SCT DCS Matters

This note outlines the connections of the hardware components of the DCS system. Some possible configurations are discussed. The grounding and shielding implications are covered by a note from Ned Spencer.

fig 1 indicates the main components of the system from sensors to the ELMBs at the PP3 area.
The number and categories of sensors are as follows, but some of these numbers may change especially the number of mechanics temperature sensors, for which there is as yet little information.

	barrel 3	barrel 4	barrel 5	barrel 6
Cooling Pipe Temperature	32	40	48	56
gas temperature (fsi)	32	32	32	32
mechanics temperature	10	12	14	16
humidity	3	3	5	5
radiation	8	8		

Table 1

All temperature sensors are ntc thermistors 10K at 25 degrees C. Each thermistor is connected to a single twisted pair. The humidity sensors each require 3 twisted pairs and the radiation sensors require 2 pairs each.
In addition to the sensors mounted on the barrels there will be sensors mounted on the Thermal Enclosure, both inside and outside. I assume that sensors inside the TE must be treated in the same way as the barrel sensors from the point of view of grounding and shielding.

The cooling pipe sensors are connected to both IBOXes and ELMBs, all other sensors are connected to ELMBs only.

All sensors shall be DC isolated from the barrel structure.

The wiring from the sensors should be disconnectable at the PP1 area.

At the PP1 area there shall be printed circuit boards - patch panels - which connect the sensor wiring to the cables which carry the sensor signals to the IBOXes and ELMBs.

All conductors should be capacitively decoupled to a 'shield plane' in these pcbs, with this shield plane connected to the PP1 base plate by as low an impedance as possible. The decoupling capacitors should be surface mount types and there should be the option that some of these may be -if necessary - replaced by zero-ohm resistors. All tracks connecting the conductors to the shield plane via the capacitors should have minimal length. The shield layer should be as continuous as possible. It is likely that these conditions can only be met by using multilayer boards. The shields of the cables connecting the PP1 boards to the IBOXes and ELMBs shall be connected to the shield layer of the patch-panel pcbs.

The IBOX power supply and the ELMB analog supply shall be floating. This means that the sensor circuitry is entirely floating. If there are safety implications to the system being floating these should be addressed in a way which does not violate the principles of SCT Grounding and Shielding.

The present design of IBOX has outputs which are referenced to its ANALOG GROUND and the ELMB's ANALOG GROUND. This means that the output cables are directly connected to the sensor cabling. This is not satisfactory and the IBOX outputs should be optically isolated.

fig 2 shows the ground connections for sensors connected only to ELMBs with fig 3 showing the connections between analog grounds for those sensors going to both IBOXes and ELMBs.

Ned's grounding and shielding notes are included here.

Notes on phone meeting Martin Morrissey and Ned Spencer, July 30, 2002

SCT DCS grounding and shielding

General strategy: The sensor cable shields will be part of the barrel shield system. The analog grounds of the IBOX and ELMB will tie to this shield. This front portion of DCS will otherwise be isolated, with floating power supplies and optoisolators on signal connections. The cables, modules, and connections will avoid cross-ties that compromise the isolation by creating ground loops.

Digital signal isolation: Here is a change from what we discussed: In either power supply location case, the digital outputs at PP3 should be opto-isolated at PP3. This simplifies the grounding and shielding system: digital opto-isolation is easier to design than a choke array equivalent to the module cable PP3 choke. Opto-isolation is much more effective isolation than common-mode chokes. The digital signal cable outside PP3 can be referenced to convenient local grounds.

Power: The IBOX and ELMB need an isolated power supply set for each group of modules that service a cable bundle that starts at the barrel shield. The cables shields at the ELMB should have the same grouping as they have at PP1. The ELMBs and respective power supplies should not go across different cable groups established at PP1. The sensor grouping for an ELMB should occur on the barrel haet spreader plates. The best powering solution is a power supply at PP3 that is radiation qualified for that environment.

The more likely power configuration is remote supplies placed at US15 and USA15. The remote supply will probably not need remote sensing, since the IBOX and ELMB will have internal regulators, and the loads are small (~100 mA). The supply voltage can allow for the cable drops and a reasonable voltage drop across the module regulators.

The ELMB/IBOX has three power potentials in its present design, plus a fourth possible one for the opto-isolator drive. The digital and analog supplies can be separated by series chokes to isolate them from one another. Each supply line pair needs a common-mode choke like the PP3 module cable choke array, with a similar magnetic shield.

The third potential for the CAN bus needs some analysis. It could need to be separate, since the CAN bus could include opto-isolation. A fourth potential will be needed for the opto-isolated IBOX outputs. Perhaps the CAN bus potential will work for this function.

Sensor cable at PP1: The DCS will be referenced to the barrel thermal shield. The sensor cables will have aluminum foil shields. The cable shields will be complete: the cable connectors need a metal shell, with a tie to the cable foil and to the board connectors, as well as using a drain pin in the connector. This shield will have a very good connection to the heat spreader plates at PP1 and also to ELMB analog ground. Martin's Figure 2 needs modification to show this tie. (done, mm)

At PP1 will be a PC board with a connector to accommodate the shielded sensor cable. Each sensor conductor will have a cap location on the board, 10-100 nF, tied to the heat spreader plate node. A resistor should also fit this layout location. The bypassing will reference the sensor conductors to the barrel main shield.

There could be a conflict in the AC referencing of the sensor conductors, since one of any pair is grounded at the ELMB to complete the biasing path and the other leg has a cap in the ELMB to analog ground. So the default could be to load both the PP1 sensor caps, and test the configuration.

: The purpose of the circuitry at PP1 is to create a common reference potential across the module cables. The heat spreader plates need a very strong electrical bridge across them: 5-10% of the electrical conductivity of the heat spreader cross-section itself. The bridge resistance will be dominated by the connection design, alochrome plus a compressed mesh should be sufficient. The bridges should not enclose metal from other systems: that is, conductors not referenced to the barrel thermal enclosure. If a good bridge is designed, then we need not be concerned about the routing of the sensor cables on the spreader plates.

It has been proposed that sensor wiring at each end of a barrel should be grouped in 2 bunches to go to the PP1 area. An alternative would be to group the wiring into 4 bunches at each end. The numbers of sensors and of wire pairs is shown in table 2, with a possible division into 4 quadrants. Note that the division of the sensors among the quadrants where the number of sensors is not a multiple of 4 is fairly random, so the table should not be regarded as definitive.

		barrel 3							barrel 4				
	sensors	pairs	q0	q1	q2	q3		sensors	pairs	q0	q1	q2	q3
cooling	32	32	4	4	4	4		40	40	6	4	6	4
Fsi	32	32	4	4	4	4		32	32	4	4	4	4
Mech	10	10	2	1	1	1		12	12	2	1	1	2
Humidity	3	9	0	3	3	0		3	9	0	3	0	0
Rad	8	16	2	2	2	2		8	16	2	2	2	2
			12	14	14	11				14	14	13	12
		barrel 5							barrel 6				
	sensors	pairs	q0	q1	q2	q3		sensors	pairs	q0	q1	q2	q3
cooling	48	40	6	6	6	6		56	56	8	6	6	8
Fsi	32	32	4	4	4	4		32	32	4	4	4	4
Mech	14	14	2	1	2	2		16	16	2	2	2	2
Humidity	5	15	3	0	3	3		5	15	0	3	3	0
Rad													
total pairs per quadrant, each barrel			15	11	15	15				14	15	15	14
total pairs per quadrant, all barrels			55	54	57	52							

Table 2

The number of pairs per quadrant for all barrels is approximately 60. This would be 120 for the case where there are 2 bunches of wiring per end.

According to Andy Nichols there are 4 places, evenly distributed at the PP1 area, allocated to DCS wiring. I believe that it is easier to design the DCS PP1 patch panels if all 4 places are used, with a quadrant's wiring from all barrels combined at a patch panel. All 4 patch panels would be identical.

It should be noted that numbers are not given for sensors inside and outside the TE, also for the heaters on the outside.

JST 1mm connectors are proposed, from the same family as used in the Detector Module PP1. Because of their small size, hand crimping may not be practical and it is proposed to start with twisted pair lengths which are crimped at one end, then cut to size and attached to the sensors. Groups of pairs will be formed into bunches, perhaps by sleeving, and the crimps will be inserted into connector housings.

If all wiring in a quadrant for each barrel were taken to a single connector a 30-pin connector would be required, ie 4 such connectors for all barrels. However it is difficult to remove the crimps from the connector housing safely and some thought should be given to how easily a mechanical section such as a 4-pipe cooling unit could be removed if necessary, for example for repair, without damaging the wiring. One answer to this problem could be to have multiple connectors each one serving a small mechanical section, but this could lead to an unwieldy number of small connectors.

Perhaps a compromise might be to have a separate connector for each group of 4 cooling pipe sensors and take all other wiring of a quadrant to 1 connector, on the grounds that the cooling pipes are the most fragile item and therefore most likely to need replacement. There is a problem in that the power cables for the barrels divide into 2 groups, one going to US15 and the other to USA15. For this reason it may be necessary that the 4 sensors of some 4-pipe loops actually split into 2 groups of 2 in order to avoid the situation where the interlock matrix in USA15 would be controlling some power modules in US15 and vice versa. (This situation in fact already exists because the "vertical split" of the barrel module cables in the current design means that in some cases the cables of a 4-pipe cooling unit are split 3:1 to USA15 and US15. However I'm hoping this design feature can be changed). With careful adjustment of the wiring it might be possible to squeeze all non-cooling pipe sensors into a 20 pin connector (the number of pairs for non-cooling sensors per barrel is 38, 39,38 and 35), but the occupancy is so high that there is little flexibility left and therefore I'd suggest at the moment a 30 pin connector, given also that there is little firm information with regard to mechanical temperature sensors. Fig 4 indicates a possible layout for pp1. The output connectors are not specified. The space available for the boards is 60 mm wide, (Andy Nichols). Space must be left for connection to the PP1 baseplates, so perhaps 40 mm is available for the components. The TE sensors and heaters must not be forgotten. In the absence of any real information could we make some random guesses? Say 64 sensors on the inside, ie 8 per quadrant at each end. A 20-pin 2-row connector? The same number outside? And 64 heaters? Each 25 watts? 1A? It may be that these numbers would be difficult to handle in a single board, so I would propose that there should be a separate PP1 for sensors and heater supply wires from the outside of the TE. It may be that these conductors do not require decoupling at the PP1 area, so it might be reasonable to accommodate sensors from inside the TE on the general sensor PP1. This pp would be mounted in-line with the barrel dcs pp1, in the same way as the module pp1s are mounted in pairs.

The cable proposed to take the sensor wiring from PP1 towards the PP3 area is a 21 pair cable. This cable therefore is not directly compatible with IBOX and ELMB inputs (34-pin 0.1" headers) and a patch panel is required to achieve connection.

Fig 5 shows a scheme for connecting the redundant cooling sensors to IBOXes. The 4 IBOX outputs associated with each sensor pair would be fed to an Interlock Matrix which would decide on the basis of those 4 inputs what interlock signals to assert. Also indicated is a possible way of connecting the power to ELMBs and IBOXes.

Fig 6 indicates the components required at the PP3 area. Those not yet designed shown in red.

Given the large amount of work required and given that the piecemeal development of ELMB and IBOX has resulted in a situation where we have elegant components and an inelegant system the question must be asked, should we not take a step back and design a system taking as starting point the naked ELMB ie without motherboard, the IBOX design but not its implementation.

Table 3 shows how a quadrant's sensors might be accommodated in a single ELMB. Of course the sensors of the TE are not included.

Table 3

Cooling sensors A	Cooling sensors B	FSI gas temp sensors	Humidity 1 sensor
Cooling sensors A	Cooling sensors B	FSI gas temp sensors	Humidity 1 sensor
Cooling sensors A	Cooling sensors B	FSI gas temp sensors	Radiation 2 sensors
Mech temp sensors	Mech temp sensors	FSI gas temp sensors	
ch 0:15	ch 16:31	ch 32:47	ch 48:63

Fig 7 indicates how the ibox / interlock matrix system might look. The red Xs indicate the places at which opto isolation / coupling is implemented.

M.Morrissey
3-august-02

Main Hardware Components of SCT DCS

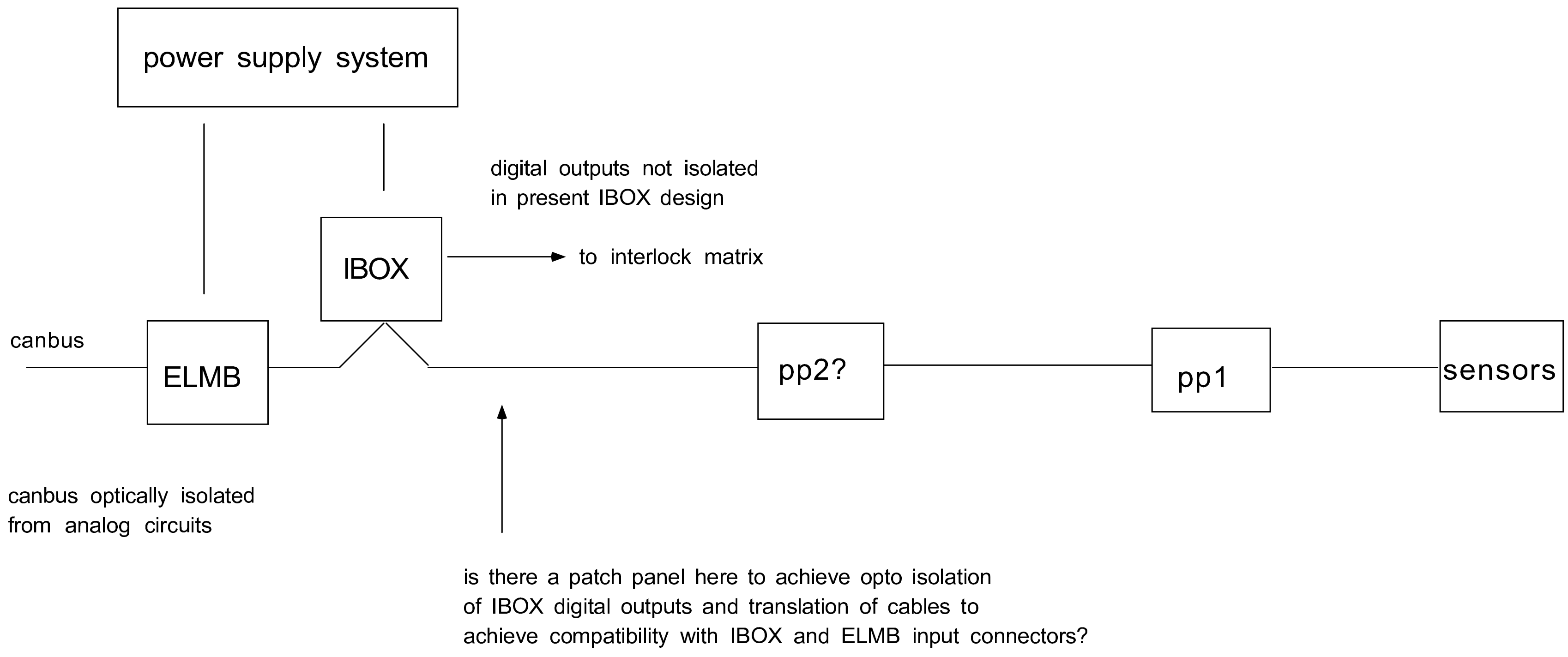
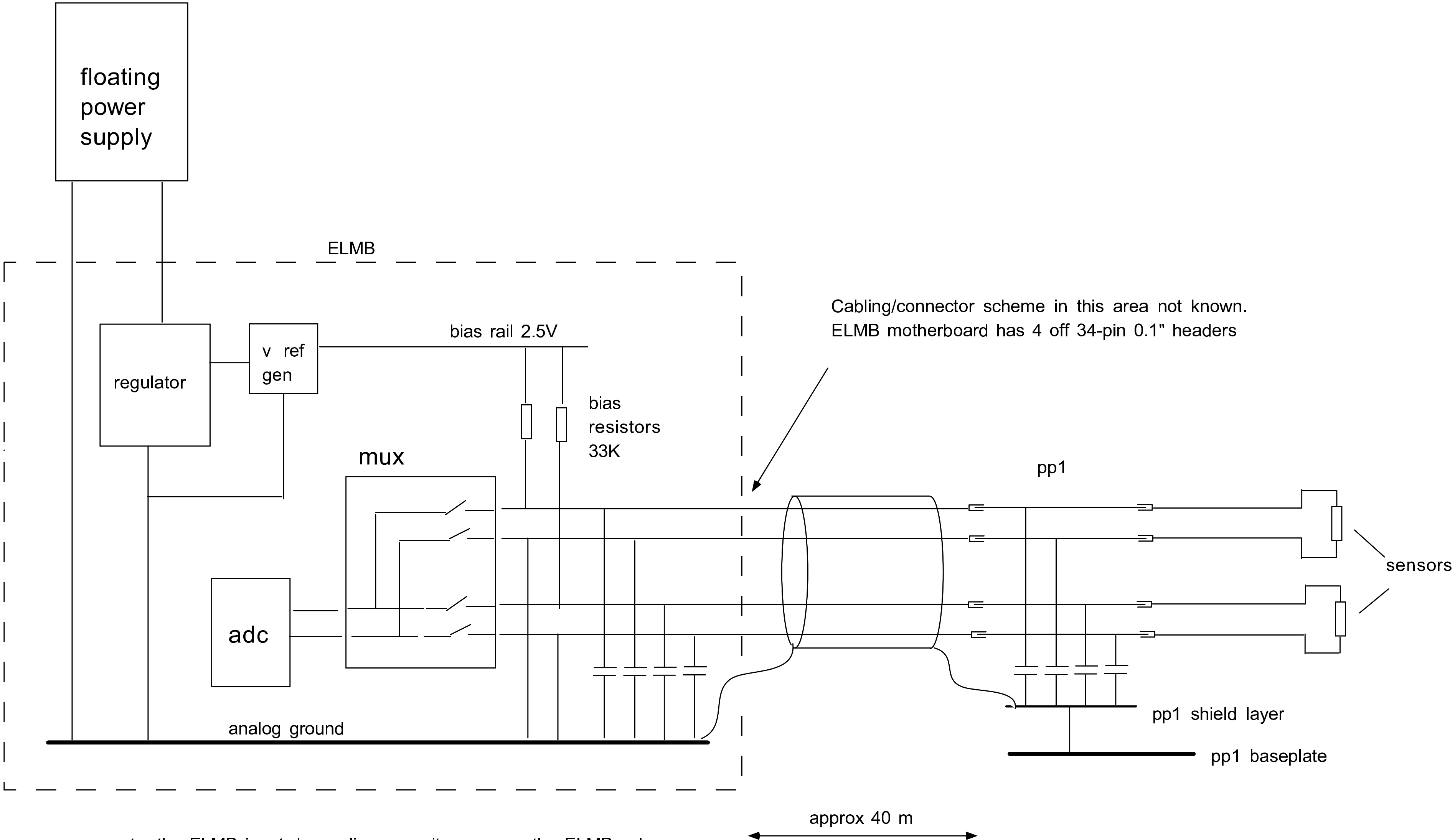
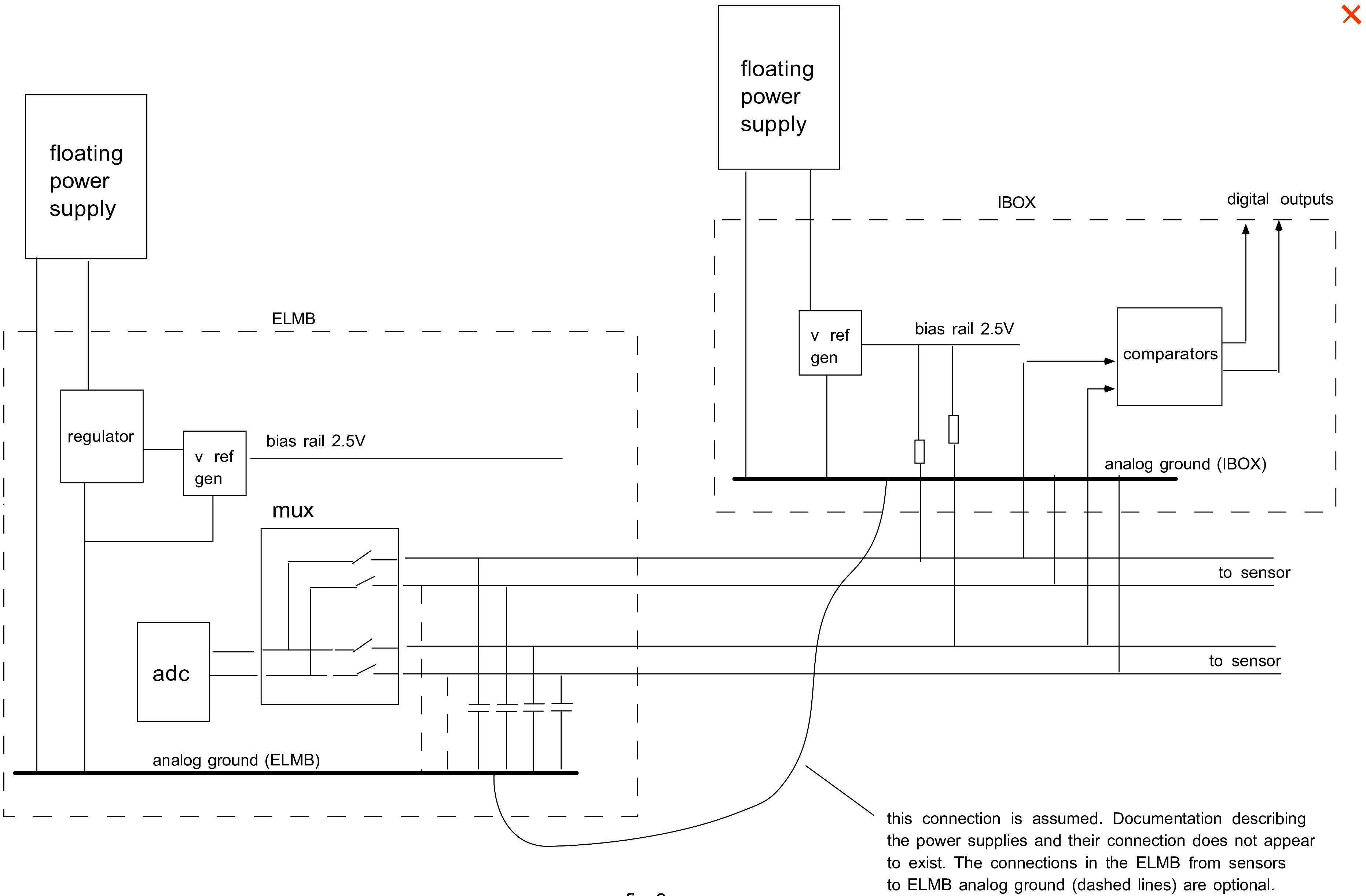


fig 1



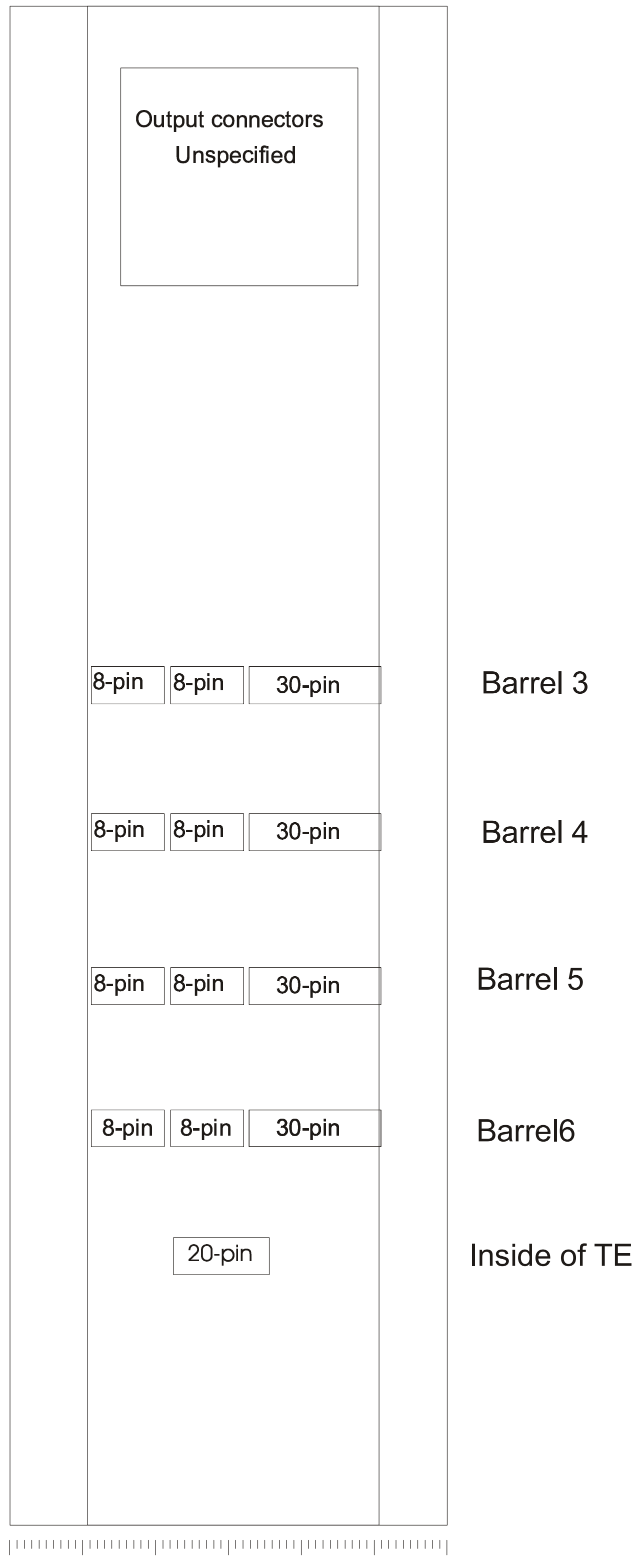
note: the ELMB input decoupling capacitors are on the ELMB pcb.
the bias resistors and the connections of inputs to analog gnd
are located on the plug-in adaptors

fig 2



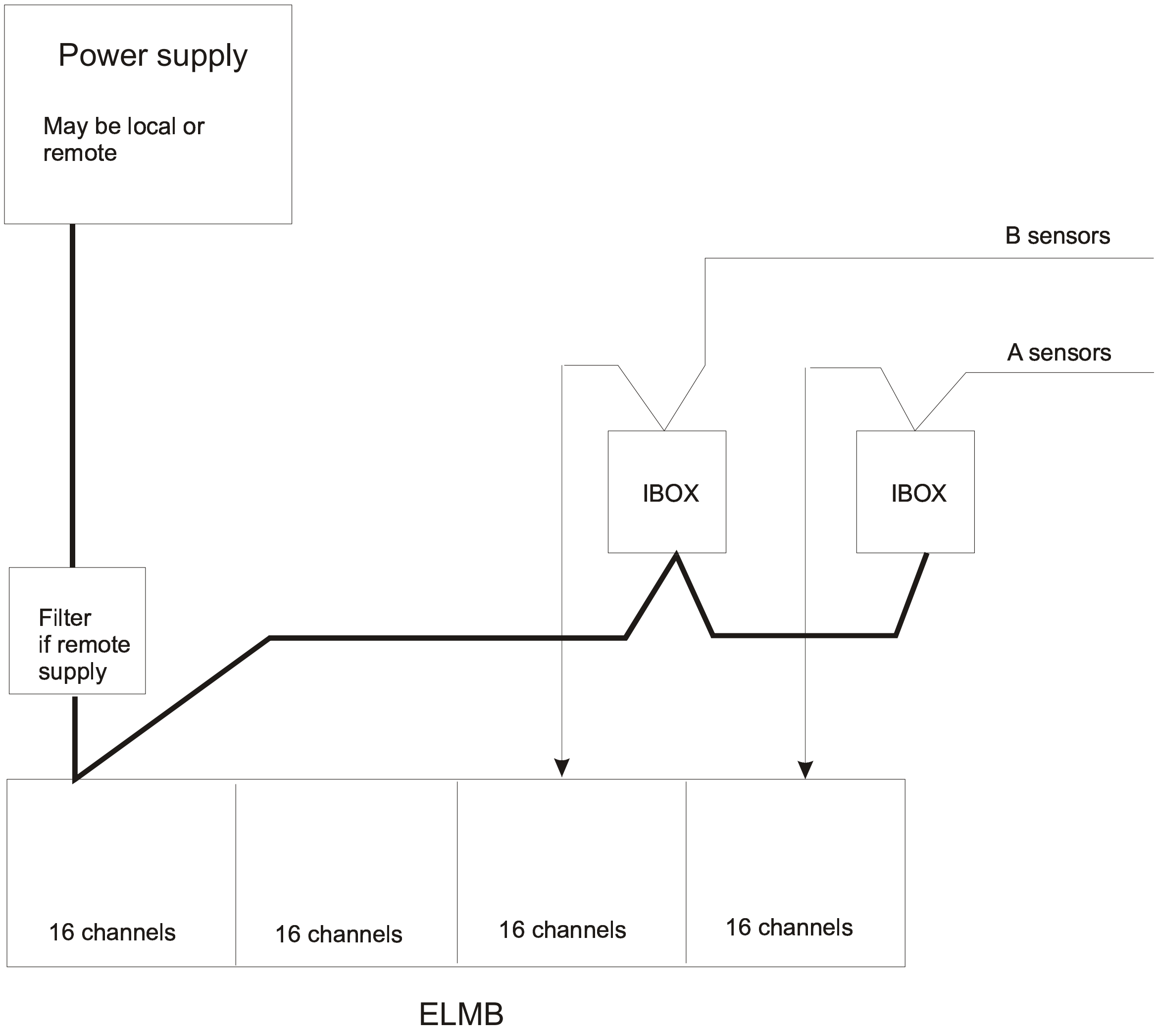
floating power supply
ELMB
regulator
v ref gen
bias rail 2.5V
mux
adc
analog ground (ELMB)
floating power supply
IBOX
digital outputs
v ref gen
bias rail 2.5V
comparators
analog ground (IBOX)
to sensor
to sensor
this connection is assumed. Documentation describing the power supplies and their connection does not appear to exist. The connections in the ELMB from sensors to ELMB analog ground (dashed lines) are optional.

fig 3



Sketch indicating possible layout for dcs ppb1
based on 4 pp1s per barrel end

Fig 4

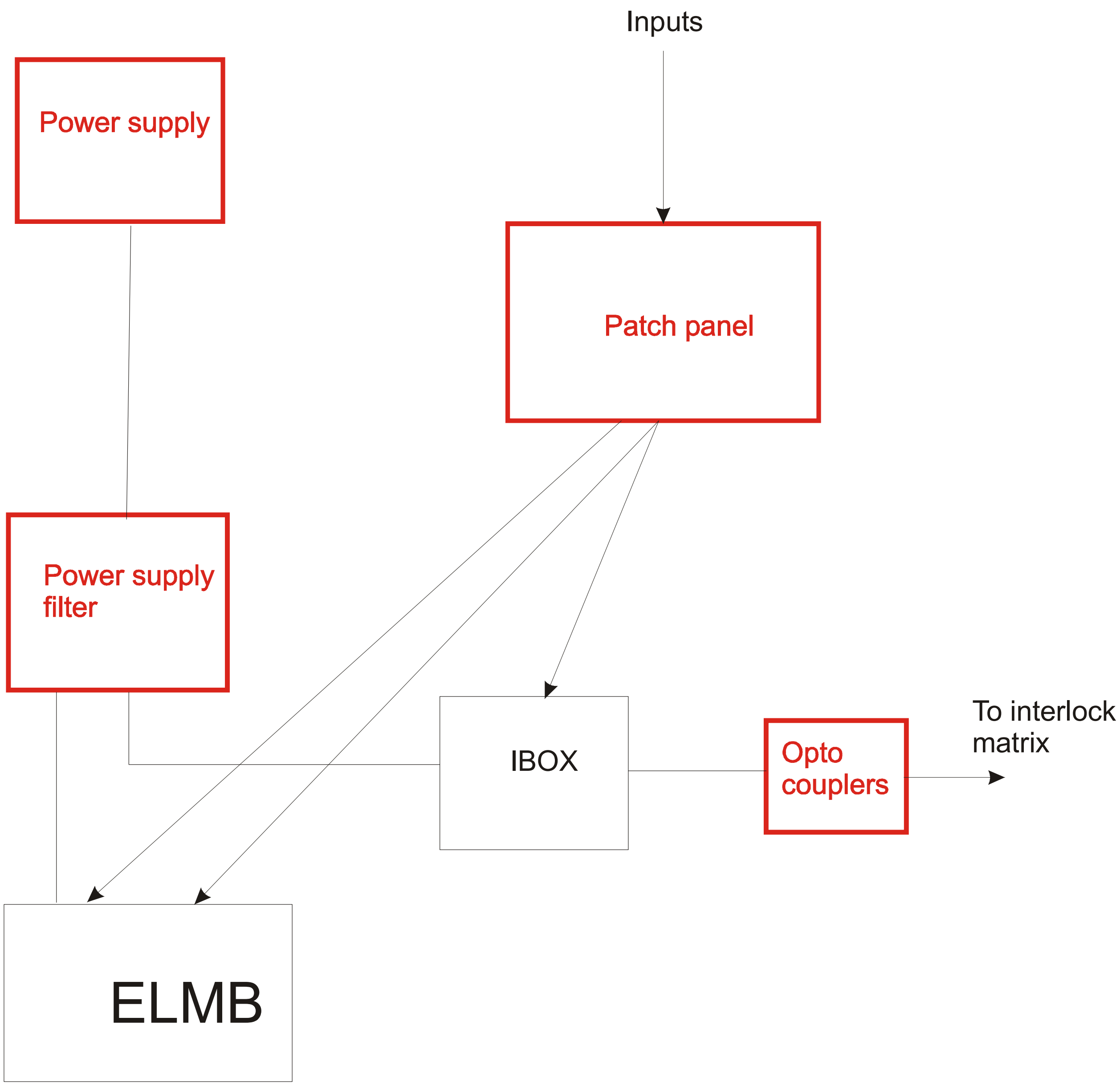


Notes: all cooling pipe sensors are duplicated for redundancy.
Sensors of each pair go to separate IBOXes

A power supply may power more than 1 ELMB but may power only ELMBs associated with a single DCS_PP 1

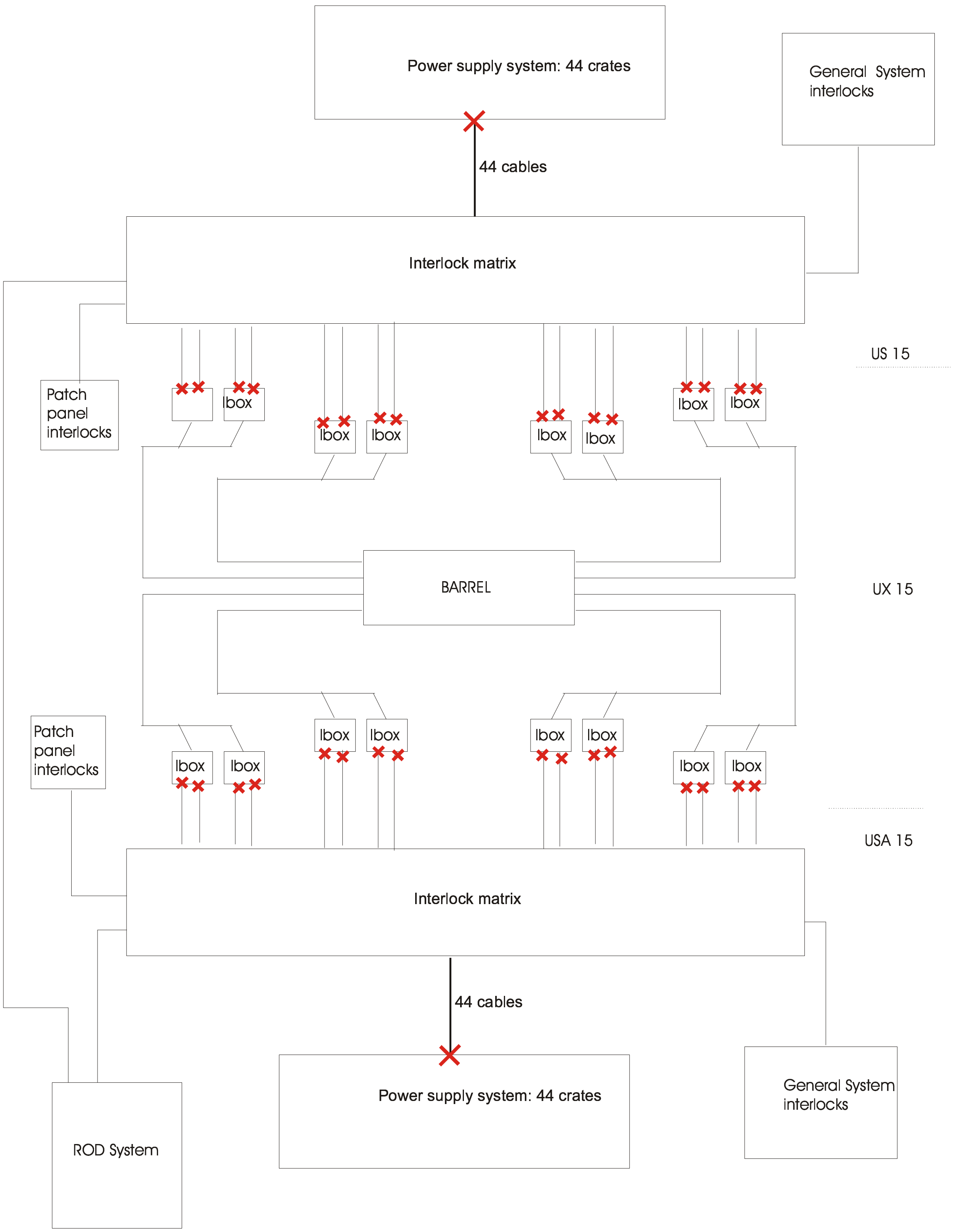
ELMBs require 2 supplies, analog and digital in addition to the CANBUS supply.
. If these (analog and digital) are separate supplies then it is the analog supply which must feed the IBOXes

Fig 5



Inputs
Power supply
Patch panel
Power supply
filter
IBOX
Opto
couplers
To interlock
matrix
ELMB

Fig 6



Power supply system: 44 crates
General System interlocks
44 cables
Interlock matrix
US 15
Patch panel interlocks
Ibox
Ibox
Ibox
Ibox
Ibox
Ibox
Ibox
BARREL
UX 15
Patch panel interlocks
Ibox
Ibox
Ibox
Ibox
Ibox
Ibox
Ibox
Ibox
USA 15
Interlock matrix
44 cables
Power supply system: 44 crates
General System interlocks
ROD System

Fig 7