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GLAST LAT SYSTEM SPECIFICATION	Subsystem/Office Calorimeter Subsystem	
Document Title **Specification for the Calorimeter PIN Photodiode Assembly**		

Gamma-ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

Specification for the Calorimeter PIN Photodiode Assembly

DOCUMENT APPROVAL

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CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes	DCN #
1		Initial Release for EM Prototype Parts	
2	5 Feb 2001	Modified per vendor recommendations	
3	20 Feb 2001	Modified per vendor recommendations, EM Parts	

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1 PURPOSE

This document specifies the mechanical, optical and electrical characteristics of the PIN photodiode assembly for the Calorimeter subsystem of the GLAST Large Area Telescope (LAT). This assembly consists of a ceramic carrier containing two Silicon PIN photodiodes. A kapton ribbon cable provides electrical interconnect. The optical window of the assembly is coated with a clear epoxy resin.

2 SCOPE

These specifications apply to the PIN photodiode assembly prototypes for the Calorimeter subsystem of the GLAST LAT. The prototypes shall be designed, fabricated and tested in the Engineering Model of the calorimeter subsystem. Approximately 250 diodes shall be delivered for the Engineering Model. Subsequent to the testing of the photodiode prototypes, this specification shall be modified to detail the final design, fabrication, testing and documentation for the PIN photodiodes for the GLAST flight instrument. Approximately 4400 diodes shall be purchased for the flight instrument and spares.

This release of the specification applies to the Engineering Model prototype PIN photodiode assemblies only. These diodes shall be manufactured, to the extent possible, with identical materials and processes as the flight instrument diodes but with documentation and quality assurance procedures more commensurate with commercial fabrication procedures. This will allow the vendor to establish process parameters and manufacturing methods for the flight hardware. The details of the manufacturing and quality controls for the flight procurement shall be negotiated with the vendor and this specification shall be modified to reflect new applicable requirements from MIL-PRF-38534 and MIL-STD-883 that are acceptable to the GLAST project at NASA/GSFC. NASA/GSFC project and the LAT management shall review the specification for flight parts prior to procurement.

3 DEFINITIONS

3.1 Acronyms

CAL	The Calorimeter subsystem of the LAT
GLAST	Gamma-ray Large Area Space Telescope
EM	Engineering Model
FM	Flight Model
GSFC	Goddard Space Flight Center, NASA
LAT	Large Area Telescope
NASA	National Aeronautics and Space Administration
TBR	To Be Resolved

3.2 Definitions

γ	Gamma Ray
μsec, μs	microsecond, 10^{-6} second
nm	nanometer
μm	micrometer
mm	millimeter
cm	centimeter
eV	Electron Volt
MeV	Million Electron Volts, 10^6 eV
ph	photons

4 APPLICABLE DOCUMENTS

Documents that are relevant to the development of the GLAST LAT Calorimeter and its requirements include the following:

LAT-SP-00010	"GLAST LAT Performance Specification", August 2000
LAT-SS-00018	"LAT CAL Subsystem Specification", January 2001
GLAST00110	"Mission Assurance Requirements (MAR) for Gamma-Ray Large Area Telescope (GLAST) Large Area Telescope (LAT)", NASA Goddard Space Flight Center, Current Draft Sept 20, 2000

NPD 8010.2B	"NASA Policy Directive, Use of Metric System of Measurement in NASA Programs"
Hamamatsu Photonics K03-B70065	Specification for the Silicon PIN photodiode, S3590 SPL 2CH, dated 6 August 1998.
MIL-PRF-19500	Performance Specification for Semiconductor Devices
MIL-STD-750	Test Methods for Semiconductor Devices
EIA-625	Requirements for Handling Electrostatic Discharge Sensitive Devices (ESDs)
IPC-FC-231	Flexible Base Dielectrics for Use in Flexible Printed Wiring.
IPC-FC-232	Adhesive Coated Dielectric Films for Use as Cover Sheets for Flexible Printed Wiring and Flexible Bonding Films
IPC-FC-241	Flexible Metal Clad Dielectrics for use Flexible Printed Wiring
IPC-FA-251	Assembly Guidelines
IPC-MF-150F	Metal Foil for Printed Wiring Applications
IPC-6013	Qualification and Performance Specification for Flexible Printed Wiring Boards
IPC-2223	Design Standard for Flexible Printed Wiring Boards
MIL-C-55302/65	Requirements for Connector and other applicable documents specified in NR documents
NASA-STD-8739.3	Soldered Electrical Connections

5 INTRODUCTION

The GLAST mission is a NASA-launched gamma-ray mission to be launched in 2005. The expected mission lifetime is greater than 5 years. The Large Area Telescope (LAT) instrument is the primary experiment on GLAST and consists of an Anticoincidence Device, a silicon-strip detector tracker, a CsI calorimeter (CAL), and a Trigger and Dataflow system. The principal purpose of the LAT is to measure the incidence direction, energy and time of cosmic gamma rays. The measurements are streamed to the spacecraft for data storage and subsequent transmittal to ground-based analysis centers.

The LAT calorimeter is a hodoscopic array of CsI(Tl) scintillation crystals. Scintillation light is collected by PIN photodiodes and processed by charge sensitive preamps. The CAL subsystem consists of a 4×4 array of identical modules. Each module is a hodoscopic array of 96 CsI scintillation crystals and associated readout electronics. Each crystal is approximately $27 \times 20 \times 336$ mm in size with a PIN photodiodes attached on each end.

Two photodiodes, one large and one small, are required at each end of the crystal to support the electronic measurements over the required dynamic range of the energy depositions. These two diodes are mounted in a single carrier with a kapton cable interconnect. The diode assembly shall coupled to the CsI crystal using an optical epoxy or a silicon elastomeric casting (similar to Mapsil 213).

This specification identifies the mechanical, optical and electrical characteristics of this PIN photodiode assembly consisting of a ceramic carrier, diode pair, and interconnect cable.

6 REQUIREMENTS

6.1 Mechanical Configuration

The contractor shall provide two Silicon PIN photodiodes mounted in ceramic carrier with kapton interface cable attached.

6.1.1 Case Outline

6.1.1.1 External dimensions

The ceramic carrier shall be 22.3 (±0.2) mm × 15.0 (±0.2) mm × 1.8 (±0.2) mm. (see Figure 1)

6.1.2 Part or Identifying Number (PIN)

A unique part number shall be applied to the back ceramic carrier. Traceability shall be maintained for individual parts that are part of the assembly.

Hand written serial number in ink shall be acceptable for EM parts.

6.2 PhotoDiode

6.2.1 Description

The ceramic carrier shall contain two silicon photodiodes manufactured with Silicon material and controlled processes appropriate for space flight quality parts. We reference the previous GLAST

Table 1. Electrical and Optical Properties of PIN Diode A (small diode) at 20 °C

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Active Area Size	–	–	–	10.5 × 2.4		mm
Spectral Response Range	λ	–	–	320 ~ 1100	–	nm
Peak Wavelength	λp	–	–	960	–	nm
Photo Sensitivity	S_1	λ = λp	–	0.66	–	A/W
	S_2	λ = 540 nm	0.33	0.37	0.41	A/W
Dark Current	I_D	V_R = 70V	–	1.0	3.0	nA
Terminal Capacitance	C_t	V_R = 70V f = 1 MHz	–	10	15	pF
Cut-off Frequency	f_C	V_R = 70V, λ=830nm, R_L=50Ω, -3DB	–	45	–	MHz
Maximum Reverse Voltage	V_{Rmax}		100			V
Depletion Voltage	V_D				70	V

PIN photodiode development at Hamamatsu Photonics, part number S3590 SPL 2CH that was developed for the Naval Research Laboratory in 1998. The Hamamatsu specification number for the S3590 SPL 2CH part is K03-B70065, dated 6 August 1998. This material was ~ 300 μm thick and had ~ 200 μm depletion depth. For the PIN photodiodes defined here, we specify a ~300 μm depletion depth design. The characteristics specified in Tables 2 and 3 are based on the Hamamatsu S3590-08 characteristics.

6.2.2 Performance Specification

6.2.2.1 Diode A

The smaller of the two PIN photodiodes in the carrier shall be designated Diode A and shall have an active area of 10.5 × 2.4 mm. Table 1 specifies the electrical and optical characteristics of Diode A at 20 °C.

Table 2. Electrical and Optical Properties of PIN Diode B (large PIN) at 20 °C

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Active Area Size	–	–	–	10.5 × 14.5		mm
Spectral Response Range	λ	–	–	320 ~ 1100	–	nm
Peak Wavelength	λp	–	–	960	–	nm
Photo Sensitivity	S_1	λ = λp	–	0.66	–	A/W
	S_2	λ = 540 nm	0.33	0.37	0.41	A/W
Dark Current	I_D	V_R = 70V	–	3.0	10.0	nA
Terminal Capacitance	C_t	V_R = 70V f = 1 MHz	–	65	100	pF
Cut-off Frequency	f_C	V_R = 70V, λ=830nm, R_L=50Ω, -3DB	–	35	–	MHz
Maximum Reverse Voltage	V_{Rmax}		100			V
Depletion Voltage	V_D				70	V

6.2.2.2 Diode B

The larger of the two PIN photodiodes in the carrier shall be designated Diode B and shall have an active area of 10.5 × 14.5 mm. Table 2 specifies the electrical and optical characteristics of Diode B at 20 °C.

6.2.3 Photodiode Accommodation

6.2.3.1 Electrical Connections

Bonding and connections to the silicon (TBR).

6.2.3.2 Silicon Photodiode Mounting and Isolation

The two photodiodes shall be mounted in such a manner to preserve electrical isolation. The electrical and optical characteristics of the two photodiodes are addressed in Table 1 and Table 2.

6.2.3.3 Optical Window Material

The photodiodes shall be coated with a clear epoxy resin to protect their sensitive surfaces and to maintain effective and reliable coupling to the scintillation crystals. An epoxy similar to that used in the Hamamatsu Silicon PIN Photodiode S3590 SPL 2CH delivered to NRL shall be used. It is understood that this epoxy has been qualified for space flight in ESA's INTEGRAL program for

Table 3. Absolute Minimum and Maximum Conditions

Parameter	Symbol	Value	Unit	Remark
Reverse Voltage	VR_{Max}	<100	V	
Operating Temperature	T_{opr}	– 20 thru +35	°C	Non-condensing
Storage Temperature	T_{stg}	– 20 thru +50 – 30 thru +50	°C °C	EM Parts, Non-condensing FM Parts, Non-condensing
Temperature Rate of Change		TBR	°C/hr	
Max Atmospheric Pressure		1.1	atmos	
Min Atmospheric Pressure		$< 10^{-6}$	Torr	Must operate in space vacuum

the PICsIT experiment. Any deviation from this epoxy shall be negotiated with the GLAST LAT Calorimeter Team.

6.2.3.4 Optical Surface Flatness

The clear epoxy resin shall fill the ceramic carrier wells for the photodiodes, cover the recessed ceramic isolation wall between the cells, and shall be polished to a flat optical mounting surface. The optical mounting surface shall be flat to within ±2.0 µm.

6.2.3.5 Alignment of Optical Surface to Ceramic Surface

The optical epoxy surface shall be aligned with the ceramic surface to within ±5.0 µm.

6.2.3.6 Absolute Maximum Ratings

Table 3 identifies the absolute minimum and maximum ratings for the photodiode assembly during laboratory testing and ultimate space flight. Note: for the Engineering model parts, the storage temperature range has been reduced.

6.2.4 Radiation Requirements

6.2.5 Technology Flow

6.2.6 Reliability

6.2.7 Certification of Manufacturer

6.2.8 Qualification Requirement

6.2.9 Screening Requirement

6.2.10 Derating Requirement

6.2.11 Program Parts Control Board

6.2.12 Precap Inspections

6.2.13 Destructive Physical Analysis

6.2.14 Subcontractor Controls

6.2.15 Facilities and Standards

6.2.16 Manufacturing Controls

6.2.17 Nonconforming Material Control

6.3 Ceramic Carrier

6.3.1 Specification

The ceramic carrier shall be 22.3 (±0.2) mm × 15.0 (±0.2) mm × 1.8 (±0.2) mm. (see Figure 1)

6.3.1.1 Photodiode accommodation

The two silicon photodiodes shall be mounted in the ceramic carrier with isolated wells for each diode as indicated in Figure 1**.** The ceramic barrier wall isolating the two wells shall be recessed 510 µm below the top of the ceramic outer wall.

6.3.1.2 Electrical connections

The carrier shall provide isolated connections (4) to the individual diode cathodes and anodes in the form of brazed iron-nickel alloy (kovar) pins, 0.46 mm in diameter on 0.8 mm pad. The connections shall be oriented as indicated in Figure 1 with the two cathode connections adjacent to each other. The pins shall extend 9 mm from the back of the ceramic carrier. (See Figure 1.) A kapton cable shall be soldered to the kovar pins as indicated.

6.3.2 Substrate flow diagram and sample planning

6.3.3 Manufacturing Storing Instructions (MSI) Process and Material Specification

6.3.4 Qualification

6.3.5 Screening

6.3.6 Vendor Selection

6.3.7 Acceptance Criteria

6.4 Kapton Cable i.e., Flexible Printed Wiring Board as per IPC-6013

6.4.1 Specification

Material type and construction is extremely important in designing flexible printed wiring. All materials shall be specified on the master drawing. For clarification, it is suggested that cross-sectional views be used to highlight material selection.

At the fabricator's option, flexible metal clad dielectrics and adhesive coated dielectric films may be manufactured using individual components per IPC-MF-150, IPC-FC-231, IPC-FC-232, and IPC-FC-241.

6.4.1.1 Kapton Cable

The mechanical configuration of the kapton cable is specified in Figure 2. The cable shall be soldered to the pins of the ceramic carrier. The cable length shall be 2.5 cm (TBR).

6.4.1.2 Kapton

The kapton ribbon shall be constructed from 1 mil (25 μm) thick (minimum) base material with two1 mil (25μm) thick (minimum) covers enclosing two conductive layers.

6.4.1.3 Conductors

Four copper conductors shall provide individual paths for the cathode and anode of each diode. One-half ounce rolled, annealed, copper foil shall be used for the conductors (thickness, ~1.4 mil or 35 μm) per IPC-MF-150F. Tin/Lead plating shall be applied to exposed copper surfaces (pads). Minimum thickness of Tin/Lead plating shall be 0.4 mil.

6.4.1.4 Adhesives

Adhesives that bond the copper foil to the base material and the cover material shall be ~1 – 1.5 mil thick. Adhesive that bonds reinforcing films to the base material shall be ~ 1 – 1.5 thick per IPC-FC-232.

For EM parts adhesion strength shall meet IPC class 2 requirements. This issue will be further investigated for FM parts.

6.4.1.5 Reinforcement – Ceramic Carrier Pads

The termination points of the conductors shall be stiffened using normal flex cable procedures to provide thru hole solder pads at the diode carrier end of the cable. The ends of the cable shall be reinforced with ~3 mil (76 μm) material as shown in Figure 2. The holes for the carrier connection shall be plated thru holes with finished diameter (~ 0.9 mm) sufficient to provide clearance around the bottom fillet of the kovar pin for flush mounting of the cable. Solder pads shall be 1.8 mm in diameter and tin/lead plated with minimum thickness of plating of 0.4 mil. One layer of the kapton is removed around these interconnects to expose the solder pads. The clearance hole in the reinforcement shall be ~2.2 mm in diameter, fully exposing the solder pad.

6.4.1.6 Reinforcement – Electronics Board Pads

The termination points of the conductors shall be stiffened using normal flex cable procedures to provide SMT solder pads at the electronics board end. One layer of the kapton is removed around these interconnects to expose the solder pads. Solder pads shall be tin/lead plated with minimum thickness of plating of 0.4 mil. The ends of the cable shall be reinforced with ~3 mil (76 μm) kapton as shown in Figure 2. The connection stiffening shall result in a ~300 μm thick flex cable at the electronics board pads.

6.4.1.7 Shielding

There shall be no conductive shielding layers in the cable.

6.4.1.8 Kapton cable attachment

The kapton cable shall be soldered to the base of the kovar pins on the ceramic carrier such that the top of the cable is less than 0.8 mm from the ceramic. Gold plating on all surfaces that become part of finished solder connections shall be removed by two or more successive tinning operations (solder pot or iron), or by other processes demonstrated to have equivalent effectiveness.

All solder used for tinning and solder connections shall conform to ANSI/J-STD-006. Flux-cored solder shall be either composition SN60 or SN63 containing flux types R or RMA, or equivalent. For all soldering applications where adequate subsequent cleaning is not practical, only solder containing flux type R shall be used. Solid solders (no flux) for use in solder pots shall be of the same composition.

For the prototype diodes, the pins shall not be cut after soldering of the kapton cable. (It is likely that the vendor shall be required to cut the excess length of the pins after soldering for the flight units.)

6.4.2 Materials Selection

6.4.3 Vendor Selection

6.4.4 Process Control

6.4.5 Qualification

6.4.6 Acceptance Testing

6.4.7 Environmental Requirements

6.4.8 Coupon Selection

6.4.9 Solderability Requirement

6.5 Assembly of PhotoDiode

6.5.1 Requirements

6.5.2 Die Attach (Photo Diode)

6.5.3 Die Attach Controls

6.5.4 Wire/Ribbon Bond Controls

6.5.5 Manufacturing Standing Instructions Process and Material Specification

6.5.6 Qualification of Assembly and Testing

6.5.7 Epoxy Controls and Application Methods

6.5.8 Soldering of Flex Cable as per NASA Standards and Controls

6.5.9 Verification of all above controls

6.5.10 In Process and Final Inspections

7 QUALITY SYSTEM AUDITS AND CONTROLS

8 CONTROL OF PURCHASES

8.1 Manufacturing Controls

8.1.1 Drawings and Specifications

8.1.2 Production Process and Fabrication

8.1.3 In Process Inspection

8.1.4 Process Controls

8.1.5 Final Inspection and Configuration

8.1.6 Testing

8.1.7 Handling and Storage

8.1.8 Preservation, Marking, Labeling, Packaging and Packing

Finished assemblies shall be packed and shipped in protective electrostatic shielding containers.

9 END ITEM DATA PACKAGE

9.1 Customer Source Inspection

9.2 Nonconformance Control Board

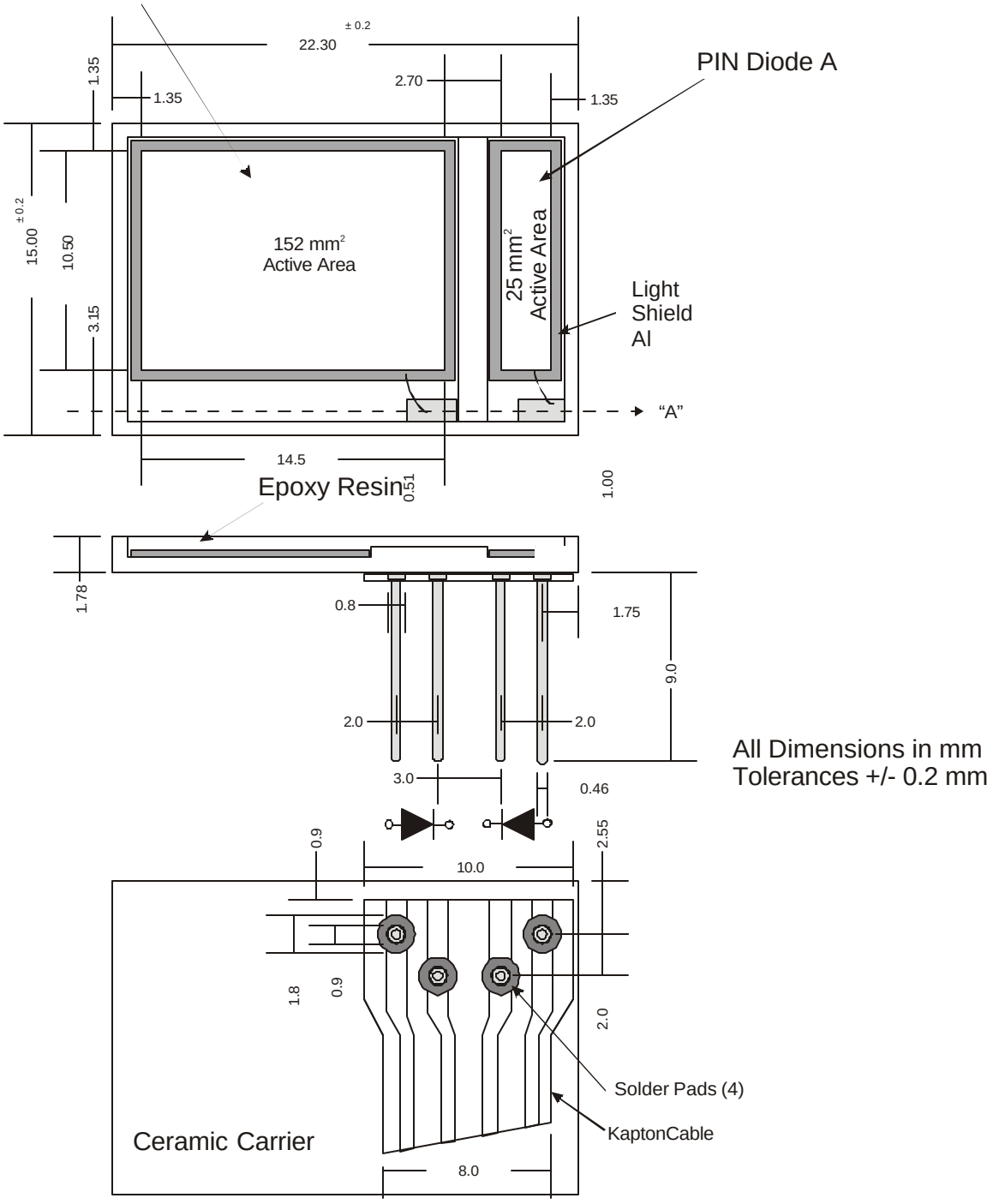
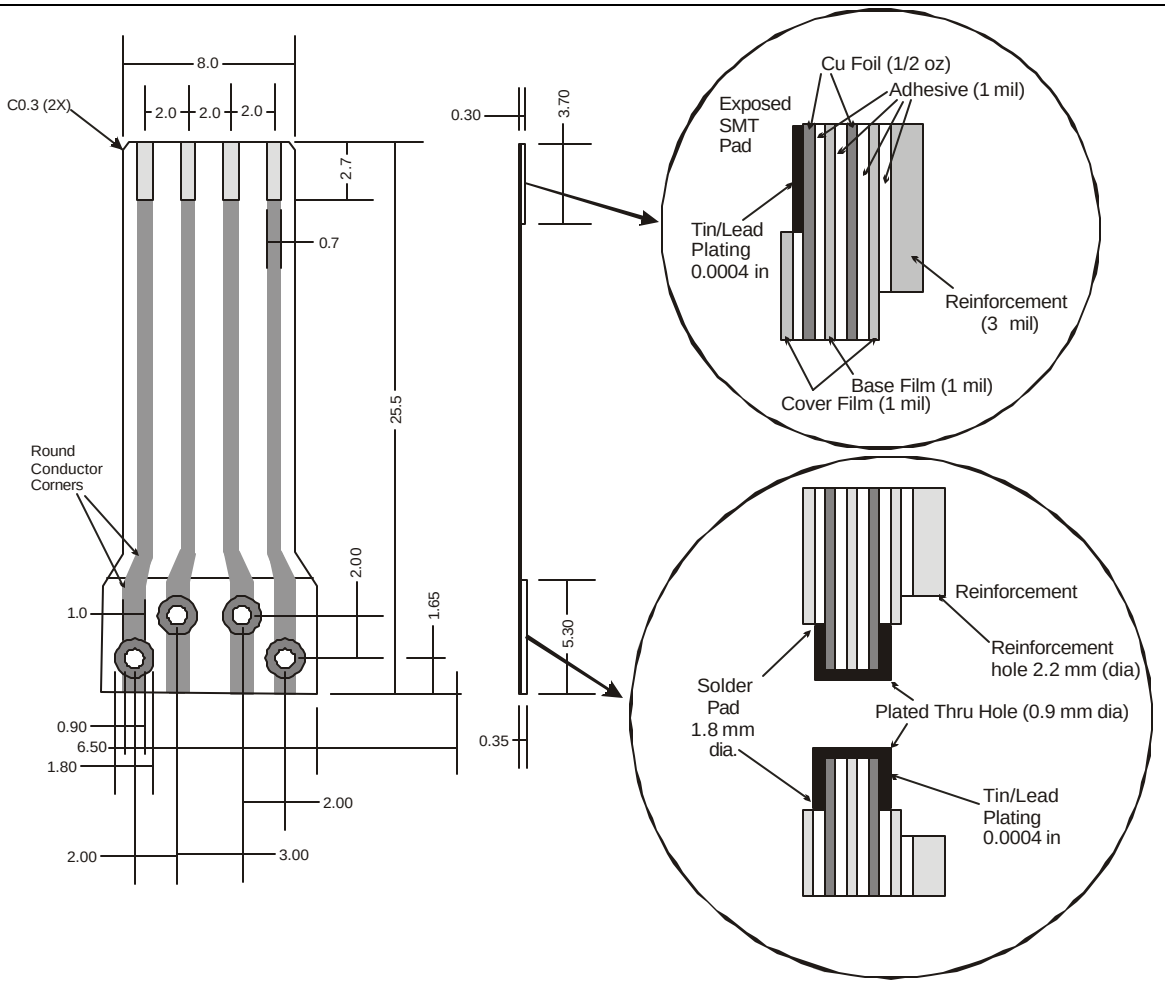
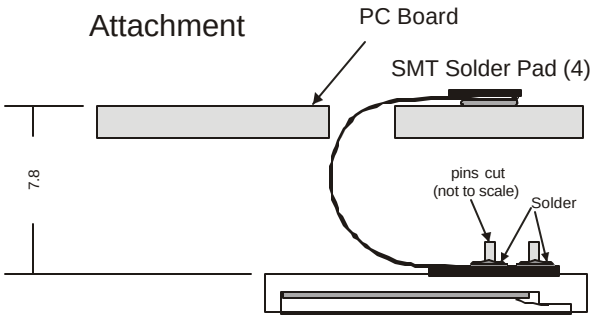


Figure 1. Mechanical Configuration of the GLAST CAL PIN Photodiode Assembly





Kapton Cable Concept

NOTE: PC Board Connection is SMT solder mount with 2 mm pitch. During testing the PC board connection will be made using a ZIF flat flex cable receptacle. The PC board end of the kapton cable is designed to be compatible with a MOLEX Flat Flex Cable receptacle, part number 52207-07. This is a 1.0 mm pitch 7 contact connector for 0.3 mm thick flex cable contacts. Three of the contacts in the connector are not used.

Figure 2. Mechanical Specification for Kapton Interconnect and Attachment