## LCLS Beam Loss Monitor Interface Module Engineering Specification

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Brief Summary: This document describes the functional design of the Beam Loss Monitor Interface Module (BLM-IM) responsible for Photomultiplier Tube (PMT) signal conditioning and interfacing the Beam Loss Monitor (BLM) to the Machine Protection System (MPS) Link Node Chassis.

Change History Log

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<th>Sections Affected</th>
<th>Description of Change</th>
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<td>00</td>
<td>Mar 14, 2008</td>
<td>All</td>
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1. INTRODUCTION

1.1. Purpose
This Engineering Specification Document (ESD), in conjunction with the associated fabrication specifications and drawings, defines the requirements for the Beam Loss Monitor Interface Module (BLM-IM) that is to be used in the Linac Coherent Light Source (LCLS) undulator system. The purpose of the BLM-IM is to condition the PMT output of the Beam Loss Monitor (BLM); provide a remotely variable high voltage, with control voltage monitoring, to the PMT; and provide a heartbeat LED source to the PMT to test the functionality of the system before each beam pulse.

1.2. Scope
This ESD defines the required interface specifications of the BLM-IM with that of the PMT module and the Machine Protection System (MPS) Link Node Chassis.

1.3. Description
The BLM-IM consists of a charge amplifier to condition the PMT signal, a variable high voltage power supply and an LED to pulse the PMT before each beam pulse.

The BLM-IM will be housed in an aluminum enclosure designed to provide radio frequency interference (RFI) shielding. The housing will be mounted below the girder at the upstream end of the undulator.

1.4. Design Philosophy
The interconnections of the BLM-IM to both the PMT module and the MPS Link Node Chassis are illustrated in Figure 1. Commercially available components will be utilized as much as reasonable.

As a component of the MPS system, the BLM system will be designed and implemented to facilitate end-to-end testing, at the full beam pulse repetition rate, to confirm functionality of the system. The BLM-IM will be designed such that major failures are detected by this system wide test.

The Interface Module will be designed and implemented to ensure there are no exposed voltages greater than 50V.

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**Figure 1: BLM-IM Interconnections**
2. REQUIREMENTS

The requirements for the Beam Loss Monitor Interface Module are derived from the following documents:

- Undulator Beam Loss Monitor (PRD # 1.4-005)
- LCLS Machine Protection System Requirements (ESD # 1.1-312)

The BLM-IM interfaces the BLM detector to the MPS Link Node Chassis. The BLM-IM chassis provides three functions, which will be discussed later in this document. The three functions are:

- Condition the PMT output signal via a charge sensitive amplifier.
- Provide a remotely variable high voltage source for the PMT with remote monitoring capability.
- Provide a heartbeat source to the PMT as an indication of the BLM system health.

The Argonne National Laboratory/Advanced Photon Source (ANL/APS) shall provide the detailed drawings and procurement specifications for fabrication of parts and purchasing of catalog items for a minimum of 15 units plus 3 spare units.

2.1. Power Supply

The BLM-IM requires +12V @ 500mA.

An external power supply will be located in the undulator control rack. This power supply is capable of delivering +12V @ 1A.

2.2. High Voltage Power Supply Circuit

The photomultiplier tube requires a maximum voltage of -1000V.

The power supply module chosen is a variable supply with an output ranging from 0V to -1000V with a control voltage of 0V to +5V. The nominal operating range is expected to vary from -400V to -1000V. The variability of the high voltage power supply allows for a gain adjustment on the PMT. This power supply module also provides a voltage monitor output that is a buffered representation of the programming voltage.

2.3. PMT Signal Conditioning Circuit

The output signal from the PMT is a negative current pulse whose integral is proportional to the number of photons detected.

The technique used for the signal conditioning is a charge sensitive preamplifier. This output is a video bandwidth (approximately 26MHz) analog signal with amplitude ranging from 0V to 1.5V when terminated with 50Ω. The charge amplifier chosen has a decay time constant fixed at 50μs and gain fixed at 15mV/pC resulting in a full-scale output of 1.5V with a 200pC input. Pin compatible charge amplifiers, with different sensitivities are available.
The MPS Link Node chassis shall terminate this signal with 50Ω and is responsible for digitizing the peak of this signal. Since the decay time constant is slow, several samples will be taken at the peak of the waveform and averaged. An example of a charge amplifier output is shown in figure 2.

![Graph](image)

Figure 2: Example of a charge sensitive amplifier output.

2.4. **Heartbeat Circuit**

The heartbeat circuit is used to pulse the PMT before each beam pulse. This function is intended to provide a heartbeat indication that the instrument is operational.

The MPS Link Node chassis will provide a differential, EIA-485 compliant, logic high trigger pulse with a minimum pulse width of 250ns to the BLM-IM as a heartbeat trigger signal. The BLM-IM will differentially detect the trigger and generate an appropriate pulse to drive a fiber transmitter that provides a light pulse to the PMT. This light pulse will not saturate the PMT.

3. **CONNECTORS AND CABLELING**

3.1. **Interface to MPS Link Node Chassis**

3.1.1. **Control/Monitor connector:**

This connector will be a 9-pin D-sub receptacle with front metal shell. The cable connecting to this connector shall be a shielded twisted pair, multi-conductor cable with overall shield. Each conductor shall be a minimum of 22 AWG stranded copper. The pin definitions are shown in Table 1.
Table 1: Control/Monitor cable pin definitions

<table>
<thead>
<tr>
<th>BLM-IM Pin</th>
<th>MPS Link Node Pin</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>HVControl+</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>HVControl Shield</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>HVMonitor-</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>Heartbeat Shield</td>
</tr>
<tr>
<td>5</td>
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<tr>
<td>8</td>
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<td>HVMonitor Shield</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>Heartbeat+</td>
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Note that the heartbeat trigger signal has been moved from a separate coaxial cable to a twisted shielded pair. This was done to allow differential signaling, which provides better common mode noise immunity.

3.1.2. PMT signal connector:
This connector will be a right angle, pc mount jack receptacle SMA style connector. The cable shall be a LMR series, low loss, 50Ω coaxial cable terminated with SMA connectors. The signal will be a decaying pulse with amplitude proportional to the beam loss detected. The signal will have a level of 0V to 1.5V when terminated in 50Ω.

3.2. Interface to PMT Assembly

3.2.1. High voltage connector:
This connector will be a SHV jack bulkhead connector. This connector as well as the cable used shall be rated for use with greater than 2000V. The signal will be a DC voltage ranging from 0V to -1000V.

3.2.2. PMT signal connector:
This connector will be a right angle pc mount jack receptacle SMA style connector. The cable shall be a LMR series, low loss, 50Ω coaxial cable terminated with SMA connectors. The signal will be a short pulse, of the order of a few nanoseconds, with amplitude proportional to the loss detected.

3.2.3. Heartbeat connector:
This connector will be a fiber SMA style connector. The cable shall be a multimode fiber terminated with SMA series connector.
4. APPENDIX

Photomultiplier Tube
Model R7400U-04
Hamamatsu Photonics
http://sales.hamamatsu.com/assets/pdf/parts_R/R7400U_TPMH1204E07.pdf

High voltage power supply
Model CA10N
Emco High Voltage Corporation
http://www.emcohighvoltage.com

Charge Amplifier
Model CR-112
Cremat, Inc

DC-DC Converter
Model BWR-12/415-D12A
MuRata Power Solutions
http://www.cd4power.com/data/power/bwr7-10wa-series.pdf

Fiber Optic Transmitter
Model HFBR-1505AZ
Avago Technologies