PMT High Voltage Power Supply Status

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Overview

PMT HV Base Board

Digital Interface

Power

Digital control

Analog Interface

PMT Anode signal

High voltage

Digital Optical Module Main Board (DOMMB)

PMT
The Three Prototypes

“Old Iseg”—Aug. 2002 prototypes

“New Iseg”—Split ground implemented.

“EMCO”—Passive base approach consisting of three components:
Passive base, HV generator, & digital interface.
Photos

“New Iseg”

EMCO Passive Base

HV Control Board

EMCO HV Generator
Treat Them Equally

Every effort was made to make the DOMMB interface uniform among the three prototypes.
## Chronology—2003

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
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<tbody>
<tr>
<td>Feb. 20</td>
<td>EMCO reps visit UW-Madison</td>
</tr>
<tr>
<td>Mar. 11</td>
<td>Iseg head visits DESY / Zeuthen</td>
</tr>
<tr>
<td>Apr. 28</td>
<td>EMCO generators (20) and bases (20) arrive</td>
</tr>
<tr>
<td>May 9</td>
<td>Operate EMCO generator with DOMMB</td>
</tr>
<tr>
<td></td>
<td>New Iseg bases arrive (8)</td>
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<tr>
<td>June 24</td>
<td>New Iseg bases arrive (22)</td>
</tr>
<tr>
<td>July 23-24</td>
<td>LBNL Workshop   ➔ &quot;Old Iseg will do!&quot;</td>
</tr>
<tr>
<td>Aug. 12</td>
<td>IceCube report on proto evaluation by NK</td>
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<tr>
<td></td>
<td>Comments on proto sent to Iseg</td>
</tr>
<tr>
<td></td>
<td>Request for technical information from Iseg</td>
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<tr>
<td></td>
<td>The “crack incident”</td>
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<tr>
<td>Sep. 8</td>
<td>NK report ➔ &quot;Refocus on EMCO&quot;</td>
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<tr>
<td></td>
<td>Trip to EMCO</td>
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<tr>
<td>Oct. 1</td>
<td>PO for samples (4) sent to EMCO</td>
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</table>
The Three Prototypes (summary)

Old Iseg or New Iseg?
- New Iseg with isolated grounds performs *badly*
- New Iseg with directly connected grounds performs *badly*
- New Iseg with $1M\Omega$ jumper performs very similarly to Old Iseg
- Old Iseg is cheaper than New Iseg
- Old Iseg consumes less power than New Iseg

Old Iseg

Iseg or EMCO?
- Both have similar noise levels
- $V_{dy1}$ is fixed in Iseg approach
- Iseg is cheaper than EMCO

Iseg

Trouble with the “New Iseg”
New Iseg--Isolated Ground

Output voltage is very unstable with no ground-connecting jumper

Previously reported at LBNL Workshop (July 23-24, 2003)

Data by John Kelly
(hv_2000_iseg_psl.pdf)
Connecting Grounds with a Zero Ω Jumper

Previously reported at LBNL Workshop (July 23-24, 2003)
Comparison using DOMMB ATWD

http://www.ssec.wisc.edu/~kitamura/HVstatus081203/PMTBaseComparisonWithATWD1.pdf
Noise Comparison

All the bases have similar random noise levels observed at the secondary side of the signal coupling transformer.

<table>
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<th>ISEG NEW</th>
<th>EMCO</th>
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<td>NOISE AT OUTPUT*</td>
<td>mVpp</td>
<td>1.22 ± 0.13</td>
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<td>µVrms</td>
<td>214 ± 18</td>
<td>208 ± 18</td>
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*At 50Ω oscilloscope input using a 50Ω cable. 100 nsec window (400 pts.) The scope background is 1mVpp, 190µVrms over 100 nsec.

Previously reported at LBNL Workshop (July 23-24, 2003)
# Overall Comparison

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<td><strong>1ST DYNODE VOLTAGE</strong></td>
<td>FIXED (600V)</td>
<td></td>
<td>SCALE WITH OUTPUT</td>
</tr>
<tr>
<td><strong>POWER AT MAX OUTPUT (mW)</strong></td>
<td>130</td>
<td>280</td>
<td>250</td>
</tr>
<tr>
<td><strong>COST (US$)</strong></td>
<td>~150</td>
<td>~260</td>
<td>~600</td>
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*At 50Ω oscilloscope input using a 50Ω cable. 100 nsec window (400 pts.) The scope background is 1mVpp, 190µVrms over 100 nsec.

Previously reported at LBNL Workshop (July 23-24, 2003)
Thoughts at the End of July, 2003

- Select and pursue “Old Iseg”-style design
- Need further tests
- Must improve communication with vendor
- Must examine design details
- Conduct Failure Modes and Effects Analysis (FMEA)
Failure of an Old Iseg Board
... drop Iseg as our primary candidate of the PMT HV Base board supplier and bring the alternative vendor to our focus.

--NK’s report dated September 8, 2003

http://www.ssec.wisc.edu/~kitamura/reports/HVstrategy.pdf
EMCO High Voltage Corporation

- Located in Sutter Creek, California, USA
- In HV business for 30+ years
- Has delivered twenty (20) each of HV Generator and PMT Base Board
- The prototypes performed as specified in all tested parameters

Trip report by NK:
http://www.ssec.wisc.edu/~kitamura/reports/EMCO_trip_rpt.pdf

Trip report by George Anderson:
http://www.ssec.wisc.edu/~kitamura/reports/Emco%20Meeting%20Report%209.19.03.pdf
Buying 5000+

Bidding process is necessary

In process:
Define / refine specifications
Requirements & Specifications

- PMT Modular HV Power Supply ERD
- HV Control Board Specification Control Drawing
- PMT HV Base Board Specification Control Drawing
- HV Generator Source-Controlled Drawing

![Diagram of PMT Modular High Voltage Power Supply](image)

- HV Control Board
- HV Generator
- High voltage
- Digital Interface
- PMT HV Base Board
- PMT anode signal
- Dynode voltages
- Power
- Digital control
- Digital Optical Module Main Board (DOMMB)
- Photomultiplier Tube (PMT)
Requirements Documents

PMT Modular High Voltage Power Supply Requirements Document (9000-0039-02*)

“Passive Base”

PMT High Voltage Board Requirements Document (9000-0039*)

PMT High Voltage Power Supply Requirements Document (9000-0039-01*)

*George Anderson has been maintaining these documents.
Improved Specifications

- **PMT Base Board**
  - New pulse-coupling transformer design
  - Through-hole components
  - Additional RC filter at HV entry
  - Improved output cable attachment

- **HV Generator**
  - "HV_DISABLE" pin is added
  - Modified MON and PROG analog range
  - Higher-voltage-rated output cable
  - Eliminate GAIN_ADJ trim-pot

- **HV Control Board**
  - Higher reliability due to fewer components (delete three ICs)

[http://www.ssec.wisc.edu/~kitamura/HVReview_091603.htm](http://www.ssec.wisc.edu/~kitamura/HVReview_091603.htm)
PMT Base Board
Toroidal Transformer

**Old Transformer**
RG178 coaxial cable
⇒ Rated at 1000Vrms

**New Transformer**
22 AWG silicone-insulated bifilar
⇒ Rated at 10kV
Toroidal Transformer Response

Each curve is an average over 1000 triggers.

Laboratory HV supply with an EMCO passive base was used.

Temperature = \(-40^\circ\text{C}\)
PMT gain = \(\sim 1 \times 10^7\)

The bifilar transformer performs better!

http://www.ssec.wisc.edu/~kitamura/toroid.htm
Output Cable Attachment

Proposed

Iseg

EMCO
HV Generator

Spec changes:

- Change PROG range from 0..4095V to 0..2047V
- Change MON range from 0..4095V to 0..2047V
- Add “HV_DISABLE” pin (No reliability penalty. Optional usage)
- Eliminate GAIN_ADJ trim-pot (No need for absolute accuracy)
- Use higher-voltage-rated output cable

⇒ Overall simplicity and increased reliability
HV Control Board

Spec changes:

- Change **PROG** range from 0..4095V to 0..2047V
  - Eliminates x 2 OP-AMP
  - Eliminates –5V power switch

- Change **MON** range from 0..4095V to 0..2047V
  - Eliminate 0..4096V REF

- Overall simplicity and increased reliability
Tasks Ahead

- Test Rev 3 Main Boards with the EMCO passive base / HV generator.
- Test new EMCO samples (4) with Rev 3 Main Boards
- Have EMCO deliver 60 each of the PMT Base Board and the HV Control Board (including the HV Generator)
- Complete specification control drawing for the bid package
- Create verification plan
Conclusion

Just as System concluded after the recent PDR, mature in design but weak in verification.