PFR-057 Title: Misconnected ADC voltage reference on DFB

Assembly : IDPU	**SubAssembly : DFB**	
Component : ADCs (U36 and U42)	**Units Affected:** X X X X X X	**Units fixed:** X 0 0 0 0 0
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Failure Occurred During (Check one √)

X Functional test □ Qualification test □ S/C Integration □ Launch operations □ Other (Flight Assy)

Environment when failure occurred:

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

Problem Description

(In this section it is important to document the specific symptoms which exhibited the problem. In the event we see it happen again, we would like to know as much as possible.)

Testing of flight unit F3 (serial number 004) at LASP has revealed that the gains on all channels are strongly dependent on temperature. Results from this test for the Vx channels (i.e. +/-100V single-ended channels) are included here as figure 1.

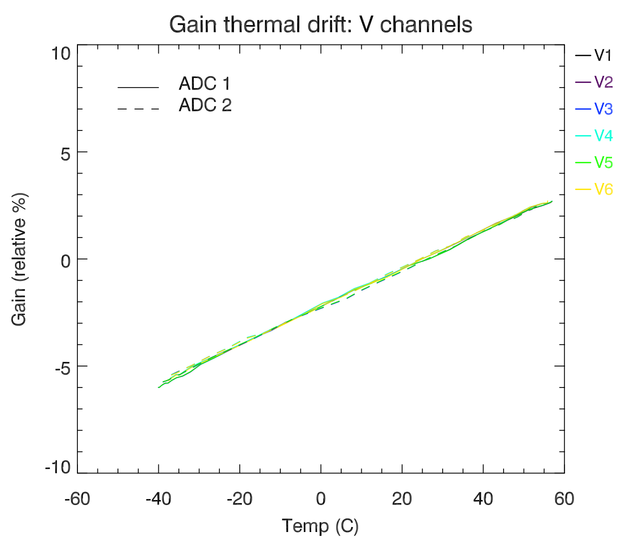

Figure 1: Gain as a function of temperature for the Vx channels on flight unit F3 (SN004). Gain is given as relative to the gain at 25 C.

All other channels showed similar results, as did flight board F2 (SN 003). The total drift of roughly 10% over the temperature range was not expected, and is out of the acceptable range given the science requirements.

Another related aspect of the problem is that the gains (at room temperature) were all slightly lower than predicted. For example, the gain for the SCM channels was set for a maximum range of +/- 4.7V, instead of the expected 5V.

Analyses Performed to Determine Cause

(How do we know how the failure happened? Was it a bad part, bad handling, what?)

The fact that all of the channels drifted in precisely the same manner led us to consider the stability of the A/D converter reference voltages. By probing on the ETU A/D, we found that it was using a reference voltage of roughly 2.3V, rather than the expected 2.5V. This led us to look at the circuit again.

The recommended setup for using the internal 2.5V voltage reference on the LTC1604 A/D converter (from the manufacturer's data sheet) is sketched in black in figure 2. The circuit implemented on the ETU and flight boards is the same, except that it unintentionally includes the connection shown in red.

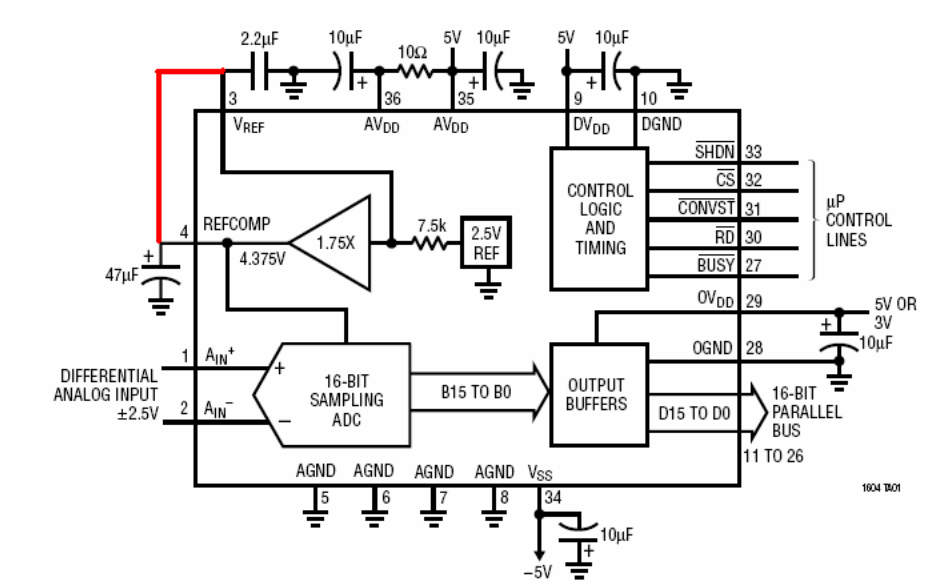

Figure 2: In black: manufacturer's recommended setup for the LTC1604, using the 2.5V internal reference. In red: extra connection on ETU and flight boards.

By connecting pins 3 and 4, the 1.75X amplifier is placed in an unstable configuration, with its output connected back to its input. The exact performance of the voltage reference circuit therefore depends on the details of the internal amplifier. Experimentally (by looking at the ETU), what happens is that pins 3 and 4 are driven to a voltage of roughly 4V, rather than the expected 4.375V. This drops the effective reference voltage from 2.5V to 2.3V, which explains the higher than expected gains. Furthermore, the effects of temperature/time/radiation on the circuit are unclear.

On the ETU, we consequently lifted pin 3 and allowed it to float. Although this isn't exactly equivalent to removing the red trace in figure 2, it did allow us to test the hypothesis that the feedback on the amplifier was causing the thermal drift problems. After lifting the pin, the voltages on pins 3 and 4 assumed the expected values of 2.5V and 4.375V, respectively. The gains for each channel also changed to what was originally expected.

Thermal testing of the ETU after modification revealed that the temperature stability of the gains was at least as good as 0.5% over the full temperature range. Higher precision measurements would require a different test setup, as the temporal stability of the function generator seemed to be playing a role in the measurement.

Corrective Action/ Resolution

(How do we fix the unit? And how do we make sure it doesn't happen again?)

It is relatively straightforward to fix this problem on the flight boards. Figure 3 is a fragment from the schematic. On the board, the traces from pins 3 and 4 connect on the top layer, before going through a via that eventually connects to C175 and C173, as shown in figure 4.

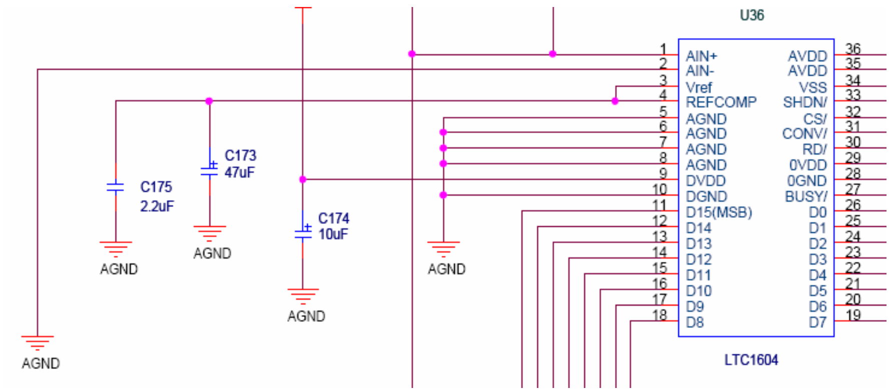

Figure 3: Fragment of the schematic for the ETU, showing A/D1. Flight board schematic is identical in this section.

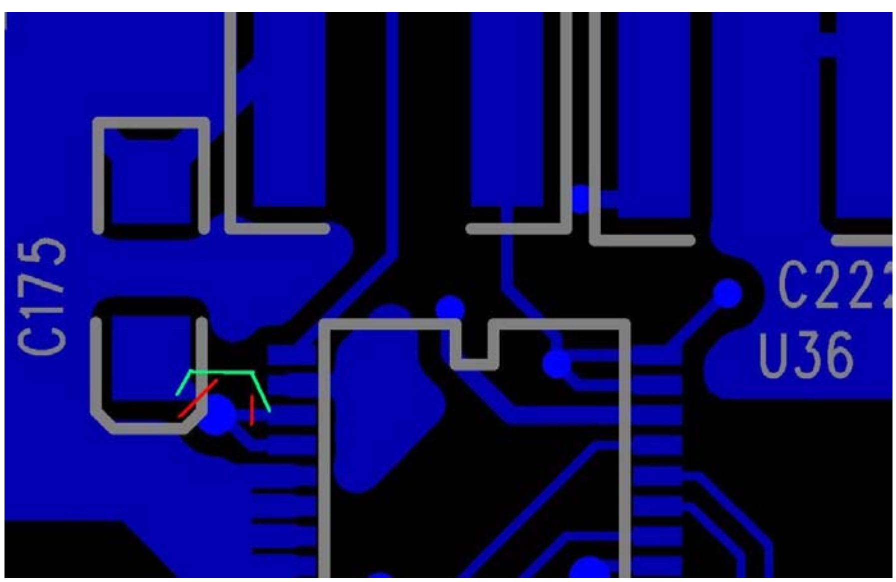

Figure 4: Layout of the top layer of the board. Green line: jumper for repair. Red lines: cuts for repair.

To fix this problem on the flight board, the procedure is:

1. Cut the trace between pin 3 of U36 and the via it is connected to (see red line in figure 4).
2. Cut the trace between this same via and C175 (see other red line in figure 4).
3. Solder a wire between C175 and pin 3 of U36 (see green line in figure 4).
4. Repeat above 3 steps for U42 and C179.

This repair should be done on all boards.

Acceptance:
MAM: Ron Jackson_________________________; MSE: Ellen Taylor_____________________________

PM: Peter Harvey___________________________; Cognizant Engineer___Chris Cully_____________

Date of Closure_____________________