EUROPEAN ORGANIZATION FOR PARTICLE PHYSICS

Technical specifications of High Voltage Power Supply for the Atlas Tile Hadron Calorimeter

ATLAS Tile Calorimeter Collaboration

CERN, 18th August 1999

TECHNICAL DESCRIPTION

1. Scope

The specification describes the requirements for the supply of the main high voltage power supply for the Tile Calorimeter. It will be the vendors' responsibility to deliver the power supply according to the proposed schedule and the proposed requirements with complete technical and service specification and documentation.

2. General Characteristics

The light produced in the active part of the detector will be registered by ten thousand photomultipliers (PMT). The Tile Calorimeter PMTs are supplied by the main high voltage power supply. The system reflects the division of the Tile Calorimeter into 256 modules, which are electronically equivalent and independent. Each HV channel leads into the module, where a special HV distributor supplies up to 48 PMTs. The HV distributor inside each module is able to set individually voltage for each PMT.

Two output HV main power supply levels are requested for each channel. The levels are –950V and –830V for each channel, with maximum current of 20 mA/channel. The main requirements for the HV output channels are short and long term service stability, and very low noise 20 mV pp over a wide frequency range. The main HV power supply is composed of 16 independent and equivalent power supply units – crates each with 16 output HV channels. Each crate is both locally and remotely controlled, and provides safety protection against short circuits and HV cable disconnection.

If switching power supply principle is used for power supply construction , the PFC (power factor correction) is requested.

The product will conform the EC standards: IEC 61010-1 (1990-09).

3. Mechanical Description

The HV supply system is located in two 19-inch racks. Each rack contains 8 HV crates of 6U height. Each crate has 8 cards with 2 HV channels per card, and a communication and control unit.

4. Front Panel

The front panel contains possibility of local operation of the communication and control unit via display and a keypad. All functions can be used by local manual operation.

5. Back Panel

The remote control ports use two (one male and one female) Cannon 9-pin connector. Output voltages are connected to the 16 SHV connectors that are placed on isolation plate placed in the window with maximum dimensions 120 x 120 mm. This solution is required only for prototype. For serial production other connector will be specified. The dimensions of window will not change.

6. Remote and Manual Control

Each crate is controlled by a single-chip microcomputer. The computer monitors and controls all the functions and the parameters of the crate. The output voltage level or the switch on/off state of each output channel is indicated by LEDs. When a switch-on of a voltage level is requested, the control unit checks if:

- the load is connected,
- the load current is between minimum and maximum value and
- there is no overvoltage (e.g. from another crate connected by chance)

If these conditions are not fulfilled, the protection algorithm is activated and the channel is automatically switched off. The communication and control unit continuously monitors these conditions. If they are violated, the channel is switched off, a red LED indicates the state, and a message is sent to the remote controller.

All functions are controlled either manually or remotely over serial bus. For the remote control the CAN BUS 2.0 is chosen and will be specified later. The bidder is requested to prepare space for plug-in module (CAN BUS remote control) on the control board that will be later delivered by the customer. Space for plug-in module will enable following functions:

The power supply will communicate with this module by serial protocol on the level 5V, 5V for logical 1 and 0V for logical 0, 9600 Bd, 8 data bits, 1 stop bit. Plug-in module will be a PCB 100 x 100 mm and 20 mm height. The module will be powered from the power supply by 5V/500mA. All pins of communication connector (Cannon 9pin) will be connected to the plug-in module. The manufacturer will deliver power supply with a temporary replacement module, which will contain only RS-422 converter and SW enabling to test the remote control functions during the delivery procedure.

Protocol will have following commands:

For one channel:

- switch on
- switch off
- switch on level –830V
- switch off level –950V
- read output voltage
- read output current
- read output status:
  undervoltage, overvoltage, overcurrent, undercurrent

For all channels:

- local operation
- remote operation
- all channels on
- all channels off

The commands for switching on/off the output and the commands changing output levels are independent. Each command sent to the power supply unit is analysed and executed by the unit. When the power supply is operated remotely the manual control is disabled.

Manual control is executed via keypad and display on the communication unit and has the same functions as the remote control. Special button at the front panel switch off all channels.

7. Interlock

The power supply has an interlock with by-pass. It is based on current loop with a maximum current of 20mA. When the current circuit is broken the power supply will switch all channels off. If the current returns to the proper value the supply must not restart the previous state. The channels are switched on by the explicit manual or remote command. State of interlock is sent to the remote control. It is strictly requested that the interlock signal is directly connected to the switch what can switch off all channels. Solutions with software decision are not acceptable.

8. Electrical parameters

Each HV output channel provides two output voltage levels –830V and –950V. Each output channel is individually set to the proper voltage level by means of the communication and control unit, and its status is indicated by LEDs. Each channel has overcurrent and undercurrent protection. The voltage and current of each output channel are measured and available to remote and manual control. The input power of the whole system will be less than 7 kW for all 16 crates. A summary of the electronics specifications of the HV power supplies is presented in the following table

Parameter	Value
Input line voltage range	230V ± 10 %
Input line frequency	50Hz
Output DC nominal voltage (changeable)	- 830V
	- 950V
Channel outputs with common floating ground	
Max. voltage between the floating ground and	
the frame of the device	± 500V
Output voltage accuracy	± 0.25%
Line regulation at input line voltage 220V +-10 %	± 0.01%
(load current 12.5mA)	
Load regulation of the channel voltage	± 0.02%
Long-term stability	± 0.1%
Temperature coefficient	(50ppm) /deg C
Ripple and noise due to switching	Max. 20mV
and spurious voltage in the band up to 20MHz	
(peak to peak value)	
Overcurrent protection	
Protection initiating current	20mA ± 1mA
Time of drop of the output voltage to 5%	max. 50ms
Undercurrent protection	
Protection initiating current	2mA ± 0.5mA
Time of drop of the output voltage to 5%	max. 50ms
Load characterisation	
Capacitance of the load	~ 1µF
Response time of the current protection	500 ms
Expected channel current	16mA
Disconnecting of the load reported as defect	
Time of drop of the output voltage to 5%	max. 350ms
Operating temperature range	5 to 40 deg C

Some specific notations have the following definitions:

Output voltage accuracy: For a fixed output load, the tolerance in percent of the output voltage with respect to its nominal value, when other parameters are within allowed ranges.

Line Regulation: The change of output voltage if the input voltage is varied between its specified limits, with constant load and temperature.

Load Regulation: The change of output voltage from its nominal value when the load is varied between its specified limits.

Long-term stability: The change in output voltage with time, due to component ageing.

9. Grounding

The 16 output channel grounds in a crate will be connected into a common ground that is floating with respect to the ground of the crate. Two possible ground connections are anticipated:

- Connection of the common ground to some other ground via connector
- Connection of the common ground to the crate ground by means of removable bridge

The type chosen will depend on the ATLAS grounding policy.

The maximum allowed voltage difference between the common ground and the crate grounds is 500V.

10. Quantity

The components for 256 output channels of the main HV power supply with reserve parts are listed in the table. The first unit delivered is called prototype.

Part	**Number of pieces**	**Number of pieces Reserve**	**ALL**
19-inch, 6U crates with main power supply	**16**	**2**	**18**
6U cards with two HV channels each	**128**	**32**	**144**
6U communication and control units	**16**	**2**	**18**

11. Quality Checking

The quality-checking plan has two parts. The first part is done by producer and the second one by customer.

Quality checking plan of the power supply producer

Producer is obliged to follow the following steps before, during and after production in addition to their standard quality control:

- Visual and electronic check of all input details
- Visual and electronic check of all assembled cards
- Grant access to the customer to the production facility to check all steps of production and tests
- Burn of all final products
- Test of functionality in both local and remote regimes

- Measurement of main parameters according technical specification
- Measurement of temperature coefficient of prototype and one randomly selected (by customer) piece of power supply

Following quality checking protocol will be delivered together with each unit (details open to discussion):

QUALITY CHECKING PROTOCOL FOR MANUFACTURER				
Unit serial number:		Date:		
Parameter	**Minimum value**	**Maximum value**	**Measured value**	**OK/BAD**
Input line voltage 230V, output current 12.5 mA				
Output DC voltage –830V level full load – U1	827.925	832.075		
Output DC voltage –950V level full load – U2	947.625	952.375		
Input line voltage 230V – 10 % , output current 12.5 mA				
Output DC voltage –830V level full load	U1-0.01%	U1+0.01%		
Output DC voltage –950V level full load	U2-0.01%	U2+0.01%		
Input line voltage 230V + 10 %, output current 12,5 mA				
Output DC voltage –830V level full load	U1-0.01%	U1+0.01%		
Output DC voltage –950V level full load	U2-0.01%	U2+0.01%		
Input line voltage 230V maximum load at all channels				
Output DC voltage –830V level	U1-0.02%	U1+0.02%		
Output DC voltage –950V level	U2-0.02%	U2+0.02%		
Input line voltage 230V minimum load				
Output DC voltage –830V level	U1-0.02%	U1+0.02%		
Output DC voltage –950V level	U2-0.02%	U2+0.02%		
Ripple and noise due to switching	-	20 mVpp		
Temperature coefficient	-	(50ppm) /deg C		
Overcurrent protection				
Protection initiating current	19mA	21mA		
Time of drop of the output voltage to 5%	-	50ms		
Undercurrent protection				
Protection initiating current	1.5mA	2.5mA		
Time of drop of the output voltage to 5%	-	50ms		
Load characterisation				
Response time of the current protection	-	500ms		
Disconnection of the load reported as defect				
Time of drop of the output voltage to 5%	-	350ms		
Result				

Quality checking plan of the customer

After the delivery of each unit by the producer the customer will make the following tests:

- Visual check of all electronics and mechanical details
- Detailed electronic test of various parameters according to the technical specifications
    - Test of all functions in Local / Remote modes
        - Setting of voltage levels
        - On/off switching
        - Behaviour in all combinations of output failure
    - Measurements

- Output voltage accuracy (all levels, all 16 outputs)
  - vs load
  - Stability of output voltage under maximum load (14 days period)
- Measurement of safety thresholds
  - Stability
- Measurement of noise
- Remote control test

- Short term stability test and, for the prototype, long term stability test

If the product fails to meet the specifications, it is returned to the producer for replacement. The responsible for the quality control is the Institute of Physics in Prague.

12. Delivery Schedule

A delivery scheme, best suited to ATLAS needs, is:

Prototype production	15 January 2000
Prototype test at Inst. of Phys.	15 March 2000
1st batch 9 units (4x16 channels)	15 October 2000
test 1st batch at Inst. of Phys.	15 November 2000
2nd batch 8 units	1 May 2001
test 2nd batch at Inst. of Phys.	1 June 2001

All relevant Quality Control documents and certificates will accompany each delivered crate unit. ATLAS will do acceptance of each crate unit in the 60 days after the arrival.

13. Packing and Shipping

The power supply units will be delivered one by one, packed in an adequate way. The producer should propose to ATLAS the packing intended to be adopted, for approval.

The destination of each shipment is Institute of Physics, Prague, Czech Republic.

ATLAS reserves the right to reject HV supplies damaged during transport because of bad protection.