STEREO IMPACT

PROBLEM REPORT
PR-1032
FM2 IDPU Cold Start 2
2005-01-14

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:	**Serial Number:** FM2
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

During IDPU FM2 Thermal Vac, the last operational cold cycle, the IDPU did not start up correctly at +35Volts. It had worked correctly for the previous cycling and also minutes before at +24Volts. After failing to turn on at 35V, it failed to start at any voltage. The current on the primary was 100mA, about half of normal. Power-up was repeatedly attempted as the instrument warmed up. On one occasion the system started and worked correctly for 14 seconds before spontaneously returning to the bad state. Note that the symptoms are different from those of PFR1031.

Analyses Performed to Determine Cause

After the chamber was vented the instrument was returned to the bench and operated correctly. It continued to function properly after cycling in a thermal chamber and extensive operations on the bench.

The low current indicates that part of the converter did not start. The unloaded supply takes more than 100mA (due to current being delivered to limiting zeners). We know the digital supplies were not working because the processor did not come up, and we verified with the ETU that the 100mA is consistent with the digital supply not starting. Inspection of the digital supply indicates a reverse biased Tantalum capacitor in the circuit – C46, see schematic below. Note in the schematic that the polarity is not indicated; early on in the design the capacitor was a ceramic part, but when the value increased it changed to tantalum without the part symbol changing. This resulted in an ambiguous input to the layout program and incorrect polarity indications on the silk screen. If C46 were to short (or at least increase its leakage to ~100uA) the digital supply would not start, resulting in the symptoms seen. Extended exposure to warmer conditions could have allowed the part to heal itself. The part is a CWR06NH335KC 3.3uF 50V part, LDC P017196332. Review of all IMPACT/PLASTIC power converter designs show that the SEP LVPS has the same problem (see PFR 1025).

Shortly after this problem was identified but before the solution was implemented, the IDPU FM1 unit started showing similar symptoms. It was disassembled and the capacitor was measured before any further thermal cycling. It was found that the C46 capacitor bias had dropped from 5V to 2.3V due to increased leakage current (caused by being reverse biased). This validates the analysis above.

Corrective Action/ Resolution

√ Rework ☐ Repair ☐ Use As Is ☐ Scrap

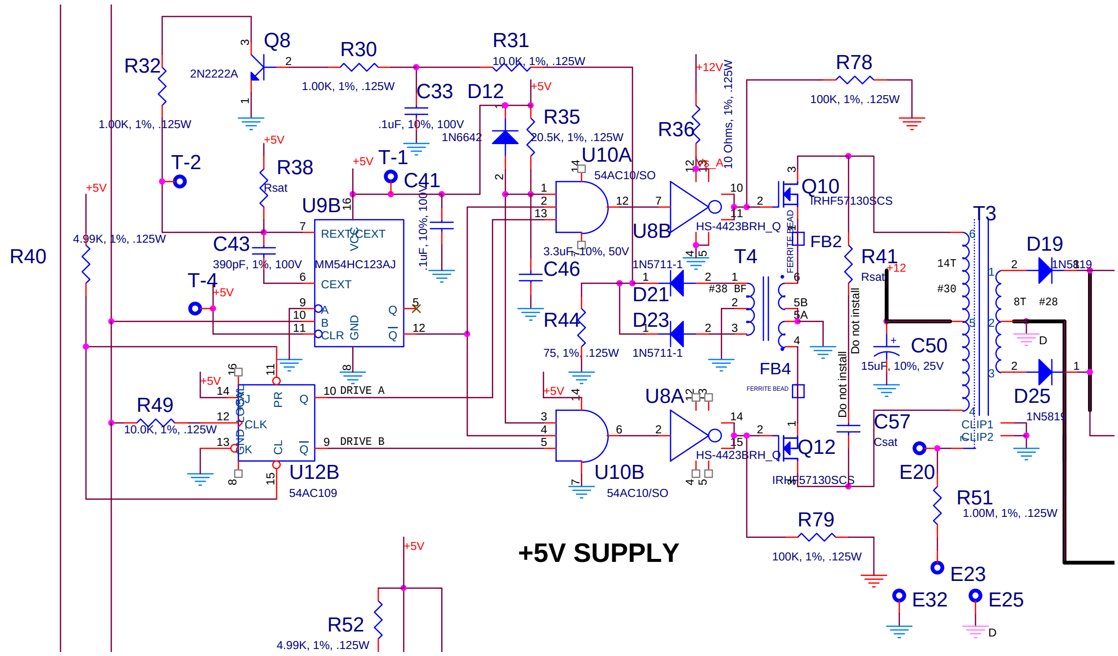
Replace the reverse-biased capacitors and retest (CPT, workmanship vib, 4 cycles thermal vac). Redlined drawing includes polarity identifiers. The circuit was not stressed due to this error.

Date Action Taken: 2005-1-14 **Retest Results**: Success. Passed 4-cycle thermal vac, workmanship vib

Corrective Action Required/Performed on other Units √ Serial Number(s): FM1, done, retested like FM2

Closure Approvals

Subsystem Lead: ____________ Date: ________
IMPACT Project Manager: ____________ Date ________
IMPACT QA: ____________ Date: ________
NASA IMPACT Instrument Manager: ____________ Date: ________



IDPU LVPS schematic, digital supply section.   C46 is the suspect part.

Date: Tue, 18 Jan 2005 13:19:50 -0500
From: Shane Hynes <Shane.Hynes@gsfc.nasa.gov>
Reply-To: Shane.Hynes@gsfc.nasa.gov
Organization: STP
X-Accept-Language: en-us, en
To: David Curtis <dwc@ssl.berkeley.edu>
CC: Lillian Reichenthal <Lillian.S.Reichenthal.1@gsfc.nasa.gov>,
Mike Jones <michael.d.jones.1@gsfc.nasa.gov>
Subject: [Fwd: Re: [Fwd: [Fwd: Fwd: IDPU FM2 problem]]]

Hi All,
I am always amazed at Henning's knowledge..... see below:
Shane

-------- Original Message --------
Subject: Re: [Fwd: [Fwd: Fwd: IDPU FM2 problem]] Date: Tue, 18 Jan 2005 11:31:46 -0500
From: Henning W Leidecker
<mailto:Henning.W.Leidecker@nasa.gov><Henning.W.Leidecker@nasa.gov> Reply-To:
<mailto:Henning.W.Leidecker@nasa.gov>Henning.W.Leidecker@nasa.gov Organization: Code 562 / GSFC / NASA To: <mailto:Shane.Hynes@gsfc.nasa.gov>Shane.Hynes@gsfc.nasa.gov
References: <mailto:41E85453.9080804@gsfc.nasa.gov><41E85453.9080804@gsfc.nasa.gov>

Dear Shane,

A solid tantalum capacitor is polarized, and really should not be operated with reversed voltage. A reversed voltage "eats" the dielectric and causes increasing leakage resistance, which causes localized heating, which accelerates the destruction of the dielectric (etc): the "end game" is for the resistance to drop percipitiously to (order of magnitude) an ohm.

The time for this to happen varies. Applying full rated voltage in the inverse direction will usually induce failure in seconds, but the ambient temperature matters a bit --- hot quickens and extreme cold delays.

Applying less than 15% of the rated voltage (reversed) will typically never result in a short. Again, temperature matters: operating at the high-temperature limit AND at 15% of rated (reversed) voltage would be ill-advised.

The rules call for derating these caps to 50% of their military rating. So you put a 20V cap into a 10V circuit. The downside of this is that the cap will support a reversed voltage for some hours to weeks --- you can hope that the testing program will "surface" the failure before you launch.

Further derating (say to 30% of rated voltage) delays the shorting caused by operating in a reversed condition longer. The CALIPSO spacecraft suffered this problem: a power supply to a detector system brought in +V on one line and -V on another, with a common return. There were solid tantalum caps on both lines, oriented in the same manner: this made the board look nice, but the cap on the -V volt line was reverse-biased. This cap was rated at three times V, and it endured hundreds of hours of this, until it shorted during a final test sequence in France just before integration with the launch vehicle. The shorted condition showed about 4 ohms at the applied voltage: the power supply was not able to supply more than a few hundred milliamperes, and so it did not drive the destruction of this capacitor as far as a beefier supply would have.

We have an electronics board from a ground station for the TDRSS system in our lab. A solid tantalum shorted on this board and burned a hole right through the board and caused great damage to the surroundings. This power supply was able to provide about 40 to 50 amperes and much of that wound up going through this cap. This particular cap was installed with correct polarity, but we suspect it was seeing excessive AC ripple, and this is very bad for these sorts of caps.

The melting point of tantalum is well over 3000C and so the tantalum slug does not easily melt and flow open, which would interrupt the current; rather, it just sits there and glows with a white-hot incandescence and destroys everything around it, if the power supply is able to provide lots of current. For this reason, you can get solid tantalum caps with internal fuses so that an internal short gets limited in its ability to destroy everything around it.

There were two solid tantalum caps that shorted on one of the TDRSS spacecraft a few years ago. They were being operated at roughly 50% of their rated voltage, reversed, and they took many hours to short. The evidence pointed to a rework event in which an incompletely trained installer replaced some caps, and installed these two backwards. But --- just in case --- we reviewed every one of the (more than 800) solid tantalum caps. For most, we had good "close out" images that clearly showed correct orientation. For about 200, we had no images. So we worked through this list, arguing that any caps with more than 40% of rated (reversed) voltage would short during the 1000+ hours of ground testing --- so survivors HAD to be installed correctly --- while any caps running at less than 15% of (reversed) rated voltage would never short. We got lucky, and every one of the 200 caps fit one or the other of these conditions.

I am puzzled about the "will not short at less than 3 volts" remark, unless this remark applies to caps with rated voltage of 20 volts (note: 3 V is 15% of 20 V). One can procure solid tantalum caps rated at (say) 5 V, and running such a cap at a reversed 3 V would be expected to short it in a time much less than your mission life. Perhaps the quoted "mil" remark is made in a context in which only caps rated at 20V or more are being used?

I agree that solid tantalum caps, operated in forward bias (not reversed) will show occasional events in which their leakage current jumps briefly to a few tens of kilo-ohms and then returns to a few tens or meg-ohms (or more). This is sometimes called "sintillation". Each burst is a shorting event in which the dielectric covering a bit of a grain of tantalum breaks down; then, the local heating induces the magnesium oxide filler to break down and form an insulating layer over the shorting site. (This does require some current: this can come from the charge stored in the rest of the cap, but the voltage has to be 30% or more of the rated voltage.) The final condition is very slightly more leakage since the new insulating layer is not as effective as the original one. But essentially the short has been healed. Still, too

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much of this results in loss of the ability to heal.  In particular,
too much local heating frustrates the reaction producing the insulator,
and the situation runs away into a bad short.

If you have a solid tantalum cap that is suspected of misbehaving, then
a direct measurement of its capacitance and its leakage is reasonable.
If the leakage is high, one can open the cap and carry out an
electroplating of its tantalum slog --- deposits of copper mark shorted
tantalum grains.

Regards,
Henning Leidecker

On Friday 14 January 2005 06:22 pm, Shane Hynes wrote:
> Hi Henning,
>   You're the guru I was referring to below :-) .  Do you have any
> thoughts on the question posed at the bottom of this email chain?
> Any help would be gratefully received.
>
> Shane
>
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