WSPR Reported S/N Measurements

G4JNT 7 Feb 2010

To try to get to grips with some abnormally high reported S/N values of my WSPR beacon, here are the results from a series of controlled measurements made over a range of input signal levels and receiver bandwidths.

The test setup consisted of a laptop running the WSPR2 software sending a constant test message (callsign 'T3ST' !) at 100% duty cycle. The 1500Hz tone output drove a direct audio to RF upconverter [1] giving an RF output at 230kHz. The audio level from the laptop was adjusted so the upconverter delivered -30dBm of RF into a switchable attenuator controlled in 1dB steps up to a maximum of 120dB followed by a 40dB fixed attenuator. The output from this went into an SDR-IQ receiver which was controlled from the desktop shack PC. The demodulated audio from the Spectravue software running the SDR-IQ appears from a dedicated USB 'headphone dongle'. This audio signal from this is wrapped round with a patch cable to the PCs own soundcard for input to the WSPR2 software, running in monitor mode.

The SDR-IQ was used in CW mode with a BFO of 1500Hz to allow the range of narrow CW filtering options to be used. Bandwidths in steps of 50Hz width from a minimum of 100Hz are available in the Spectravue software driving the SDR-IQ. It proved necessary to offset the received signal from dead centre of the RF band due to the non-zero NCO output that can be found on the SDR-IQ when operating with very narrow bandwidths due to maths rounding errors in the receiver's DSP chip.

By adjusting the RF attenuation and SDR-IQ receiving bandwidth, the S/N value as reported by the WSPR decoding software could then be plotted.

Results.

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Hz \	*110*	*107*	*105*	*100*	*90*	*80*
100	**-14**	**-13**	**-12**	**-6**	**+3**	**+8**
150	**-22**	**-20**	**-17**	**-13**	**-3**	**3.5**
200	**-26**	**-24**	**-20**	**-16**	**-6**	**+2**
300	**-27**	**-24**	**-22.5**	**-16**	**-7**	**+2**
500			**-22.5**		**-7**	**+2**

Range of attenuation and bandwidth values tested, with the reported S/N ratios.

The lowest decoding level occurred at around 110dB attenuation, with around –140dBm into the receiver. Some decodes were achieved with a few dB more attenuation, but results were not consistent showing successive reported S/N values more than 1dB apart and so were not included in the table. All values listed are the average of two or three successive readings.

It is clear that WSPR is reporting the wrong S/N values at narrow bandwidths, but when receiver bandwidth exceeds 250 – 300Hz, no further increase makes any difference (hence the paucity of measurements at 500Hz). This suggests that WSPR is measuring the noise in the entire 200Hz of bandwidth searched by the decoder; when the input noise bandwidth is less than this it makes an erroneous estimation.

At low S/N values the reported S/N is more than 10dB above the correct value seen at wider bandwidths.

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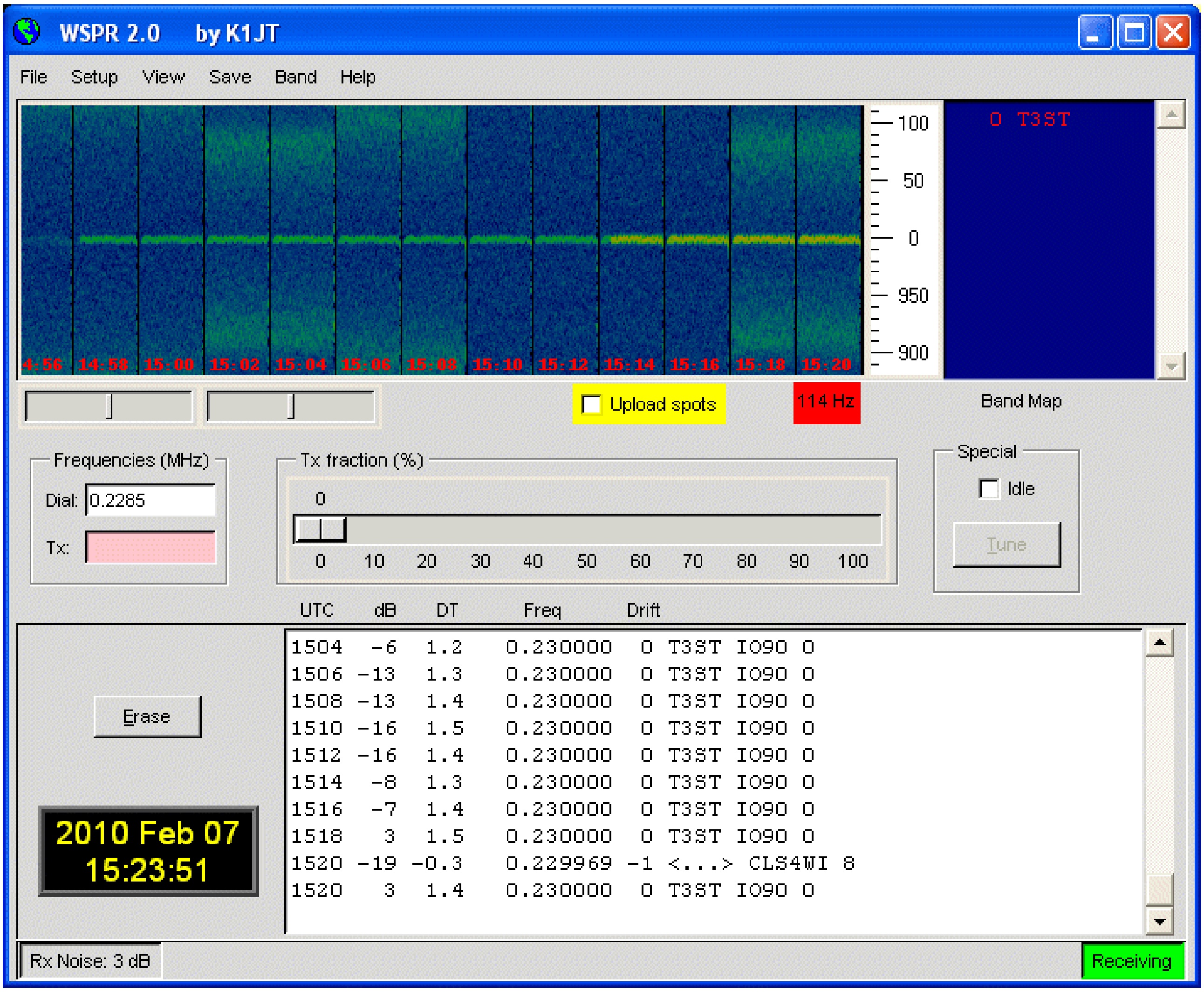
Other Issues

At 100Hz bandwidth, the decoding took an inordinately long time – in fact at the higher S/N ratios it could take over one minute for the decoded callsign to appear. Also, at these narrower bandwidths a few false decodes, or ghost signals, were see whereas at 300Hz and above, decodes occurred almost immediately the signal ceased, with no ghosts. Again, the limited noise bandwidth is clearly confusing the decoder

It is a great pity that SDR-IQ bandwidth can only be changed in 50Hz steps, as the effect is so dramatic, it could do with a finer resolution.

The picture below shows a screen dump of the WSPR screen with different Rx bandwidths. It is clear from the upper spectrum plots when the 100, 150 and 200Hz bandwidths have been selected, with the dead portions showing up in the background noise colouration away from the centre portion. Note also the false decode in one of the 100Hz bandwidth sessions.



[1] www.g4jnt.com/LFUpconv.pdf