PMT HV Base Board Engineering Requirements

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Preliminary Design Review
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Outline

IceCube PMT HV Base Board ERD **version 2.3** (March 7, 2003)
http://www.ssec.wisc.edu/~kitamura/NK/PMT_Base/PMTHVBaseERD_ver2.3.pdf

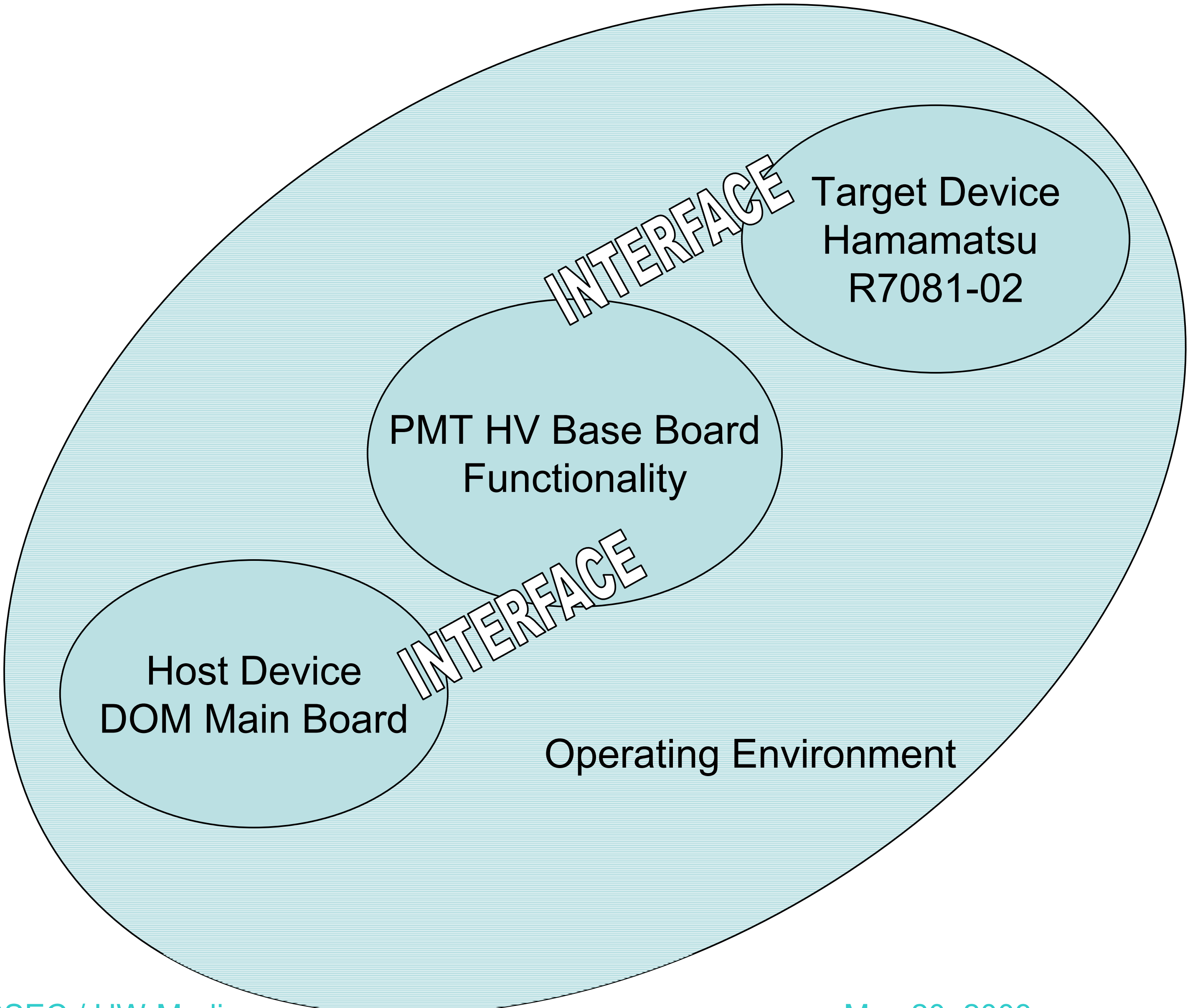
1. Functionality overview

2. Design status
   ➔Status of the dual-track approach
   ➔Known design / requirements issues
   ➔Requirements update

3. Document walk-through with summary tables
   ➔Is the requirement valid (justified)?
   ➔How do you verify it?
   - **T**est
   - **A**nalysis
   - **I**nspection
   - **D**emonstration
   - **S**imilarity

4. Discussion

ERD


Target Device
Hamamatsu
R7081-02
INTERFACE
PMT HV Base Board
Functionality
INTERFACE
Host Device
DOM Main Board
Operating Environment

Purpose of the PMT HV Base Board ➔Page 6, Section 2, Paragraph 4

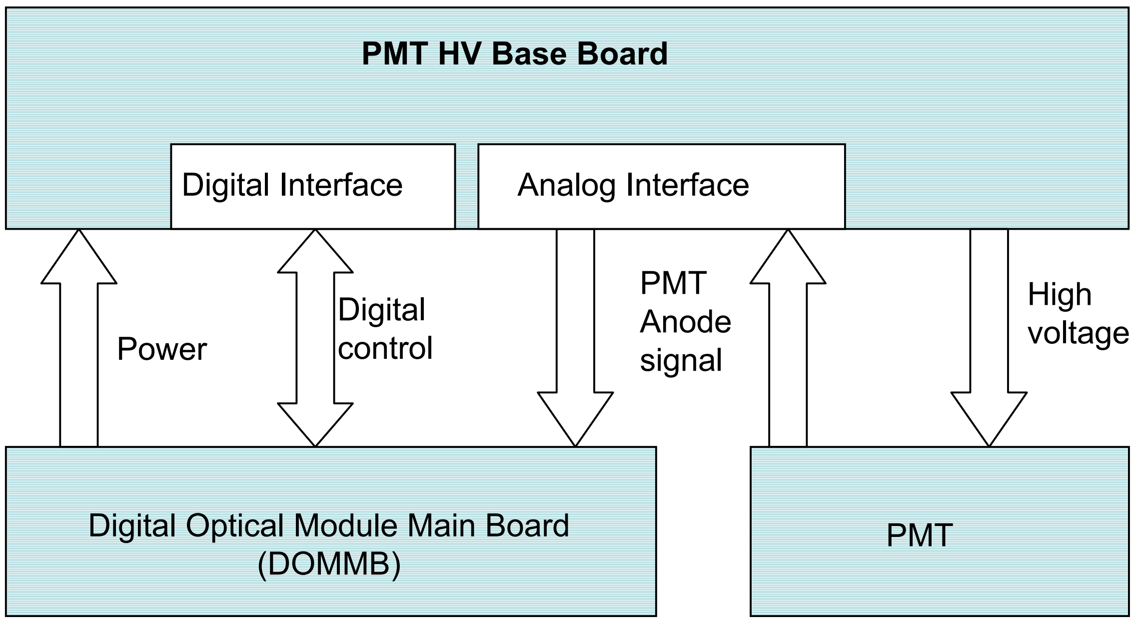


Fig 2.1

Dual-Track Design Approach

Active Base (All-in-one) approach

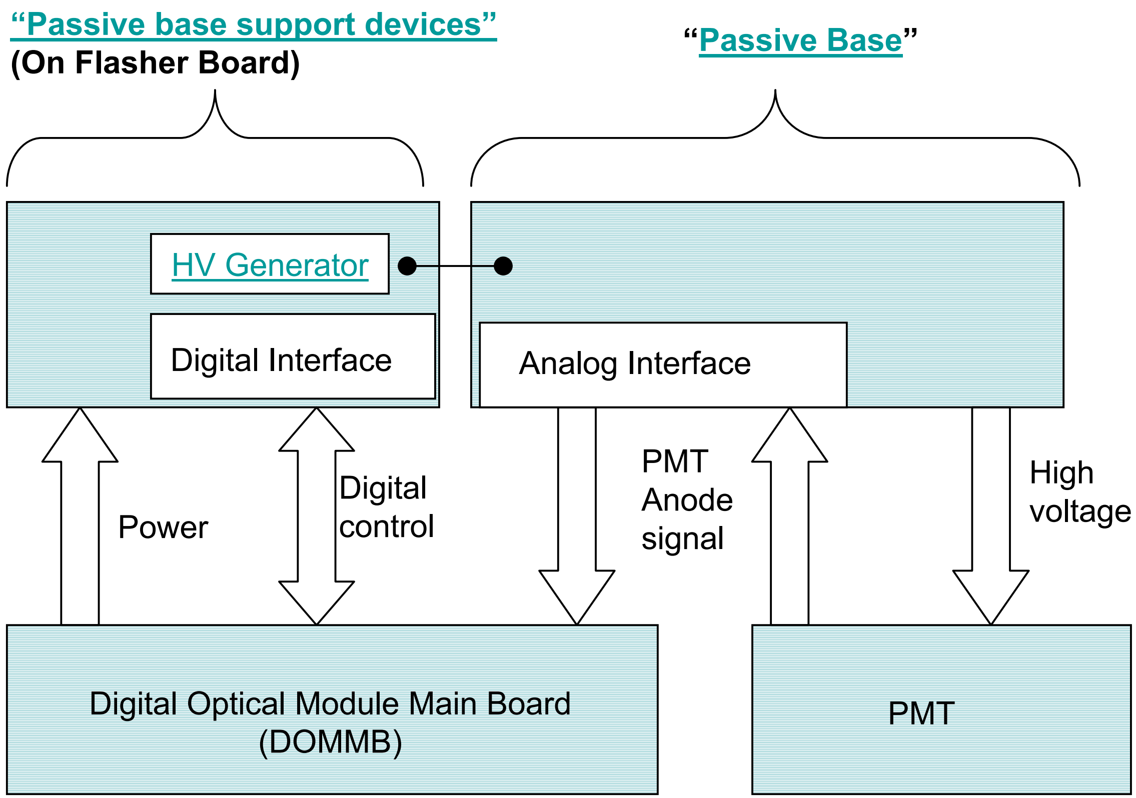
➔ERD assumes this as a default configuration

Passive Base approach

➔Section 3.1.1.1 allows an alternative configuration
➔ERD Supplement (ver 0.00c, Jan. 13, 2003) defines alternative requirements
http://www.ssec.wisc.edu/~kitamura/NK/PMT_Base/PMTBaseERD%20suppl0.00c.pdf

Alternative Design-- “Passive Base” Approach

- Classical approach to operate PMT
- Simpler (and modular) basic components
- No cost advantage (unlike initially anticipated)



Comparison of the Requirements Between the Two Approaches

Requirement	ERD Section	Active Base	Passive Base
Fixed 1st Dynode Voltage at 700V	3.1.4.1.A	Yes	No. Vdy1 scales with Vtotal
Cathode-Anode voltage adjustable over 1000-2000VDC	3.1.4.1.B	Yes	Yes
Dynode 2-Anode voltage ratio (Table 3.1)	3.1.3.2	Yes	Yes. Plus a high Vdy1 fraction per Hamamatsu.
Split ground	3.2.2.1	Yes	No. Insert ferrite bead between grounds.
Clean ground wire	3.2.2.1.E	Yes	No
Ribbon cable	3.2.5.2	Yes	Yes. Connector on interface board.
Component placement	3.3.3	Yes	Remove (c), (d), (e), (g)

PMT HV Base Board
Alternative Design

Selection Criteria for the Passive Base Design

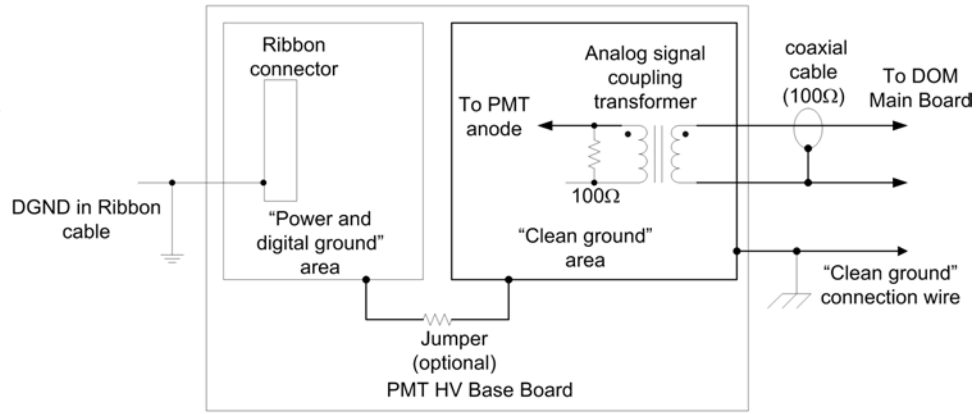
- ❑Simpler and more reliable➔(subjective value)
- ❑Reliable source of components➔No
- ❑Cost advantage➔No
- ❑Lower power consumption➔No
- ❑Better performance➔Needs test
- ❑Technically sound➔Yes

Status:

- ❑20 units each of HV generators and passive base boards have been received from vendor.
- ❑One based on those components is available for DOM tests

3.2.2.1 Split-ground requirement

Fig 3.1, page 13



Justification:

Avoid ground loop
Avoid oscillator noise

Counter argument:

Ground loop can be avoided by other means
Oscillator noise will propagate anyway

Vendor response:

Isolation amplifier adds much to the board power needs and the cost
Leads to lower feedback gain and poorer voltage regulation

Verification:

Comparison of noise levels between configurations w/ and w/o the requirement in question.

3.2.3.1 Signal coupling with a coaxial toroidal transformer

Justification:

- Superior pulse response compared to capacitive coupling
- An alternative using a large HV capacitor is a reliability concern

3.2.3.1.B Transformer specification (use RG-178 coaxial cable)

- RG-178 has a maximum operating voltage of only1000Vrms (RF).
- Can't find a suitable, thin, flexible cable with Vmax>2000VDC.

Observation:

A sample of RG-178 has been lab tested w/o failure
The Teflon dielectric should withstand well over 2000V
The 1000Vrms at RF is a much harsher condition than 2000VDC

3.5.1 Conformal coating

3.5.1.1 Masking requirement

The PMT HV Base Board shall be delivered by the vendor without conformal coating

The conformal coating shall be applied at the OM production facility, after the Board is mounted on the PMT.

Summary of Physical Interface / Electrical, Mechanical

➔Table 2.1, page 8.

Connection method	Comments	Section
Plated-thru PMT mounting holes	Serves both Electrical and Mechanical purposes	3.2.4
Coaxial cable for PMT pulses	Carries fast, sensitive pulse signals	3.2.3
2mm ribbon cable	Digital and power. Space saver compared to 2.54mm-pitch	3.2.5.2
Clean ground wire	Ground for the HV-side of the split ground plane	3.2.2.1.E

3.1 The PMT HV Supply

		Justification / Source of requirements
3.1.2	Dynode chain voltage (Table 3.1)	Hamamatsu datasheet
3.1.2.1	Cathode is at ground	Low noise advantage
3.1.4.1.A	Dy1 fixed at 700VDC	PMT measurements at UW to assure P/V Sufficiently high, allowed by Hamamatsu Gain adjustment is a needed function Note 3 (p.25)
3.1.4.1.B	Vc-a digitally adjustable 1000-2000VDC	
3.1.4.2	HV digital monitor	Useful to monitor actual voltage
3.1.5	Anode current sourcing capability	(a), (b) support constant noise current (c) rare event, allow slow recovery
3.1.6	Stability of 4V/week	2% gain change by analysis
3.1.7	Noise ripple < 0.5mVpp	<< trigger threshold, Note 8

3.2 Electrical

		Justification / Source of requirements
3.2.1.3	Maximum power is 300 mW	(More is likely needed, vendor)
3.2.2.1	Split ground (Fig 3.1)	Avoid ground loop Avoid oscillator noise in pulse output
3.2.3	Coaxial toroidal transformer for pulse signal coupling.	AC-coupling is needed Hi-bandwidth connection Does not require large capacitor
3.2.4	PMT mounting holes	PMT pinouts drawing
3.2.5.1	3.3V CMOS logic	DOMMB requirements
3.2.5.2.B	2mm ribbon connector	Needs less board area
3.2.5.2.C	Two conductors per signal in ribbon cable	Redundancy for reliability

3.2 Electrical (continued)

		Justification / Source of requirements
3.2.5.3	Two chip-select lines	Support three digital functions (DAC, ADC, IDENT)
3.2.5.5.A	Power ON/OFF	ON and OFF are both required modes of operation
3.2.5.5.C	On power-up the voltage is at minimum supported value	Safe default behavior
3.2.5.6.A	Board ID readout	DAQ software design

3.3 Physical

		Justification / Source of requirements
3.3.2	Board size and shape	OM integration
3.3.3	Component placement	OM integration
3.3.5	Minimum trace spacing to meet IPC-2221 §6.3	IPC document
3.3.6	Manual soldering compatibility	Production operating procedure

3.4 Environmental

		Justification / Source of requirements
3.4.1.1	Operating temperature is –40 to +27C	In-ice operation, excludes icetop
3.4.1.2	Storage temperature is –55 to +45C	Storage and transport environment
3.4.1.3	Prefer components rated below –55C Vendor must disclose otherwise	
3.4.2	Pressure range 40kPa to 100kPa	Actual operating environment

3.5 Miscellaneous

		Justification / Source of requirements
3.5.1	Conformal coating is required	The IPC rule assumes dielectric coating (Coating to be applied at OM production site)
3.5.1.1	Proper masking before applying conformal coat	(Requirement to be removed)
3.5.2	Silkscreen marking	Needed for inspection and production

Conclusion

Test against the *Exit Criteria*

Is the ERD in good shape?

Risk items have been identified:

- Toroidal transformer requirement
- Split ground requirement

Alternatives

- Requirements are defined
- Selection logic defined