Progress Toward a Full Uncertainty Propagation Machinery for EDGES: II

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Description

This report describes the progress toward a full uncertainty propagation procedure for EDGES. It explores aspects not described in the previous report, available at: http://loco.lab.asu.edu/memos/edges_reports/report_20150212.pdf For a general description of the pipeline, please read that document.

The main purpose of this document is to explore the effect of the phase of the antenna S11. Three cases are compared. In all cases, the magnitude is -15 dB, completely flat in frequency in the range 100 to 200 MHz. The phases are different, and shown in Figure 1. The black trace corresponds to the steepest phase, the blue trace is the intermediate case, and the red trace is the extreme case of zero phase across the frequency range.

Figure 2 shows the scale, offset, and noise wave parameters obtained during calibration of the receiver. The scale and offset are modeled with 6th degree polynomials, and the noise wave parameters are modeled with 3rd degree polynomials.

Figures 3 through 30 show the isolated effect of each source uncertainty, for the three cases of antenna phase. The color of the traces correspond to those in Figure 1. The 1σ bounds are obtained after removing a 4-term Log-Poly model from 2000 MC realizations of calibrated antenna temperature.

Figures 29 and 30 show the impact of systematic uncertainty in the magnitude and phase of the antenna S11 itself.

Finally, the combined effect of all the uncertainties is presented in Figure 31, and Figure 32 shows the effect of only the systematic uncertainty (S11, and physical temperature of the ambient load, hot load, and open cable).
The plots from Figure 3 onward show a clear dependence of the uncertainty level and shape, on the phase of the antenna S11. The steeper the phase in the 100-200 MHz range, the more ripples that appear. The cases of highest sensitivity to the antenna phase are:

- Physical Temp. of Open Cable
- Spectrum of Open Cable
- S11 of LNA
- S11 of Open Cable
- S11 of Antenna

The uncertainty due to the sources listed above can be significantly reduced by reducing the antenna delay.

Even for zero antenna delay, there is residual ripples in the shape of the uncertainties due to the modeling of the other quantities, and the covariance between their parameters. Understanding this structure at a deeper level requires more investigation.
Figure: (1)
Figure: (2)
SOURCE UNCERTAINTY: Physical Temp. of Ambient Load

Figure : (3)
SOURCE UNCERTAINTY: Physical Temp. of Hot Load

Figure: (4)
SOURCE UNCERTAINTY: Physical Temp. of Open Cable

Figure: (5)
SOURCE UNCERTAINTY: Spectrum of Ambient Load

Figure: (6)
SOURCE UNCERTAINTY: Spectrum of Hot Load

Figure: (7)
SOURCE UNCERTAINTY: Spectrum of Open Cable

Figure: (8)
Figure : (9)
Figure: (10)
Figure: (11)
SOURCE UNCERTAINTY: Phase S11 of Ambient Load (STAT)

Figure: (12)
Figure: (14)
Figure: (15)
Figure: (16)
SOURCE UNCERTAINTY: Mag S12S21 of SR Cable (STAT)

Figure: (17)
SOURCE UNCERTAINTY: Phase S12S21 of SR Cable (STAT)

Figure: (18)
SOURCE UNCERTAINTY: Mag S11 of LNA (SYST)

Figure: (19)
SOURCE UNCERTAINTY: Phase S11 of LNA (SYST)

Figure: (20)
SOURCE UNCERTAINTY: Mag S11 of Ambient Load (SYST)

Figure: (21)
SOURCE UNCERTAINTY: Phase S11 of Ambient Load (SYST)

Figure: (22)
SOURCE UNCERTAINTY: Mag S11 of Hot Load (SYST)

Figure: (23)
Figure : (24)
Figure: (25)
Figure: (26)

SOURCE UNCERTAINTY: Phase S11 of Open Cable (SYST)
SOURCE UNCERTAINTY: Mag S12S21 of SR Cable (SYST)

Figure: (27)
SOURCE UNCERTAINTY: Phase $S_{12S21}$ of SR Cable (SYST)

Figure: (28)
Figure: (29)
SOURCE UNCERTAINTY: Phase S11 of Antenna (SYST)

Figure: (30)
Figure: (31)
SOURCE UNCERTAINTY: Only Systematic

Figure: (32)