PMT Modular HV Supply Design Status

IceCube

December 2003
Madison Instrumentation Workshop

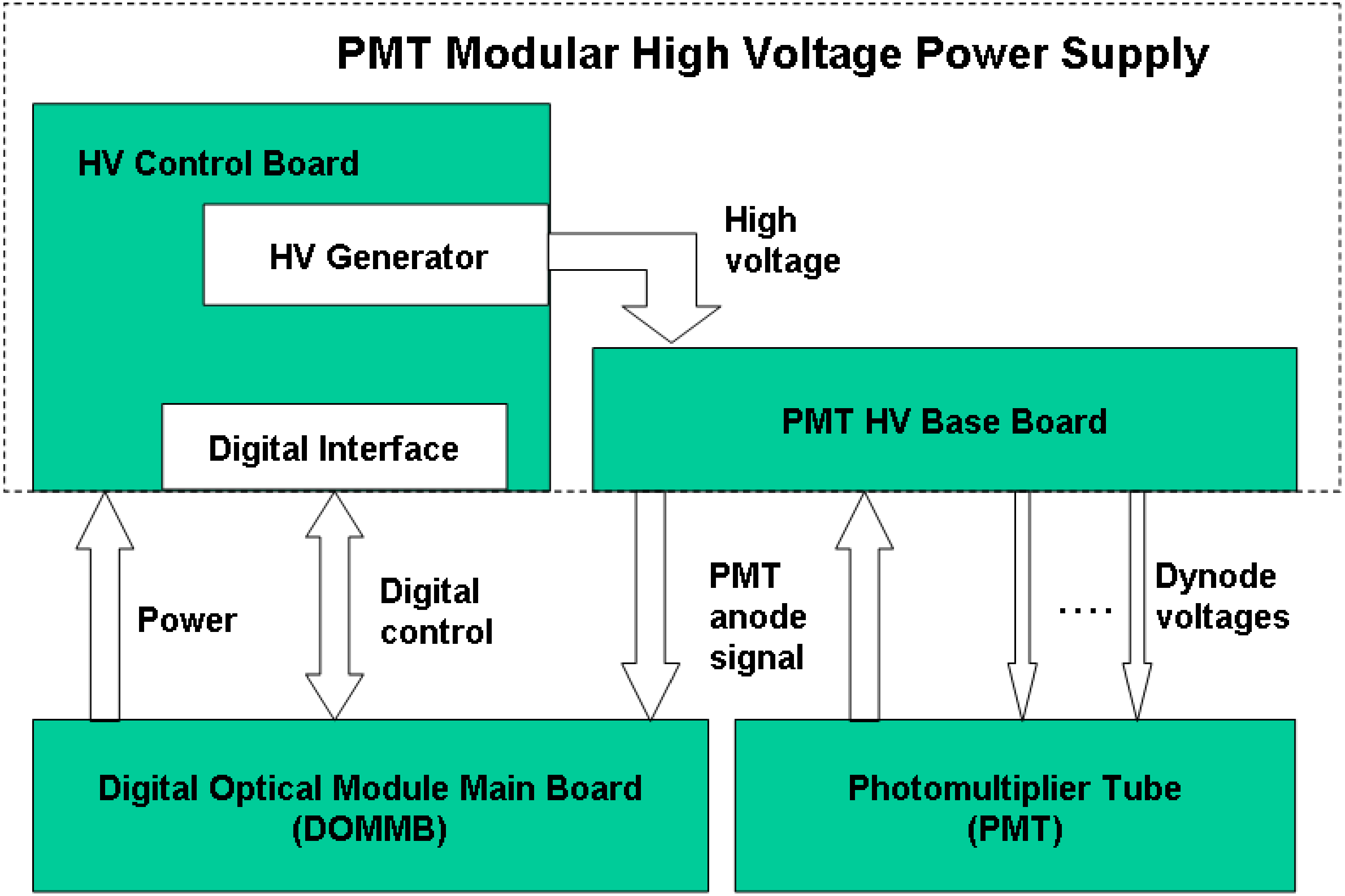
Nobuyoshi Kitamura

UW-Madison

Outline

- Documentation status
- Action Items status
- Design changes
- Design Verification
- Collaboration framework

Modular Design



Documentation

ERD for PMT Modular HV Power Supply

HV-DOMMB Interface Requirements

Procurement Documents

PMT Base Board

- •Specification Control Drawing
- ✓Board mechanical drawing
- ✓Board envelope drawing
- ✓Schematic diagram
- ✓Toroidal transformer specification

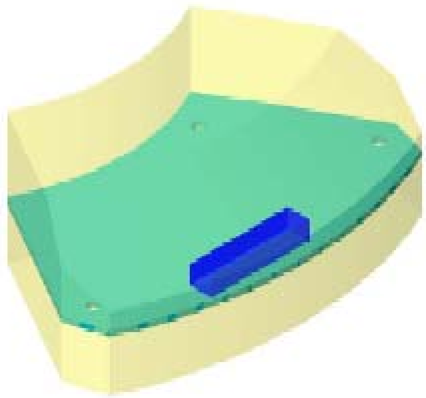
HV Control Board

- •Specification Control Drawing
- ✓Board mechanical drwaing
- ✓Board envelope drawing
- ✓Schematic diagram
- ✓Parts List
- •HV Generator Source Controlled Drawing

http://amanda.wisc.edu/kitamura/HVM/HVM1.htm

Component Envelope Drawing

Allows the maximum usage of the available volume for the vendors' design.



PSL 5549C104 Glen Gregerson (portion)

http://amanda.wisc.edu/kitamura/HVM/5549104c_b.pdf

Documentation Status

ERD—There are requirements to be refined / added (➔Action Items)

All the documents need to be reorganized.

Action Items from May 03 PDR

Log#	Title	Status	Work with:
1	PMT HV trade study	Closed	
4	Coax negative margin	Closed	
5	HV system margins		system
6	Interface noise margin		G.Pryzybylski
7	Voltage monitor range	Response submitted	
8	Turn-on and transient power		G.Przybylski
9	Applicable PWB specs	Response submitted	
10	Output droop	Done prelim. measurement	C.Wendt
11	Power state management	In progress	
12	Drift adjustment by software	Status submitted	C.McParland

PDR-1: HV Trade Study

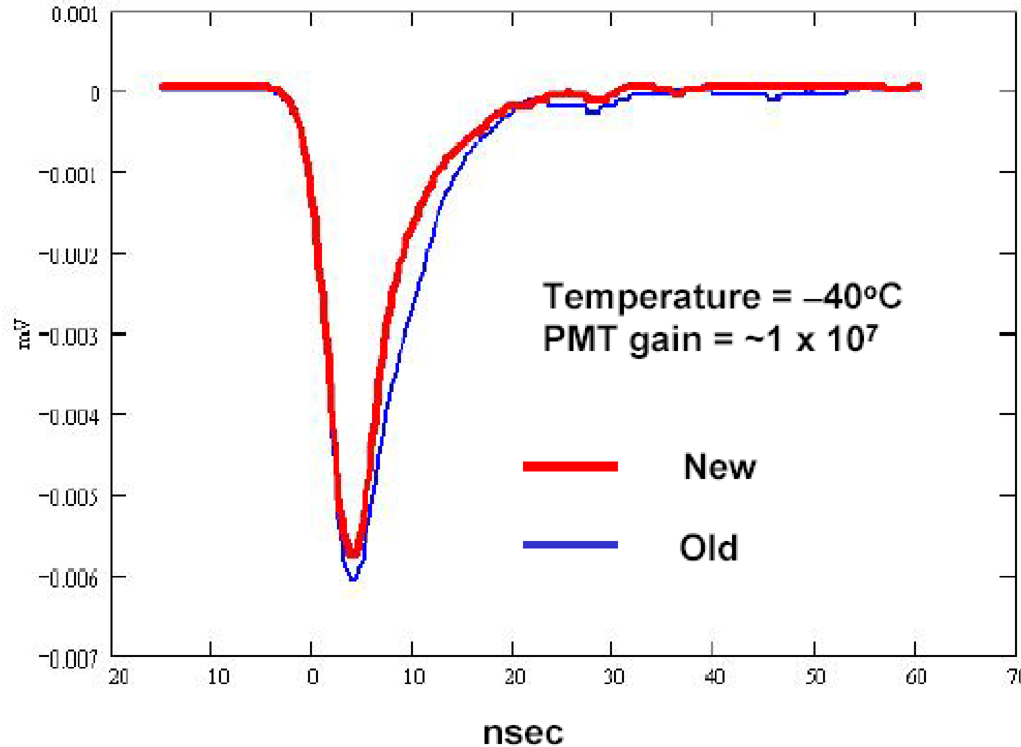
- "Active Base"—Integrated, unique, proprietary design. The vendor confidence is a major issue.
- "Passive Base"—A number of potential vendors. Satisfactory performance of prototypes from current vendor.
- Time / resource constraints precludes a "second-run" on Active Base.
- More price and power consumption for Passive Base. No other downsides.
- Focus on "Passive Base". Pursue alternative vendors thru European channel.

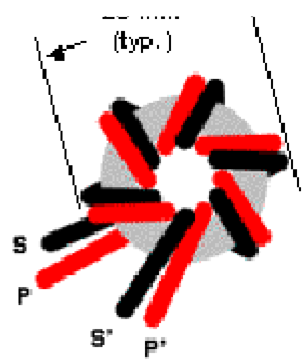
See summary on DocuShare:

PDR4: Coax negative margin

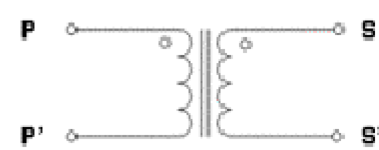
Old

New





10kV per wire



http://amanda.wisc.edu/kitamura/HVM/toroid_spec.pdf

PDR-5: HV System Margins

Determine the parts margins in the HV system for short term overvoltage acceptance testing and long term reliability/stability.

- **L, C, R and cabling are involved in the HV system.**

- **Current design implementation (R, C) relies on vendor’s expertise.**

PDR-6: Interface Noise Margin

Reconcile the interface requirements between the PMT HV and the DOMMB including noise types and noise margin.

- ❑ The DAC and ADC use a 3.3V logic (both level- and edge-sensitive).
- ❑ The IDENT uses a 3.3V OneWire protocol (level-sensitive).
- ❑ All the communication is dictated by the DOMMB.
- ❑ No communication glitch has been encountered in the lab.

PDR-7: Voltage Monitor Range

Main point:

Is it necessary to monitor output voltage beyond the nominal maximum voltage (2047V)?

Proposed:

Monitoring up to 2047V is sufficient.

Voltage run-off beyond this limit may be detected by other means.

Monitoring up to, e.g., 2100V adds cost and complexity.

PDR-8: Turn-on and transient power

Specify the peak turn-on and other transient power requirements in addition to the steady state power.

- The steady-state power is 300mW plus bleeder (40mW) max.
- The load capacitance is known (~20 μF?).
- The HV generator tolerates +15V (steady-state).
- The active devices (ICs) are designed for 5V operation with absolute maximum of ???V.
- The main board power supply has transient load limits, which must be compiled into this requirement.

PDR-9: Applicable PWB Specs

Review the applicable PWB design specifications for minimum spacings.

Response submitted.

Reviewed *IPC Generic Standard* for trace spacings requirements.

The parameters are:

- **Voltage**
- **hi/lo altitude**
- **Overcoat or none**
- **Conformal coat or none**

The numbers in the previous versions of ERD are okay.

PDR-10: Output droop

Specify the acceptable droop for a specific optical step function input.

This requirement must be added to the ERD.

Need to define the requirement based on physics requirements

Lab work in progress with Chris Wendt.

Preliminary measurements demonstrate that the droop never becomes prominent over the DOMMB digitizing time window. (Meeting the physics-based requirement appears to be a non-problem.)

PDR-11: Power-state management

Create a state table for all conditions of power ON/OFF including transients vs. allowed conditions and actions such as cold start, warm start, warm-up, reboot delays, etc.

A HV_DISABLE logic signal has been added to the interface. The use of this signal allows the HV system to be power cycled under more well-defined conditions.

PDR12: HV Monitoring and Adjustment by SW

Create a requirement allocated to software for monitoring and adjusting PMT gain and other parameters due to drift.

This is likely a multi-loop control problem based on HV Monitoring and Gain Measurement.

Reading the HV ADC introduces noise in the analog signal chain. Thus HV Monitoring requires a special software coordination.

Design Changes

DOMMB-HV Interface
20-pin → 24-pin connector to accommodate HV_DISABLE.

HV Control Board
Same functionality with fewer components due to specification changes for HV Generator.
Output cable changed from RG178 to RG403.

PMT Base Board
New toroidal transformer design
Thru-hole components
No conformal coating upon delivery

Design Verification

(A) Most items are obvious—verified by "inspection":
➔Examples: "Is there a +5V power in the cable?"

(B) Digital and analog functions are tested straightforwardly by communicating with the DOMMB.
➔Examples: Read Board ID

(C) (B) combined with manual measurement of analog output.
➔Examples: DAC code vs. HV output.

(D) Items requiring special attention or setup. Some are in response to the action item work:
D1: Voltage stability
D2: Anode voltage ripple
D3: DC-current sourcing capability
D4: Pulse-current sourcing capability
D5: "droop" requirement test (optical response)
D6: Transformer pulse-response (not in the ERD (yet))

Collaboration issue (Proposed / speculated)

- Some of the Design Verification Tests will be split between Wisconsin and Wuppertal.

- Wuppertal has proposed a component-level accelerated test suite (needs rework).

- Long-term tests, including HV stability, may be suited for Wuppertal.

- Wuppertal will identify an alternative vendor for the HV components.

Conclusion