EDGES MEMO #176

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To: EDGES Group

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Subject: Checks and cross-checks of EDGES calibration

1] Standard calibration cross-checks

After calibration the hot, cold, open and shorted cables are treated as antennas as a check that a flat spectrum is obtained with the correct temperature within the expected noise.

2] 3-position switching noise bias

The "initial spectrum" calculated from

$$T_{ant} = T_{cal}\left(P_{ant} - P_{load}\right)/\left(P_{cal} - P_{load}\right) + T_{amb}$$

Where P_{ant}, P_{load} and P_{cal} are the power spectra on the antenna, internal load and internal load with noise diode turned on.

T_{cal} and T_{amb} are initial values for scale and offset.

T_{ant} is the initial spectrum in Kelvin

The division by (P_{cal}-P_{load}) results in a bias due to the noise. Simulations show that for one 3-position cycle of 32768 × 2 × 40960 samples (400 Ms/s which equals 6.7 seconds at 6 kHz resolution the bias is -6.1×10^{-2} T_{cal} and 6 mK in T_{amb} for an assume T_{rec}= 200 K, T_{load} = 300 and T_{cal} = 1000 K. However this bias is of no consequence as it is removed in the calibration. To check this the calibration and simulator spectra can be computed with different assumed values of T_{cal} and T_{amb} as long as the same values of T_{cal} and T_{amb} are used for all the spectra the final results should not and do not change.

Another check was made in which the antenna, load and calibration spectra were averaged before computing the 3-position switched spectrum. This changed the final calibrated spectrum of the simulator by less than 1 mK. This averaging is found to degrade the results of field data on a real antenna by a very small amount owing to the imperfect bandpass correction due to the changes of the bandpass.

3] Effects of long cables

The 3-position switching is designed to make the EDGES calibration independent of the cables to the back-end or the back-end itself. In order for this to be true the out of band noise which may have a small effect on the receiver noise at the low end of the band is injected at the receiver so that the relative contribution is determined by the receiver. Since most receiver calibrations

are done in the lab with short cables a “cross-check” should be made in which an antenna simulator is tested with and without long cables using the same calibration to verify complete independence on cable length.

4] Linearity test

So far antenna simulations have been mismatched ambient load made with an attenuator at the end of a cable. While this provides a good check on calibration accuracy it doesn’t stress the linearity. Using a hot attenuator would be an improvement but this requires an accurate knowledge of the temperature along the path from the hot load to the receiver. In addition it is difficult to heat an attenuator about 400 K without changing its characteristics. Another test would be to use a noise diode which puts out several thousand degrees. In this case the actual noise diode spectrum could be measured with several different attenuations for consistency. A loss pass filter could be used to provide a large range of power levels similar to those from the foreground.