STEREO IMPACT

PROBLEM REPORT
PR-1027
FM1 IDPU T.Vac.
2004-11-23

PR Numbers: 1xxx=UCB, 2xxx=Caltech/JPL, 3xxx=UMd, 4xxx=GSFC/SEP, 5xxx=GSFC/Mag, 6xxx=CESR, 7xxx=Keil, 8xxx=ESTEC, 9xxx=MPAe

Assembly : IDPU	**SubAssembly :**
Component/Part Number: A560 SN001	**Serial Number:** FM1
Originator: David Curtis	**Organization:** U.C. Berkeley
Phone : 510-642-5998	**Email :** dwc@ssl.berkeley.edu

Failure Occurred During (Check one √)

□ Functional test √ Qualification test □ S/C Integration □ Launch operations

Environment when failure occurred:

□ Ambient □ Vibration □ Shock □ Acoustic
□ Thermal □ Vacuum √ Thermal-Vacuum □ EMI/EMC

Problem Description

The IDPU passed CPT at 28V bus voltage but failed to start at bus voltages below 26V (the requirement is that it start down to 24V). Once started at 28V, it continued to run if the bus voltage was decreased to 24V. The power-on current profile even at 28V was also unusual. This occurred both at hot and cold plateaus of the first operational cycle. (+55C, -23C) The low bus voltage test is not normally done every CPT; the last time it was done was during power converter tests, at which time it functioned correctly. When the box was opened and the circuit was analyzed the diode D5 and the resistor R11 were both found to have failed.

Analyses Performed to Determine Cause

Results of the failure analysis F/A#Q40407 (Hi-Rel FR-124066) indicate that there was a failure in the die which show signs of having dissipated some power for a while (it had heated up). It was thought that the original source of the problem was probably some kind of transient (possibly ESD). That transient may not have immediately caused the part to fail completely (it may have already been damaged when it seemed to be working in early board-level tests), but dissipation of power over time may have caused the part to worsen. Age of the part does not seem to be a factor.

It is hard to damage the part in circuit because it is in series with a large resistor that limits the current, and in parallel with a large capacitor that limits transient. Once damaged, we thought that enough energy might be able to pass through the series resistor to slowly heat up the damage site (which is very small) over time. But it is not clear what the source of the initial damage might be. Either it was damaged (perhaps by ESD) prior to or during installation, or perhaps due to probing in early tests (there is a test point connected to the diode which is probed during test). We believe we followed the usual ESD protection procedures at all times. We did not think any other part of the circuit was liable to be stressed by the failure or the transient which precipitated it. The FM2 IDPU LVPS does not have this problem.

Corrective Action/ Resolution

√ Rework □ Repair □ Use As Is □ Scrap

1. Removed and replaced D5 (JV4106-1, LDC 8704) and R11 (RWR81N15R0FS) LDC0334 and retested on the bench; now turns on down to 20V and has a nominal turn on transient.
2. Resume thermal vacuum test at t/v cycle 3.
3. After T/V cycle 5 it was found that an old LDC was used so LDC 8704 was replaced with LDC 0150. Due to the old LDC, this part was also replaced on IDPU LVPS FM1/FM2 and SWEA LVPS FM1/FM2. Note: There was not enough information to know if an old LDC may have contributed to the failure. Repeated bench test/box test plus 2 more t/v cycles (including CPTs at plateaus) on the IDPU LVPS FM1.

Date Action Taken:____November 23, 2004__ **Retest Results**:_Success, board level/box level

Corrective Action Required/Performed on other Units □ Serial Number(s): Yes. Ref #3.

Closure Approvals

Subsystem Lead: _____ Date:_____
IMPACT Project Manager: _____ Date _____
IMPACT QA: _____ Date:_____
NASA IMPACT Instrument Manager: _____ Date:_____

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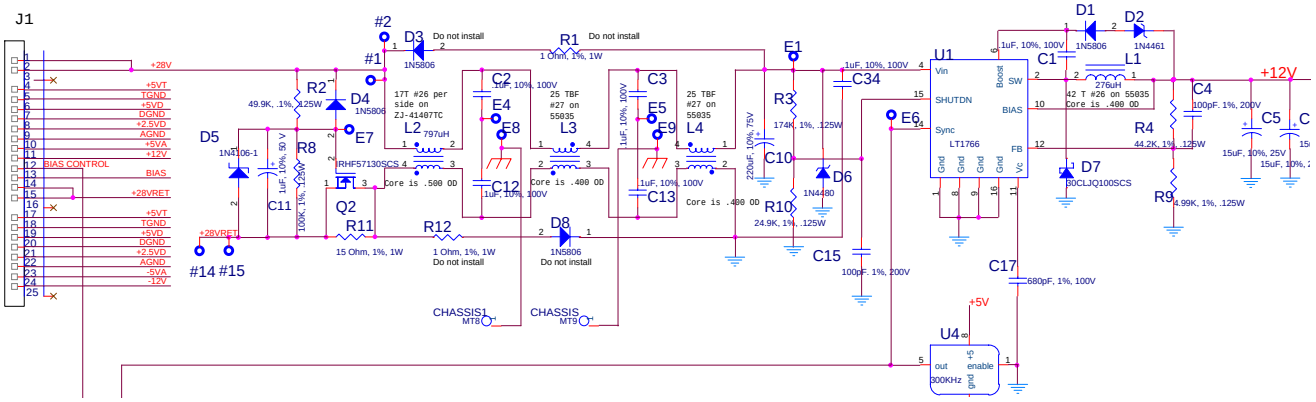
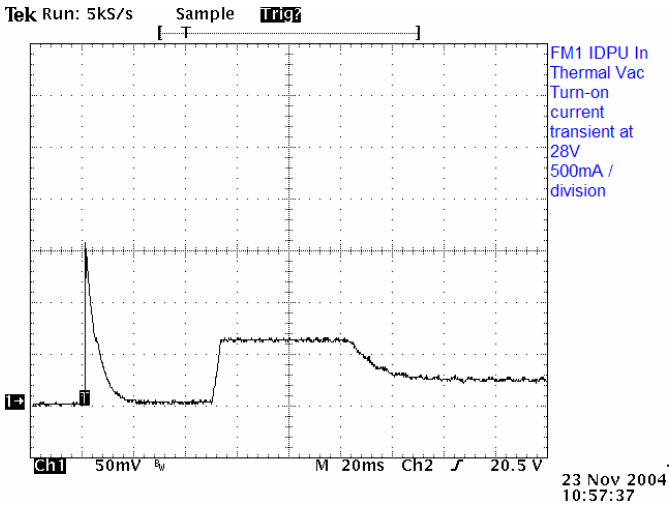
Thermal vacuum was discontinued after the first operational cycle and the unit was tested on the bench. It continued to fail to start at bus voltages less than 26V. The failure and unusual turn-on current transient is consistent with the soft start circuit not turning off (Q2 not tuning on; see schematic next page). Using the ETU IDPU supply we were able to replicate the problem by shorting across D5 to disable the soft start turn off. We opened the flight IDPU and measured the resistance across D5, which was found to be ~1 ohm. We also noticed that R11 was discolored (which is consistent with the soft start circuit not functioning correctly, since all the instrument current was now running continuously through this resistor while in vacuum and hot for several hours).
There are a few components that could have caused this failure. We started by removing D5, which proved to be the source of the problem. The short went away and the diode by itself was shorted. We checked D4 (in circuit) and it was functioning correctly.

We tested the FM2 LVPS, which does not have this problem.

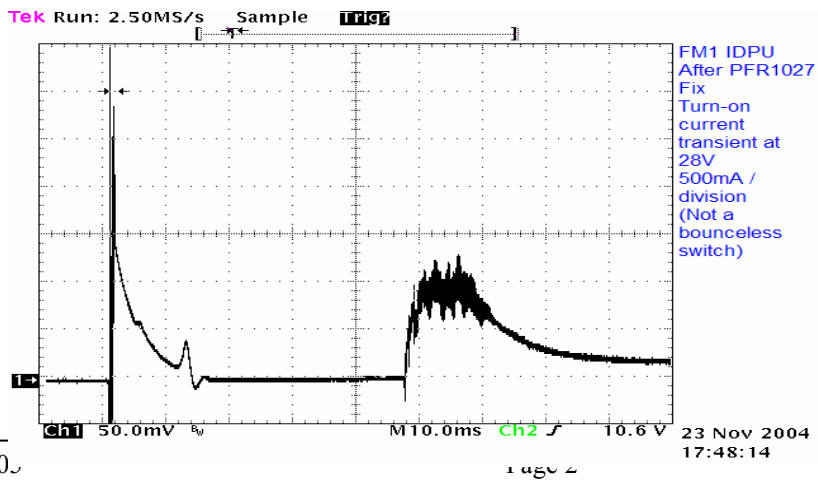
IDPU LVPS Front End



Unusual Turn-on Transient



Normal turn-on transient (after fix)



12/9/2004

Results of the failure analysis indicate that there was a failure in the die which show signs of having dissipated some power for a while (it had heated up). It was thought that the original source of the problem was probably some kind of transient (possibly ESD). That transient may not have immediately caused the part to fail completely (it may have already been damaged when it seemed to be working in early board-level tests), but dissipation of power over time may have caused the part to worsen. Age of the part does not seem to be a factor.

It is hard to damage the part in circuit because it is in series with a large resistor that limits the current, and in parallel with a large capacitor that limits transient. Once damaged, we thought that enough energy might be able to pass through the series resistor to slowly heat up the damage site (which is very small) over time. But it is not clear what the source of the initial damage might be. Either it was damaged (perhaps by ESD) prior to or during installation, or perhaps due to probing in early tests (there is a test point connected to the diode which is probed during test). We believe we followed the usual ESD protection procedures at all times. We did not think any other part of the circuit was liable to be stressed by the failure or the transient which precipitated it

Corrective Action/Resolution continuation

Removed and replaced D5 (JV4106-1, LDC 8704) and R11 (RWR81N15R0FS). Retested on the bench; now turns on down to 20V and has a nominal turn on transient. The nominal power level of the IDPU dropped 10% (since we are no longer wasting power in the 15 ohm resistor). Since the power level has been at the higher level since integration of the IDPU, this dates the failure to before integration but after the supply-level turn-on test. Resumed t/v test at cycle 3.

After compleing t/v cycle 5 it was found that an old LDC was used so LDC 8704 was replaced with LDC 0150. Due to the old LDC this part was also replaced on IDPU LVPS FM1/FM2 and SWEA LVPS FM1/FM2. Note: There was not enough information to know if an old LDC may have contributed to the failure.

Completed the final 2 thermal vacuum cycles. CPTs at plateaus with hot and cold starts. All passed successfully.

To: Vinod_Patel
From: Antonio Reyes <areyes@pop400.gsfc.nasa.gov>
Subject: FRB on JNATXV1N4106-1, LDC 8704
Attendees: Mike Jones, Lillian Reichenthal, Antonio Reyes, Dave Curtis (Telecon)

References: IMPACT PR-1027-FM1/IDPU-TVac
Hi-Rel F/A Report # FR-124066

On January 14, 2004, at 1:30 PM, Bldg 6/S126, a failure review (FRB) was held in Lil's office to discuss the failure (PR-1027) of a 500 milliwatt, low-noise zener diode, used in the STEREO/IMPACT-IDPU FM1. The LVPS failure occurred in thermal-vacuum during box level testing.

Problem Description: The IDPU passed CPT at 28V bus voltage but failed to start at bus voltages below 26V (the requirement is that it start down to 24V). Once started at 28V, it continued to run if the bus voltage was decreased to 24V. The power-on current profile even at 28V was also unusual. This occurred both at hot and cold plateaus of the first operational cycle. The low bus voltage test is not normally done every CPT; the last time it was done was during power converter tests, at which time it functioned correctly.

The IDPU assembly was opened and the resistance across D5 was measured, which was found to be ~1Ω. It was also noticed that R11 was discolored (which is consistent with the soft start circuit not functioning correctly, since all the instrument current was now running continuously through this resistor while in vacuum and hot for several hours). First, D5 was removed, which proved to be the source of the problem. The short in the box went away and the diode revealed to be shorted.

The failed device (D5, manufactured by Microsemi, P/N JANTXV1N4106-1, LDC 8704) was sent to Hi-Rel Lab for analysis. Electrical testing confirmed the failure. Inspection of the device after de-capsulation revealed a large damage site in the center of the die as well as several cracks originating from the damage site.

The observed damage on the diode was due to a long-term over-current condition. This resulted in the localized heating, and subsequent alloying and cracking of the die. The cause of the failure may have been an ESD event caused during assembly of the board, or similar type transient during probing of the board. This would have led to a leakage site (possibly in the 10s of KΩ) that allowed normal operation initially and gradually dropped in resistance over time as the alloying progressed.

Disposition: Damaged devices (D5 & R11) were replaced. For D5, a newer LDC was used (Microsemi, D/C 0150) and the assembly was retested on the bench showing a nominal turn "ON" transient and output power level (Within specification). The IDPU Termal-Vac was reassumed, thereafter.

Regards,

Antonio Reyes
STEREO Parts Engineer
X65927

HI-REL
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GODDARD SPACE FLIGHT CENTER
Report Number: FR- 124066
Reference Number: 11307
December 7, 2004

DIODE
Part Number: JV4106-1
Manufacturer: Microsemi
Quantity: One (1)

Submitted By: _____
Ken Turner

Approved By: _____
Mark Gores

Goddard Space Flight Center
Report Number FR-124066

INTRODUCTION

Hi-Rel Laboratories received one (1) diode from Goddard Space Flight Center for failure analysis. The diode was identified by the part number JV4106-1, date coded 8704 and manufactured by Microsemi. This report will be in reference to GSFC Job # Q40407FA.

ANALYSIS PROCEDURE/RESULTS

External Visual inspection revealed no anomalies on the device.

Radiographic Inspection was performed using a Fein Focus 160.24 Radiographic Inspection System. X-ray images were generated in top and side views in the "as received" condition. Examination of the X-ray images revealed no obvious anomalies.

Electrical Testing was performed using a Tektronix 576 curve tracer. Testing revealed that the device was short circuited.

Decapsulation was performed by grinding into one end of the device parallel to the die. The slug was removed using nitric acid, exposing the die.

Internal Visual inspection revealed a severe damage site in the center of the die and multiple cracks emanating from the damage site.

SUMMARY/CONCLUSION

The failure of the device was verified. No anomalies were noted in external or radiographic inspection. Electrical testing revealed that the device was short circuited. Inspection of the device after decapsulation revealed a large damage site in the center of the die as well as several cracks originating from the damage site.

The observed damage on the diode was due to a long term overcurrent condition. This resulted in the localized heating, and subsequent alloying and cracking of the die. Based on discussions with personnel involved in the testing of the application circuit, the initiating cause of the failure may have been an ESD event caused during assembly of the board, or similar type transient during probing of the board. This would have led to a leakage site (possibly in the 10s of Kohms) that allowed normal operation initially and gradually dropped in resistance over time as the alloying progressed.

Figure: 1A
Sample:
Subject:
Optical macrograph of the device as received.

Figure: 1B
Sample:
Subject:
Rotated view of the device.

Figure: 1C
Sample:
Subject:
Rotated view of the device as received.

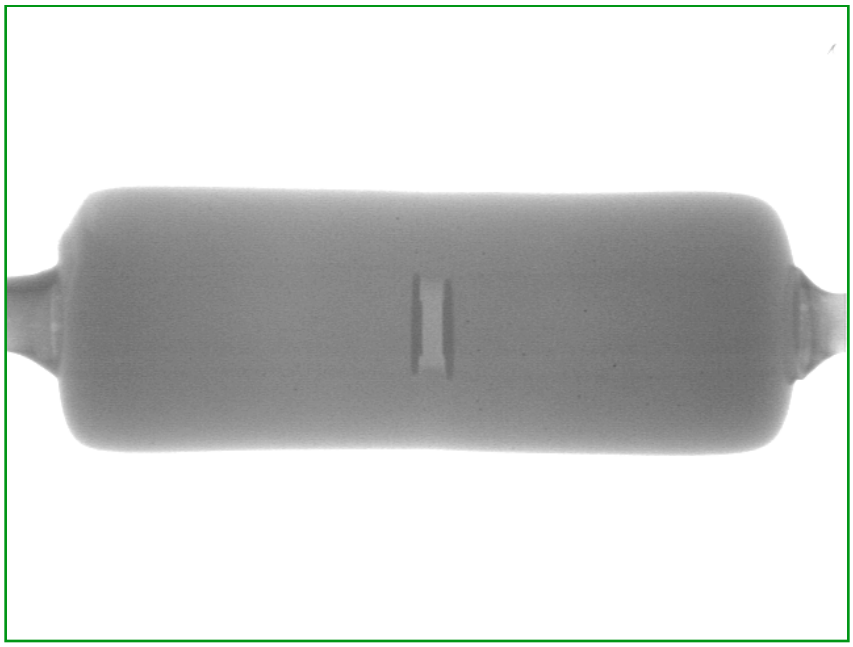

Figure: 2A
Sample:

Subject:
X-ray image of the device.

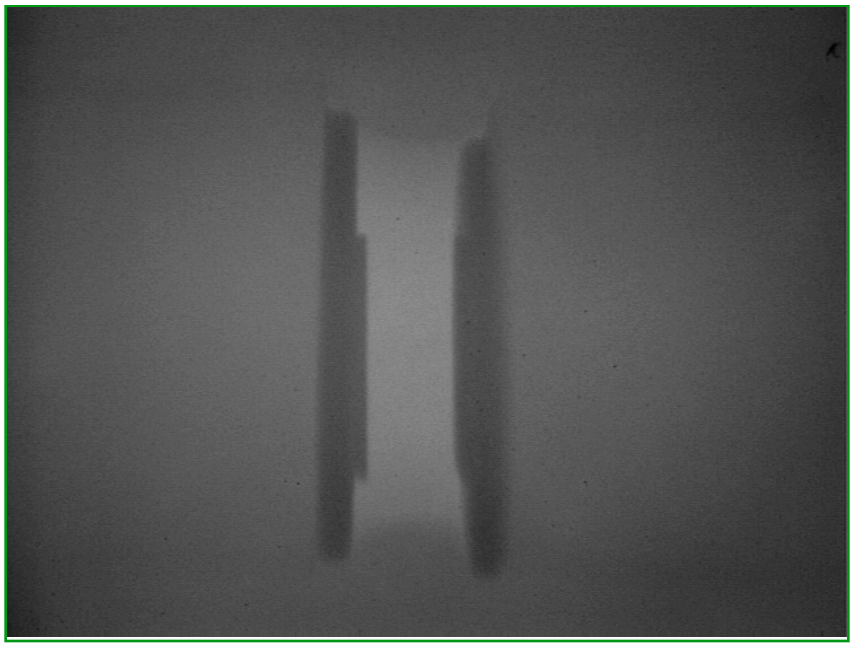

Figure: 2B
Sample:

Subject:
Close up view of the die in figure 2A.

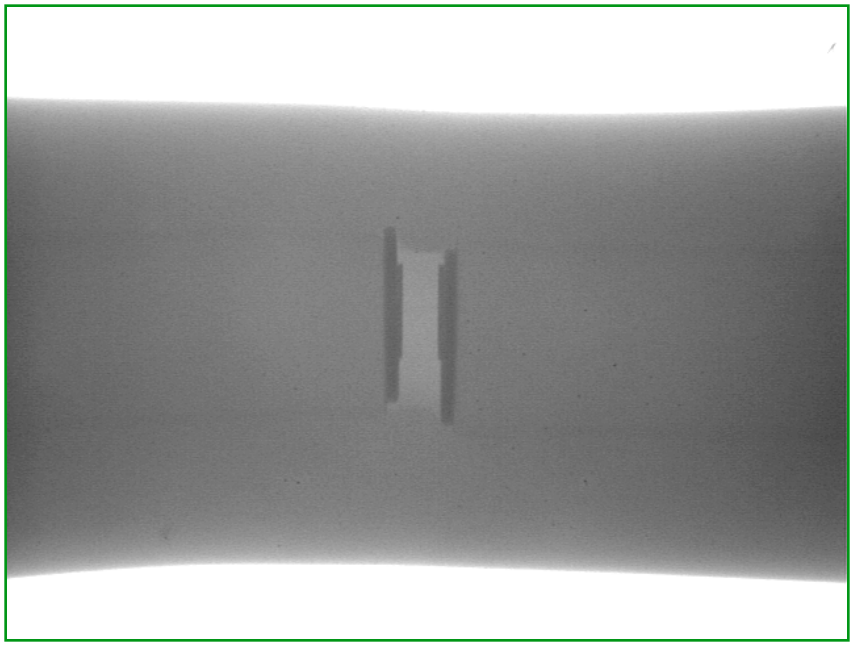

Figure: 3A
Sample:
Subject:
Rotated X-ray image of the device.

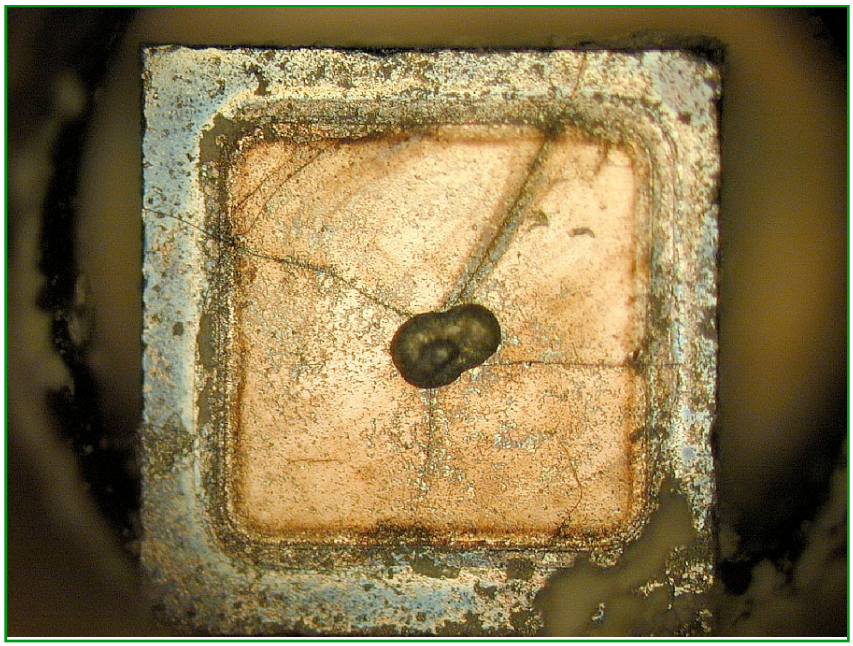

Figure: 3B
Sample:
Subject:
Die micrograph of the device after decapsulation. Note the alloying and cracking of the die.