EE LED Pulser System Layout

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1 On the Dees

Fig. 1 shows a rough drawing of a dee marked with the locations of the four LED pulser cards, one LED master fanout, and 13 high voltage REDEL connectors, each of which carries two spare coax cables from the HV crates. Each freehand line represents a set of four cables: LVDS+, LVDS-, I2C clock, and I2C data. The master fanout box therefore has 16 outputs to serve the four LED pulser cards per dee: four LVDS+, four LVDS-, four I2C clock, and four I2C data. It takes four signal inputs: the master LVDS+, LVDS-, I2C clock, and I2C data. Both the input and output connectors on the master fanout box are 50-ohm SMC connectors (CERN stores catalog part number 09.46.09.260.0, although the actual connectors on the cards right now were purchased from an American company), as are the four signal inputs on each LED pulser card.

All intra-dee cabling (e.g. between the master fanout box and the LED pulser cards, as represented by the freehand lines in Fig. 1) is done with the standard EE brown radiation-hard coaxial cable. In June 2008, one dee's worth of all required intra-dee cables was cut and fitted with SMC plugs (CERN stores part number 09.46.09.015.1) by me. Those cables were then tested for shorts (by myself and Sasha Ledovskoy) and used to connect the four dee 1 LED pulser cards to the dee 1 master fanout box. On a test bench in Bldg. 867, we were able to successfully run this system with all LEDs illuminated at the highest possible intensity setting, at pulsing frequencies in the range zero Hz to approximately 50 kHz, with no ill effects. Typical current draws were noted in my lab book for various scenarios (e.g. one LED pulser card illuminated, two LED pulser cards illuminated, etc.). The individual DAC channels on the LED pulser cards were addressed using a Windows-based serial terminal program called RealTerm (`http:`

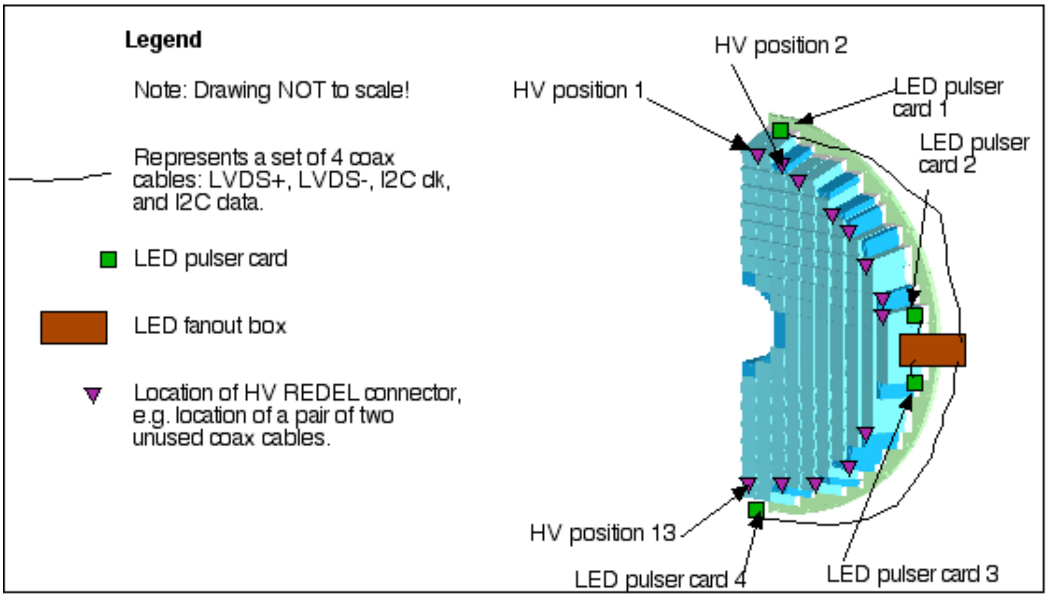

Figure 1: One dee marked with the locations of the four LED pulser cards, one LED master fanout, and 13 HV REDEL connectors.

//realterm.sourceforge.net) running on Sasha's laptop. RealTerm provides an interface through which to send ASCII commands over a USB line to an I2C controller card (”I2C2PC,” available from www.i2cchip.com). The controller card then sends the commands over the I2C bus to the DACs. In the proposed LED control system for CMS, the functionality of RealTerm will be handled by standard Unix file management commands.

All cables carrying the LVDS timing signals from the master fanout boxes to the LED pulser cards will be 349.5 cm long, give or take a few centimeters. No maximum tolerable variance in the cable lengths has been decided upon, but perhaps this is something we should measure. The length of 349.5 cm was deemed necessary such that the cable would reach all the way from the master fanout box to the LED pulser cards located furthest away from it. For the LVDS cables running from the master fanout box to the LED pulser cards right next to it, there is room for the extra cable length to be coiled up. Since the I2C cables are carrying ”slow” controls, their lengths are irrelevant to LED event timing. These cables fall into two groups: those carrying the I2C signals from the master fanout box to the LED pulser cards furthest away, at a length of 3.5 m; and those carrying the I2C signals to the closest LED pulser cards, at a length of 0.5 m. Technicians and engineers in the Crystal Palace have begun to cut and fit connectors to the rest of the intra-dee cables for dees 2, 3, and 4. As of mid-June 2008, that process is partially

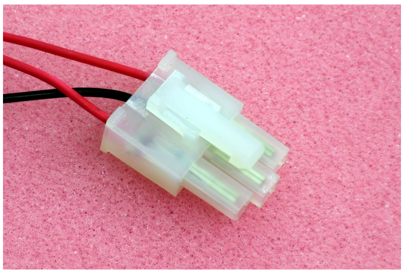

Figure 2: Power connector for the LED pulser cards.

Position of Spare HV Coaxes	Use in LED System
no. 1	power to LED pulser card 1
no. 6	power to LED pulser card 2
no. 7	LVDS+, LVDS- input to master fanout box
no. 8	I2C clock, I2C data input to master fanout box
no. 9	power to LED pulser card 3
no. 13	power to LED pulser card 4

Table 1: Proposed uses for the spare HV cables.

completed.

Each of the four LED pulser cards must also receive low voltage power, which will be carried on the spare coaxial cables in the HV bundles. It was decided in a Crystal Palace meeting on June 14, 2008 that a pair of coaxial cables would be necessary to power one LED pulser card. One cable would carry +14 V on its inner conductor, the other cable would carry the current return path on its inner conductor (0 V), and the outer conductors of both cables would be grounded to the dee chassis. The master fanout box will be powered by a jumper cable from one of the LED pulser cards.

The four inputs to the master fanout box (LVDS+, LVDS-, I2C clock, and I2C data) will also be carried on the spare coax cables in the HV bundles. My numbering scheme, shown in Fig. 1, has the topmost (on the page and in CMS) HV connector as no. 1, the next down from it as no. 2, and so on all the way down to the bottom-most connector, which is no. 13. Table 1 shows my proposal for how the spare coax cables be used for the LED system. The cables carried in connectors 7 and 8 (signal cables) will need to be fitted with the SMC connectors described above. Mike Arenton has provided us with the appropriate power connectors (three-pronged white plastic, see Fig. 2), complete with tinned jumper leads, but we have yet to couple these power connectors to the ends of the HV spares.

2 At the Intermediate Patch Panel

The +14 V power cables running from the dees to the intermediate patch panel will have **male** BNC ends. The cables carrying the current return path (0 V) will have **female** BNC ends. The LVDS and I2C cables will have LEMO ends. All these connectors apply to the patch panel end of the cables; see Sec. 1 for the appropriate connectors at the dee ends. The male BNC, female BNC, and LEMO will help prevent cabling mistakes in which, for instance, +14 V is accidentally sent down a trigger line. These decisions were made at a Crystal Palace meeting on June 14, 2008.

3 In the Service Cavern

48 LED-related cables will enter the service cavern from the intermediate patch panel:

- 16 carrying +14 V power to the LED pulser cards (four per dee),
- 16 carrying 0 V current return path from the LED pulser cards (four per dee),
- four carrying LVDS+ (one per dee),
- four carrying LVDS- (one per dee),
- four carrying I2C clock (one per dee), and
- four carrying I2C data (one per dee).

The cables running from the intermediate patch panel to the service cavern have already been laid. They are still in need of connectors at the patch panel end (see Sec. 2) and at the service cavern end.

Two Thurlby Thandar TTi PL330TP (`http://www.tti-test.com/products-tti/text-pages/psu-plp-series.htm`) power supplies will be used to provide +14 V to the LED pulser cards. One will be located near the EE+ HV rack, while the other will be located near the EE- HV rack. Each supply has two identical, independently controllable outputs, so in practice there will be one power source per dee. One endcap's worth of power cables (16) will go to each Thurlby Thandar module. The modules to be used will be the ones currently located in Bldg. 867. One of these was used for the tests described in Sec. 1, in which the stripped ends of the power wires were simply connected right to the output of the supply. This should be sufficient for operation

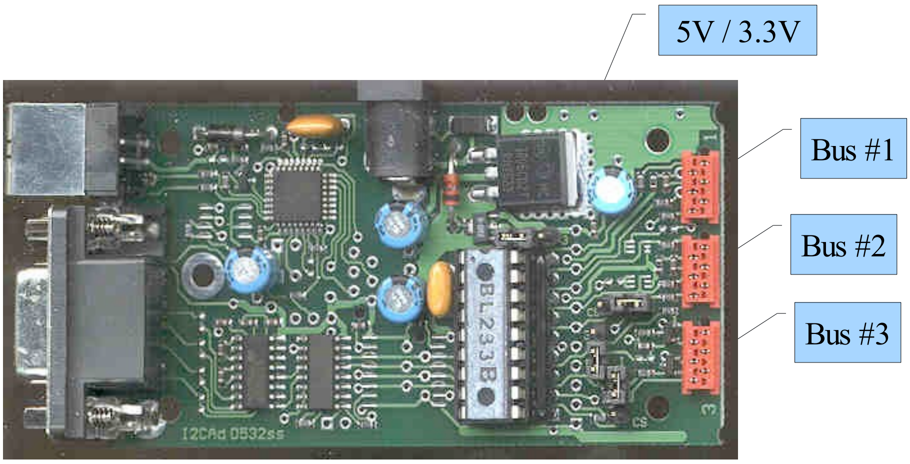

Figure 3: Top view of the I2C controller card, with the I2C buses marked.

in P5, but if it presents a safety hazard, solder lugs or some other type of connector may have to be fitted to the ends of the power cables.

The eight LVDS trigger cables will go to two (serving EE+ and EE-, respectively) LED control boxes to be built by Mike Arenton. One of its purposes will be to couple the LVPECL trigger signals[1] coming from the EMTC to the coaxial trigger cables that serve the dees. The control boxes will be respectively located near the racks they serve, and delays will be programmed into the EMTC to make sure that all trigger signals arrive at the dees simultaneously.

Finally, the eight I2C cables will go to two[2] I2C controller cards, two LVDS +/- pairs per card (one card serves EE+, one card serves EE-). The I2C controller cards (described in Sec. 1, see Figs. 2 and 3) have three 6-pin bus connectors, of which only pins 1 (data) and 4 (clock) are wired to the corresponding I2C cables.[3] A way to couple the I2C cables to the I2C bus connectors has yet to be established.

The I2C controller cards will sit on or near the LED DAQ PC (see next section).

[1] At the moment only one signal is wired in the EMTC, but according to Marc Dejardin, up to four can be wired.

[2] Each I2C controller card has three I2C buses, so only two I2C controller cards are needed to serve the four dees.

[3] In the proposed LED DAQ, we may want to use pin 5, the interrupt input, as well.

#	4 Way	6 Way	
1	SDA	SDA	
2	VDD	VDD	
3	VSS	VSS	
4	SCL	SCL	
5		INT / CS	Interrupt input (active low) *or* Chip select for SPI (jumper select)
6		VAUX	Aux supply. Not connected

Figure 4: Pins on the I2C bus (taken from the I2C2PC datasheet).

4 The LED DAQ PC

The LED DAQ PC, which has yet to be purchased, will sit in the EE+ or EE- HV rack. It has seven main fucntions:

1. **To communicate with the LED pulser cards via the I2C controller cards.** As explained in Sec. 1, using Unix file management commands, simple ASCII strings can be sent over a serial line to address the individual DACs on the LED pulser cards.[4] In this way, a C++ program can tell the DAC to raise or lower the light intensity of the LEDs, as well as poll the interrupt input of the I2C controller card, query the status registers, and load programs into the EEPROM of the I2C controller card.

2. **To receive commands from the laser supervisor and report status messages back to it.** Communication between the laser supervisor PC (which also talks to the EMTC) and the LED DAQ PC will be via TCP/IP sockets. Upon receipt of specific commands from the laser supervisor, the LED DAQ PC will initiate communication with the DACs.

3. **To communicate with the LED power supply.** The Thurlby Thandar modules (see Sec. 3) can be controlled and monitored by a computer. The LED DAQ PC will monitor the current and voltage of the supply, be notified if the power supply shuts off, and be able to turn the supply back on.

4. **To change settings in the LED control card.** This includes changing the pulsing frequency and going into a standalone running mode

[4]The DAC chip used is the AD5391, manufactured by Analog Devices. The datasheet is available at `www.analog.com/UploadedFiles/Data_Sheets/AD5390_5391_5392.pdf`).

(i.e. use internally generated triggers).

5. **To continually request and store information about the current state of the LED system.** The power supply current and voltage and the pulsing frequency and amplitude will be recorded and stored so as to monitor the health of the system.

6. **To interface with DCS such that the above information can be written to the ECAL conditions database.** Following the protocol set by the laser DAQ PC, the LED DAQ PC will cache a certain amount of LED system information (defined in no. 5 above) locally, as well as send information to DCS so that it can be written to the ECAL conditions DB for later use. Ideally, the shifter should be able to pull up plots of the information recorded in the DB at will.

7. **To raise an alarm if something goes wrong.** For instance, if the power supply trips, a message should be sent to the laser supervisor (or the ECAL supervisor?) for display to a shifter.

The current proposal is to buy either a Dell PE2950 or PE1950, which are the CMS standards, for this purpose. The only outstanding constraint is that the PC fit a card with extra Ethernet ports, since three Ethernet ports will be needed in total:

1. One port connects to an Ethernet-to-serial adapter (1:3) serving the I2C controller, LED control card, and power supply for EE+

2. One port connects to an Ethernet-to-serial adapter (1:3) serving the I2C controller, LED control card, and power supply for EE-

3. One port connects to the CMS network for TCP/IP communication to the laser supervisor

5 Special Needs for the Power Supply

The LED pulser cards can sometimes go into a “failure mode” in which the trigger is ignored and the LEDs are on DC. The cause of this is an improper termination on the card that has since been fixed. With the improper termination, a reflection trigger pulse arrives at the LEDs just tens of nanoseconds after the real trigger pulse, which does not leave enough time for the voltage regulators to recover from the last pulse. Consequently, they cannot provide enough voltage and the boards go into a "locked up" state[5] in which they are stuck on DC. If this state persists for longer than a few minutes, resistors on the card will burn out. The most noticeable and reliable symptom of this state is excessive current draw. Therefore, overcurrent trip circuits must be built for the LED power supplies. Note that it is not good enough for the power supply to just reduce the voltage when the current draw gets too high, because it is the voltage regulator failing to supply the required 12 volts that puts the boards in the locked-up state in the first place. The power supply must be turned off when the current goes above a certain limit.

Ideally the trip circuit would have a programmable value of the current at which the supply should trip, but a reasonable hard-and-fast limit would work as well. If the trip circuit cannot be easily interfaced to the existing Thurlby Thandar modules, a different non-PVSS power supply might have to be purchased.

6 The Proposed LED Control Box

Fig. 4 shows a diagram of the EE LED system (minus the ECAL trigger and DAQ), including the LED control boxes. The LED control box interfaces to the EMTC (RJ45 cable) and the LED DAQ PC (serial cable?). This box needs to

- receive the four LVPECL pairs from the EMTC, route two of them to the other control box, and couple the LVPECL signals carried on RJ45 cables to LVDS signals carried on coaxial cable;
- generate trigger pulses independently of the rest of the system; and
- divide down (and multiply up?) the EMTC trigger frequency

As shown in Fig. 4, two control boxes could be built, each one serving either EE+ or EE-, with the ability to relay two of the four input EMTC signals over RJ45 cable to the other box.[6] The coupling to the LVDS coaxial trigger cables has not been defined yet.

We are assuming that the four LVPECL pairs have independently programmable delays in the EMTC. If this is not the case, then the LED control box should also include such delays for each trigger line. In addition, we might want to include the ability to veto the trigger lines independently.

[5] Mike Arenton (mwa5u@virginia.edu) and Bob Hirosky (rjh2j@virginia.edu) are the experts on the LED driver circuit.

[6] This is just a thought - we will have to discuss the details with Mike Arenton and other experts.

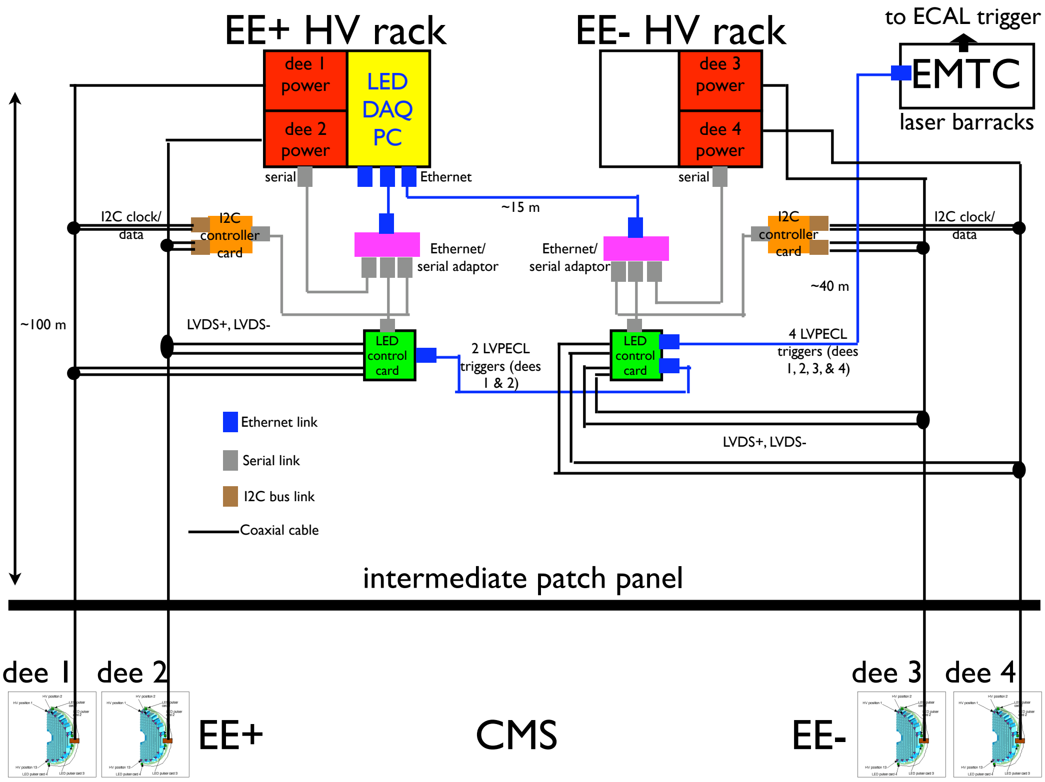

Figure 5: Layout of the LED system from the dees up to the service cavern.

7 Cabling To-Do List

- Decide which of the HV spares will do what job Ken Bell, Crystal Palace engineers?
- Fit SMC connectors to the dee ends of the HV spares that will carry the four signal inputs to the master fanout box Ken Bell, Crystal Palace engineers?
- Decide how to couple the dee ends of the HV spares to the white plastic LED card power connectors Ken Bell, Crystal Palace engineers?
- Fit appropriate connectors to cables at the intermediate patch panel Ken Bell, Crystal Palace engineers?
- Decide how to couple the I2C cables to the I2C bus connectors on the I2C controller cards in the service cavern UVa, Ken Bell, Crystal Palace engineers?
- Decide how to couple the LVDS cables to the LED control boxes Mike Arenton, Ken Bell, Crystal Palace engineers?

8 Other To-Do List

- Purchase the LED DAQ PC UVa, Attila Racz
- Design the power supply trip circuit Mike Arenton
- Design the LED control box Mike Arenton, UVa