UPDATE ON CC2500 DETERIORATION

Last November I was writing about an issue with 2.4 GHz transceivers that were deployed on street lights as part of Jožef Stefan Institute's testbed for radio communications. Some radios based on Texas Instruments CC2500 integrated circuit seemed to degrade after they were mounted out doors. In the most extreme case, there was almost an -30 dB drop in receiver sensitivity and maximum transmit power dropped to insignificant levels.

The leading theory at the time was that some component has deteriorated over time due to environmental effects. After some initial testing it appeared that the coaxial cable between the radio PCB and the connector is to blame. However having more boards with this issue in the lab showed that in most cases it's not possible to restore original characteristics only by changing the coaxial cable.

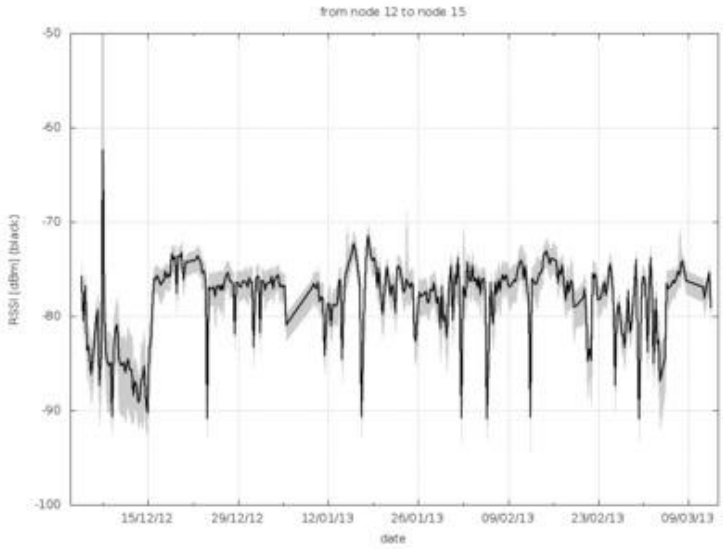
I then fired up the soldering iron and did a brute-force approach: on three bad radio boards I manually replaced components one by one, preforming automated tests of the board after each replacement. While replacing the coaxial cable did have a small effect (0.3 dB in the best case), only replacing the CC2500 integrated circuit itself seemed to restore the correct performance. So the suspicion immediately fell on the transceiver chip itself.

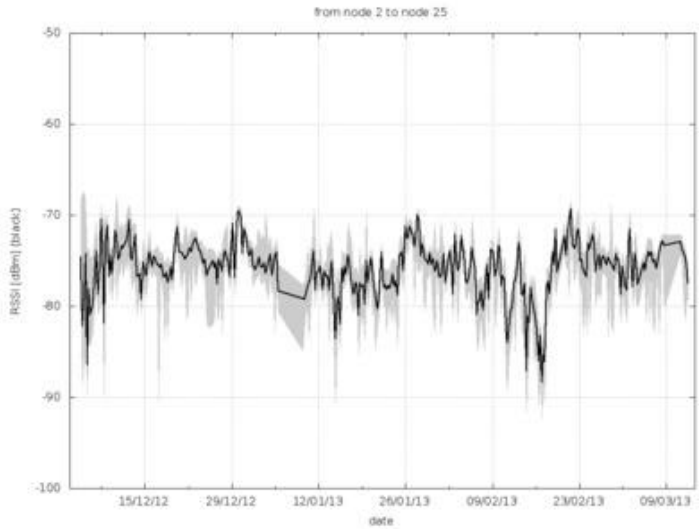
Since I did not exhaustively test all radios for sensitivity and transmit power before deployment, I couldn't be sure whether the radios have been bad from the start or whether they degraded due to environment. The fact that only radios that have been deployed out-doors have had this issue pointed to the second explanation, but since more radios were deployed out-doors than in-doors that could have been a coincidence as well.

As a test, I also brutally heated up one of the newly replaced CC2500 chips with a hot air gun. After such test, the radio board had similar symptoms as the boards that were unmounted from the testbed as defective: the digital part of the IC still functioned correctly, but receiver's sensitivity dropped permanently by 33 dB. Unfortunately I did not record the temperature to see how much heating is actually required.

To test the other theory, I set up a long-running experiment on the testbed that recorded received signal strength between neighboring pairs of newly replaced radios 4 times a day between December 2012 and March 2013. If radios were deteriorating over time, I should be able to see the signal strength drop during these three months.

Here are two typical plots of these measurements over time:





As you can see, while there is a lot of variation in the signal strength, there is no obvious downward trend. Variation is probably due to weather and or large things moving around the radios (these are mounted in an industrial zone, so moving trucks and other such things are not an uncommon occurrence).

So, it currently looks like we either mounted already defective radios or they were damaged by a one-time event after deployment (which is hard to imagine). The fact that over-heating damages radios in a similar way may point to an error in manufacturing, although that's not a popular opinion, since these boards were soldered using a lead solder and radio ICs are supposed to support a RoHS process that involves higher temperatures. It's also a theoretical possibility that the radios were damaged during summer (the test above was obviously done over winter months), although again it's very unlikely that sun would overheat the radios.

Source:
https://www.tablix.org/~avian/blog/archives/2013/03/update_on_cc2500_deterioration/