ANNEX C. KIWISDR FREQUENCY CORRECTION WHEN RUNNING ONLY KIWIRECORDER.PY

This investigation into FST4W highlighted - not for the first time - that most WsprDaemon users using KiwiSDRs with only their standard GPS aiding were reporting received spots at different frequencies than those from KiwiSDRs with phase-lock GPSDOs. Hence this investigation to document and trace, as far as possible, the root cause.

The key visualisation tool was a Grafana Dashboard of the frequency difference between two stations, and their individual receivers if more than one, as reported to the WsprDaemon wsprdaemon_spots_s extended spots database table on a selected band for transmissions they both decoded the same WSPR sender at the same time. Thus at each two-minute time interval we will have zero or more estimates of frequency difference. Unless specified all the frequency differences were on 20 m. All sites had adequate GPS coverage up to the maximum of 30 fixes/minute. All times are UTC.

Below are the key steps in our finding: Standard KiwiSDR GPS corrections are not made when only kiwirecorder.py connections to the receiver are active. The corrections are made if a browser connection to the Kiwi is active - either a receiver connection or an admin page.

1. Verify the frequency comparison method

This is done by comparing the frequency difference where both stations are using phase-lock GPSDOs. Figure C.1 is the frequency difference over 48 hours for KF6ZEO, San Francisco, Ca. and WB7ABP/K Santa Rosa, Ca., separated by about 80 km, the rms difference is 0.13 Hz. Gaps are when there were no common stations decoded.

Conclusion: We have a suitable frequency comparison method good to about 0.13 Hz.

Figure C1. Frequency difference time series over 48 hours for two phase-lock KiwiSDR stations KF6ZEO and WB7ABP on 20 m. The rms difference was 0.13 Hz.

2. Compare a phase-lock KiwiSDR to a standard GPS KiwiSDR.

Figure C2 is for KFS (receiver KIWI_SW) with a standard GPS aided KiwiSDR and WBPABP/K with phase-lock GPSDO. First, the frequency difference scale has had to be expanded to -6 Hz to +3 Hz to cover the differences. Second, the record is characterised by periods (of variable length) dominated by slow drift terminating in a sharp jump to a value that is not zero, but is about -1.5 Hz.

Conclusion: There is a problem with standard KiwiSDR GPS aiding, drift is not compensated on the expected 2 second basis, and there is a frequency offset when correction (the sharp changes) seems to happen.

Figure C2. Frequency difference time series over 48 hours for one standard and one phase-lock KiwiSDR stations KFS and WB7ABP on 20 m.

3. Compare two standard GPS KiwiSDRs at the same site.

These two KiwiSDRs at the same site are in an outside shed subject to a temperature variation of about 15˚C over a day. Here a -30 Hz to +20 Hz scale is needed to show the frequency difference. The main characteristics are slow drifts and sudden jumps. Two of the jumps, at 1400 on 08/25 (after which the difference remained near zero for some hours) and 0832 on 08/27 end at zero difference, the others do not. What this combination adds is is that, at times, it is possible to get a zero difference frequency between two GPS aided KiwiSDRs.

Figure C3. Frequency difference time series over 48 hours between two standard KiwiSDR receivers at one site on 20 m, G3ZIL_2 and G3ZIL_3.

4. Investigation into the cause of these observations.

Our investigation used the frequency difference Dashboard, a 10 MHz HP10554 OCXO phase-locked GPSDO, and receivers G3ZIL_2 (v1.498) and G3ZIL_3 (v1.554). A key fact is that in normal operation these KiwiSDRs are used with WsprDaemon only, which access the receivers using kiwirecorder.py.

First test: With the GPSDO having been on for 30 minutes:

- Open a Chrome browser window to G3ZIL_2 and, at 10 MHz, check the IQ_display against the GPSDO - about 25 seconds for one rotation, with some clockwise and anticlockwise variation in between.

- Open a Chrome browser window to G3ZIL_3 check the IQ_display - about 30 seconds for one rotation, with some clockwise and anticlockwise variation in between.

Results: Frequency difference was zero and the average absolute frequency for each was correct to better than 0.1 Hz. This was not expected given the time series in Figure C3.

What seemed to have happened, without any change whatsoever to either of the KiwiSDR GPS admin screens, was that the frequency difference had jumped to zero from its previous value of -30 Hz. This is the first step at the left in Figure C4. All we had done was to open browser windows to the two receivers. The windows were closed at 1000, and the difference increased, they were opened again at 1008 and the difference jumped back to zero. This was repeated several times to check that the same thing happened - the difference drifted from zero with browser windows closed, but immediately returned to zero with both windows open. We showed a receiver window was not needed, the same happened with admin windows.

Conclusion: Standard KiwiSDR GPS corrections are not made when only kiwirecorder.py connections to the receiver are active. The corrections are made if a browser connection to the Kiwi is active - either a receiver connection or an admin page.

Figure C4. Frequency difference time series over 48 hours between two standard KiwiSDR receivers at one site on 20 m, G3ZIL_2 and G3ZIL_3.

We can now understand the behaviour in Figure C3 as having had browser windows open to both receivers simultaneously for the two occasions when the difference returned to zero, and when there was a jump to other than zero, a browser window was connected to one or other of the receivers, so its offset step-changed to zero, but the other offset was still present.

Workaround: Keep admin browser windows open to both receivers when otherwise only using kiwirecorder.py. That was done from Firefox on the M93 ThinkCentre, and the result was near zero differences from 1900 on 08/28 to 1200 on 08/29 with a mean difference of -0.006 Hz and an rms difference of 0.10 Hz, 0.03 Hz less than the rms difference between two GPSDO KiwiSDRs 80 km apart.

5. Confirmation

It had been an unsolved puzzle for some time as to why the frequency difference between standard GPS aided KiwiSDRs at WA2TP were near zero (+0.004 Hz) with little variation (rms 0.12 Hz), Figure C5. Based on our findings above, we asked Tom, WA2TP, whether he kept browser connections to all his KiwiSDRs in addition to their kiwirecorder.py connections for WsprDaemon - and the answer was 'yes' 24/7 browser connections were kept running from his Linux computer.

The reason why Tom achieved this excellent performance is now clear - it is what the KiwiSDR GPS aiding is capable of if kept running.

Figure C5. Frequency difference time series over 48 hours between two standard KiwiSDR receivers at WA2TP on 20 m.