LOW VOLTAGE POWER SUPPLY SYSTEM FOR ENDCAP MUON STATION ME1/1 OF THE LHC DETECTOR CMS

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The CMS (Compact Muon Solenoid) detector of the new CERN[1] accelerator LHC (Large Hadron Collider) consists of a few subdetectors. One of them contains different types muon-chambers, united in groups called stations. The high number of measuring channels in each chamber needs a large multichannel front-end electronic system, consuming high current and power from the low voltage power supply system. Supplementary problems come from the very high magnetic field (about 4 T) and radiation dose in the region of muon chambers and their front-end electronics.

The low voltage power supply system of the ME1/1 station, described in this paper, is an example of the specific problems and their decisions in such a task. In order to avoid the magnetic and radiation field influence as well as power losses in the connecting cables, intermediate DC 300 V power supplies, located about 100 meter far from the CMS detector are used. They supply a few groups of DC-DC converters, which are housed in magnetic shielding boxes, placed around the detector surface. Each two chambers are power supplied by one DC-DC converter group through relatively short cables (10-12 m). All supplying voltages necessary for the front-end electronic devices are provided by insensitive to magnetic and radiation field low power voltage regulators mounted on each chamber.

The CMS (Compact Muon Solenoid) detector of the new accelerator at CERN LHC (Large Hadron Collider) includes [1] three large parts – one barrel and two endcaps. There are in each part many layers of different subdetectors - tracker, electromagnetic calorimeter, hadron calorimeter and various types of muon proportional chambers. The Cathode Strip Muon Chambers (CSCs) in each endcap are united into groups, called stations. The first station in each endcap "ME1/1" consists of 36 CSCs (fig.1) [2].

The task of the ME1/1 low voltage power supply system is to provide supplying voltages for the front-end electronic devices located on each muon CSCs - 7 cathode front-end boards (CFEB) with 96 channels on each one, 18 anode front-end boards (AFEB) with 48 channels and one anode local charged tracks board (ALCT).

Two different supply voltages are needed for normal operation of this FEE system: +5 V for the digital circuits and +6 V for the analog circuits. The total consumption from both power supply sources by all front-end electronic boards of one CSC as well as for each ME1/1 station is summarised in Table 1.

The high current and power values lead to a basic contradiction, which have to be solved by suitable structure of the LV power supply system: on the one hand the low voltage power supply units have to be as nearer as possible to the CSCs, in order to avoid high power losses in the conductors; on the other hand the high

[1]European Laboratory of Particle Physics "CERN" – Geneva, Switzerland

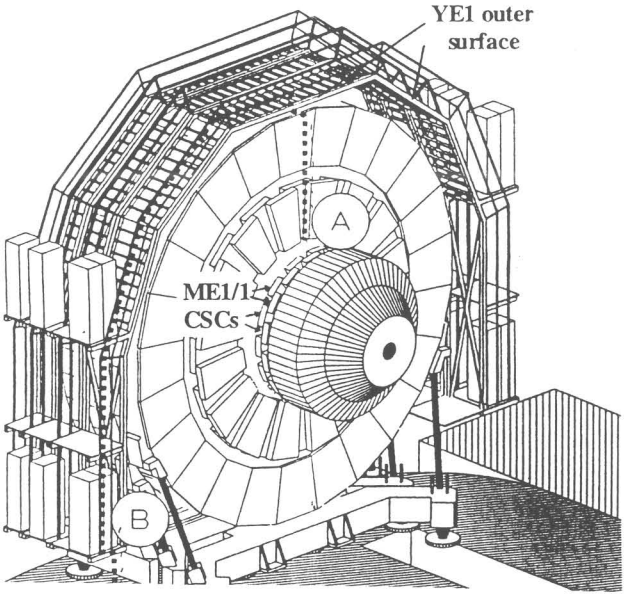
YE1 outer
surface
A
ME1/1
CSCs
B

Fig. 1

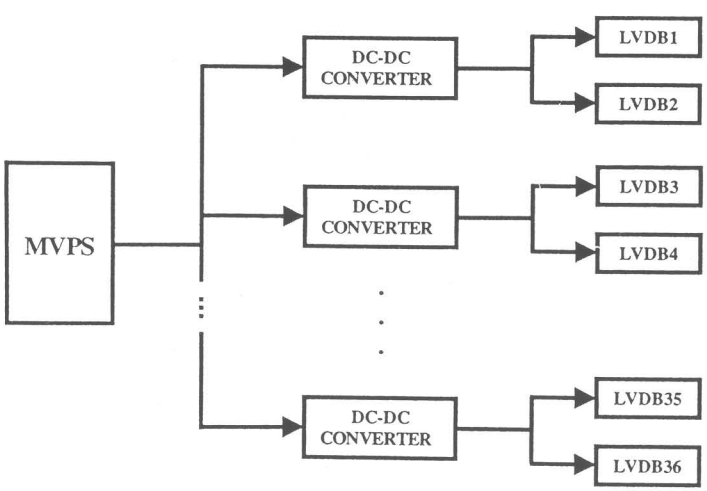
MVPS
DC-DC
CONVERTER
DC-DC
CONVERTER
DC-DC
CONVERTER
LVDB1
LVDB2
LVDB3
LVDB4
LVDB35
LVDB36

Fig. 2

magnetic field around the chambers disturbs the normal function of the power supply units. Therefore a compromise decision has been accepted for the structure of

Table 1

Voltage, V	Current per CSC, A	Power per CSC, W	Current per ME1/1, A	Power per ME1/1, W
+6	7.75	46.5	279	1674
+5	12.5	62.5	450	2250

the low voltage power supply systems for all endcap muon stations – each system is divided into three functional parts (fig. 2):

- Intermediary DC power supply unit (common for all ME stations of each endcap), providing a voltage of about 300 V (MVPS). It is located apart from the magnetic field and is connected by about 100 m long cables to the circular feed cables, installed around each endcap yoke iron disc.
- DC-DC converters, producing both front-end electronic system-supplying voltages (see table 1) from MVPS output. The ME1/1 converters are positionned on the outer surface of the yoke iron ring YE1 (see fig. 1) – away from the high magnetic field region but relatively near to the CSCs (see fig. 3). The residual magnetic field on the YE1 surface (about 1 kG) however requires some form of magnetic shielding of the DC-DC converters.
- Low voltage distribution boards (LVDB) – one board is mounted on each CSCs. In LVDB both low voltages fed by the DC-DC converters are distributed to the front-end electronic boards – low voltage regulators are used for individually adjusting of all voltages supplying each board.

Table 2

VICOR type DC-DC converter	Maximal I_{OUT}, A	Nominal U_{OUT}, V	ME1/1 LVS U_{OUT}, V
V300B12C250A	20.8	12	7
V300C12C150A	12.5	12	6

In order to optimise the length of the connecting cables to the LVDBs, the DC-DC converters are separated into 18 groups (distributed across 20 degrees on the YE1 edge) – one group supplies two LVDBs. As DC-DC converters two type of devices produced by VICOR Corp. [3] are chosen (table 2). The output current of the first one is sufficient for +6 V power supplying of both CSC LVDBs (see table 1). Its output voltage is adjusted at 7 V to cover about 1 V voltage drop in the cable and LV regulators. For +5 V power supply two converters of the second type are used (one for each CSC LVDB) because of the higher current. Their output voltage is adjusted at 6 V by the same reason.

Each group of 3 DC-DC converters together with 4 LC-filters (the LV output voltages to each LVDB pass through individual filters) are mounted on one PC

board, located into a soft iron magnetic shielding box. This box reduces the magnetic field to about 130 G, while investigations show [4], that VICOR DC-DC converters operate without problems in magnetic fields till 150 G.

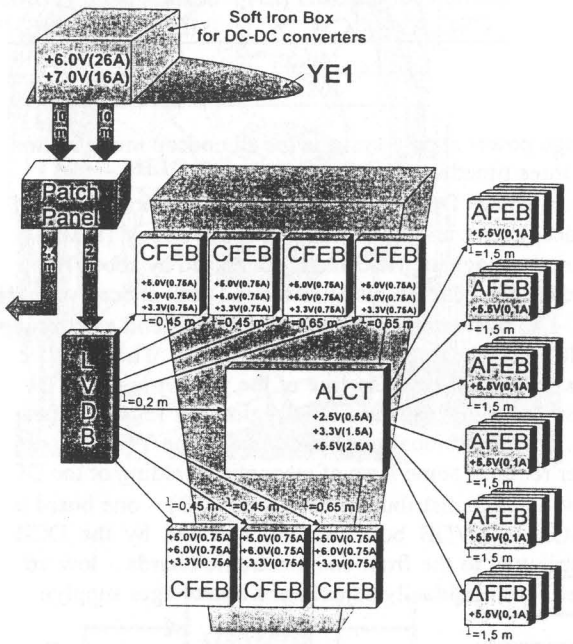

Fig. 3

The structure of the LV system of one CSC is shown on fig. 3. The LVDB is located on each chamber to minimise the wire runs and hence voltage drops to the CFEBs and ALCT (AFEBs supply voltage passes through ALCT). There are on LVDB 24 low power voltage regulators providing all necessary voltages for the front-end electronic boards. Special regulators, insensitive to the magnetic and radiation field are used.

REFERENCES

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3. VICOR Express. USA, 1999.

4. Citterio, M., J. Kierstead. Are Switching Power Supplies Acceptable for the Liquid Argon Calorimeter Front-end Electronics? Preprint of Brookhaven National Laboratory, Upton, NY, USA, 1999.