Gamma-ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

LAT TEM Power Supply System
Statement of Work
Version 2.0
## CHANGE HISTORY LOG

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1 Scope

This document describes the requirements for the design, production, and test of a space flight qualified power-supply system for the Large Area Telescope (LAT) instrument for the GLAST space mission.

1.1 Purpose

The power supply system supports the Tower Electronics Module (TEM) of the LAT. The Tower Electronics Module Power-Supply (TEM-PS) accepts regulated 28V ±1 V power from the spacecraft bus and outputs 8 voltages to the TEM.

The supplies must meet all specifications as specified herein over an input voltage range of 28V ±1 V and an operating temperature range, as specified in the LAT Environmental Specification, LAT-TD-00788.

1.2 Functional Description

The TEM-PS provides 8 independent regulated DC voltage outputs derived from the 28V input power. The output voltages are to be obtained using 6 separate DC/DC converters. The outputs of two of the 6 converters are filtered by two sets of output filters to provide 4 voltage outputs. Low noise and high efficiency are critical for several of the supplies.

1.3 Deliverables

This document provides for the design, fabrication, assembly, integration, test and delivery of a power supply system comprised of power supply modules. The deliverable hardware items are TEM-PS units (boxes) which have been qualified and tested.

The scope of the effort includes the delivery of the following:

- Two engineering models (flight configuration, non-flight parts)
- One qualification model (flight configuration, flight parts)
- 18 flight models
- Approved EEE parts list, radiation analysis, and parts stress analysis as per LAT-MD-00099-03
- FMEA and Worst Case Analysis
- Thermal Analysis

Note: Engineering models are to have flight fit, form and function but can be made from non-flight parts. They are expected to have interfaces the same as the flight units.

1.4 Workmanship Standards

The supplier shall use the NASA preferred standards identified in the NASA technical standards program in the NASA Online Directives Information System (NODIS). See http://standards.nasa.gov/.
GLAST LAT shall use the following NASA and commercial & LAT workmanship standards:

a. NASA-STD-8739.3 - Soldered Electrical Connections
b. NASA-STD-8739.4 - Crimping, Interconnecting Cables, Harnesses, and Wiring
c. NASA-STD-8739.5 - Fiber Optic Terminations, Cable Assemblies, and Installation
d. NASA-STD-8739.7 - Electrostatic Discharge Control
f. NASA-STD-8739.2 - Workmanship Standard for Surface Mount Technology
g. IPC-2221 - Generic Standard On Printed Board Design
h. IPC-2222 - Sectional Standard on Rigid PWB Design
i. IPC-6011 - Generic Performance Specification for Printed Boards
j. IPC-6012 - Qualification and Performance Specification for Rigid Printed Boards
k. GSFC-S-312-P-003 - GSFC Procurement Specification for Rigid Printed Boards for Space Application and other High Reliability Uses
l. LAT-DS-01448 - LAT Rigid PWB Procurement, Quality Assurance, and Qualification Requirements

Alternate workmanship standards may be used when approved by the project. The supplier shall submit, for review and acceptance, the alternate standard and the differences between the alternate standard and the required standard prior to project approval.

1.5 Printed-Wiring Boards Requirements

According to NASA standards listed in the “Workmanship” and “Applicable Documents” section in this document, also LAT-DS-01448 - LAT Rigid PWB Procurement, Quality Assurance, and Qualification Requirements

1.6 Test Requirements

The parts, assembly, and testing requirements for the qualification model and flight-models are outlined in this document. The supplier is expected to prepare a test plan and submit it to SLAC for review and approval prior to any design reviews. The Test Plan shall identify the levels at which the TEM-PS design requirements are verified, and the sequence by which the verification tasks are accomplished.

The supplier is expected to use flight-approved parts per the LAT EEE Parts Plan, LAT-MD-00099. Where possible, the supplier shall use previously NASA approved parts. A proposed EEE Parts List shall be provided prior to the power supply PDR, and a final parts list shall be provided at the CDR. These part lists must be reviewed and approved by the LAT Parts Control Board (PCB) prior to flight assembly.

The supplier shall deliver flight qualified TEM-PS assemblies tested to LAT specifications. If the supplier has existing flight qualified designs, they are encouraged to
use them. Existing qualified designs must meet parts requirements as per LAT-MD-00099 and heritage data should be reviewed prior to acceptance of heritage designs. Qualified designs shall meet or exceed the qualification parameters outlined in LAT-TD-00788.

1.7 Review Requirements

The following reviews shall be conducted at the vendor’s location to the vendors common practices for the type of review.

- Preliminary Design Review
- Critical Design Review
- Manufacturing Readiness Review
- Test Readiness Review
- Production Readiness Review
- Pre Ship Review

2 Definitions & Acronyms

2.1 Definitions

A

A, An  Analog
A  Analysis
Acc  Accuracy
adj  adjustable

C

cm  centimeter

D

D, Dg  Digital
D  Demonstration
DR  Data Rate

E

Eff  Efficiency

F

F  Functional

H

Hz  Hertz, unit of frequency, s⁻¹

I

I  Inspection

K
kHz kilohertz, $10^3 \text{ Hz}$

M

MHz Megahertz, $10^6 \text{ Hz}$
msec millisecond, $10^{-3} \text{ s}$
mV millivolt, $10^{-3} \text{ V}$

P

Performance

p-p peak-to-peak

P/F Pass/Fail

S

s, sec seconds

T

Test

Ti Time

V

Volt

W Watt

2.2 Acronyms

A

C

CAL Calorimeter

D

DAQ-EM Data Acquisition System – Electronics Module

DC Direct Current

E

EMC Electromagnetic Compatibility

EMI Electromagnetic Interference

EOL End of Life

G

GLAST Gamma-ray Large Area Space Telescope

I

2/4/03, 8:37 AM
3 Applicable Documents

Documents relevant to the design, production, and test of the TEM supplies include:

3.1 NASA Documents

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<td>433-MAR-0001</td>
<td>Large Area Telescope Instrument Mission Assurance Requirements Document</td>
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<td>GSFC-4333-RQMT-0005</td>
<td>Electromagnetic Interference Requirement Document</td>
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<tr>
<td>GSFC-311-INST-001</td>
<td>“Instruction for EEE Parts Selection, Screening, and Qualification”</td>
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<td>NASA-RP-1161</td>
<td>“Evaluation of Multi-layer Printed Wiring Boards by Metallographic Techniques”</td>
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<td>NASA-STD-8739.2</td>
<td>Workmanship Standard for Surface Mount Technology</td>
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GSFC-311-INST-001  “Instruction for EEE Parts Selection, Screening, and Qualification” Level 2
GSFC-S-312-P-003  GSFC Procurement Specification for Rigid Printed Boards for Space Application and other High Reliability Uses

3.2 GLAST/LAT Documents

LAT-TD-01281-01  LAT TEM Power Supply Interface Control Document (ICD)
LAT-TD-00778  LAT Environmental Specification
LAT-MD-00099  LAT EEE Parts Program Control Plan
LAT-MD-00408  LAT Test and Verification Plan
LAT-SS-00107  LAT Mechanical Parts Plan
LAT-MD-00471  Control of Non-Conforming Product
LAT-MD-00404  LAT Contamination Control Plan
LAT-MD-00039  LAT Performance Assurance Implementation Plan
LAT-DS-01448  LAT Rigid PWB Procurement, Quality Assurance, and Qualification Requirements

3.3 Military Documents

MIL-STD-130F  Marking for Shipment and Storage
MIL-STD-1246B  Military Standard Product Cleanliness Levels and Contamination Control Program
MIL-B-5087B  Bonding, Electrical and Lightning Protection for Aerospace Systems
MIL-STD-461C  Electromagnetic Emission and Susceptibility Requirements for the Control of EMI
MIL-STD-1540B  Test Requirements for Space Vehicles

3.4 Other Applicable Documents

ANSI/IPC-A-600  “Acceptance Criteria for Printed Wiring Boards”
GSFC S-312-P003  “Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses”
IPC-2221 Generic Standard On Printed Board Design
IPC-2222 - Sectional Standard on Rigid PWB Design
IPC-6011 - Generic Performance Specification for Printed Boards
IPC-6012 - Qualification and Performance Specification for Rigid Printed Boards
4 TEM-PS Overview

4.1 Module Description

The TEM Power Supply System consists of a collection of power supply modules that collectively supply the power to three subsystems. The sub-systems are called Calorimeter (CAL), Tracker (TKR), and Data-Acquisition (DAQ).

The voltage and power output requirements are shown in Table 4-1. The table provides the voltage, current and power required to be supplied by the TEM-PS.

The power requirements specified in this document are the module End of Life (EOL) requirements at the output of the power supply modules. The mission required lifetime is 5 years minimum with a goal of 10 years.

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<td>0 to 150 adj</td>
<td>0 to .004</td>
<td>0.6</td>
</tr>
<tr>
<td>DAQ-Digital</td>
<td>3.3</td>
<td>.90</td>
<td>2.97</td>
</tr>
</tbody>
</table>

4.2 TEM-PS Design Configuration

The TEM-PS may be implemented as single or multiple Printed Wiring Board(s) (PWBs). The designs may be implemented using off the shelf or custom/hybrid designed components.

A single level board solution with components mounted on only one side is preferable, but not required.

4.3 Input EMI filtering

Each TEM-PS power supply assembly shall have it’s own input EMI filter. At the supplier’s option, an input filter may be provided for each DC/DC converter.

4.4 Power Conversion & Filtering

The TEM-PS shall provide regulated conversion of the primary DC input voltage to 8 independent output voltages using 6 power supply modules. Each output (8 total) shall have its own output filter.
4.5 **Power Supply Module Control**

4.5.1 **Control Signals**

Two CMOS control signals are provided that shall control the power supply modules output enable/disable state. Zero volts disable the outputs; 3.3 volts enables the outputs.

The control signals are of secondary potential.

4.5.1.1 *Tracker Power Supply Modules*

All Tracker 1.5V, 2.5V, 0-150V power supply modules of a PS assembly are to have a common output control (TKR- ENABLE).

4.5.1.2 *Calorimeter Power Supply Modules*

All Calorimeter 3.3V, 0-100V power supply modules of a PS assembly are to have output control (CAL-ENABLE).

4.5.2 **Voltage Adjustment Signals**

The adjustable power supplies (0-100V and 0-150V) are to be programmable in < 1 volt increments by an analog 0-2V control signal (CAL-Bias Set, TKR-Bias Set). The lower voltage limit can exceed 0V but must be below 10V.

5 **TEM-PS Module Configuration**

The TEM PS is to be designed using 6 power supply modules to provide the 8 required voltages.

CAL-3.3-Analog and CAL-3.3-Digital are generated from a single DC-DC converter using independent output filters. The TKR-2.5-Analog and TKR-2.5-Digital voltages are also generated from a single DC-DC converter using independent output filters.

**Table 5-1 TEM-Power Supply Output Specification**

<table>
<thead>
<tr>
<th>Supply Type</th>
<th>Voltage, V</th>
<th>Current, I</th>
<th>Power, W</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 CAL-3.3-Analog/Digital</td>
<td>3.3</td>
<td>1.33</td>
<td>4.40</td>
</tr>
<tr>
<td>2 CAL Bias</td>
<td>0 to 100</td>
<td>0 to .003</td>
<td>0.3</td>
</tr>
<tr>
<td>3 TKR-1.5-Analog</td>
<td>1.5</td>
<td>2.0</td>
<td>3.00</td>
</tr>
<tr>
<td>4 TKR-2.5-Analog/Digital</td>
<td>2.5</td>
<td>2.60</td>
<td>6.50</td>
</tr>
<tr>
<td>5 TKR Bias</td>
<td>0 to 150 adj</td>
<td>0 to .004</td>
<td>0.60</td>
</tr>
<tr>
<td>6 DAQ Digital</td>
<td>3.3</td>
<td>.90</td>
<td>2.97</td>
</tr>
</tbody>
</table>
Figure 5-1 PS Module Configuration

[Diagram showing PS Module Configuration with various voltages and components like TKR, TRK, CAL, DAQ, Thermisters A and B, and filters.]

- TKR enable
- TKR 1.5V
- TKR 2.5V
- TRK 0-150V
- CAL enable
- CAL 3.3V
- CAL 0-100V
- DAQ 3.3V
- Input filter
- CAL Bias Set
- TKR Bias Set
- 28 V
- Thermister A
- Thermister B
5.1 Mechanical Dimensions
The TEM_PS shall be confined in the TEM_PS enclosure. The TEM-PS volume required within the enclosure shall be less than or equal to 25 cm wide x 25 cm long x 5 cm high.

5.2 Packaging/Enclosure and PWB Configurations
The mechanical enclosure is provided by the customer. Mechanical drawings of the proposed enclosure can be provided by the customer on request.

The power supply modules may be placed on individual printed-wiring boards (PWB), on fewer boards, or preferably one board. Suppliers are to provide implementation details of packaging within the enclosure with recommended modification of the inside of the enclosure for tailored thermal and mounting solutions. The customer must agree to those changes.

6 Supplier Response Configurations and / Pricing Options
Three options for responding to this specification are available. For each option the customer furnished items shall be provided.

6.1 Customer Furnished Items
SLAC shall provide to the supplier the TEM-PS box. Supplier shall integrate their unit into the furnished box.

Supplier shall provide SLAC with mechanical Interface Control Drawings (ICD), which provides the necessary detail for SLAC to make changes to the inside of the box to house/mount the power supplies.

6.2 Option 1 Custom TEM PS module
In this option, the supplier shall custom design all elements (i.e. no 3rd party DC/DC converters), integrate and test the TEM –PS. Supplier may use in-house DC/DC converters. Configuration of the TEM-PS is shown in figure 6-1.

6.3 Option 2: TEM PS using supplier & 3rd party components
In this option, the supplier shall custom design the 1.5V, 150V, 100V power supply modules.

The 3.3V and 2.5V supplies are 3rd party qualified DC/DC converters. (Note: 3rd party converters can be obtained down to 2.7V, so for Option 2 the 2.5V supply voltage should be read as 2.7V).

Supplier shall integrate and test the complete TEM –PS unit. This configuration is shown in Figure 6.1.

Alternative input filtering configurations can be suggested by the vendor.
6.3.1 Customer Furnished Items

As an option, SLAC shall provide the 2.5 V and 3.3V qualified power supply hybrids for the supplier to incorporate into their design. This must be delineated in any quotation submitted.
6.4 **Option 3 –PWB with 1.5V/100V/150V Custom Circuit**

In this option the supplier provides a single PWB with the 1.5V, 100V and the 150 V power supply modules only. The portion of the Power Supply System subject to option 3 is shaded in Figure 6.2.

The volume of the PWB assembly may take up no more than 50% of the available volume per the LAT TEM Power Supply Interface Control Document (ICD).

**Figure 6-2 Option 3 Power Supply Modules, option 3 shaded**

---

6.4.1 **Customer Furnished Items**

SLAC shall provide the 2.5 V and 3.3V qualified power supply modules on a compatible PWB to occupy the remaining 50% of the TEM-PS box.

6.4.2 **Integration and Test**

Supplier shall integrate SLAC provided components with supplier provided components. Supplier shall perform qualification test program and acceptance test program. Test program details will be provided by SLAC.
7 Power Supply System Requirements

7.1 Interface Requirements

7.1.1 Electrical

The TEM-PM has following required electrical interface:

- 28-V Input Power Feed and Return
- Digital input to enable/disable the CAL supplies
- Digital input to enable/disable the TKR supplies
- Analog CAL Bias Voltage Set: used to adjust the CAL Bias supply level
- Analog TKR Bias Voltage Set: used to adjust the TKR Bias supply level
- Eight output supply voltages
- Two thermistors to monitor the temperature

7.1.1.1 Electrical connector

Electrical signals shall be terminated to two connectors. Type and Pin-out are described in the LAT TEM Power Supply Interface Control Document (ICD).

7.1.2 Mechanical

The TEM PS envelope dimensions and mass are described as follows.

7.1.2.1 Module Volume

The total available module volume is 25 cm wide x 25 cm long x 5 cm high.

7.1.2.2 Mass

The total mass of the TEM-PS assembly shall not exceed 3.2 kg. The initial proposed enclosure itself weighs about 2.2 kg. It is expected that the enclosure will be optimized for weight and structure as required to stay within the mass budget with SLAC’s approval. It is anticipated that the weight of the enclosure itself can be reduced by as much as 0.5 kg.

7.2 Thermal

7.2.1 Thermal Design Requirements

7.2.1.1 Thermal Control

Each power module shall be cooled by passive flow of heat through its interface to the LAT thermal/mechanical interface. Junction temperatures shall be less than 60°C during normal operation and less than 110°C during qualification.
7.2.1.2  **Survival Temperature Range**
As specified in the LAT Environmental Specification, LAT-TD-00788.

7.2.1.3  **Operating Temperature Range**
As specified in the LAT Environmental Specification, LAT-TD-00788.

7.2.2  **Temperature Monitoring**
The power supply modules shall include two (for redundancy) thermistors (YSI-44909, 30kohm) to provide a nominal power supply operating temperature signal as measured at the heat sink interface. The two terminals of each thermistor are routed to the TEM-PS interface connector.

A 1 kΩ isolation resistor shall be implemented in each thermistor lead. The isolation resistor tolerance shall not exceed 1%.

7.3  **Environmental**
All power supply modules shall meet the structural and thermal environment requirements defined in the LAT Environmental specification, LAT-TD-00788.

7.3.1  **Radiation**
The TEM-PS must survive the radiation environment as outlined in LAT-TD-0788, LAT Environmental Specification.

7.3.2  **Total Ionizing Dose**
The top level dose requirement is 4.5 krad (Si) for the 5 year GLAST mission.

7.3.3  **Single Event Effects (SEE)**
- The TEM-PS shall be designed such that no single event effect can cause permanent damage to a system or subsystem.
- Any affects SEU's have on component operations shall be temporary and correctable by automatic reset or ground command.
- Applicable Linear Energy Thresholds (LET), see LAT-TD-0788

7.3.4  **EMI/EMC**
TEM-PS shall conform to EMI/EMC requirements for radiated emissions (RE), conducted emissions (CE), radiated susceptibility (RS) and conducted susceptibility (CS) per GSFC-433-RQMT-0005, “EMC Requirements.”

This document is being revised and new limits for the CE/CS shall be met as follows:
- CE: 106 dBuV from 50 Hz to 10 MHz
- CS: 94 dBuV from 50Hz to about 250kHz, from there 100 dBuV up to 10MHz.
7.3.5  Mission Life

7.3.5.1  Design Lifetime

The required mission duration is 44,000 hours (5 years) with a goal of 88,000 hours (10 Years per the GLAST project Specification, GSFC 433-SPEC).

7.3.5.2  Reliability

The series failure rate of a single TEM-Assembly shall not exceed 700 failures per billion hours. The failure rate shall be calculated at the nominal power dissipation assuming a 45 C mounting interface in a space flight environment. Failure rates shall be calculated per MIL-HDBK-217F. A failure is a degradation of more than 10% from the specified performance.

7.3.5.3  Operability

The TEM-PS shall be designed such that the failure or degradation of components at the predicted rate shall not result in a loss of more than 10% of effective power in 5 years. A power module shall be capable of normal operation after being subjected to the environmental conditions given in LAT-SP-00010, Section 5.3.12, Environmental.

7.3.5.4  Maintainability

The assembly shall be designed to operate as specified without maintenance. No electrical trimming, mechanical adjustment, or internal alignment shall be required following manufacturing and acceptance tests. No special tools shall be required to install, operate, or maintain the assembly unless specified herein.

7.4  Grounding & Isolation

Refer to “LAT TEM Power Supply Interface Control Document (ICD)”

7.5  Contamination Control

Contamination control shall be performed, maintained and reported per LAT-MD-00404, “LAT Contamination Control Plan.”

The LAT TEM-PS shall be designed, fabricated, cleaned, and packaged in compliance with the LAT contamination control plan. The following criteria apply:

7.5.1.1  Use of non-metallic materials

Non-metallic materials shall be selected, and/or processed, to have a Total Mass Loss (TML) of 1.0% or less, and Collected Volatile Condensable Material (CVCM) of 0.1%. All material shall be approved by SLAC. A material list shall be approved prior to flight fabrication.

7.5.1.2  Handling

During and following cleaning operations, handle parts and assemblies with clean, lint-free gloves and package appropriately to maintain cleanliness.
7.5.1.3 Cleanliness

7.5.1.3.1 Prior to staking and conformal coating, PWAs shall be cleaned per supplier internal procedure.

7.5.1.3.2 Clean mechanical components prior to assembly using vapor degreaser and/or Isopropyl alcohol rinse to remove lubricants and other contaminants.

7.5.1.3.3 During assembly, maintain cleanliness, particularly of surfaces interior to the chassis. Clean as needed and inspect to meet Visibly Clean, Highly Sensitive criteria: Under incident light level >100 ft-candles and an observation distance of 6-18 inches, there shall be no evidence of particulate or other contamination. Repeat inspection under UV light.

7.5.1.3.4 Following acceptance testing, clean exterior of assemblies to meet Visibly Clean, Highly Sensitive and vacuum-bake assemblies at a temperature between +65°C and +75°C and at a pressure less than 10⁻⁵ Torr. Monitor the chamber with an RGA and maintain temperature and vacuum until the partial pressures of all gasses of AMU between 60 and 100 are below 1 x 10⁻⁸ torr.

7.5.1.4 Packaging and bagging

7.5.1.4.1 Following assembly bake out, bag assembly using ESD approved Capran 980, Ameri-Stat 5200, or 3M 2100. Purge bag with dry nitrogen and seal. Repeat process with second bag. Are we double bagging?

7.5.1.4.2 Prior to the over-wrap, flight-deliverable cables shall be cleaned using Isopropyl alcohol, and vacuum-bake assemblies at a temperature between +65°C and +75°C and at a pressure less than 10⁻⁵ torr. Monitor the chamber with an RGA and maintain temperature and vacuum until the partial pressures of all gasses of AMU between 60 and 100 are below 1 x 10⁻⁸ torr. After application of the over-wrap, clean cables with Isopropyl alcohol. Bag cables, purge bag with dry nitrogen and seal. Repeat process with second bag.
7.6 Storage and Transportation

7.6.1 Storage

Storage and transportation requirements of the TEM-PS are presented in Table 7-1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>0°C to +40°C</td>
</tr>
<tr>
<td>Humidity</td>
<td>30%-55%</td>
</tr>
<tr>
<td>Pressure</td>
<td>ambient</td>
</tr>
</tbody>
</table>

Table 7-1 Storage and Transportation environment Levels

7.6.2 Transportation

7.6.2.1 Transport Environment

An environmental enclosure shall be in place around the TEM-PS during transport. The TEM-PS shall not be exposed to environmental levels that exceed the limits specified in Table 7-1 during transportation operations. Transportation materials and processes shall conform to the contamination control and electrostatic control requirements of this document.

7.7 Non-Operating Environments

7.7.1 Limit Loads

<table>
<thead>
<tr>
<th>E-Box Flex Post</th>
<th>Design</th>
<th>Acceptance</th>
<th>Qual</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tension</td>
<td>694</td>
<td>694</td>
<td>868</td>
<td>N</td>
</tr>
<tr>
<td>Compression</td>
<td>323</td>
<td>323</td>
<td>404</td>
<td>N</td>
</tr>
<tr>
<td>Shear</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>N</td>
</tr>
</tbody>
</table>

7.7.2 Sine Vibration

The unit shall perform as specified herein after non-operating exposure to the sine vibration environment detailed in Table 7-1. Test levels are shown per test program. The TEM-PS has only Qualification and acceptance to consider.
Table 7-2 LAT TEM-PS Sine Vibration levels

<table>
<thead>
<tr>
<th>Acceptance Test Levels</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Axis</td>
<td>Freq. (Hz)</td>
<td>Test levels</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.27 cm (0.5 in.) double amplitude</td>
</tr>
<tr>
<td>Thrust</td>
<td>5 to 6.2</td>
<td>6.2 to 50</td>
<td>1.0 g (zero to peak)</td>
</tr>
<tr>
<td>Lateral</td>
<td>5 to 50</td>
<td>0.7 g (zero to peak)</td>
<td>4 octaves/min</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Proto Flight Qualification Test Levels</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Axis</td>
<td>Freq. (Hz)</td>
<td>Test levels</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.27 cm (0.5 in.) double amplitude</td>
</tr>
<tr>
<td>Thrust</td>
<td>5 to 7.4</td>
<td>7.4 to 50</td>
<td>1.4 g (zero to peak)</td>
</tr>
<tr>
<td>Lateral</td>
<td>5 to 6.2</td>
<td>6.2 to 50</td>
<td>1.27 cm (0.5 in.) double amplitude</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qualification Test Levels</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Axis</td>
<td>Freq. (Hz)</td>
<td>Test levels</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.27 cm (0.5 in.) double amplitude</td>
</tr>
<tr>
<td>Thrust</td>
<td>5 to 7.4</td>
<td>7.4 to 50</td>
<td>1.4 g (zero to peak)</td>
</tr>
<tr>
<td>Lateral</td>
<td>5 to 6.2</td>
<td>6.2 to 50</td>
<td>1.27 cm (0.5 in.) double amplitude</td>
</tr>
</tbody>
</table>

7.7.3 Random Vibration

The unit shall perform as specified herein after non-operating exposure to the random vibration environment detailed in Figure 7-1

Figure 7-1 TEM-PS Random Vibration Levels

(Qual: 2 min per access, Flight acceptance 1 min per access)
7.7.4 Acoustic
The TEM-PS shall perform as specified herein after exposure to the non-operating acoustic environment. This requirement must be verified by analysis. It shall be tested at the integrated LAT level.

7.7.5 Pressure
The TEM-PS must survive the following pressure profile non-operating.

![Pressure Profile Graph]

7.7.6 Thermal Environments
The TEM-PS Test, Operating and Thermal environment are provided in Table 7-3.

**Table 7-3 TEM-PS Test, Operating and Survival Temperatures**

<table>
<thead>
<tr>
<th>Qua Level</th>
<th>A/T Low</th>
<th>Ops Low</th>
<th>Ops High</th>
<th>A/T High</th>
<th>Qual High</th>
<th>Survival Low</th>
<th>Survival High</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEM</td>
<td>-40</td>
<td>-35</td>
<td>-30</td>
<td>50</td>
<td>55</td>
<td>60</td>
<td>-40</td>
</tr>
</tbody>
</table>

7.7.7 Thermal / Vacuum
The TEM-PS shall perform as specified herein after exposure to the non-operating survival temperatures when at pressures between ambient and $10^5$ torr.
7.8 **Operating Environments**

7.8.1 **Thermal / Vacuum**

The TEM-PS shall perform as specified herein at test and operating temperatures from -30°C to +50°C measured at the outside of the enclosure on two opposite sides.

The unit shall perform as specified herein at operating pressures of less than or equal to $10^{-5}$ torr.

7.8.2 **Electrostatic Discharge**

a. The TEM-PS and the individual modules shall be designed using best practices to minimize susceptibility to ESD damage in ground handling and on-orbit operations.

In all cases, signals at component interfaces shall include reasonable protection against damage due to ESD or accidental connection to a potentially damaging signal or ground. NASA-STD-8739.7 or an approved substitute shall be used as a guideline for handling of ESD-sensitive components.

7.9 **Design and Construction Requirements**

7.9.1 **Identification & Marking**

The TEM-PS shall be marked with clear part number and unique serial numbers. Marking ink shall meet NASA outgassing requirements.

7.9.2 **Design Criteria**

7.9.2.1 **Hardware Qualification**

a. Qualification of all flight Hardware shall be achieved through a combination of analysis and testing.

b. All structure worthiness shall be demonstrated through detailed stress and dynamic analysis.

7.9.3 **Parts, Materials, and Processes**

a. Parts, materials, and processes used in the design and construction of the unit shall be previously flight proven and consistent with the requirements herein.

b. EEE parts shall be per the LAT Parts Program Control Plan, LAT-MD-00099, as well as GSFC-311-INST-001 as tailored for the LAT program in LAT document PAIP LAT-MD-00039, level 2. All EEE parts must be approved by the LAT parts control board prior to use.

c. Supplier shall submit their proposed parts list to LAT parts engineering within 90 days after contract award prior to PDR.

d. Materials and processes shall be per LAT Mechanical Parts Plan, LAT-SS-00107.
7.9.4 Workmanship
The workmanship of the unit shall be in accordance with the LAT Mission Assurance Requirements Document 433-MAR-0001, PAIP LAT-MD-00039 and NASA standards as specified herein.

7.10 General Requirements

7.10.1 Design Margin
Each power supply module is to be designed with 50 % margin over the specified power requirement.

7.10.2 Input Power
The LAT power supply module shall use $28 \pm 1\text{V DC}$ as the primary input power. See LAT TEM Power Supply Interface Control Document (ICD).

7.10.2.1 Power Feed
Each TEM-PS receives two 28-V supply wires and two returns. The supply and return wires should be connected in parallel to each other on the supply.

7.10.2.2 Primary Power Control
The higher-level LAT power system will provide control of source power to the TEM-PS Modules.

7.10.2.3 Circuit Protection
No primary circuit protection is required on the TEM-PS. Circuit protection for the TEM-PS shall be provided at the power distribution unit feeding each TEM-PS.

7.10.3 Output

7.10.3.1 Isolated Output
Each power supply module shall provide isolated subsystem power per the subsystem requirements. No subsystem shall obtain power from another subsystem or subsystem power supply.

7.10.3.2 Load Variation
Each power supply module must be able to maintain its respective regulation requirements to a 10% variation in output to the active load.

7.10.3.3 Minimum Load
All power supply modules must accept a minimum load of 10% of the nominal load as listed in table 7.5.
7.10.3.4 Maximum Load

All power supply modules other than CAL-Bias and TKR-Bias must have a maximum load rating of 50% more than the required load current. The CAL/TKR Bias load rating must be 10% more than the required load.

7.10.3.5 Circuit Protection

All power supply modules are to be short circuit protected and output short tolerant. A failure of a module or voltage output should not affect either an adjacent module or adjacent TEM-PS.

7.10.3.6 Power Control

The Tracker and Calorimeter power supply modules are required to have enable inputs to disable the output power.

7.10.3.6.1 Control Signals

A CMOS 0 – 3V control signal will enable or disable the output of the power supply module. With the control signal, 0V is disable, 3.3V is enable (see LAT TEM Power Supply Interface Control Document (ICD), which supercedes this document, for details). The input should be pulled up in the supply so the supply is enabled in case of an open connection failure. Isolation between the control signal and the power supply is required.

7.10.3.6.2 Tracker Power Supply Modules

All Tracker 1.5V and 2.5V power supply modules are to have an enable/disable capability that disables the output.

7.10.3.6.3 Calorimeter Power Supply Modules

All Calorimeter 3.3V power supply modules are to have an enable/disable capability that disables the output.

7.10.4 Power Supply Rise Time

Power-up output voltage rise-time shall be greater than 0.1 msec/V and less than 10.0msec/V.

7.10.5 Power Supply Turn on overshoot

The overshoot shall be less than 10% above quiescent output voltage and shall settle in two cycles.

7.10.6 Abnormal Transients

The TEM-PS shall not be damaged to momentary power bus transients in the range of –1 to +40VDC for up to 500 milliseconds.
7.10.7 EMI/EMC

See section 7.3.4

7.11 Specification for the Fixed Voltages

In table 7-4, the specifications for the fixed output voltages are given. Specification values applicable to all the fixed supplies are listed in the following chapter.
Table 7-4 Power Supply Module Specifications

<table>
<thead>
<tr>
<th>Supply Type</th>
<th>Voltage V</th>
<th>Current A</th>
<th>Power W</th>
<th>Efficiency %</th>
<th>Accuracy %</th>
<th>RMS Noise mV</th>
<th>Bandwidth</th>
<th>Noise Spikes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAL-3.3-Analog</td>
<td>3.3</td>
<td>.33</td>
<td>1.1</td>
<td>75%</td>
<td>±5%</td>
<td>0.1mV</td>
<td>0-500kHz</td>
<td>1mV</td>
</tr>
<tr>
<td>CAL-3.3-Digital</td>
<td>3.3</td>
<td>1.0</td>
<td>3.3</td>
<td>75%</td>
<td>±5%</td>
<td>1mV</td>
<td>0-500kHz</td>
<td>1mV</td>
</tr>
<tr>
<td>TKR-1.5-Analog</td>
<td>1.5</td>
<td>2.00</td>
<td>3.0</td>
<td>69%</td>
<td>±5%</td>
<td>0.2mV</td>
<td>0-1MHz</td>
<td>1mV</td>
</tr>
<tr>
<td>TKR-2.5-Analog</td>
<td>2.5</td>
<td>.60</td>
<td>1.5</td>
<td>75%</td>
<td>±5%</td>
<td>0.2mV</td>
<td>0-1MHz</td>
<td>1mV</td>
</tr>
<tr>
<td>TKR-2.5-Digital</td>
<td>2.5</td>
<td>2.0</td>
<td>5.0</td>
<td>75%</td>
<td>±5%</td>
<td>1mV</td>
<td>0-1MHz</td>
<td>5mV</td>
</tr>
<tr>
<td>TEM-Digital</td>
<td>3.3</td>
<td>.90</td>
<td>3.25</td>
<td>84%</td>
<td>±5%</td>
<td>10mV</td>
<td>0-1MHz</td>
<td>10mV</td>
</tr>
</tbody>
</table>

7.11.1.1.1 Output Power
The maximum output power for each power supply module is as listed in table 7-5.

7.11.1.1.2 Output Voltage
The maximum output Voltage for each power supply module is as listed in table 7-5.

7.11.1.1.3 Efficiency
The minimum efficiency shall be as listed in Table 7-5 and measured with 28 volts input and at nominal load current.

7.11.1.1.4 Output Voltage Accuracy
Output Voltage Accuracy shall be ±5%.

7.11.1.1.5 Line Regulation
Line Regulation shall be .1% over the input voltage and frequency range.

7.11.1.1.6 Load Regulation
Load regulation shall be .1% from 10% to 100% of nominal loads listed in Table 7-5 and with a nominal 28 volt applied at the input.

7.11.1.1.7 Noise Spikes (Ripple)
Maximum noise spikes at the switching frequency shall be equal or less than specified in Table 7-5.

7.11.1.1.8 RMS Noise
RMS noise between 0 and 1 MHz shall be equal or less than specified in Table 7-5.
7.12 Specifications for the Programmable Voltages

There are two programmable voltage supplies, one to reverse-bias the diodes for the tracker, and one to reverse-bias the diodes of the calorimeter.

Table 7-5 Programmable Power Supply Module Specifications

<table>
<thead>
<tr>
<th>Supply Type</th>
<th>Voltage</th>
<th>Current</th>
<th>Power</th>
<th>Efficiency</th>
<th>Accuracy</th>
<th>RMS Noise</th>
<th>Bandwidth</th>
<th>Noise Spikes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAL Bias</td>
<td>0 to 100</td>
<td>0 .003</td>
<td>0.3</td>
<td>50</td>
<td>± 0.5</td>
<td>1mV</td>
<td>0-500kHz</td>
<td>5mV</td>
</tr>
<tr>
<td>TKR Bias</td>
<td>0 to 150</td>
<td>0 .004</td>
<td>0.6</td>
<td>50</td>
<td>± 0.5</td>
<td>10mV</td>
<td>0-1MHz</td>
<td>5mV</td>
</tr>
</tbody>
</table>

7.12.1 Output Power
The maximum output power for each power supply module is as listed in table 7-5.

7.12.2 Output Voltage
The maximum output Voltage for each power supply module is as listed in table 7-5.

7.12.3 Efficiency
The minimum efficiency shall be as listed in Table 7-5 and measured with 28 volts input and at nominal load current.

7.12.4 Output Voltage Accuracy
Output Voltage Accuracy shall be as listed in Table 7-5.

7.12.5 Line Regulation
The line regulation shall be .1% over the input voltage and frequency range.

7.12.6 Load Regulation
The load regulation shall be .1% over the input voltage and frequency range.

7.12.7 Programming Range
The input control voltage for the tracker bias is 0 to 2V, which results in an output volt range as specified in Table 7.5. The programming accuracy shall be less than 5%. The input range can start at greater than 0V but less than 10 V, as long as it is specified by the vendor and approved by SLAC.

7.12.8 Input Impedance
The resistance of the control voltage input shall be at least 10 kohm, the input capacitance shall be less than 100 pF.

7.12.9 TEM-PS Mechanical Packaging
Best practice for flight hardware.
7.13 TEM-PS Interface Summary

The TEM-PM has following interface signals (details see LAT TEM Power Supply Interface Control Document (ICD))

- Power Supply Input: 2 wires, nominal 28 V
- Power Supply Input Return: 2 wires, nominal 0 V.

Power supply output:
- TKR 1.5V and Return
- TKR 2.5V Analog and Return
- TKR 2.5V Digital and Return
- TKR Bias Voltage and Return
- CAL 3.3V Analog and Return
- CAL 3.3V Digital and Return
- CAL Bias Voltage and Return
- DAQ 3.3V and Return

Control Inputs
- CAL Bias Voltage Set and Return
- TKR Bias Voltage Set and Return
- TKR 1.5V/2.5V Enable
- CAL 3.3V Enable

Monitoring Outputs
- Thermistor A Terminal 1 and 2
- Thermistor B Terminal 1 and 2

8 Quality Assurance Provisions

8.1 Government Source Inspection

During performance of this Order, the Supplier’s Quality Control (or Inspection) System and manufacturing processes may be subject to review, verification, and analysis by authorized Government Representatives. Government inspection or release of product prior to shipment is not required unless Supplier is otherwise notified. The Supplier shall provide a copy of the Order to the Government Representative upon request.

8.2 Pre-award Survey of Prospective Supplier

When deemed necessary by the Buyer, a pre-award survey will be conducted of a prospective Supplier’s technical, quality assurance, production, or financial capability. Evaluation of documented quality assurance program/system(s) applicable to materials to
be produced or services to be performed by the prospective Supplier may include but not be limited to inspection and test controls, calibration of measuring and test equipment, special process controls, material storage and handling, and drawing change controls.

### 8.3 SLAC Source Inspection

All items covered by this Order are subject to source inspection by SLAC’s Customer’s Quality Representative within normal Supplier business hours. Upon written direction from SLAC’s Purchasing Department, the Supplier shall make the necessary provisions to permit SLAC’s Customer to verify the quality of work and items referenced on the Purchase Order.

The Supplier shall submit adequate records of all inspections and tests, including the actual measurements made and values obtained, to demonstrate compliance with all Purchase Order and Specification requirements for the product being submitted for source inspection. The records shall indicate the nature and number of observations made, the number and type of deficiencies found, the quantities approved and rejected and the nature of corrective action taken as appropriate. The Supplier shall furnish, at no additional cost, the necessary equipment and facilities, and perform tests as required by SLAC’s Source Inspector, to demonstrate conformance to the Purchase Order and item Specifications and Drawings.

The SLAC Source Inspector will review all data for compliance to specification and inspect the items as applicable, for verification against Supplier data.

Source Inspection will entail a data review of the Supplier’s inspection data for the material, including but not limited to dimensional inspection data, process data, C of C, material certificates, etc.

### 8.4 Quality Management System Requirements

The Supplier shall define and implement a quality system based on ANSI/ASQC Q9000 (1994 or 2000 revision) that properly encompasses products and services to be provided. Third party registration is NOT required. The quality manual, as required by the ISO standard, shall be provided to SLAC within 30 of contract award for review.

The supplier shall require, in writing, subcontractors of all tiers to comply with all applicable quality program/system requirements.

#### 8.4.1 Inspection Instruction Submit

The Supplier shall prepare and submit a complete inspection and test plan for approval. The instruction shall include the following:

- Inspection instructions that specifically state “how” the inspection/tests will be performed. The inspection instructions shall be clear, concise, and complete regarding:
  - Inspection test methods
  - Test equipment requirements and set-up for each inspection/test
  - Step-by-step procedure for conducting the inspection test including accept/reject criteria
8.4.2 Technical Review Requirements

The following reviews shall be conducted at the supplier’s facility.

- Preliminary Design Review
- Critical Design Review
- Production Readiness Review
- Manufacturing Readiness Review
- Test Readiness Review
- Pre Ship Review

8.4.3 Certificate of Conformance

Each shipment of material must be accompanied by a Supplier certification that the shipped material conforms in all respects to applicable specifications and/or standards, that complete physical and chemical test reports, as required, are on file and available for review, and that process and product testing and inspection control of raw material is in conformance with all applicable specifications, drawings and/or standards of all articles on this Purchase Order. The certification must be signed and dated by an authorized representative of the Supplier.

The Supplier shall certify that adequate records of all inspections and tests, including the actual measurements made and values obtained, to demonstrate compliance with all Purchase Order and Specification requirements for the supplied product are on file and will be made available upon SLAC’s request. The records shall indicate the nature and number of observations made, the number and type of deficiencies found, the quantities approved and rejected and the nature of corrective action taken as appropriate.

8.4.4 Final Acceptance

Notwithstanding the inspection requirements at the Supplier’s facility, final acceptance of the TEM-PS’s shall take place following delivery to and testing by SLAC.

SLAC reserves the right to perform any or all tests/inspections which would be required to verify that the TEM-PS’s conform to the requirements of the manufacturing documents (drawings and specifications) supplied to the Supplier as part of the statement of work. TEM-PS’s which fail any of the tests/inspections performed will be deemed unacceptable and returned to the Supplier for replacement or repair at no cost to SLAC. SLAC will be the sole judge as to whether unacceptable TEM-PS’s may be repaired.

8.4.5 MRB Authority

The Seller does not have Material Review Authority under this Purchase Order. Any departure from the physical or functional requirements of the governing SLAC Engineering drawing or specification found by the Seller shall be immediately identified to SLAC through the Buyer, together with all details of the Seller’s proposed disposition of the discrepancy, the number and identity of units involved, an explanation of its
causes, the proposed action to be taken to prevent its recurrence and the point at which
the corrective action will take effect. The Seller shall take no action to rework or repair
the discrepancy, or ship the unit to SLAC, until the Buyer provides written proof that the
Seller’s proposed disposition of the discrepancy and corrective action in his design or
processes has been approved by the SLAC Material Review Board. MRB actions are to
be performed on “minor non-conformances”, defined as a nonconformance which does
not adversely affect:

Health or safety
Performance
Interchangeability, reliability or maintainability
Effective use or operation
Weight or appearance (when a factor)

“Major non-conformances” (any nonconformance other than a minor that cannot be
completely eliminated by rework or reduced to a minor nonconformance by repair) will
require a deviation/waiver request being submitted to SLAC.

9 Verification & Quality Assurance Test Program

9.1 General
The Verification & Quality Assurance Test Program will constitute proof that the TEM-
PS conforms to the design, material, processes, EEE parts construction and performance
requirements as specified in this document. Each requirement shall be verified by the
test(s) or assessment(s) as specified in this section. Verification of compliance with the
requirements may be achieved through one or more of the verification methods specified
herein. Component flight items and the assembled TEM-PS systems will be subjected to
qualification and acceptance test programs. These programs are based upon the
requirements in the LAT Test and Verification Plan, LAT-TD-00408. This document
governs the test program for the TEM-PS and should be used as a reference for test
activities.

The verification and quality assurance test program will be reviewed at the PDR, CDR
and at the Test Readiness Review.

9.1.1 Qualification Test Program
A qualification test will be conducted on the TEM-PS to the levels provided in the LAT
Environmental Specification, LAT-TD-00788 per the LAT Test and Verification Plan,
LAT-TD-00408.
9.1.2 Acceptance Test Program

An acceptance test program will be conducted on the TEM-PS to the levels provided in the LAT Environmental Specification, LAT-TD-00788 per the LAT Test and Verification Plan, LAT-TD-00408.

9.1.3 Test Data Packages

9.1.3.1 End Item Test Data Packages

All tests performed on LAT qualification, proto-flight and flight hardware (including flight spares) will have the corresponding test data collected by the test conductor. All collected data will be retained per the LAT Performance Assurance Implementation Plan, LAT-MD-00039.

The End Item Test Data Package is the collection of all pertinent test data taken in support of certifying an item for flight. This data package will be permanently retained and portions of it will be sent with the flight unit as required for use in higher level test assemblies.

The original End Item Test Data Package will be retained at the supplier’s facility. A copy of this package will be duplicated and maintained in the LAT data center.

9.1.3.2 Test Records

A test record containing the performance detail information of each test and the step by step procedural execution log will be made and retained for each test performed on each test article. This record will be included in the End Item Test Data Package.

9.1.3.3 Test Data Sheets

Test data sheets will be used to record pass/fail data and to record performance metrics as required by the test procedure. These data sheets will be used to support the certification that an item is ready for flight. The test data sheets will be included in the End Item Test Data Package.

9.1.3.4 Recording

Test support material such as photographs, electronic data files and other support material will be collected and included in the End Item Test Data Package.

9.1.3.5 Data Identification Requirements

Data recorded in support of a test of qualification level or flight hardware or software will be identified with the following information:

- Test procedure number
- Test paragraph number
- Unit under test identification
- Unit serial number
- Date and time
- Test software name
- Test software version number & revision date
- Data approvals
- Test conductor
9.1.3.6 Qualification/Acceptance Test Data Summary Package

This package is delivered to I,T&C, Systems Engineering and the LAT Data Center with delivery of all flight units. It provides the information necessary to integrate the unit into the next higher level of assembly. The package will contain:

- Identification
- Unit identification (drawing or part number with revision level)
- Unit serial number
- Date and time of release for delivery
- Responsible engineer approval
- Quality assurance certification (as required)
- Other approvals as necessary

Mechanical Summary Data

- Mass
- CG
- Dimensions
- Interface flatness and surface finish

Electrical Summary Data

- Power consumption (steady state, minimum @ idle, maximum @ peak)
- Start-up voltage profile
- Start-up current profile
- Noise Measurement

Steady state
- Minimum power
- Maximum power

Unit Performance Data (as required and applicable)

Unit Support Data

- Calibration curves (i.e. thermistors, voltage range, etc.)
- Software version report
- Hardware installation record
- Mate/de-mate log
- On-time log with operational hours

Test Execution Information

- Hi-Pot test
- Isolation test
- Insulation resistance test

Quality Assurance Data

- Non-conformance report summary
- Inspection records
- Storage, handling, shock records

Other material information as required

9.1.4 Non Conforming Material Reports (NCR)

A log of all Non-conforming material reports (NCR) will be kept on each qual/flight unit. This log will be maintained as part of the end-item data package and will be delivered with the unit.
9.1.5 Mate/De-mate Log
A mate/de-mate log will be kept on each flight connector. This log will travel with the flight hardware and be used to track the mating of flight connectors.

9.1.6 Hardware Installation Log
A hardware installation log will be kept on each flight unit. This log will travel with the flight unit and is used to track the installation of flight mechanical interfaces.

9.2 PERFORMANCE VERIFICATION MATRIX
The Performance Verification Matrix for the TEM-PS is shown in Table 9-1. This indicates how the performance of elements of this specification will be verified. Wherever practicable, verification shall be accomplished at the component level. The basic concepts underlying the verification matrix are as follows. An element of the specification can be verified at the highest level in 1 of 4 ways: Test (T), Inspection (I), Analysis (A) or Demonstration (D). In the latter 3 cases the verification metric is Pass/Fail (P/F). In the case of Test, there are 2 possibilities. The element can be verified by means of a Functional (F) Test in which some feature either functions or does not. In this case the test metric is P/F. If, on the other hand, the element needs to be verified in a quantitative manner in a Performance (P) Test the test metric will be some measurable item such as Time (Ti), Data Rate (DR), or an Analog (An) or Digital (Dg) measurement.

Key: T: Test; I: Inspection; A: Analysis; D: Demonstration
F: Functional; P/F: Pass/Fail; P: Performance; Ti: Time; DR: Data Rate; An: Analog;
Dg: Digital
### Table 9-1 Specification Table

<table>
<thead>
<tr>
<th>Item</th>
<th>Verification</th>
<th>Test Type</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
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<td>CAL 3 V</td>
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</tr>
<tr>
<td>Power Provided</td>
<td>T</td>
<td>P/F</td>
<td></td>
</tr>
<tr>
<td>Efficiency</td>
<td>T</td>
<td>P/F</td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td>T</td>
<td>P/E</td>
<td>An</td>
</tr>
<tr>
<td>RMS Noise</td>
<td>T</td>
<td>P</td>
<td>An</td>
</tr>
<tr>
<td>Bandwidth</td>
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<td>P</td>
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</tr>
<tr>
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<tr>
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<tr>
<td>Power-up output voltage rise-time</td>
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<td>P</td>
<td>An</td>
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<td>CAL Bias 0 to 100 V adj</td>
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<td>P/F</td>
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<td>Programming Range</td>
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<td>Minimum Load</td>
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<td>Maximum Load</td>
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Table 9-1 (Continued)
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<td>Power Provided</td>
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<td>P/F</td>
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<td>P/F</td>
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Table 9-1 (Continued)

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<td>An</td>
</tr>
<tr>
<td>Minimum Load 0.1 µA</td>
<td>T</td>
<td>P</td>
<td>An</td>
</tr>
<tr>
<td>Maximum Load 0.1 mA</td>
<td>T</td>
<td>P</td>
<td>An</td>
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</table>
Table 9-1 (Continued)

<table>
<thead>
<tr>
<th>Item</th>
<th>Verification</th>
<th>Test Type</th>
<th>Metric</th>
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<tr>
<td>DAQ-EM</td>
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<td></td>
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<tr>
<td>Power Provided</td>
<td>T</td>
<td>P/F</td>
<td></td>
</tr>
<tr>
<td>Efficiency</td>
<td>T</td>
<td>P/F</td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td>E</td>
<td>F</td>
<td>An</td>
</tr>
<tr>
<td>RMS Noise</td>
<td>T</td>
<td>P</td>
<td>An</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>T</td>
<td>P</td>
<td>An</td>
</tr>
<tr>
<td>Noise Spikes</td>
<td>T</td>
<td>P</td>
<td>An</td>
</tr>
<tr>
<td>Line Regulation</td>
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<td>P</td>
<td>An</td>
</tr>
<tr>
<td>Load Regulation</td>
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<td>P</td>
<td>An</td>
</tr>
<tr>
<td>Survival Temperature Range</td>
<td>T</td>
<td>P</td>
<td>An</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
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<td>P</td>
<td>An</td>
</tr>
<tr>
<td>Power-up output voltage rise-time</td>
<td>T</td>
<td>P</td>
<td>An</td>
</tr>
</tbody>
</table>

### 9.3 TEM-PS Qualification Test Program

A complete qualification program will be executed for the TEM-PS. The objective of this test program is to qualify for flight the subject components prior to production. For the purpose of the Qualification Test Program, qualification hardware will be fabricated and tested using flight material, parts, processes, and using flight approved procedures.

Qualification tests will be performed on the TEM-PS system. These tests will be conducted to the qualification test level specified in the LAT Environmental Specification, LAT-TD-00778.

#### 9.3.1 Required Elements

The following elements are required in the TEM-PS qualification test program.
- Electrical Interface Tests
- EMI/EMC Tests
- Mechanical Tests
- Limited Performance Tests
- Comprehensive Performance Tests
- Random Vibration
- Sine Sweep Vibration
- Thermal Vacuum Test
- Humidity/storage Tests
- Burn-In – Failure free performance

#### 9.3.2 Electrical Interface Tests

Electrical interface tests are conducted to insure integrity of the electrical interfaces. Depending on the circumstances, one or more of the following tests will be performed:
Signal distribution
Power Distribution
Command Distribution
Grounding
Isolation
Insulation Resistance
Hi-Pot

9.3.3 Comprehensive Performance Tests

Comprehensive performance tests as appropriate will be conducted prior to and after each environmental test. These tests will exercise all unit operating modes as well as primary and redundant circuits and paths. Parameters will be varied over their specification ranges to insure that the unit performs as designed.

9.3.4 EMI/EMC

Tests for radiated emissions and susceptibility will be performed on each component at the qualification level. Tests to be performed are outlined in the EMC portion of the specification and are called out in GSFC-433-RQMT-0005, “EMC Requirements”. (Please see updated CS and CE in the earlier EMI/EMC section).

EMI/EMC tests may be performed on the first production unit in the flow as appropriate for the article being tested. It may be necessary to perform the test more than once if the possibility of a change in the hardware configuration due to environmental testing (vibration, thermal vacuum etc.) is possible.

9.3.5 Limited Performance (Functional) Tests

LPTs will be performed during, and between environmental tests, as appropriate, to demonstrate that the functional capability of the unit has not been degraded by an environmental test.

9.3.6 Mechanical Tests

9.3.6.1 Static Load Tests

Static load tests will be conducted on the qualification model only. Flight models will be qualified by similarity to the qualification model.

9.3.6.2 Random Vibration

Random vibration tests will be performed on the TEM-PS with the unity off.

9.3.6.3 Sine Sweep Vibration

The qualification TEM-PS will be subjected to a sine-sweep vibration test.

9.3.6.4 Mass Properties

Mass properties (mass and CG) will be collected on each TEM-PS. A mass properties report will be prepared and submitted as part of the data package.
9.3.6.5 Dimension and fit-checks

Dimension and fit-checks will be performed on the LAT-PS prior to delivery.

9.3.7 Thermal Cycling under Vacuum

Thermal cycling under vacuum (1X10⁻⁵ torr) will be performed on all TEM-PS systems. All TEM-PS systems will be subjected to 12 cycles at for qualification. A soak/dwell of 1-hour minimum at each temperature extreme will be observed. Maximum ramp rate for a cycle is 20°C / hour.

A hot and cold turn on sequence will be performed at each dwell point.

Limited performance tests will be performed during transitions for the purpose of monitoring the instrument systems for failures and intermittent operations.

The Thermal Vacuum Cycle profile for Qualification is shown in Figure 9-1. The vendor may propose an alternative profile which may be approved by SLAC.

**Figure 9-1 Qualification Thermal Vacuum Cycle Profile**

- 12 cycles
- Pressure of <1X10⁻⁵ Torr
- 20°C / hour Max Ramp Rate
- Stability of < 3°C /hr rate of change
- Dwell at High & Low Temps for 1 Hour (min)
- Limited Performance Tests during transitions

**Comprehensive Performance Test regime at Ambient, High and Low Temperatures at First and Last Thermal Cycles**
- Reach soak temperature
- Turn unit off
- Stabilize at soak temperature
- Turn unit on
- Perform CPT

**Limited Performance Tests are performed as indicated. Operating modes will be checked and units will be monitored for failure and intermittent operation.**
- Reach soak temperature
- Turn unit off
- Stabilize at soak temperature
- Turn unit on
- Continue LPT

9.3.8 Humidity / Storage Tests

Humidity / Storage tests will be performed as appropriate for the hardware. Survivability to the minimum requirement must be demonstrated by either analysis or test.
9.3.9 Burn-In
Burn in tests at the at the Qualification high temperature +0 / -5 °C will be used to achieve 150 hours of failure free power on time prior to delivery to completion of the qualification program.

9.3.10 Test Data Review
Test data sheets and the detailed test data will be reviewed by the appropriate subsystem engineering, GLAST Performance Assurance and GLAST Systems Engineering.

Before flight hardware will be delivered, the reviewers will certify that the data package is qualified for flight.

Decisions to accept nonconformance's (variances from Buyer drawings and specifications) detected at Supplier's facilities must be made by Buyer. Shipment of nonconforming items must be accompanied by a Buyer Approved Supplier Disposition Report.

9.4 TEM PS Module Acceptance Test Program
An acceptance test program will be conducted on components that are produced in quantity and are represented by an appropriate qualification program. The objective of the acceptance test program is to provide a production test program for subassemblies that are manufactured in quantity for use on the LAT.

9.4.1 Required Elements
The following elements are required in the TEM-PS Acceptance test program.
Electrical Interface Tests
Mechanical Tests
Limited Performance Tests
Comprehensive Performance Tests
Random Vibration
Thermal Vacuum Test
Burn-In – Failure free performance

9.4.2 Electrical Interface Tests
Electrical interface tests are conducted to insure integrity of the electrical interfaces. Depending on the circumstances, one or more of the following tests will be performed:

Signal distribution
Power Distribution
Command Distribution
Grounding
Isolation
Insulation Resistance
Hi-Pot

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9.4.3 Comprehensive Performance Tests

Comprehensive performance tests as appropriate will be conducted prior to and after each environmental test. These tests will exercise all unit operating modes as well as primary and redundant circuits and paths. Parameters will be varied over their specification ranges to insure that the unit performs as designed.

9.4.4 EMI/EMC

Vendor to provide SLAC with a report explaining that the flight-assemblies will meet the Qualification EMI/EMC performance as required. No EMI/EMC performance tests are required for the flight-assemblies.

However, as an option, limited conductive emission and susceptibility tests to verify the flight assemblies for CE and CS may have to be performed and results provided. Bench tests are sufficient. Pricing for that option to perform these tests on each flight-assembly is to be provided.

9.4.5 Limited Performance (Functional) Tests

LPTs will be performed during, and between environmental tests, as appropriate, to demonstrate that the functional capability of the unit has not been degraded by an environmental test.

9.4.6 Mechanical Tests

9.4.6.1 Random Vibration

Random vibration tests will be performed on the TEM-PS with the unity off.

9.4.6.2 Mass Properties

Mass properties (mass and CG) will be collected on each TEM-PS. A mass properties report will be prepared and submitted as part of the data package.

9.4.6.3 Dimension and fit-checks

Dimension and fit-checks will be performed on the LAT-PS prior to delivery.

9.4.7 Thermal Cycling under Vacuum

Thermal cycling under vacuum (1X10^{-5} torr) will be performed on all TEM-PS systems. All TEM-PS systems will be subjected to 4 cycles at for qualification. A soak/dwell of 1-hour minimum at each temperature extreme will be observed. Maximum ramp rate for a cycle is 20°C / hour.

A hot and cold turn on sequence will be performed at each dwell point.

Limited performance tests will be performed during transitions for the purpose of monitoring the instrument systems for failures and intermittent operations.

The Thermal Vacuum Cycle profile for Acceptance is shown in Figure 9-2. The vendor may propose an alternative profile which may be approved by SLAC>
9.4.8 Burn-In

Burn in tests at the at the acceptance high temperature +0 / -5 °C will be used to achieve 150 hours of failure free power on time prior to delivery to completion of the qualification program.

9.4.9 Test Data Review

Test data sheets and the detailed test data will be reviewed by the appropriate subsystem engineering, GLAST Performance Assurance and GLAST Systems Engineering.

Before flight hardware will be delivered, the reviewers will certify that the data package is qualified for flight.
Decisions to accept nonconformance's (variances from Buyer drawings and specifications) detected at Supplier's facilities must be made by Buyer. Shipment of nonconforming items must be accompanied by a Buyer Approved Supplier Disposition Report.

10 Items to be quoted
(to be filled into the official RFP SLAC form, this section is only for informational purposes)

10.1 Option 1 Custom TEM PS module
Engineering Modules: ___________ $$
Qualification Modules: ___________ $$
Flight Modules: ___________ $$

10.2 Option 2 Using supplier and 3rd party DC/DC converters
2a) Using SLAC supplied 2.5V/3.3V hybrid converters:

Engineering Modules: ___________ $$
Qualification Modules: ___________ $$
Flight Modules: ___________ $$

2b) All components/hybrids supplied by vendor:

Engineering Modules: ___________ $$
Qualification Modules: ___________ $$
Flight Modules: ___________ $$

10.3 Option 3 1.5V/100V/150V supply option

Engineering Modules: ___________ $$
Qualification Modules: ___________ $$
Flight Modules: ___________ $$

Note that at only one of the three above options will be exercised.
10.4 EMI Option: Conductive emission and susceptibility tests on all flight assemblies.
CS and CE bench tests on each flight-assembly: ________$$

11 Schedule and Deliveries

- Parts List 90 days after award

- Engineering Models: 6 months after award of contract.
- Acceptance of engineering models will occur less than 1 month after receipt of engineering models.
- Qualification Module: 4 months after acceptance of engineering models.
- Acceptance of qualification model will occur less than 1 month after receipt of qualification models.
- Flight-Models:
  - First flight-model 3 months after acceptance of qualification model,
  - Last Flight model 3 months after receipt of first flight model.