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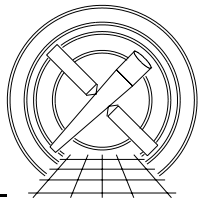

MEMORANDUM

Date: July 11, 2007
From: Royce E. Buehler
To: FDB
Subject: Closeout of DDTS defect OCCcm08039
Cc: ACIS OPS, Dan Schwartz
File: `OCCcm08039_closeout.tex`
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1 Introduction

The ACIS team has completed its investigation of the anomaly that occurred on day 2007:096 during obsid 7647. Of the explanations we were able to hypothesize, only one fits the available evidence. In the absence of a repeated occurrence, we consider the anomaly attributable to a high-energy particle hit on a capacitor associated with the +5V DPA-B power line.

2 The anomaly

The anomaly occured during obsid 7647, a TOO observation in Continuous Clocking 3 by 3 mode of 1E 1048.1-5937. Three FEPs (3, 4, and 5) reset on Saturday, day 2007:096. The time can be reconstructed fairly precisely from the partial event records from those FEPs; the last event was received by the FEP at 19:24:38.27, and the resets would have occurred some milliseconds later.

No further event records were received from these FEPs for the duration of the run. There was a drop at the same time in the +28V current (1DPICBCU) supplied to the B side of the ACIS PSMC from 1.2A to 0.9A; this is consistent with the drop expected from a reset state.

The FEPs reset a third of the way through the science run. The target being on an unaffected FEP, no observer science was lost. At the beginning of the next observation, the front end software was reloaded, and data from all chips was subsequently processed and telemetered nominally.

3 Analysis

The ACIS team considered six possible explanations for the anomaly.

1. The BEP stopped looking for events from these FEPs because it mistakenly believed the FEPs were in a reset state.

   NOT THE CASE. Drops in +5V channel DPA-B voltage (DEAHOUSE_CNTL_ADC_DPA5VHKB in ACIS DEA housekeeping) and +28V B-side PSMC current (1DPICBCU) clearly indicated a physical FEP reset. (See the pdf document 3FEP_Reset_DPA5VHKA_B.pdf for +5V data over the time in question. The A side data DPA5VHKA is included for comparison.)

2. Whether due to a software bug or an SEU, the BEP sent spurious reset commands to the FEPs.

NOT THE CASE. When the BEP resets a FEP, it sends two indicators in the software housekeeping: one to record that it has commanded a reset for that FEP, and one to note that it has found the reset completed. Only the second message appeared in software housekeeping.

Could an SEU have instigated resets from the BEP at a register level, rather than via a spuriously called software routine? No, that would have required a series of intelligently co-ordinated SEUs. The FEPs have control registers that are mapped into 6 widely spaced locations in the BEP's memory space. To reset the FEPs, each register must be rewritten in "guard" mode, which entails setting a bit in another BEP register, writing to the FEP registers, and resetting the guard bit.

3. Corruption in the ACIS flight code somehow invoked or created instructions which reset the FEPs.

   NOT THE CASE. For the reasons given above, corrupted BEP code could not have reset three FEPs simultaneously. For a corruption to have affected three FEPs in identical fashion, the affected memory would have to have been the image of the FEP code in the BEP, from which FEP software is loaded.

   We paid particular attention to this possibility, because the affected science run used CC3x3 mode. For that mode, the BEP loads a unique code image into the FEPs. The patched BEP code for the mode contains instructions, normally exercised only at the end of each CC3x3 run, which invoke a reset state on all FEPs. Although we could not propose a mechanism by which such corruption could induce resets in several FEPs without affecting them all, it seemed suspicious that resets were occuring when ACIS happened to be running exactly the patch which commands FEPs to reset.

   Accordingly, we ran CAP1033 on 2007:100 to dump ACIS flight software and the patchlist. We compared both the patched flight code and the patches stored in the BEP to images generated on the ACIS engineering unit, and found no differences. Subsequent observations run successfully in CC3x3 served as independent evidence that we could eliminate this failure mode.

4. Hung video boards. If a FEP sees no pixel data from its video board for 449 seconds, its watchdog timer will execute a reset. There had been a previous observation of Obsid 5008 in which all FEPs experienced such a spontaneous restart. In that anomaly (DDTS defect OCCcm06622), which took place at 2004:174:20, the video boards stopped sequencing, most likely because of an SEU on the BEP to DEA control line, eventually tripping the FEPs' watchdog timers. We considered whether this might have been a repitition of that problem.

   NOT THE CASE. In the current event, engineering telemetry shows no drop in DEA power, demonstrating that the video boards corresponding to the three reset FEPs continued to sequence.

> The most striking feature of the anomaly was that the affected FEPs were exactly those which are powered by DPA side B. This suggested two failure modes involving an SEU affecting the DPA-B power line:

5. Deep dielectric discharge as a result of spacecraft charging. **UNLIKELY**. Such discharges can happen infrequently, but it is a phenomenon associated with cables, not on PC boards inside metal boxes. We don't have a reset line running to the FEPs through a cable outside the EDS box, so this does not seem to be a credible scenario.

6. A spontaneous discharge in one of the +5V DC digital power filter capacitors. **PLAUSIBLE**. Capacitors are always subject to a sort of microburst phenomenon which occurs on a random, infrequent basis. Normally this is not seen on power lines – not because it doesn't occur, but

because the effects are small compared to the normal power line noise. It is possible that we had a larger event happen here, perhaps triggered by a high-energy particle passing through a capacitor. A brief, deep drop in the digital power line would cause the (power-on) reset circuitry to fire, leading to the observed reset state. Engineering telemetry showed no variation in the DPA-B power, other than the small drop consequent upon the FEPs going into reset state. But this is what we would expect. The current in the +5V power lines from the PSMC to the DPA are not directly reported, but changes can be monitored via the input power to the PSMC. PSMC-B +28V current is reported in engineering telemetry once each major frame (32.8 seconds), and the DPA-B +5V voltage, via DEA housekeeping, once each 17 seconds. Both are based on samples taken over milliseconds, so very short drops or spikes in power are highly unlikely to show a signature in telemetry.

4 Recommendations

We have not seen this anomaly before. If our best explanation (6) is correct, we expect to see it rarely, if at all, in the future; and no action could be taken to forestall a repetition in any case. The ACIS team recommends a closeout of this anomaly, to be reopened in the event of a recurrence.