bit)
d = data (5 Bit)
c = crc (5 bit)

Signal lines of the serial interface

Data in	= input stream
Data out	= output stream
clk	= data clock
reset	= interface reset

4 signal lines.

Registers of the Controller Chip:

control1	control of the Low Voltage Regulators
err_p8_1	status register of the p8 Low Voltage Regulators
err_p3_1	status register of the p3 Low Voltage Regulators
err_m2_1	status register of the m2 Low Voltage Regulators
control2	control of the Low Voltage Regulators
err_p8_2	status register of the p8 Low Voltage Regulators
err_p3_2	status register of the p3 Low Voltage Regulators
err_m2_2	status register of the m2 Low Voltage Regulators

Parallel interface

Version1:
each channel is controlled with one signal and monitored with a second one. One channel consist of the three voltages (8V/3V/-2V)
In this version we need 40 signals for control and 40 for monitoring plus 2 for supply. In total we need 82 signal lines.

Version2:
Because of the granularity of the High Voltage we need only a maximum of 32 channels to control.
For this version we need 32 signals for control and 32 for monitoring plus 2 for supply. In total we need 66 signal lines.

Version3:
if we control only two sections of a wedge we need only 16 channels to control. In this version we need 16 signals for control and 16 for monitoring plus 2 for supply. In total we need 34 signal lines.

Version4:
if we control only one wedge separately we need 8 channels to control.
In this version we need 8 signals for control and 8 for monitoring plus
2 for supply. In total we need 18 signal lines

Control of the interface access

not designed.

Decision of the Interfaces

The main interface is the interface to the ELMB. The second interface is the interface to the serial bus. The third interface is a parallel interface to switch on or off each wedge separately.

for this version we need 18 plus 6 line (total 24 lines)

Function of the Status input from the Low Voltage Regulators

OC8L,OC4L,OC2L , if there is an error on one of the 15 input signals
the output of the channel is switched off and does not recover
since the status register is reseted or the whole chip is
reseted.

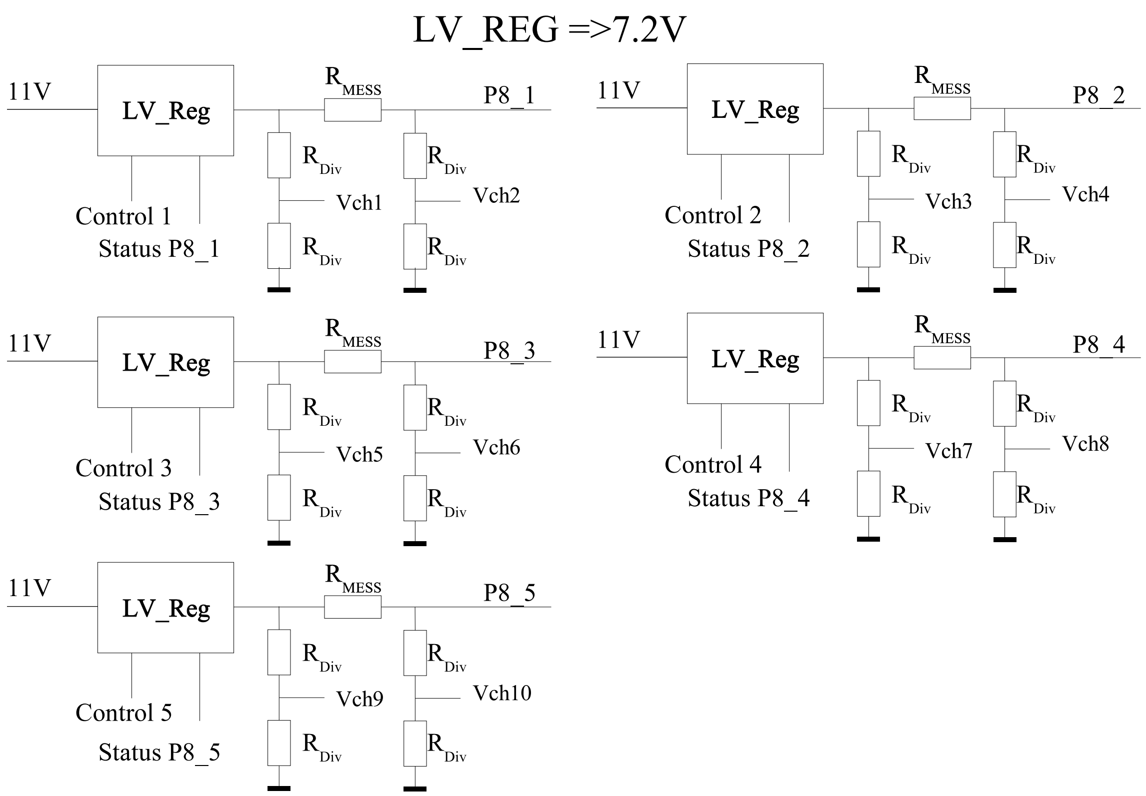
3.2.3 Usage of the ELMB

The ELMB will be used for the control and measurement of the Low Voltage Regulators. Each ELMB has 64 analog input channels and 3 digital ports. The digital ports are the port A with 8 bidirectional lines, port C with 5 outputs and port F with 8 inputs. The ELMB has a CAN bus interface with 125 kbaud transmission rate. We will use 9 ELMB‘s per one CAN bus.

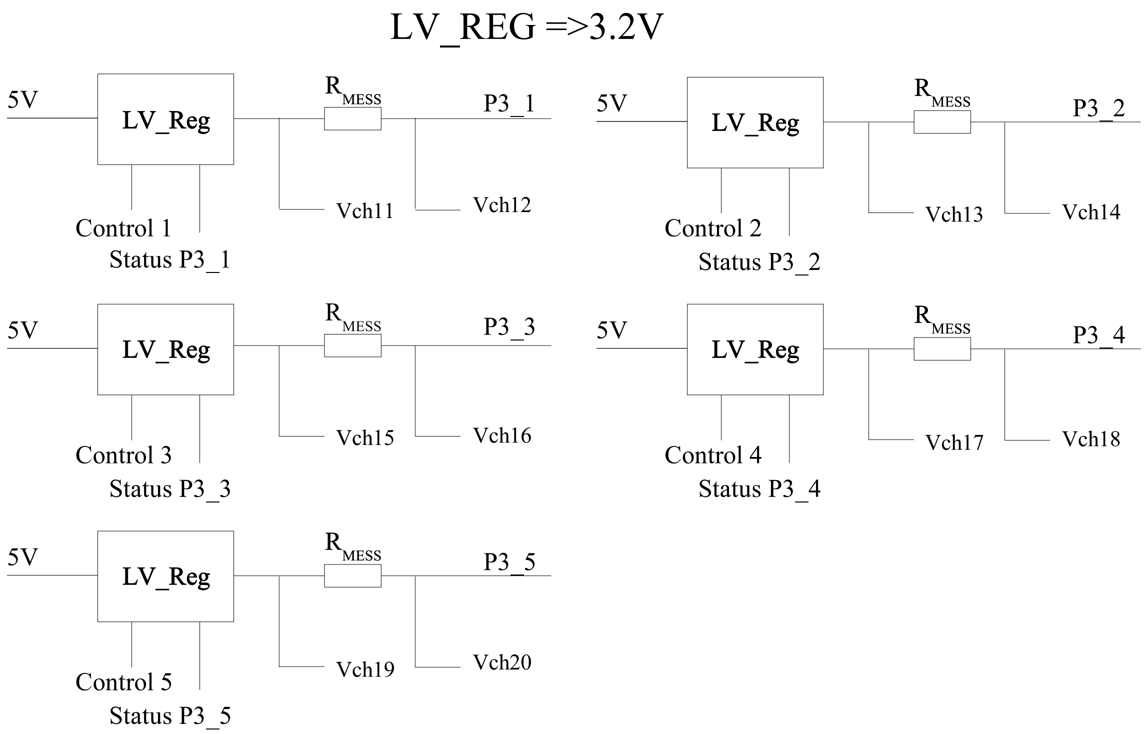
3.2.4 Low Voltage Regulators

The Low Voltage Regulators have a current regulation that will be adjusted to protect the cables in the feed through. For the voltage and current measurement it is important to know, that the ELMB has a maximum input voltage of 5 V. For this reason the Voltage before and after the current measurement resistor of the 7.2 V supply will be divided by two. For the 3.2 and the minus 1.6 supply the voltage has not to be divided. The input range will be configurated for voltages from +5.0V to -5.0V.

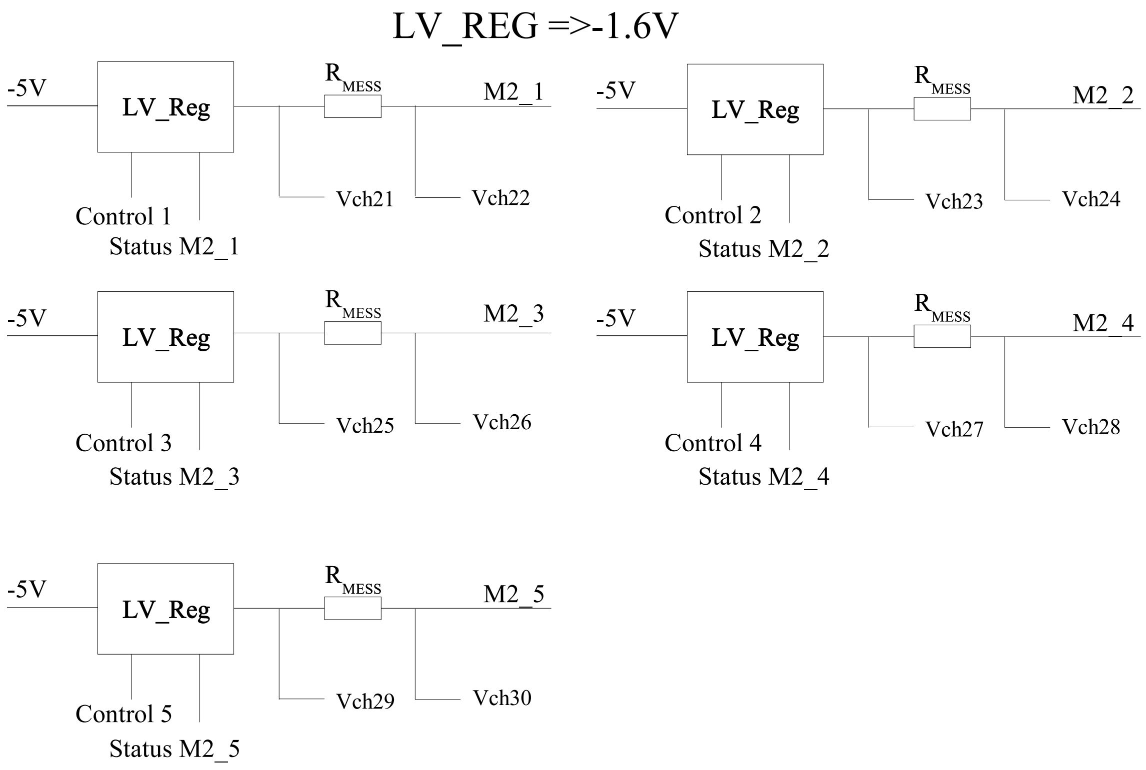
Plus 7.2 Voltage supply



Plus 3.2 Voltage supply



Minus 1.6 Voltage supply



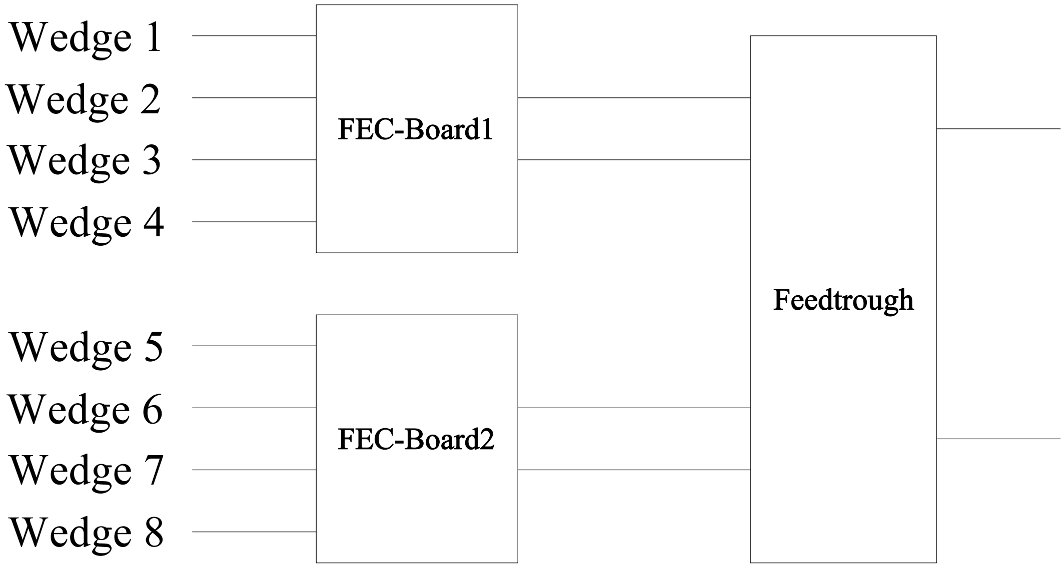
3.3 Monitor Board

see specification in appendix C.

Chapter 4

Feedthrough Board in the FEC

The Feedtrough board is mounted in the FEC. This board connects the cables from the power box with the warm cables of the feedtrough. It has only passive filters for the power supply lines. The power lines are in the middle layers of the board, the top and bottom layers of the Feedtrough board are the shielding that is connected to the FEC shielding.



The position of the Feedthrough board is as in the Atlas Cabling note AL-ES-0004 figure 19,page 29.

38	Feedthrough-board 1
37	Feedthrough-board 2
1	

Chapter 5

Connections

5.1 Cabling between the Power Box and the Front End Crate

The Power Box and the Front End Crate are connected via 8 cables, each with 36 lines with a cross-section of 0.25 mm^2 The cables are connected with 37 SUB-D connectors. On the Power Box and on the Front End Crate is a female connector

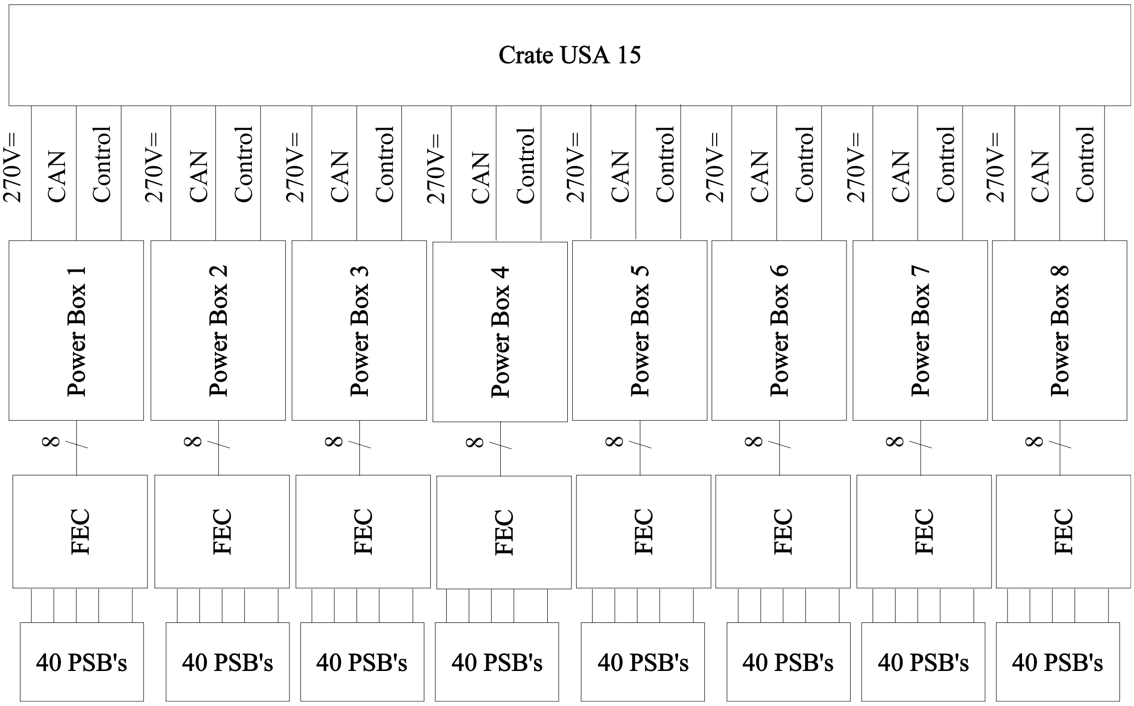
The exact position of the Power Box is not known yet.

5.2 Cabling between between USA15 and the Powerbox in UX15 in the TILE-Finger region

for each Power Box we need:

- 270V power supply cable (connector is not yet specified)
- CAN-Bus (SUB-D 9)
- Control cable
  - Powersupply for CAN-Transceiver
  - Powersupply for the digital part of the ELMB (it is forseen)
  - Control cable (not yet specified)

Cabling_USA_15_to_UX15:



Chapter 6

Testbench

For the Powerbox we need a testbench to check if the Power Box is working properly under all conditions. In this testbench will be for each output one current drop. Each channel has 3 voltages, they are 7.2V/0.5A, 3.2V/0.2A and -1.6V/0.1A . The power consumption of the three channels is 3.6W+0.64W+0.16W=4.4W. The total power consumption of the Testbench is 164W. The current of current drops should be for each channel and voltage adjustable. The current and voltage should be measured. The testbench will be built as a modular system. For the test of the Power Box we need 8 groups of current drops. Each group for 5 channels with 3 voltages for each channel. The current drop should be controllable.

Chapter 7

Fault Scenarios

What happens if some parts aren’t working in the Power Box?

7.1 CAN-Bus module(ELMB)

One CAN-Bus Module(ELMB) blocks the bus , because the transceiver has a short cut.

effect	all 9 ELMB’s of the bus can’t be accessed.
	one quadrant is with no control from the can bus.
solution	the control of the powerbox will still work with the serial controll.
probability	it isn’t probable.

One CAN-Bus Module(ELMB) slows down the bus because it sends a huge amount of messages.

effect	
solution	
probability	

In one CAN-Bus Module(ELMB) is the firmware destroyed.

effect	
solution	
probability	

In one CAN-Bus Module(ELMB) the output driver are destroyed.

effect	one wedge can not be controled with the ELMB.
solution	the control of the wedge will still work with the serial controll.
probability	possible

In one CAN-Bus Module(ELMB) the analog inputs are defect

effect	the currents can not be monitored.
solution	the monitoring can only detects overcurrents with the LVR.
probability	

No communication is possible with the CAN-Bus Module(ELMB).

effect	one wetge can not be controled with the ELMB.
solution	the control of the wedge will still work with the serial controll.
probability	

The CAN-Bus Module(ELMB) has a high input current in the digital part because of a Latch-Up Effect

effect	The ELMB can be destroyed.
solution	switch on and off the power supply of the digital part of the ELMB
probability	

7.2 Low Voltage Regulator

One Low Voltage Controller could not be switched on or off with the control input.

effect	the PSB on this supply channel can not be controlled
solution	no solution(may be switch off of the box)
probability	

One Low Voltage Controller signals a high current, but there is no high current.

effect	The Low Voltage Controller switches off the supply channel.
solution	
probability	

One Low Voltage Controller has a high input current

effect	the Box could be distroyed
solution	the Box have to be switched off.
probability	

7.3 Low Voltage Controller

The Controller (QuickLogig Chip) draws a high current,(Latch-up Effect).

effect	the controller can be distroyed.
solution	switch on and off the power supply of the controller
probability	

One of the output drivers of the controller chip is defect.

effect	the Low Voltage Regulator can not be controlled
solution	
probability	

One of the input cells of the controller chip is defect.

effect
solution
probability

The internal logic is destroyed.

effect
solution
probability

7.4 DC/DC - converter

One DC/DC converter give no output voltage.

effect
solution
probability

One DC/DC converter has on the input a short cut.

effect
solution
probability

One DC/DC converter has on the output a short cut.

effect
solution
probability

7.5 Failure in the USA 15 Crate

Failure of the PC.
  effect
  solution
  probability
Failure of the DC powersupply
  effect
  solution
  probability

Chapter 8

Grounding and Shielding

Ground problem:
solution for the digital power supply of the ELMB's:
1. external power supply from USA15.
With this solution we get one problem: there is a ground connection from the detector to the power supply at USA15. This is because of the connection of the digital part of the ELMB and the Low Voltage Regulators.
2. Power supply of the ELMB from the 9V middle Voltage. The supply need for each ELMB one LVR with one control and one monitor signal. (16 lines per box plus 2 supply)

shield:

which shielding solution should we use?

Chapter 9

Radiation Hardnes

All components in the power box and on the feed trough board have to be rad hard.

Requirement:

- TID: 120 Gy
- NIEL: $1.2 * 10^{12}\ n/cm^2$
- SEE: $6 * 10^2$

Quicklogic Chip QL3012

- Dubna 2000(preselection)
- Dubna 2002(qualification)(neutrons and gammas)
- ucl 2002(qualification)(protons for single event effects)

ELMB
see radiation test of ELMB

Low Voltage Regulators:
verification from CERN

Optocoupler
it is forseen to use the same as for the ELMB

Chapter 10

Interlock

The low voltage system has to be switched on before the high voltage is applied to protect the cold electronics. In case the low voltage system has to be switched off, first the high voltage has to be turned off. This is supposed to be done with a software interlock. For this reason it is necessary to clarify the correlation between the single high voltage channels and the corresponding low voltage PSB boards.

One wedge has two modules, one front and one rear module, each module is divided in two longitudinal sections and each section has 4 corresponding high voltage lines (HV). Section one, three and four are read out with one PSB board, section 2 is split up into two PSB boards, as shown in figure1. Each PSB board has to be supplied with 3 voltage levels, which are in sum one low voltage channel (LV).

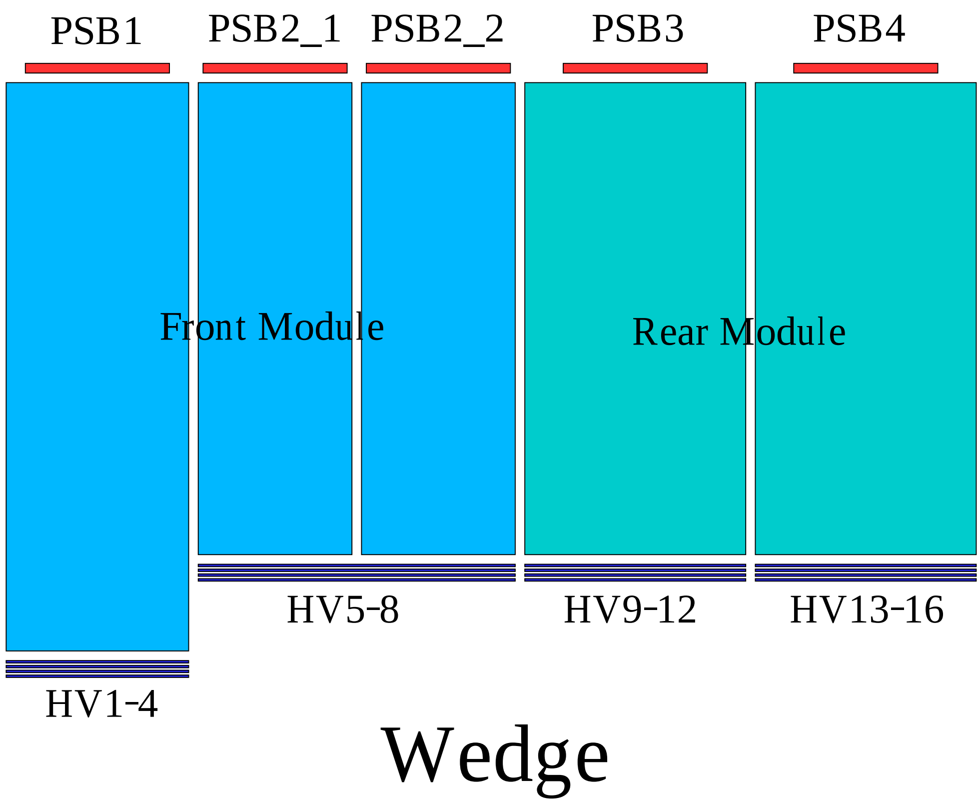


Figure 1: High Voltage channels with corresponding PSB distribution

Thus one low voltage Power Box provides one quadrant of one End Cap, this means it has 40 low voltage channels and 32 corresponding high voltage channels. Each low voltage channel and each voltage level can be switched off by hardware (over current protection in the voltage regulators) and by software (PVSS) separately.

To switch on a high voltage channel, it is required that the corresponding low voltage channel is on. Vice versa,to switch off a low voltage channel it has to be verified that the corresponding high voltage channel is off. To realize this as an software interlock, four data points in PVSS have to be created, as described in figure 2.

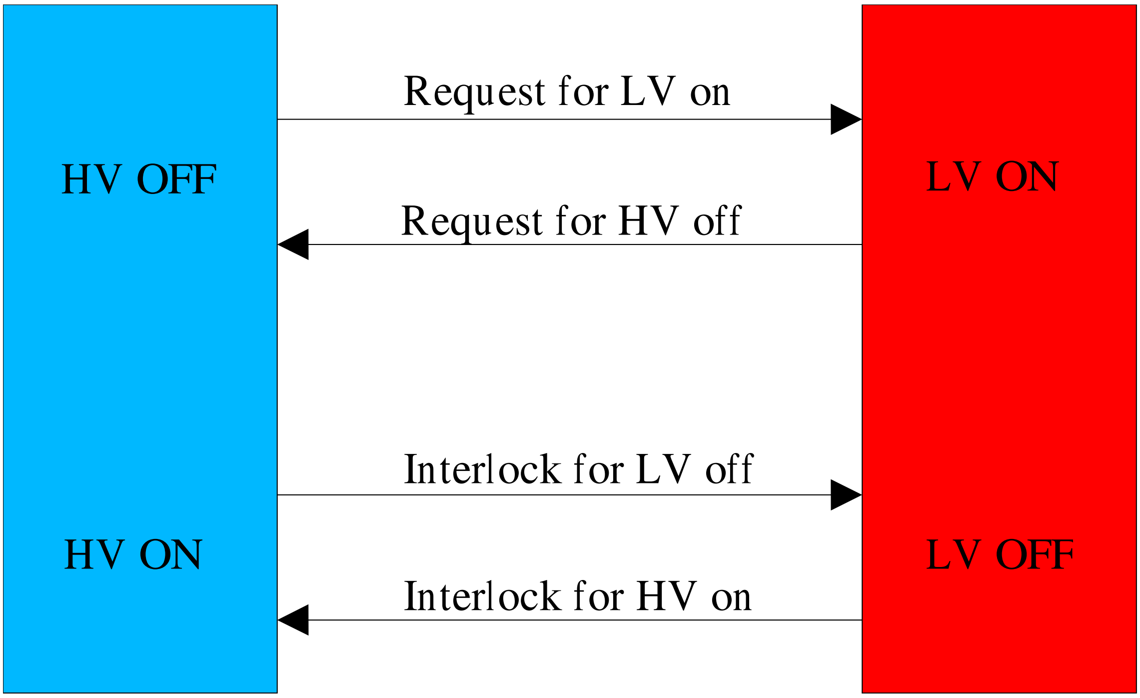


Figure 2: Four PVSS data points are needed to create an interlock between the LV and HV system.

The Figures 3 and 4 explain the conditions for HV and LV to be switched on/off.

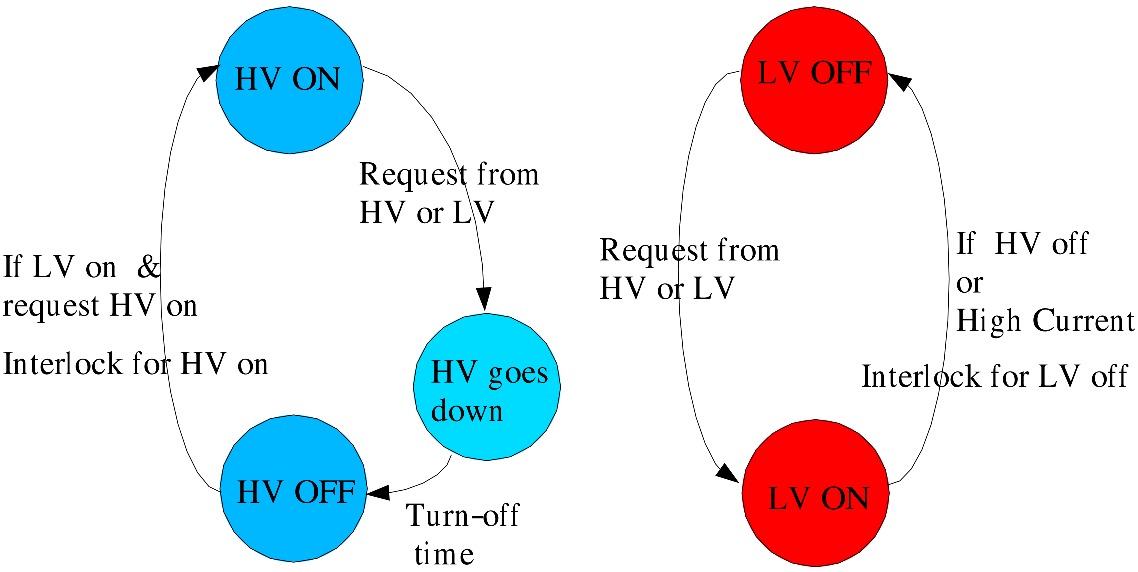


Figure 3: Phase diagram for HV and LV

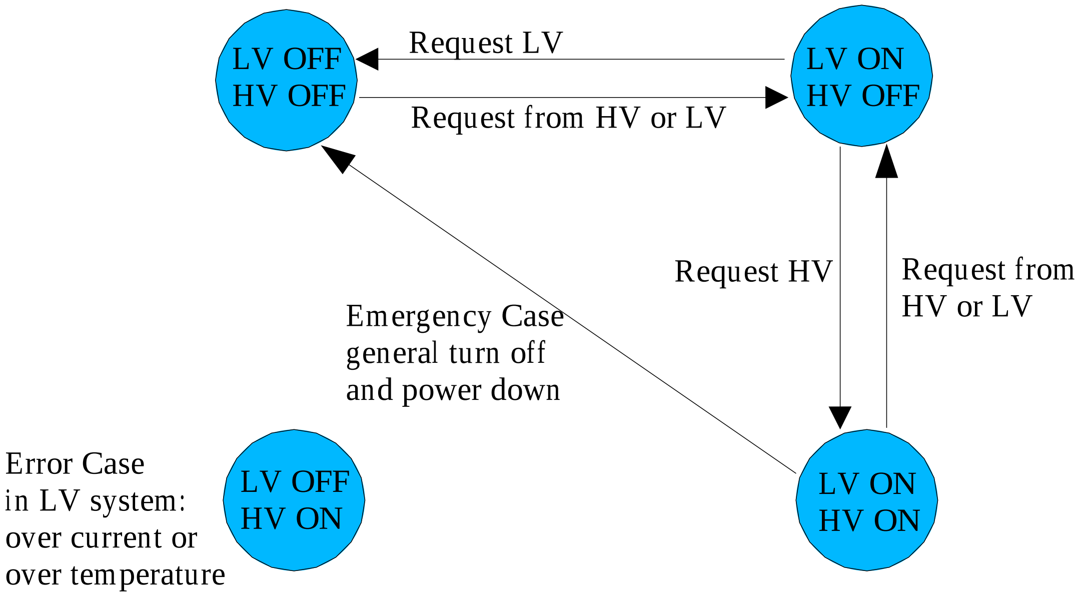


Figure 4: Conditions for HV and LV to be switched on/off

Chapter 11

Cooling

It is planned to provide the low voltage Power Box with cooling water in the space behind the Power Box, as shown in figure1. There is a tube from the edge of the tile finger to the front plane of the power box. The bolts and outlets are not yet specified.

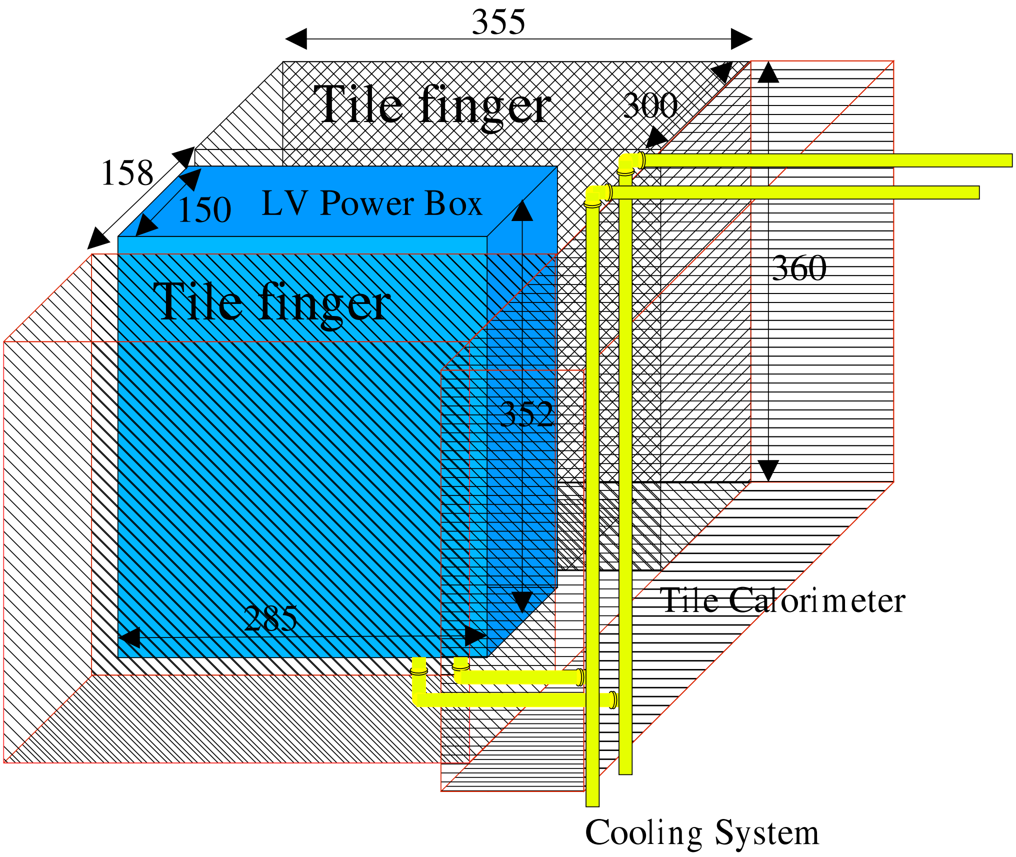


Figure1: Position of water cooling tube with respect to the Power Box and tile finger

As for the FEC power supply, cooling water circulates at a pressure of 600mbar below atmospheric pressure.

the water temperature is 18°C and the flow rate and the temperature gradient in the box are not yet specified. Heat conductive rubber (e.g. silicon) should be used between the cooling plate and components; (e.g. product from Kunze).
The cooling cables need to be specified.

Power Consumption

The power loss of the whole box will be less than 300W. The power loss is shared by the three cooling plates evenly. The loss is split up into:

Efficiency of DC/DC converters: a maximum loss of 100W is specified.

Voltage loss of voltage regulators, a maximum loss of one regulator is 0.5A*4V=2W, the minimum is 0.09*3.4V=0.3W.
120 Voltage regulators have an average loss of about 100W.

Monitoring and Control:

All output voltages and currents will be monitored. Also the internal output voltages and currents of the Power Board will be monitored. The temperature will be directly monitored. Control signals are provided indicating the correct operation of the ELMB's and the DC/DC converters. Monitoring of the digital current of the ELMB and the option to cycle the ELMB digital power will be provided. In case over current is detected, it should lead to a reset of the ELMB, but the Quick Logic Chip will still work as it is supplied with power separately.
The temperature will be measured with precision temperature depending restistors and will be monitored.

Chapter 12

Mechanics

The following figures give an impression of the Power Box.

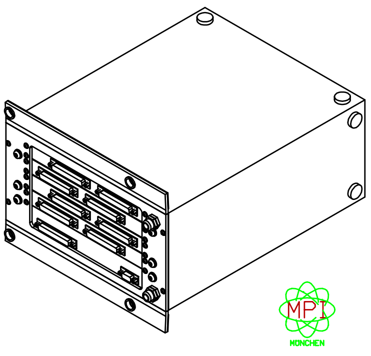


Figure 12.1: Exterior view with front plane

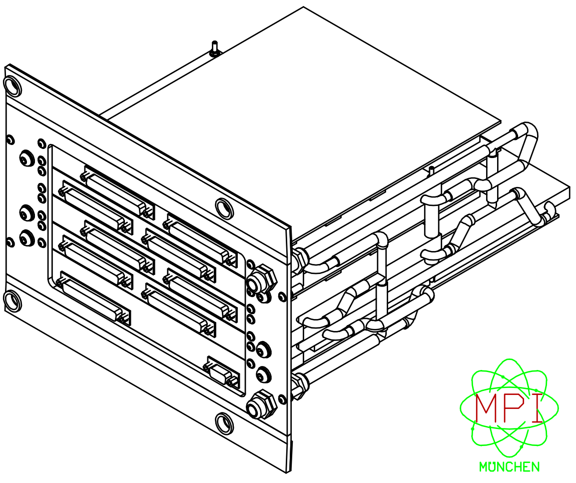


Figure 12.2: Interior view with water cooling

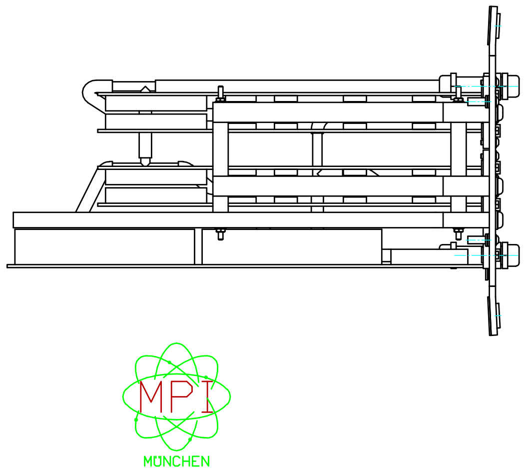


Figure 12.3: Side view

The box has to be electronically isolated and has to be shielded as it operates in a magnetic field. It will be made of aluminium and isolated with some material around or same spacers.

Dimension and weight

The dimensions are the same as BNL FEC Power Box:

150mm (width or Dj) *
285mm (z)*
352mm (R)
(coordinate system of the Detector)

The front plane of the box is 4mm thick, the body walls are 0.5mm.
The weight of the Electronic including cabling is supposed to be about 3kg. The total weight of the Power Box is supposed to be about 20kg.

Mounting of the Power Box to the tile finger

In case of an error in the box, the box should be exchanged completely. For this reason the front plane of the box will extend beyond the box boundaries on both sides. In this overlapping area with the tile-finger it is fixed with four bolts to the tile finger and isolated with plastic around each bolt.

Inputs:

Input voltage : 270 VDC nominal current maximum 2A
Connector:

Each Power Box has its own Can Bus to supply nine ELMB's. This means in total there are four Buses / Endcap. In case of an error in the CAN BUS, one quadrant will be dead. The +10V digital power and the +10V CAN BUS power for the ELMB128 are also supplied externally. A signal shows the operator that the ELMB is in operation.

Connector: one SUB-D 9 pole
Control lines
Connector: one SUB-D 37 pole
Water in
Connector:

Outputs:

hundred twenty (120) * Power Outputs to PSB Boards;
There are 40 output voltage channels with -1.6V, 3.2V, 7.2V each. These voltages are generated with ST L4913 and ST L7913 voltage regulators.
Connectors: eight SUB-D 37 pole
Connection with the cold electronic PSB boards through two Feedthrough boards (FEC_LV_Boards) with four Connectors/Board. This means 8 cabels (one for each wedge).

Water out
Connector:

Structure of the Power Box

There are three cooling plates, which are directly mounted on the front plane of the box. All printed circuit boards are fixed onto the cooling plates. There is an isolating, heat conducting foil between the cooling

plates and the electrical components on the printed circuit boards. All three cooling plates are bolted with a rod to one mechanical unit. There are four identical power distribution boards, mounted on both sides of two cooling plates. The last cooling plate is coupled to the power board.
For the cooling water there will be one inlet and one outlet. Internally the cooling plates are connected with hoses. The electrical connections inside the box are placed in z-direction behind the electronic/cooling block.
All electrical connectors will be bolted to the front plate of the box and soldered on the boards. The printed circuit boards have a dimension of 200mm*250mm, with exception of the power board with 200mm*220mm. The dimensions of the cooling plates are adjusted to the area of the electronic components, that have to be cooled.

Safety precautions

If case the box has to be exchanged it has to be made sure that the 270V are really switched off. For this case a green LED could be placed in the front plate, indicating that the 270V is switched on. The 270V cable should also be self-isolating, when disconnected.

Appendix A

Specification for the Power Board; Status 2.April 2003

On the Power Board an input voltage of 270 VCD nominal is converted in three (3) low voltage outputs.

Input and output specification

The output current requirements include a 25% increase factor for safty:

Output voltage	10V
Nominal current	25A
Output voltage tolerance	+/- 5%
Output over current protection	30A

Output voltage	6V
Nominal current	10A
Output voltage tolerance	+/- 5%
Output over current protection	15A

Output voltage	-4V
Nominal current	5A
Output voltage tolerance	+/- 5%
Output over current protection	8A

There should be four connectors with all three voltages. The connectors must be radiation hard and halogen free. Each voltage has its own ground line.

Output signals, compatible with TTL, which show the status of the DC/DC converters; for this a monitor connector is required.

Line regulation (Vi=Vi,min to Vi,max) : 1%
Load regulation (Io=Io,min to Io,max): 4%
Temperature regulation : 5%
Output ripple and noise : 150mV
Isolation :
Input to case : 1500V DC

Input to output : 1500V DC
Output to case : 200V DC

Environment:
storage temperature : -55^{o}C to +125^{o}C
Operating temperature: 0^{o}C to 70^{o}C
Radiation:
total ionising dose: 50Gray
Protons : 1E12 protons/cm2
Neutrons : 2E12/cm2
SEU : 80MeV*cm2/mg
Magnetic Field : 100 Gauss

Geometrical dimensions of the board:

The maximum board size, including the cooling plate, is 220mm *200mm * 25mm. The board, including the cooling plate will be mounted on a 5mm thick Aluminium plate, which will be fixed to the front plate of the power box. For the cooling system, connectors with 6mm inner diameter and 8mm outside diameter are required. The inflow and outflow of the cooling must be on the same side of the cooling plate. For the required position of the connectors see figure below:

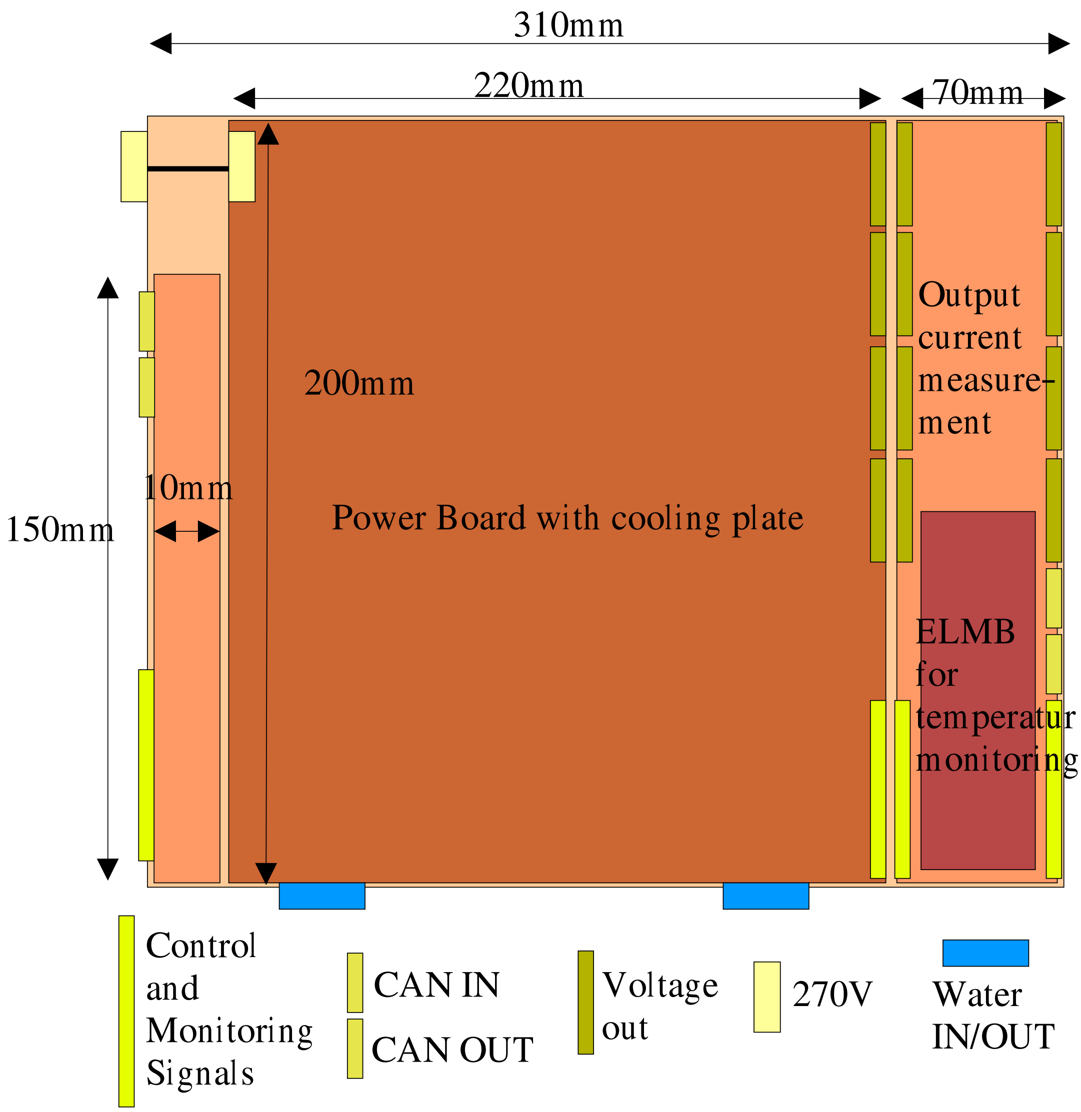


Figure A.1: Geometrical dimensions and position of connectors

Features:

- To have a safety factor of 100% two voltage converters should be put in parallel; an output control signal for each shows the correct functionality and in case of an error, that the converter has turned off
- "Power on" soft start; no current spikes at "power on"
- Short and over current protection
- Over temperature protection 65°C

- Capability to switch on/off each voltage externally
- Possibility of monitoring the output current and voltage
- start up time (when input voltage applied) max . 200ms
- operation in open-loop should be possible
- maximum worst case power loss of 100W

In case of any problems with those parameters, please don’t hesitate to ask and it can be discussed.

Appendix B

Specification for Monitoring Board; Status 2.April 2003

The ELMB will be mounted to the board for temperature and voltage/current measurement. These voltages/currents are the outputs of the Power Board. To measure the temperature PT100 temperature dependent resistors will be used. For mechanical reasons, there will be a small connector board, called the adapter board, between the font plate of the box and the Power Board. The Power Board could be produced and designed by an external company. Behind the Power Board, there will be the monitoring board.

Input and output specification for the adapter board

Input

Can Bus
Connector: two SUB-D 9 pole; will be fixed in the front plate of the box.

Output:

Control lines for temperature and control signal monitoring
Connector: one SUB-D 37 pole; will be fixed in the front plate of the box.

Input and output specification for the monitoring board

Input:

Can Bus distribution to one of the boards in the box;
Connector: SUB-D 9 pole; the 2 required connectors has to be radiation hard and halogen free.

Four times the three voltage levels with corresponding ground lines:

voltage	10V	current	6.5A
voltage	6V	current	2.5A
voltage	-4V	current	1.25A

There should be four connectors with all three voltages. The connectors have to be radiation hard and halogen free.

Control lines for temperature and control signal monitoring; for this a monitor connector is required.

Output:

Control lines for temperature and control signal monitoring; for this a monitor connector is required.

Four times the three voltage levels with corresponding ground lines:

voltage	10V	current	6.5A
voltage	6V	current	2.5A
voltage	-4V	current	1.25A

There should be four Connectors with all three voltages. The connectors have to be radiation hard and halogen free.

Environment:
Storage temperature : -55°C to +125°C
Operating temperature: 0°C to 70°C
Radiation:
Total ionising dose: 50Gray
Protons : 1E12 protons/cm2
Neutrons : 2E12/cm2
SEU : 80MeV*cm2/mg
Magnetic Field : 100 Gauss

Geometrical dimensions of the board:

Maximum board size monitoring board 70mm *200mm;
Maximum board size adapter board 10mm *150mm;

The boards will be mounted and fixed to a 5mm thick Aluminium plate.

Features:

- Power Supply for analogue and digital part of the ELMB with voltage regulators

Appendix C

Specification for Distribution Board; Status 2.April 2003

On the distribution board three (3) input voltage levels are converted in ten (10) channels of three (3) low voltage output levels each.

Input and output specification

Inputs:

Input voltage	10V	current	5A
Input voltage	6V	current	1.9A
Input voltage	-4V	current	0.9A

Interfaces:

CAN Bus and Power for Can Bus
Connector: two SUB-D 9 pole

Control signals, which allow a manual switch on/off of all output voltages.

Outputs:

Each output voltage level has 10 equivalent output lines.

Input voltage	7.2V	current	0.5A
Input voltage	3.2V	current	0.19A
Input voltage	-1.6V	current	0.09A

Output over current protection for all voltage levels.
Output signals, which show the status of the voltage regulators.

Environment:
storage temperature : -55^{o}C to +125^{o}C
Operating temperature: 0^{o}C to 70^{o}C
Radiation:
total ionising dose: 50Gray
Protons : 1E12 protons/cm2

Neutrons : 2E12/cm2
SEU : 80MeV*cm2/mg
Magnetic Field : 100 Gauss

Geometrical dimensions of the board:

Maximum Board size, is 250m *200mm. The board will be mounted on a cooling plate, which will be fixed on the front plane of the power box. For the cooling system, connectors with 6mm inner diameter and 8mm outside diameter are required. The inflow and outflow of the cooling must be on the same side of the cooling plate.

Features:

- Short and over current protection
- Over temperature protection
- Capability for external switch on/off of each Voltage
- Possibility of output current and voltage monitoring
- Quick Logic works independent of ELMB
- In case of a reset of ELMB all output voltages will hold the values
- maximum worst case power loss of 50W

Appendix D

Electrical specification of Radiation Tolerant Power Box for ATLAS HEC Liquid Argon Calorimeter; Status 2.April 2003

Scope

MPI Munich will built Radiation Tolerant Power Boxes:
1) One Prototype Unit
2) Twelve production units (50% spare units)

One Power Box supplies one Quadrant with 8 Wedges; each wedge corresponds to one FEC PSB Boards and five low voltage channels, which are controlled with one ELMB. This means one power box provides 40 low voltage channels.

Input and output specification

Inputs:

Input voltage : 270 VCD nominal current maximum 2A
Connector:

Each box has its own Can Bus to supply nine ELMBs. This means in total there are four Buses / Endcap. In case of an error in the CAN BUS, one quadrant will be dead. The +10V digital power and the +10V CAN BUS power for the ELMB128 are also supplied from extern. An alive signal shows the operator that the ELMB is still in operation.

Connector: two SUB-D 9 pole
Control lines
Connector: one SUB-D 37 pole

Outputs:

hundred twenty (120) * Power Outputs to PSB Boards;
There are 40 output voltage channels with -1.6V, 3.2V, 7.2V each. These voltages are generated with ST L4913 and ST L7913 voltage regulators.
Connectors: eight (8) SUB-D 37 pole
Connection with the cold electronic PSB boards through two (2) Feed through boards (FEC_LV_Boards) with four (4) connectors per board. This means eight (8) Cabels with one (1) for each wedge.

Redundancy:

For the ELMB and DC/DC converter on the power board a redundancy of 100% is provided. In case of a failure in this components, a logic signal will indicate it via software. For the Quick Logic (QL3012-2PF144C) and the voltage regulators is no redundancy planed. In case of a failure of the Quick Logic (QL3012-2PF144C) the box has to be exchanged. In case of a failure in one voltage regulator the voltage channel has to be turned off via software. All output voltages are controlled via software and can be switched on and off separately, also manual.

Monitoring and Control:

All output voltages and currents will be monitored. Also, the internal output voltages and currents of the power board will be monitored. The temperature of the supply will be directly monitored. Control signals are provided indicating the correct operation of the ELMBs and the DC/DC converters. Monitoring of the current to the digital section of the ELMB and ability to cycle the ELMB digital section power will be provided. In Case over current is detected, it should lead to a reset of the ELM, but Quick Logic Chip will still work as it is supplied with power separately. The temperature will be measured with precision temperature dependent resistors and will be monitored.

Power Consumption

The power loss of the whole box will be less than 300W. The power loss is divided nearly equivalent through the three cooling plates. The loss is spilt up into:

- Efficiency of DC/DC converters ; maximum loss of 100W is specified
- Voltage loss of voltage regulators; maximum loss of one regulator is calculated as 0.5A*4V=2W, the minimum is 0.09*3.4V=0.3W
- 120 Voltage regulators have a average loss of about 100W

Radiation Hardness

The radiation hardness is tested for the ELMB, done by ATLAS, for the Quick Logic, done by MPI and for the Power Board, done by an external company!

Environment:
storage temperature : -55^{o}C to +125^{o}C
Operating temperature: 0^{o}C to 70^{o}C
Radiation:
total ionising dose: 50Gray
Protons : 1E12 protons/cm2
Neutrons : 2E12/cm2

SEU : 80MeV*cm2/mg
Magnetic Field : 100 Gauss