Lead-free Technology Experiment in Space Environment (LTESE)

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JUSTIFICATION

LTESE is a response to the Joint Council on Aging Aircraft (JCAA)/ Joint Group on Pollution Prevention (JG-PP) Lead-Free Solder Project, Joint Test Report, July 27, 2007 recommendations that next steps for aerospace and defense Pb-free applications include experiments to determine the effect of higher reflow temperatures on printed wiring boards and functional integrated circuits, and to gather data in operational environments. LTESE will gather data in operational environments.

JUSTIFICATION (cont'd)

- While there is no doubt that Pb-free electronic parts have flown in space before, they have never flown under totally known recorded conditions and been available for complete post flight failure analysis before. That will be the case with this experiment.

BENEFITS

The Constellation Program Workmanship Requirements document (CxP 70165) prohibits use of lead-free technology. Engineering technical authority requires space environment data in order to determine risk and make recommendations to Project Offices and Materials Review Boards when lead-free technology is incorporated into flight hardware inadvertently or through the use of COTS.

EXPECTED RESULTS

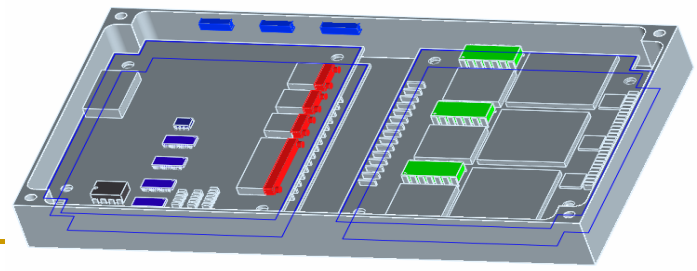
- **Intermetallic Compound (IMC) formation and growth under near zero gravity and various temperatures.**
- **Pb-free solder joint life under temperature extremes.**
- **Aging effects on Pb-free solder joints in space environments.**
- **Results of launch and reentry dynamics.**
- **Tin whisker growth under known space conditions.**
- **Possibly the formation of tin pest which can initiate at 13°C.**
- **All data to be compared to a ground unit operating for the same time in a bench environment.**

Lead-free Technology Experiment in a Space Environment (LTESE)

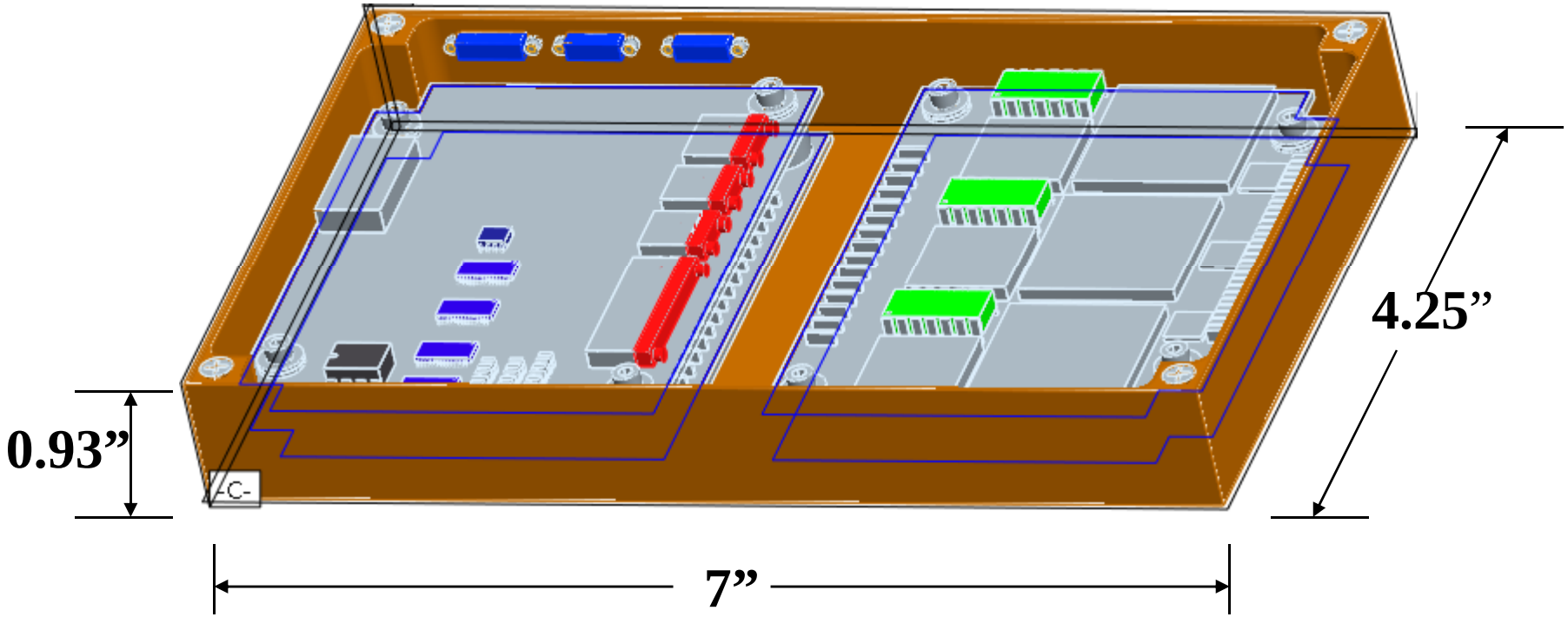
DESCRIPTION

The Lead-Free Technology Experiment in Space Environment (LTESE) experiment is 1 small active package containing test boards and a data acquisition system:

- **One Im-Ag board with Pb-free parts using Pb-free solder (COTS simulation)**
- **One SnPb board with Pb-free parts using SnPb solder (Inadvertent incorporation)**
- **One SnPb/SnPb control board (Control board)**
- **One data system board**
- **Desired environment is exposure to space environment for ~1 year**

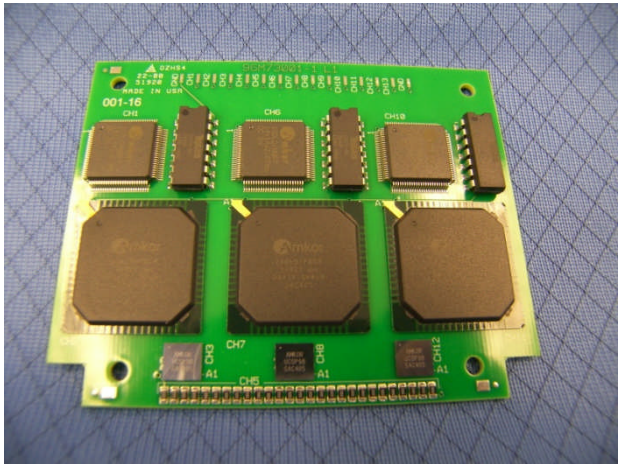


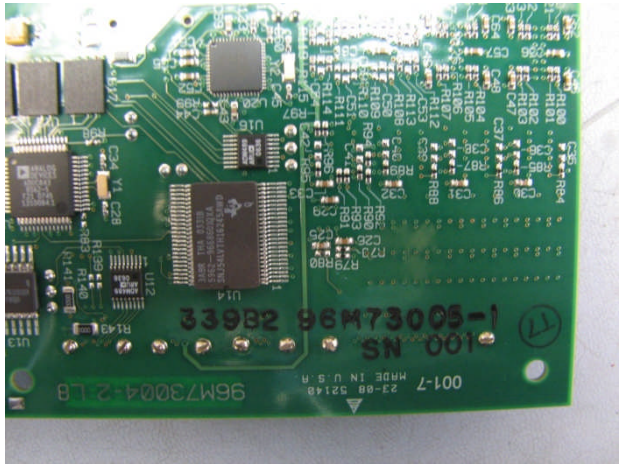
LTESE Mechanical Specifications

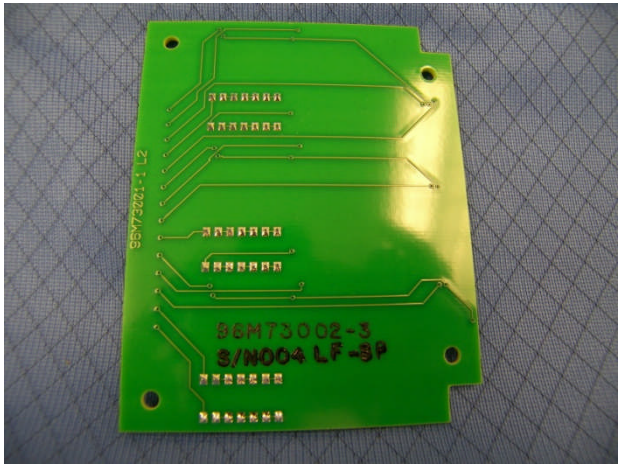


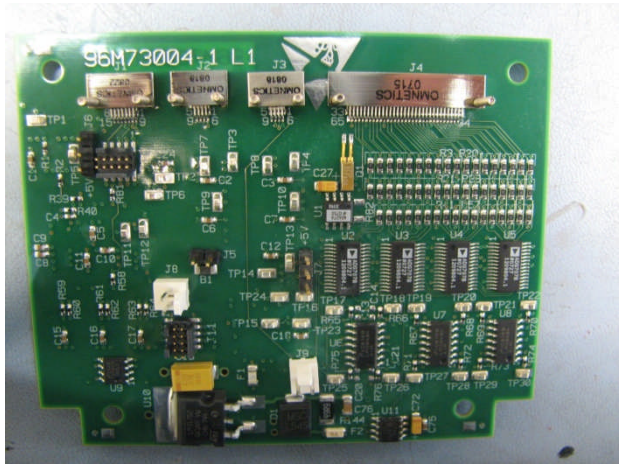
Weight : 417 gms/0.92 lbs
Coating: CHEMICAL CONVERSION COAT PER MIL-DTL-5541 TYPE II CLASS 3
Note: Cover and cabling not shown for clarity

LTESE Test and Data Boards

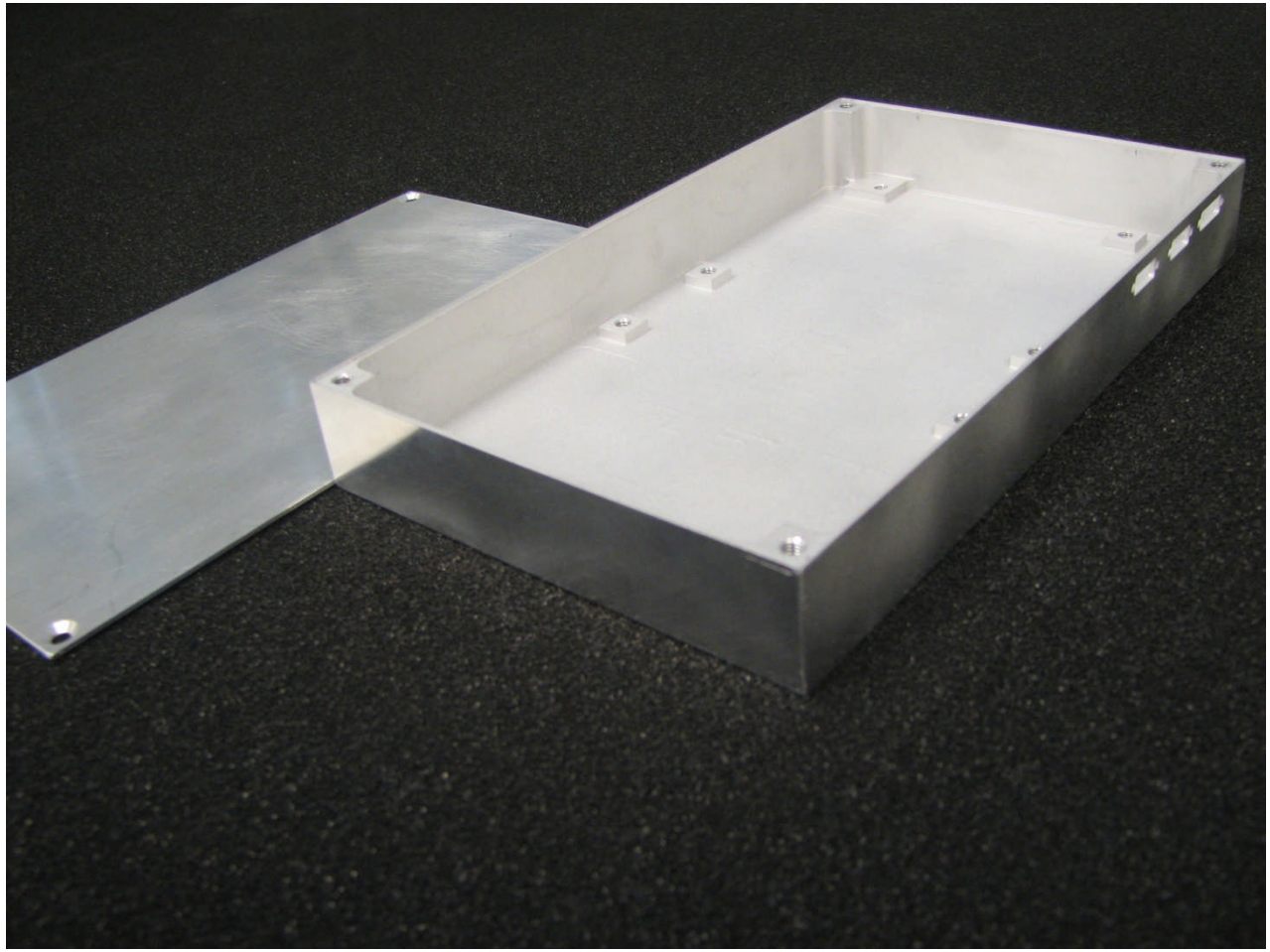




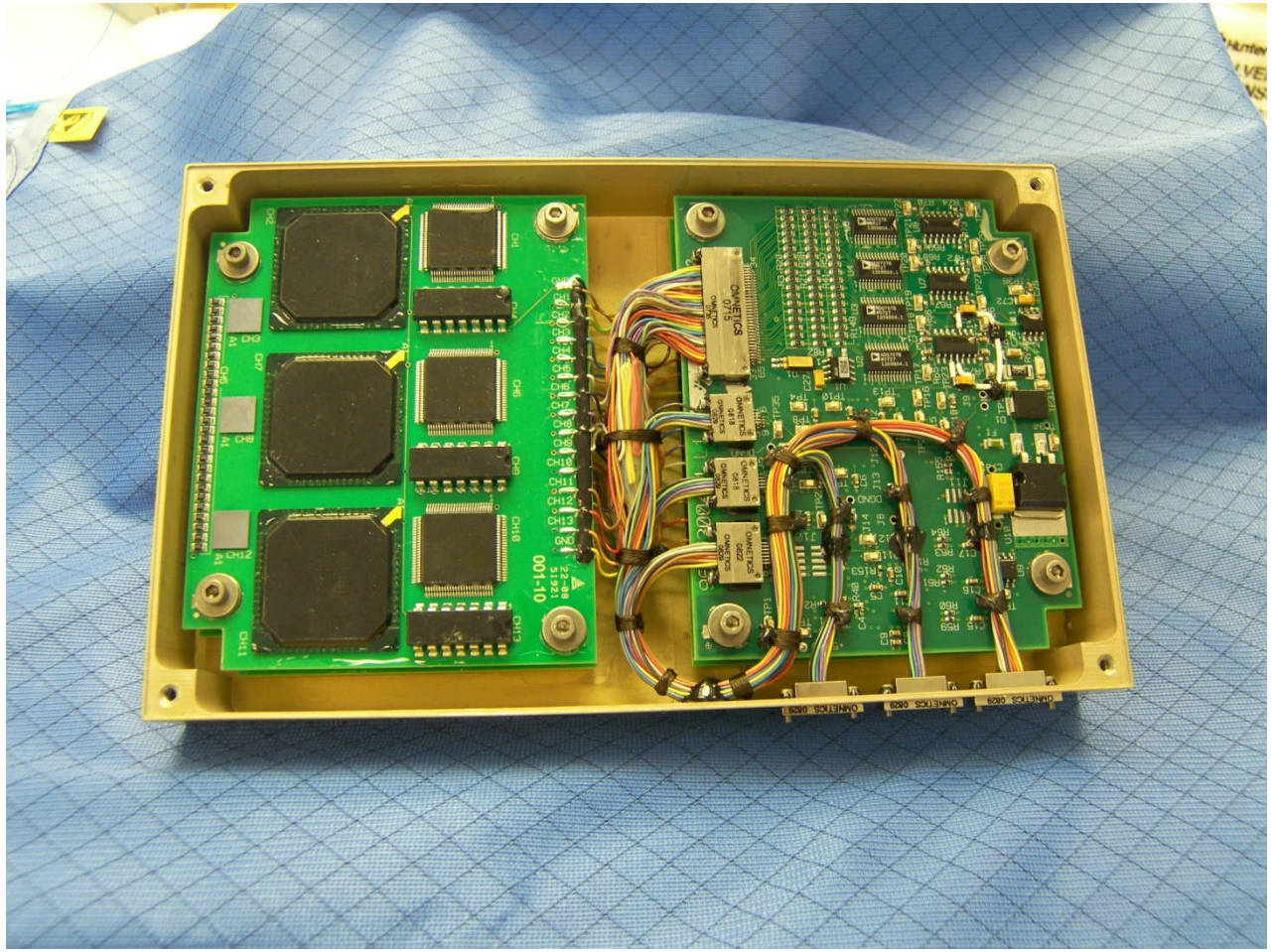




LTESE Housing



LTESE Package



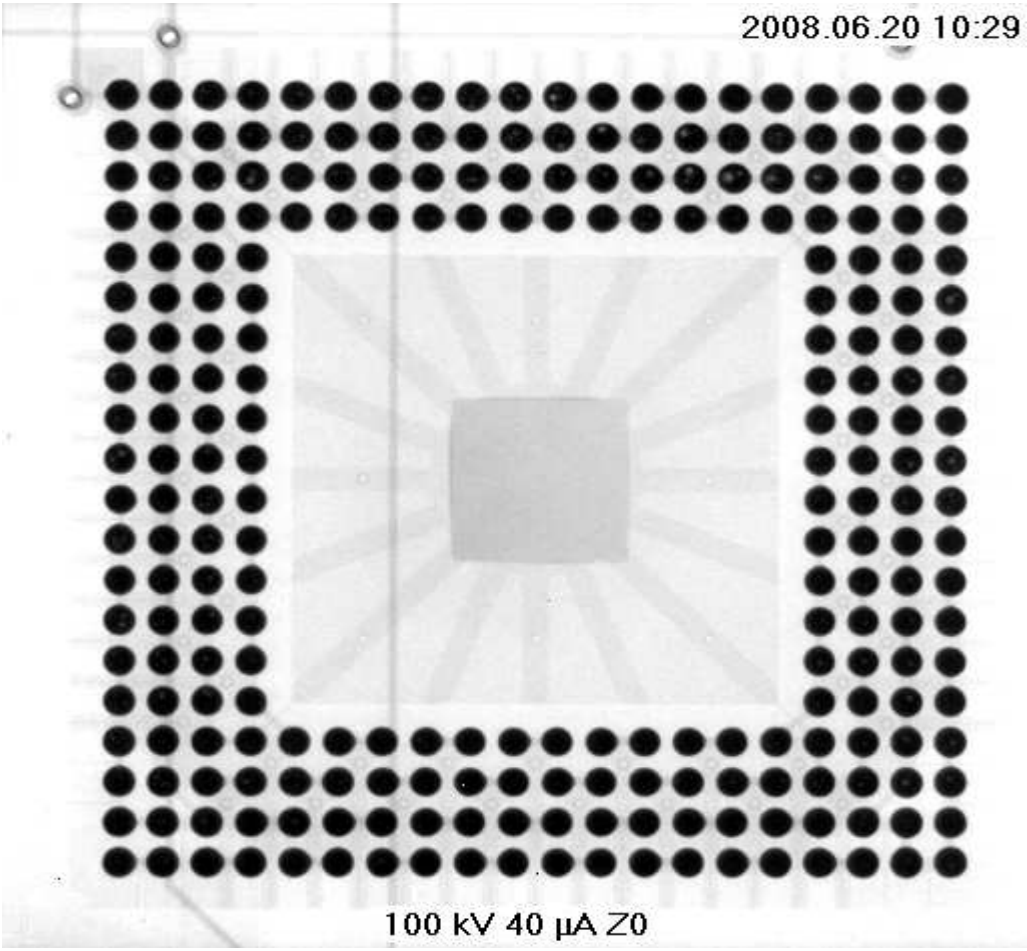
Test Board Fabrication

- **Pb-free test parts are:**
  - **PBGA256's with a SAC405 finish (Large area array)**
  - **CSP100's with a SAC405 finish (Small area array)**
  - **0805 zero ohm resistors with a SAC305 finish (Chip part)**
  - **QFP100's with 100% Sn finish (Leaded SMT part)**
  - **PDIP14's with 100% Sn finish (Through-hole part)**
- **Sn 63 with an Sn 63 profile has been used to solder the Pb-free parts into the SnPb boards**
- **SAC305 solder (Kester EN 907) has been used for the Pb-free boards**

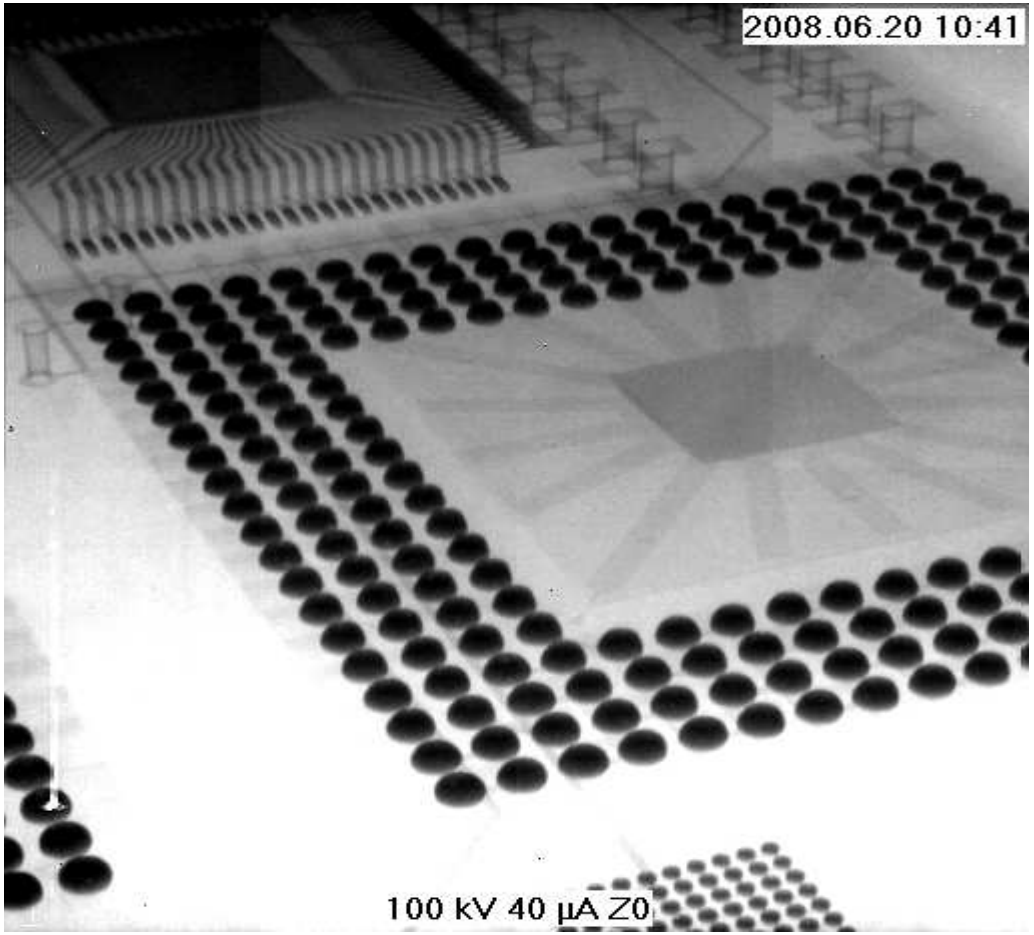
Test Board Fabrication

- **All test parts are daisy chained dummy parts (1464 solder joints per test board)**
- **Each part forms one test circuit except all 27 chip resistors form one circuit**
- **All test boards vapor phase soldered**
- **Pb-free used 240°C vapor**
- **All boards cleaned in vapor degreaser**
- **All boards conformal coated with Solithane 113-300**

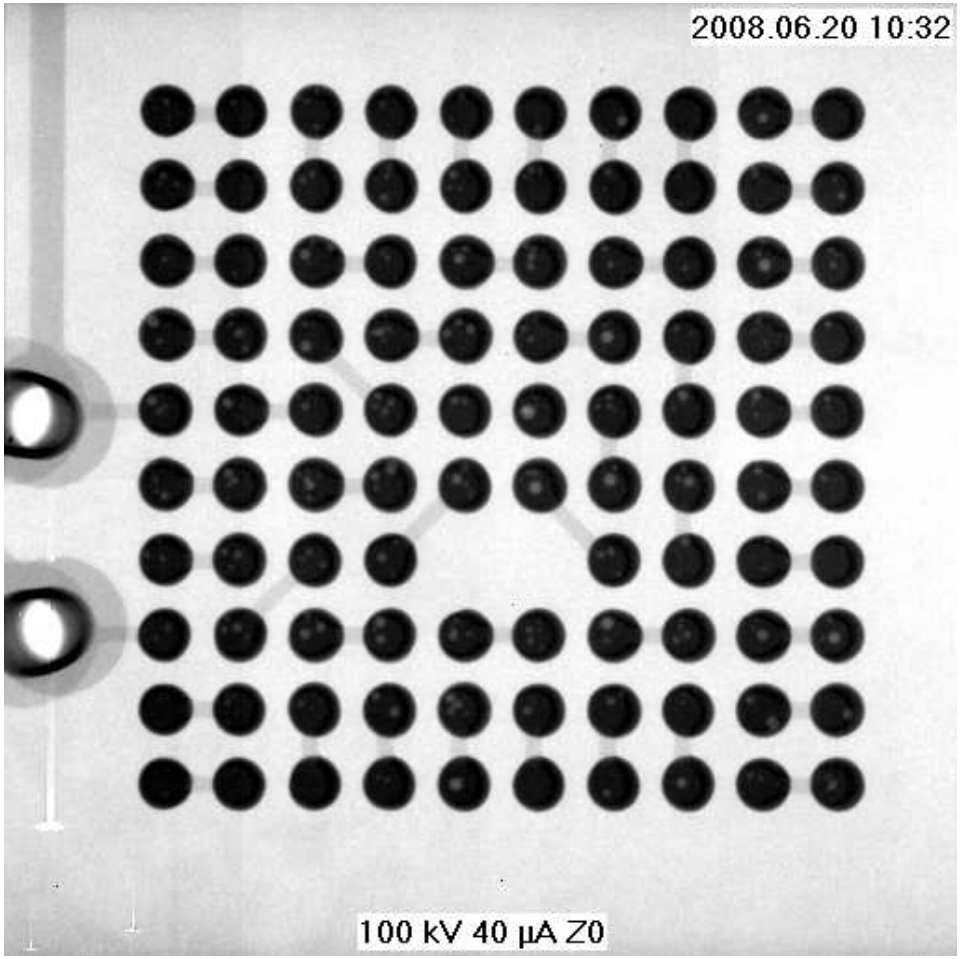
S/N 007 Pb-free/Pb-free
BGA X-Ray



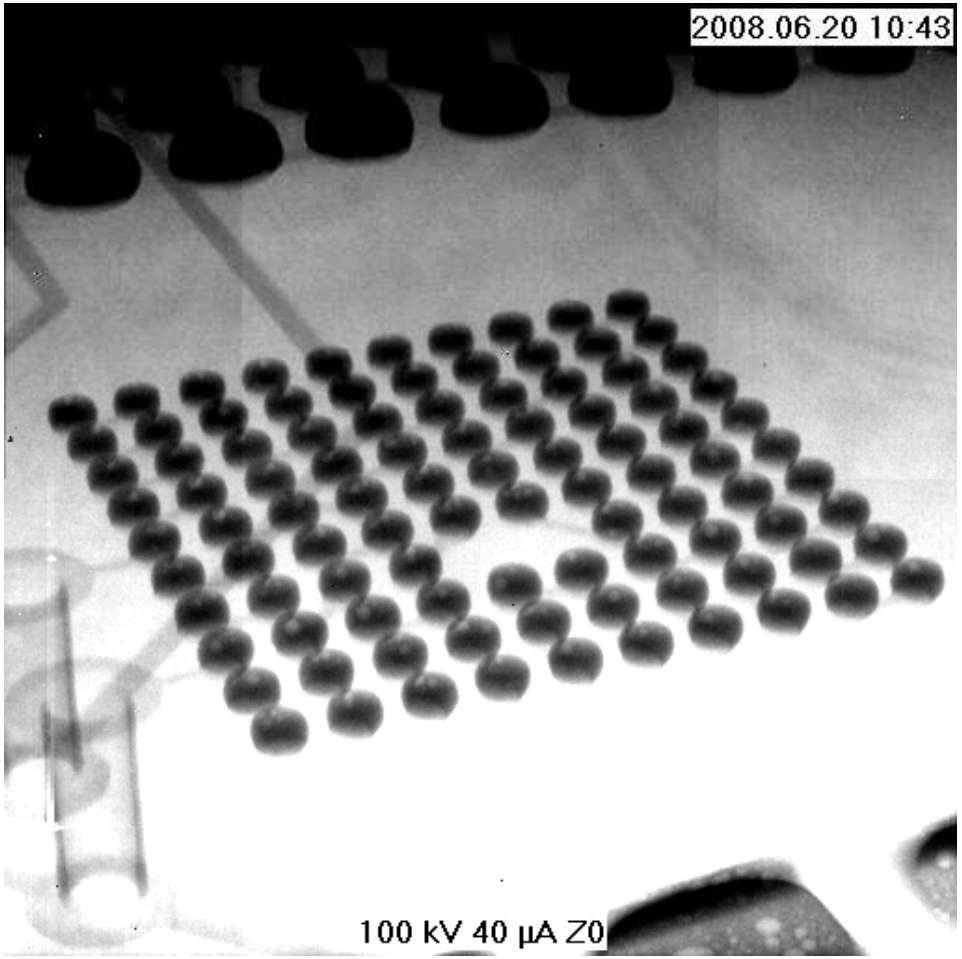
S/N 007 Pb-free/Pb-free
BGA X-Ray, Oblique



S/N 007 Pb-free/Pb-free
CSP X-Ray



S/N 007 Pb-free/Pb-free
CSP X-Ray, Oblique



Concept of Operations

- **Plan to record the resistance of each circuit and temperature in the box every 5 minutes for the time on the outside of the Station.**
- **Temperature sensor is located on the data board**
- **Parts are daisy chained and resistance of each part will be recorded individually.**
- **A duplicate package will be on the ground that will be recording the same data for comparison.**

Concept of Operations

- **Data System Operation:**
  - **When MISSE sends signal asking for sample, data system will take a measurement from our 39 test channels and the external diodes.**
    - **If data system loses communication with MISSE, will use real-time clock for timing and will store data to internal FLASH memory only.**
  - **Timestamp and health/status will be appended to the experiment data.**
  - **Data will then be transmitted to the ground and will also be stored to triple redundant FLASH memory.**

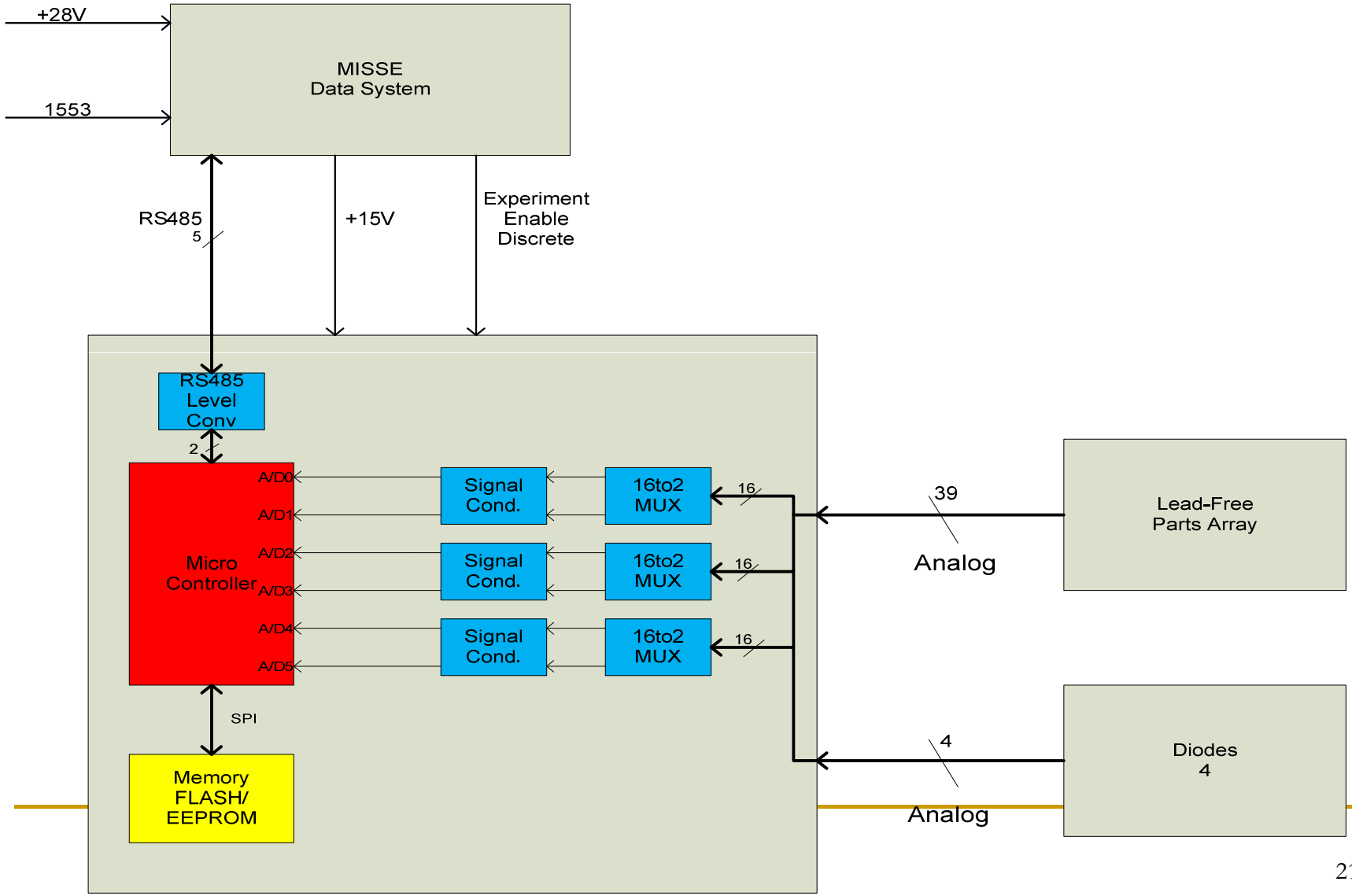
LTESE Electrical Characteristics

- **Power:**
  - **Voltage and current from MISSE: +15V @ ~800mA peak**
  - **Converted to +5.1V and +3.3V on LTESE data system board**
  - **Max Pwr: ~800mA**
  - **Average Pwr: ~450mA**
  - **Power Consumption: 12.2 W Maximum, 6.85 W Average**

LTESE Electrical Characteristics

- **Power:**
  - **Duty Cycle: MISSE-7B has proposed a ping every 5 minutes.**
    - **The data system will be on for approximately 10 seconds to record, downlink, and store the data.**
    - **Digital section of the board will be put to sleep between pings from MISSE, but 200 mA current source feeding analog channels will always be powered**

LTESE Data System Block Diagram



LTESE Communications

- **Communication:**
  - **Downlink 1264 bytes of experiment data each time LTESE is pinged by MISSE.**
  - **Downlink 1264 bytes of acknowledge/status data in response to command uplink from ground.**
  - **Frequency of uplink: infrequent. If mission duration exceeds one year, or if there is a problem, LTESE may be commanded to decrease data collection rate.**
  - **Telescience Resource Kit (TReK) ground control via MSFC Payload Operations Integration Center (POIC)**

LTESE Risks

- **Minimal rad tolerance(RS485 xmit logic is the only rad tolerant part of design)**
- **Plastic parts, subject to temperature extremes**
- **Lack of end-to-end test from LTESE through MISSE-7B, ELC, ISS and ground data systems**

Status

- All hardware manufacturing and assembly is completed.
- CDR conducted 6/17/08. No issues.
- Integration into MISSE 7 successfully completed.
- LTESE is ready to go.