GLAST Large Area Telescope:

TEM/TPS MRR

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Contents

• Presentation I (G. Haller)
  – Module Description
  – Changes since CDR
  – Design and Test Documentation
  – Engineering Module Validation
• Presentation II (B. Estey)
  – Parts, Materials & Processes
  – Procurement Status
  – Manufacturing Facilities
  – Manufacturing Flow Plan
  – Quality Assurance Plan
  – Configuration Management
  – Manufacturing Issues/Concerns
• Presentation III (P. Lujan)
  – Quality Assurance Plan
GLAST Large Area Telescope:

TEM/TPS MRR Part I

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LAT Electronics

- **Event-Processor Units (EPU)** (2 + 1 spare)
  - Event processing CPU
  - LAT Communication Board
  - SIB

- **Spacecraft Interface Units (SIU)**
  - Storage Interface Board (SIB): Spacecraft interface, control & telemetry
  - LAT control CPU
  - LAT Communication Board (LCB): LAT command and data interface

- **Power-Distribution Unit (PDU)**
  - Spacecraft interface, power
  - LAT power distribution
  - LAT health monitoring

- **Global-Trigger/ACD-EM/Signal-Distribution Unit**

- **TKR Front-End Electronics (MCM)**

- **ACD Front-End Electronics (FREE)**

- **CAL Front-End Electronics (AFEE)**

- **16 Tower Electronics Modules & Tower Power Supplies**

- **Primary & Secondary Units shown in one chassis**
TEM/TPS Mounted to CAL

LAT GRID with 16 CAL/TEM/TPS Modules

TKR not shown
Tower Electronics Module

- Main DAQ module, one on each tower
  - Controls and reads out data from TKR MCM and CAL AFEE front-end electronics
  - Zero-suppresses CAL event data
  - Buffers events in cable ASIC FIFO's
  - Assembles CAL and TKR event fragments to tower event
  - Transmits data to GASU
  - Contains monitoring and low-rate science circuits
  - LVDS interface to front-end electronics and GASU

EM Tower Electronics Module (TEM) before coating/staking
Tower Power Supply

- Tower Power Supply module, one on each tower
  - Input 28V
  - Generates low-noise voltages for
    - TKR (2.65V analog, 2.65V Digital)
    - CAL (3.3V analog, 3.3V digital)
    - TEM (3.3V and 2.5V digital)
    - TKR Bias (20V-140V programmable)
    - CAL (20V to 90V programmable)
  - Temperature sensors
Changes since TEM CDR and Power-Supply Delta CDR

- Power Supply Review from 9-22-03
  - SLAC GLAST web-site -> Electronics & DAQ -> Reviews
- TEM
  - Modification of FPGA code
    - To fix a couple of bugs
    - To change flow-control slightly to optimize dataflow throughout system
    - Code was reviewed by GSFC reviewer (Dr Rod)
  - Some resistor/capacitor values have changed to optimize monitoring ranges
  - Details of monitoring circuit have changed and a sub-set of current monitoring functions were eliminated
- TPS
  - Resistor/capacitor changes to optimize circuit performance over temperature
  - Changes in poly-switch values to protect better over temperature (instead of RXE185, split the load into two paths with a RXE110 each), increased the current sensing resistor from a 1W to a 3W resistor.
  - Changed resistor values to
    - Modify TKR 2.5V to 2.65V
    - Decrease maximum CAL Bias from 120V to 90V
  - Changed Zener diodes at Bias output voltage for new max values
  - Changed resistor values to optimize in-rush current level
- Worst Case Analysis updated to incorporate changes
- Thermal Analysis from CDR/Delta-CDR remained since changes don’t impact thermal performance
Peer Review RFA Status

• **RFA 1**
  – **Request**
    • Complete part stress and derating analysis
  – **Response**
    • The Parts Stress and Derating Analysis has been completed for the TEM Power Supply and for the PDU. The analyses are in LATDocs (LAT-TD-04516 and LAT-TD-01809) and have been provided to Tony DiVenti separately.

• **RFA 2**
  – **Request**
    • Need to get SEU report on Maxim parts out as soon as possible. Issue is not only LET but SET effects since transients can affect the power supply outputs
  – **Response (NASA)**
    • The SEU testing on the Maxim parts was done in February 2004. The devices exhibited no evidence of SET or SEL to the highest fluence tested. SEUs were observed but at a level orders of magnitudes lower than required.
Peer Review RFA Status (Continued)

• **RFA 3**
  - **Request**
    • Need to get AR-461 filter schematic plus schematic of 28-28 supply on spacecraft. Need to develop model of power and ground distribution to verify filter performance relative to 100 kHz noise. Damping of the entire filter network should also be verified to assure that an interactive among the many identical filters cannot occur.
  - **Response (SLAC)**
    • The PRU Road Show exercised the Spacecraft PRU and the LAT interface and tested the performance. The results are:
      - (1) The interface between the Spacecraft and LAT is understood (pinouts and signal definitions).
      - (2) The SIU, VCHP and DAQ feeds are stable under full load.
      - (3) The conducted EMI is within the requirement.
      - (4) The Calorimeter - Tracker mini-tower performs properly with the spacecraft PRU.
      - (5) There were no significant transients when the LAT feed is turned off when fully powered.
    • The test results are documented in LAT-AM-04670.
Peer Review RFA Status (Continued)

- **RFA 4**
  - **Request**
    - T0-220 Maxim regulators have their mounting tabs connected to ground. This has the potential of creating an undesirable ground path with associated noise problems. The optimum grounding solution for this particular configuration is to connect all elements to chassis and use the structure as the primary ground return (as diagrammed on the conference room whiteboard). It is strongly recommended that this approach be taken to assure proper instrument performance despite the fact that the approach is slightly unorthodox. As a second issue, it is also suggested that gold foil or indium foil be used to assure reproducible heat sink contact for the regulators. The grease or no intermediate material approaches are strongly recommended against.
  - **Response (SLAC)**
    - 1) The grounding approach defined in the RFA is the current implementation. The grounding tabs on the Maxim regulators are mounted directly to the enclosure, and the enclosure used as the primary ground return
    - (2) The regulators are mounted using a thermally conductive adhesive (CV-2946 Nusil). Tests on the EM hardware showed minimal temperature rise (a few degrees) across the interface.
Peer Review RFA Status (Continued)

• RFA 5
  - Request
    • Maxim part screening must be carefully done to assure that the testing provides valid verification reliability. Documented methods by Maxim are for static burn-in only (diffusion based issues) and do not represent the actual operational case planned for GLAST. In that the GLAST application is actually fairly stressful AND uses the part outside of its normal operational range (for the 1.5 volt output case), it is suggested that the screening and qual test be configured to verify the 1.5 volt configuration since it is most stressful. Note that great care must be taken with the layout and instrumentation to assure that the setup does not accidentally result in part damage.
  - Response (NASA/SLAC)
    • Parts were screened and qualification testing performed at GSFC.
RFA 6

Request

- The 28 volt converter planned for use by Spectrum Astro, uses a step-up transformer. A quick calculation indicates that the step-up ratio is probably 1.5 or more. Therefore, a failure where the control loop goes open while the bus is at 33 volts, could put as much as 50 volts on the input to the power supply regulators. Such a condition could have catastrophic consequences to the instrument such that system level redundancy could be compromised due to propagation of the failure across interfaces. Therefore, it is strongly recommended that overvoltage protection be implemented to assure protection of the hardware plus protection against failure propagation.

Response (NASA)

- Lambda identified a credible single point failure that could cause an overvoltage condition. Spectrum added a transorb across the output of each 28 volt feed to prevent the voltage from exceeding 38 V. A test was run at Lambda at the end of August to verify the design. The preliminary results show that the voltage never exceeded 38 V. Spectrum Astro is reviewing the test results and performing additional studies to ensure the test results are analytically consistent with the circuitry.
Peer Review RFA Status (Continued)

• LAT CDR RFA #6 Response
  – **Action Requested:**
    • What electrical derating criteria was used on the ASICs? Define and describe.
  – **Supporting Rationale:**
    • ASICs are required to be derated by 20% per NASA SOP for ASICs. The parts would represent a higher risk to the mission if they were not derated for their application.
  – **Response:**
    – The electrical derating criteria for the ASICs was based on EEE-INST-002 Instructions for EEE Parts Selection, Screening, Qualification, and Derating (NASA/TP-2003-212242) Section M4 Microcircuits, Plastic Encapsulated Table 4 Microcircuit Derating Requirements for PEMs.
      • Maximum Supply Voltage for Digital PEMs use the following formula for derating:
        – \( V_{n.r.} + 0.5(V_{max.r.} - V_{n.r.}) \)
          » \( V_{n.r.} \) is the nominal rated power supply voltage
          » \( V_{max.r.} \) is the maximum rated power supply voltage
      • For the GAFE, GARC, GCFE, GCRC, GCCC, GTCC, and GLTC --
        – \( V_{n.r.} \) is 3.3v
        – \( V_{max.r.} \) is 4.5v
        – Maximum Supply Voltage is 3.9 v
        – The maximum power supply for the system is 3.6v; therefore, the derating requirement is met.
      • For the GTFE and GTRC --
        – \( V_{n.r.} \) is 2.6v
        – \( V_{max.r.} \) is 4.5v
        – Maximum Supply Voltage is 3.55 v
        – The maximum power supply for the system is 2.86v; therefore, the derating requirement is met.
After TEM and TPS are tested individually, the two modules are mated and the TEM/TPS package is tested.
<table>
<thead>
<tr>
<th>LAT-DS-01481-04</th>
<th>Assembly, Tower Electronics Module</th>
<th>Signed Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAT-PS-02615-02</td>
<td>Statement of Work, TEM Assy</td>
<td>Signed Off</td>
</tr>
<tr>
<td>LAT-SS-00288-01</td>
<td>Specification, TEM Assembly</td>
<td>Signed Off</td>
</tr>
<tr>
<td>LAT-TD-03415-01</td>
<td>Test Procedure, TEM LPT</td>
<td>Signed Off</td>
</tr>
<tr>
<td>LAT-TD-03875-01</td>
<td>Electrical Interface Continuity and Isolation Test, TEM</td>
<td>Pending Sign-Off</td>
</tr>
<tr>
<td>LAT-TD-04097-01</td>
<td>TEM Interface Verification Test</td>
<td>Pending Sign-Off</td>
</tr>
<tr>
<td>LAT-TD-03831-01</td>
<td>TEM Safe to Mate Procedure</td>
<td>Pending Sign-Off</td>
</tr>
<tr>
<td>LAT-DS-00554-06</td>
<td>TEM Box Base</td>
<td>Signed Off</td>
</tr>
<tr>
<td>LAT-DS-00555-06</td>
<td>TEM Box Lid</td>
<td>Signed Off</td>
</tr>
<tr>
<td>LAT-DS-01026-02</td>
<td>TEM Connector Plate</td>
<td>Signed Off</td>
</tr>
<tr>
<td>LAT-DS-01031-02</td>
<td>TEM Connector Pin</td>
<td>Signed Off</td>
</tr>
<tr>
<td>LAT-DS-01646-04</td>
<td>Circuit Card Assembly, TEM DAQ</td>
<td>Signed Off</td>
</tr>
<tr>
<td>LAT-DS-01649-05</td>
<td>Printed Wire Board, TEM</td>
<td>Signed Off</td>
</tr>
<tr>
<td>LAT-DS-02583-03</td>
<td>PWB Fab, Loading and Assembly</td>
<td>Signed Off</td>
</tr>
<tr>
<td>LAT-DS-02588-02</td>
<td>Connector and Cable Assembly, TEM CCA</td>
<td>Signed Off</td>
</tr>
<tr>
<td>LAT-DS-01650-02</td>
<td>Schematic Diagram, TEM CCA</td>
<td>Signed Off</td>
</tr>
<tr>
<td>LAT-TD-02230-02</td>
<td>Bill of Materials, TEM CCA</td>
<td>Signed Off</td>
</tr>
<tr>
<td>LAT-TD-01782-02</td>
<td>Parts Stress Analysis, TEM CCA</td>
<td>In Review</td>
</tr>
<tr>
<td>LAT-TD-01785-02</td>
<td>Worst Case Design Analysis, TEM CCA</td>
<td>In Review</td>
</tr>
<tr>
<td>LAT-DS-03895-50</td>
<td>Programmed FPGA, GTIC</td>
<td>Signed Off</td>
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<tr>
<td>LAT-DS-04376-01</td>
<td>Program, GTIC FPGA</td>
<td>Signed Off</td>
</tr>
<tr>
<td>LAT-DS-04452-01</td>
<td>Design Database for GTIC FPGA</td>
<td>Signed Off</td>
</tr>
<tr>
<td>LAT-DS-03894-50</td>
<td>Programmed FPGA, GTIU</td>
<td>Signed Off</td>
</tr>
<tr>
<td>LAT-DS-04377-01</td>
<td>Program, GTIU FPGA</td>
<td>Signed Off</td>
</tr>
<tr>
<td>LAT-DS-04453-01</td>
<td>Design Database for GTIU FPGA</td>
<td>Signed Off</td>
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<tr>
<td>LAT-TD-01880-01</td>
<td>VHDL, LAT TEM GTIC FPGA</td>
<td>Signed Off</td>
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<tr>
<td>LAT-TD-01881-01</td>
<td>VHDL, LAT TEM GTIU FPGA</td>
<td>Signed Off</td>
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<tr>
<td>LAT-DS-03582-01</td>
<td>Spacer, TEM Connector</td>
<td>Signed Off</td>
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<tr>
<td>LAT-DS-04354-01</td>
<td>Washer, TEM CAL Baseplate</td>
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### Tower Power Supply

| LAT-DS-01482-03 | Assembly, Tower Power Supply | Signed Off |
| LAT-PS-03078-02 | Statement of Work, TPS Assy | Signed Off |
| LAT-SS-01281-01 | Specification, Tower Power Supply | Signed Off |
| LAT-TD-01652-01 | Test Procedure, Tower Power Supply | Signed Off |
| LAT-TD-04098-01 | Tower Power Supply Interface Verification Test | Pending Sign-Off |
| LAT-TD-04099-01 | Tower Power Supply Electrical Interface Continuity and Iso Test | In review |
| LAT-TD-03828-01 | TPS Safe to Mate Procedure | Pending Sign-Off |
| LAT-DS-02388-04 | Circuit Card Assembly, Tower Power Supply | Signed Off |
| LAT-DS-02389-03 | Printed Wiring Board, Tower Power Supply | Signed Off |
| LAT-DS-02465-04 | TPS Common Heat Sink Assy | Signed Off |
| LAT-DS-02548-04 | PWB Fab, Loading and Assembly | Signed Off |
| LAT-DS-02830-01 | Connector Assembly, TPS Input Power | Signed Off |
| LAT-DS-02831-01 | Connector Assembly, TPS Output Power | Signed Off |
| LAT-DS-02390-04 | Schematic Diagram, Tower Power Supply | Signed Off |
| LAT-DS-02391-04 | Bill of Materials, Tower Power Supply CCA | Signed Off |
| LAT-TD-04516-01 | Parts Stress/Worst Case Analysis, TPS CCA | Pending Sign-Off |
| LAT-DS-00995-06 | TPS (PSU) Box Base | Signed Off |
| LAT-DS-00996-04 | TPS (PSU) Box Lid | Signed Off |
| LAT-DS-03598-01 | Support Cable Harness, TPS | Signed Off |
| LAT-DS-04101-01 | Heat Sink, TPS | Signed Off |
ASICs

<table>
<thead>
<tr>
<th>GTCC ASIC - Part of TEM CCA LAT-DS-01646</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAT-TD-01812-01  Layout, GTCC ASIC</td>
</tr>
<tr>
<td>LAT-DS-01811-01  Schematic Diagram, GTCC ASIC</td>
</tr>
<tr>
<td>LAT-TD-01550-02  Specification, GTCC ASIC</td>
</tr>
<tr>
<td>LAT-TD-01810-01  Test Procedure, GTCC/GCCC ASIC</td>
</tr>
<tr>
<td>LAT-TD-02656-02  Screening and Test Plan, GTCC/GCCC ASIC</td>
</tr>
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<td>LAT-TD-01882-01  VHDL, GTCC ASIC</td>
</tr>
<tr>
<td>LAT-TD-02487-01  GTCC1 ASIC T36T Wire-bonding and Packaging Require</td>
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<tr>
<th>GCCC ASIC - Part of TEM CCA LAT-DS-01646</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAT-TD-01814-01  Layout, GCCC ASIC</td>
</tr>
<tr>
<td>LAT-DS-01815-01  Schematic Diagram, GCCC ASIC</td>
</tr>
<tr>
<td>LAT-TD-01549-02  Specification, GCCC ASIC</td>
</tr>
<tr>
<td>LAT-TD-02656-02  Screening and Test Plan, GTCC/GCCC ASIC</td>
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<td>LAT-TD-01883-01  VHDL, GCCC ASIC</td>
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<tr>
<td>LAT-TD-02486-01  GCCC1 ASIC T36T Wire-bonding and Packaging Require</td>
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- GTCC and GCCC radiation and qualification
  - SEL and SEU ok
  - TID is scheduled for next week in Italy
  - Qualification at GSFC will start after the radiated ASICs are tested on the test-setup, so it can be shipped to GSFC.
  - ASICs for flight boards were burned in and tested, full quantity required ready.
Engineering Model Design Validation

- TEM and TPS engineering modules were extensively tested
  - As EGSE in DAQ/CAL/TKR/I&T
    - >50 test-stands were tested with SLAC TPS and TEM Test Procedure
    - Safe-to-Mate and function/performance tests by CAL and TKR were performed by TKR and CAL sub-systems
    - TEM and TPS were used to test functionality and performance of TKR and CAL sub-system electronics
      - Met requirements by sub-system
    - CAL performed vibration tests on coated/staked TEM/TPS to CAL levels, passed
  - Additional TEM/TPS tests
    - Informal thermal-vacuum test -40C to 55C, passed CPT
    - Vibration tests of staked TEM passed DAQ qual levels
  - On test-bed
    - 16 TEM/TPS connected to EM PDU and GASU and to Front-End Simulator modules generating trigger and event-data
    - Run up to 10 KHz data-rates
Engineering Model Design Validation (con’t)

- On fully-instrumented tower
  - 36 TKR MCM’s
  - 4 CAL AFEE’s
  - Ran tests and passed
- Test results for TEM/TPS performance tests posted for the EGSE TEM/TPS
- E.g. TEM/TPS delivered to CAL:
- IO tested to sub-system ICD’s
- Configuration and data-taking tested
- Monitoring functions/performance tested
- Tested over
  - Frequency (16Mhz to 22 MHz, 20 MHz nominal)
  - Temperature (-40C to 55C)
  - TEM supply range (3.3V +/- 10%, 2.5V +/-10%)
- One flight PCB TEM/TPS was loaded at SLAC with mostly parts from flight lots, including flight-lot ACTEL FPGA’s
  - Passed tests from -40C to 55C over voltage and frequency
Testing

Tower Electronics Module with Tower Power Supply as part of calorimeter test at NRL

Full set of 4 CAL AFEE boards, (4 sides, 1 each)

Full set of 36 TKR MCMs (4 sides, 9 each)
Issue

• ACTEL FPGA
  – Questions about anti-fuse reliability of MEC-fabline FPGA’s
    • F/X anti-fuses were addressed by updated ACTEL programming algorithm. Parts for qual/TwrA/TwrB were programmed by ACTEL with updated algorithm
    • I/K fuses still under investigation
      – Apparently did not have any I/K failures in field/space, but were seen when testing FPGA’s in special test-cases because of F/X failures
      – Investigation to modify algorithm to possibly address I/K failures seen in test cases
      – I/K failures typically lead to skew in on-chip clock less than few 100’s psec.
      – If there are I/K failures, seem to be infant mortality issue, so investigate extending operation before delivery to I&T
    – New UMC-fabline FPGA’s available in 16 weeks
      • Possibility to use UMC devices for balance of production depending on schedule and outcome of on-going tests at ACTEL/GSFC/Aerospace Company
      • Possibility to exchange TwrA and TwrB at end if need be
  – Not clear whether change to UMC line is justified at this time