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**PPD / EED / Infrastructure Group**

Technical Note: IG\_ 20140004

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9-Jun-2014

**USCMS HCal HF Front End Crate Production Backplane**

**Design Review**

**Findings Report**

**Overview:**

This Design Review of the USCMS HCal HF Crate Production Backplane was requested on 9-Jun-2014. Information for the review was supplied by USCMS and by HCal management using the following links:

<https://cms-docdb.cern.ch/cgi-bin/DocDB/ShowDocument?docid=11590>

<https://cms-docdb.cern.ch/cgi-bin/DocDB/ShowDocument?docid=12307>

<https://cms-docdb.cern.ch/cgi-bin/DocDB/ShowDocument?docid=12212>

Though the backplane is intended to be installed in the CMS Collision Hall in CERN, the following Fermilab document was used as a guildline for this review:

<https://esh-docdb.fnal.gov:440/cgi-bin/RetrieveFile?docid=2781;filename=FNAL_Electrical_Design_Standard_7.1.pdf;version=2>

**Scope of the Review:**

The production versions of the schematic, fabrication specification and gerber data were examined a manner consistent with the delivery of current from the power supply, ultimately to the modules connected to the backplane. Findings are listed in the order in which they were found and do not necessarily indicate areas of concern, but are listed for completeness. Concerns (if any) will be summarized in the Concerns: section immediately below.

**Concerns:**

Though the datasheet for the CAEN 3100 Power Supply Board states that the maximum output current can be programmed, safety should not rely on human interaction (properly programming the supply parameters). The combination of 4 power taps in parallel for the V1 voltage net are not deemed sufficient for carrying the maximum current that the power supply can deliver.

The layer stack-up document indicates the material used to separate the copper layers is FR4. Be advised that FR4 contains materials (bromides / halogens) that may be rejected by CERN.

There are three components on shown in the prototype schematic for the ngCCM that are not protected by the on-board fuse, and are thus possibly subject to the full current available at the backplane.

**Findings:**

Power Taps.

10-pin power taps (AMP 55558-4) are used to deliver voltages V1 and VCALIB to the backplane. The manufacturer datasheet indicates that these power taps are capable of carrying up to 25A. For each power tap associated with one of these voltages, a corresponding power tap is shown connected to a common ground net in the schematic. There is one power / return pair for the VCALIB voltage and four power return pairs for V1. Using guidelines for connectors in parallel found in the Fermilab document, one would expect that the maximum current available for the V1 net on a single backplane would be 67A (4 x 25A x ⅔). The datasheet for the CAEN power supply indicates that the maximum current that can be delivered is 100A.

The single power tap for the VCALIB voltage net is supplied by a XXXX power supply capable of delivering XXA.

Backplane Current Carrying Conductors.

The layer stack-up document indicates that the V1 voltage net is distributed on 3 layers, all utilizing a 2oz. copper thickness. Examination of the gerber data for these layers (3, 8, 12) indicates that they are all implemented as copper pours that span the length of the backplane and nearly the height.

Module Backplane Connectors.

Up to 14 electronics modules can be connected to the HCal HF production backplane. According to the schematic, these are comprised of 12 QIE10 modules, one Calibration Module and one next generation Clock and Control Module. The backplane connectors associated with all of these modules in the AMP 535032-4 DIN41612 Type C 96-contact receptacle. Per the manufacturer’s datasheet, the rated current for contact in this connector is 1.5A. The number of power contacts for each type of module, and the maximum safe current that can be delivered to a module (based on guidelines for power connectors in parallel found in the Fermilab document) are summarized below.

Calibration Module (V1) – 9 contacts @ 1.5A x ⅔; 9A.

Calibration Module (VCALIB) – 4 contacts @ 1.5A x ⅔; 4A.

ngCCM (V1) – 9 contacts @ 1.5A x ⅔; 9A.

HF 24-Channel Readout Module (V1) – 9 contacts @ 1.5A x ⅔; 9A.

The designs of the three modules that connect to the HCal HF production backplane were examined to determine the level of current interrupting ability incorporated to determine if the backplane contacts would ever expect to carry more than their rated current. The results are listed below:

Calibration Module.

ngCCM.

The most recent version of the schematic for the ngCCM indicates that the V1 backplane voltage from all 9 backplane contacts is collected onto a common net on the module. Besides a bypass capacitor and a test point, this common net is connected to a series 7A fuse before being distributed to the rest of the module. Should a catastrophic failure occur on the ngCCM, the 7A fuse should limit the current seen by the backplane contacts. Note that examination of the gerber data for the prototype module indicates that two capacitors are connected to this common net. If the bypass capacitor were to fail short, the current through the backplane contacts would likely exceed the rated current. The test point is indicated to be some version of a banana plug in the schematic. There is concern that this point is not protected by the fuse. It’s unlikely that the wire connected to this test point is capable of carrying the current delivered to the backplane. If there were to be changes to the design of the ngCCM in the future, one should consider moving this capacitor, and the test point, to the other side of the fuse.

HF 24-Channel Readout Module.

The schematic for the HF 24-Channel Readout Module, and confirmed in an examination of the gerber data, indicates that the V1 backplane voltage from all 9 backplane contacts is collected onto a common net on the module. This common net is connected to a series 10A fuse before being distributed to the rest of the module. The value assigned to this fuse would allow current in excess of the current rating of the backplane contacts.

Miscellaneous Connectors.

The schematic and the Bill of Materials indicate that 8 “1-pin large jumpers” are included in the design of the backplane. Four of these devices are shown connected to the V1 voltage net and four to the common ground net. There are no current limiting devices shown in series with those connected to the V1 voltage net, indicating that an inadvertent short to ground from any of these jumpers would result in the full current of the power supply.

**Additional Comments:**

Gerber data was imported into GerbTool (V16.2.25) to be able to view the layout of the backplane. Additionally, the NC drill data was imported to provide layer-to-layer connectivity information. With this information, GerbTool was instructed to construct a net list of the backplane tying all pads that are electrically connected to common net names. The IPC356.ipc file that’s generated with the gerber data contains the net names assigned during the schematic capture / layout process. This file can also be imported into GerbTool to allow the user to query nets in the gerber data and be able to read the “real” net name. This is a very useful tool to use when reviewing gerber data.

When this procedure was used for the gerber data, drill file and IPC356 file for the HCal HF Front End Crate backplane GerbTool reported a number of open nets. This error can be interpreted to mean that when GerbTool tried to do a pad-to-pad comparison of all pads in it’s net list to all pads in the IPC356 file. An open net error is generated when at least one pad in the GerbTool generated netlist doesn’t match with the name associated with that same pad in the IPC356 file. GerbTool does provide information about the location(s) of the open nets and in the past I’ve used this information to determine if the open net error indication is serious or not for circuits. I’ve examined all of the errors to some extent and don’t understand exactly why errors are being reported. All of the reported errors are associated with internal layer 10. In cases of nets other than V1 and GND, the location of the open net is one pad of a surface mount component on layer 1. For the instances that I’ve examined, I’ve been able to verify the connection from the ngCCM through inner trace layers to all QIE10 slots and the associated surface mount component. Other than the backplane connector pads, none of the traces are located on internal layer 10.