SEPTEMBER 23, 2019

MWA
MURCHISON
WIDEFIELD
ARRAY

SUBTITLE

Gurlgamarnu

Curtin University

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1. PURPOSE

This document provides a brief report outlining the results of visual inspection and first-line testing of the first two modified beam-former boards received from Brett Douglas of Convergence Engineering.

2. CONTEXT & SUMMARY

This report is designed to feed back the results of our inspection and testing so that Brett can possibly slightly modify his procedures, and continue re-working the remaining 98 beam-former boards.

In general, CIRA is very happy with the quality of workmanship and the professional approach that has been shown by Convergence Engineering services in undertaking this work.

There are five minor points that we feel need addressing, if possible, within the scope and budget of the works under way. These issues were spread roughly equally across both boards. They will be detailed in Section 4 with accompanying photographs. Higher resolution versions of these photos will be provided along with this report. Each issue will be contained within a separate numbered subsection and these headings will indicate which amplifier chip(s) relates to the issue being discussed.

For reference:

- QPA4563 refers to the front-end amplifier chip, of which there are 16 on each board.
- QPA4263 refers to the single amplifier chip immediately after the summing junctions, marked as U229 on the board
- QPB7420 refers to the final output amplifier chip, near the SMB socket, and the associated stablisation daughterboard.

3. ACCEPTANCE & TEST PROCEDURES

This section describes the three steps taken prior to accepting the boards for re-integration and into a full beam-former assembly and then conducting final detailed performance testing.

3.1 VISUAL INSPECTION

The initial step was a visual inspection using a 5-20 times variable magnification microscope, inspecting all 16 channel input amplifiers (QPA 4563) and associated dropping resistors, the post-summing amplifier (QPA 4263) and the final output amplifier (QPB7420) and stabilisiation daughter-board.

3.2 MULTIMETER DC RESISTANCE TESTS

Subsequent to rectifying any issues identified in the above step, we use a multimeter to measure the DC resistance across the outputs of the two 5V switchmode supplies, which allows us to identify any potential supply-to-ground shorts on any of the amplifier chips. Both boards tested OK since the only detected short was rectified in the first visual-inspection test.

3.3 TEST-JIG VERIFICATION OF BASIC FUNCTIONALITY

The final testing conducted was to run the beam-former board in a test jig, send control commands to operate the various delay line switches and check for consistent gain readings across all 16 channels. This test uncovered only one fault involving the bias inductor that supplies the QPA4563 on channel “B”, but after removing and inspecting the inductor, it appears this fault is likely to have been pre-existing before Convergence undertook the maintenance work on the board. This fault was also rectified in less than 30 seconds using soldering tweezers.

4. IDENTIFIED ISSUES

4.1 EXCESS SOLDER ON POWER RESISTORS – QPA4563

In general there appeared to be somewhat too much solder surrounding the two 63.4 ohm larger resistors and associated bias inductor that drive the input amplifiers in all 16 channels. This can be seen in the first photo shown overleaf, where the designators are R268, R269 and L86 respectively.

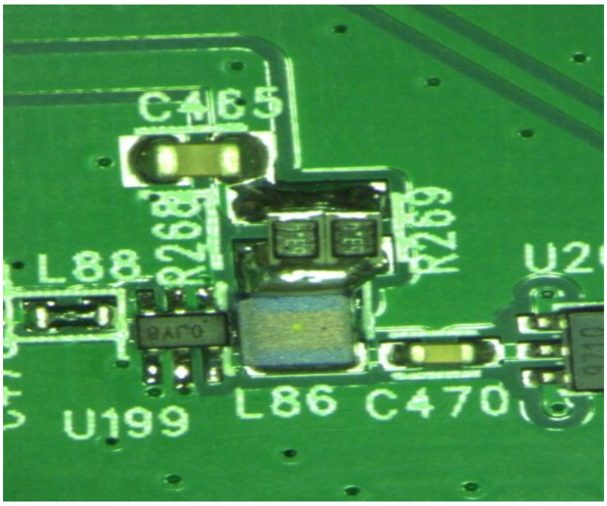

FIGURE 1: GENERALLY OK

While this excess solder does not have any immediate effect, it could leave a frozen-in strain which might manifest as a broken joint after time in service particularly due to thermal cycling on site. CIRA would prefer if some means could be found to reduce the amount of solder used on these resistors.

4.2 OFFSET/MISALIGNED POWER RESISTORS – QPA4563

There were some cases where the resistors were partly offset with respect to each other and the underlying copper pads, and in one case (shown below right), the offset was far enough that the resistor was not properly connected. An example of an acceptable offset, and one where the offset was too far, are shown over the page.

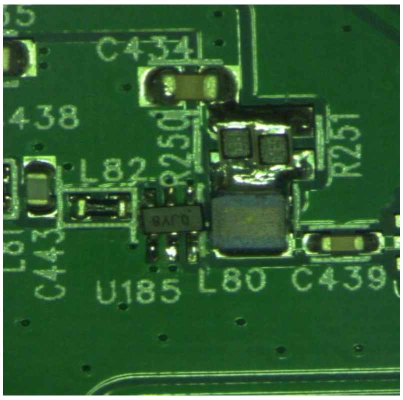

FIGURE 2: RESISTORS OFFSET, STILL OK

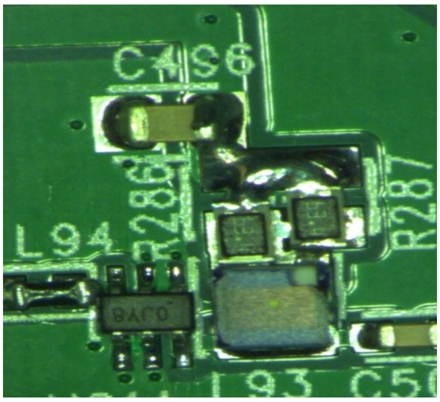

FIGURE 3: RESISTORS OFFSET, R286 TOO CLOSE TO L93

As can be seen in Figure 3 R286 has moved to be too close to the inductor, and the upper end does not make contact with the desired pad. In fact before this fault was rectified only R287 was connected in circuit. We used a pair of Weller soldering tweezers to re-melt the solder and move R286 back into proper position, after which it made proper contact.

4.3 OFFSET/MISALIGNED INPUT INDUCTOR – QPA4563

On several channels the input inductor has moved slightly from its original position (see L82 in Figure 2 on the previous page for an example of an inductor that has NOT moved). In the case shown below, the inductor had moved so far that it was no longer making proper contact, see L28 in Figure 4.

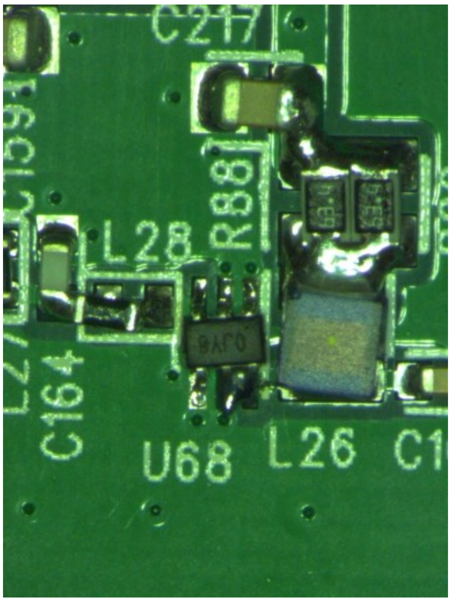

FIGURE 4: L28 MISALIGNED

Again, we used Weller soldering tweezers to correct this fault in a matter of seconds.

4.4 OUTPUT SHORTED TO GROUND– QPA4563

A short circuit between the output pin (pin 6) and ground (pin 5) on the lower side of U68 is also visible in Figure 4 above. This fault would also have been detectable using the multimeter test. Therefore, while unlikely, had the fault remained into power-up testing it would have prevented one of the 5V rails from powering up, potentially damaging the supply.

Similar to the other issues, this fault was quickly rectified using a regular pencil soldering iron and solder-wick braid.

4.5 DRY SOLDER JOINT ON GROUND PIN – QPA4263

As can be seen over the page in Figure 5 overleaf, the solder has failed to ‘wet’ the lower central ground pin of U229 (pin 2) and while it is in physical contact with the pad, it may not perform correctly at RF frequencies and could become isolated at a later time due to corrosion/oxidation of the contact surfaces.

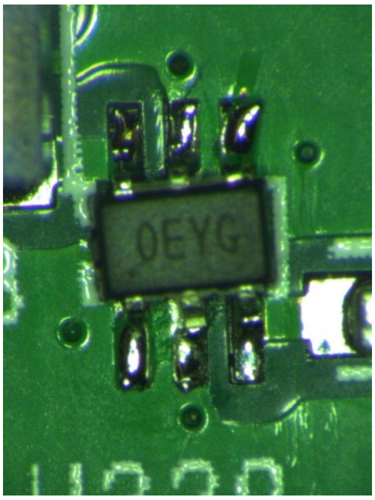

FIGURE 5: 'DRY' SOLDER JOINT ON PIN 2

This took a little more effort to correct due to the massive copper ground plane rapidly conducting away soldering heat. However re-work flux and a freshly cleaned pencil tip soldering iron were able to re-flow the solder to make a proper contact.

4.6 NO SOLDER ON CENTRAL GROUND PIN – QPB7420

On both beam-former boards, it was observed that while the stablisation daughterboard was well soldered onto the three device pins, the middle or ground pin of the device was not soldered to the pad on the main board. See below.

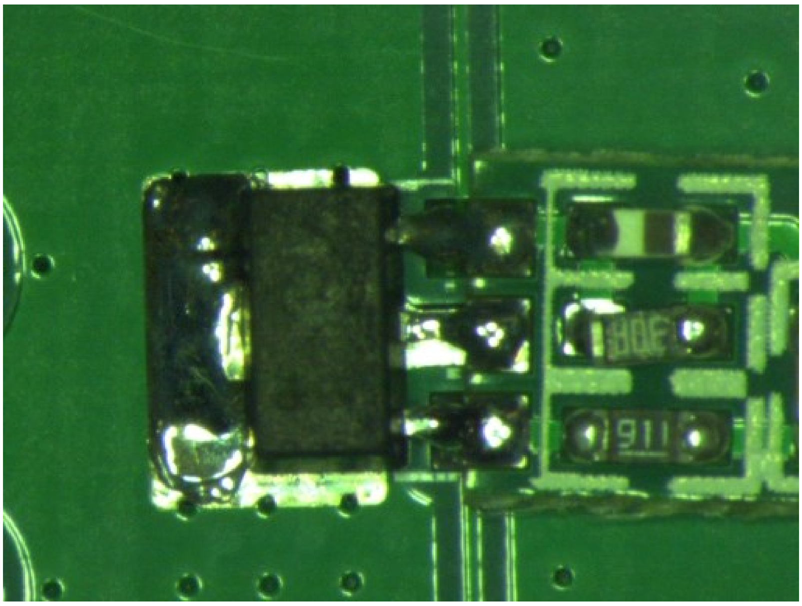

FIGURE 6: 'FLOATING' PIN 2

It is uncertain if this could have any RF performance issues particularly at higher frequencies and for long-duration observations where even the tiniest amount of systematic or internal noise can be integrated up to a point where it dwarfs the desired signal.

Therefore we would prefer if the centre pin was also soldered to the main board before the daughterboard was attached.

Addressing this issue took approximately five minutes per board, since we had to use an under-board hot-air source to bring the general board area close to soldering temperatures, and a hot-air pencil from the top to actually melt the solder. We then removed the daughterboard temporarily and used a pencil iron and re-work flux to ‘wet’ the remaining solder from pin 2 onto the pad on the main board. We then used solder-wick braid to remove excess solder from the ends of the other two pins of the QPB device, and from the castellated vias on the daughterboard. Finally we soldered the daughterboard back into place using a pencil iron and wire solder.

5. CONCLUSION

These issues were relatively quickly rectified, and multimeter testing proved the boards were safe to power up before the jig-based quick functional test.

CIRA understands that many of these issues probably stem from the large copper planes and areas that ‘sap’ heat away from components being soldered and cause issues with wetting and flow. We would appreciate feedback from Convergence if there is anything that can be done to reduce the number of these issues on future boards.