EDGES MEMO #111

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Subject: Tests of the phase and impedance stability of LDF2-50A heliax cable

Czuba and Sikora (Acta Physica PolonicaA, 119, 553, 2011) have measured the effect of temperature on several coaxial cables. Of all the cables tested LCF38-50J 3/8" heliax had the lowest change of phase with temperature. This cable is virtually identical to LDF2-50A. It has a copper plated inner conductor, polyethylene foam dielectric and a corrugated copper outer conductor. Memo's 99, 105 and 110 discuss the advantages of a large cable delay between the antenna and the LNA. This cable, if extremely stable, decorrelates the errors in the antenna S11 magnitude and phase from the broadband signature of the red-shifted hydrogen line expected to be present from the conditions of the early Universe. Effectively the presence of a large delay allows the EDGES spectrometer to detect and correct errors in the antenna reflection coefficient which produce structure in the spectrum with the periodicity of the inverse delay and its harmonics. High stability is required because changes in the cables phase or impedance produce similar structure in the spectrum. Figure 1 shows the change of S11 magnitude for a 15 K rise in temperature from about 25 to 40 C measured with a 6 dB attenuator at the far end of the 25 ft LDF2-50A heliax. The LDF cable was chosen over the LCF cable because SMA connectors are only available for the LDF cable. Figure 1 also shows the change in S11 based on a model in which the initial cable impedance is 51 ohms and changes with temperature due to the different expansion of copper (17ppm/K) in the outer conductor and aluminum (22 ppm/K) in the inner conductor. In addition the model includes the increase loss due to the temperature coefficient $\left(4\times10^{-3}/K\right)$ of the change of copper resistance. The change of S11 phase, not shown in Figure 1 was predominantly a sine wave of 0.19° and 0.21° peak to peak amplitude from the measured and modeled respectively.

The measured change in S11 magnitude is larger and shows more frequency dependent structure than the model. Possible reasons for the poor agreement are:

a. Changes in the eccentricity of the cable with temperature due to the differences in thermal expansion of copper and aluminum.
b. Non uniformity of impedance along the cable produced by variable eccentricity
c. Larger deviation from 50 ohms than the nominal 1 ohm.

Unfortunately the change in the cable is not sufficiently small to remain below 0.01 dB for the 30 C variation of temperature expected for an installation on or just below the surface. Consequently the cable will need to be temperature controlled. Since the effects of a change in temperature are much smaller for the short flexible cable connecting the antenna and its temperature cannot be controlled we will need to rely on making a small correction based on the air temperature.

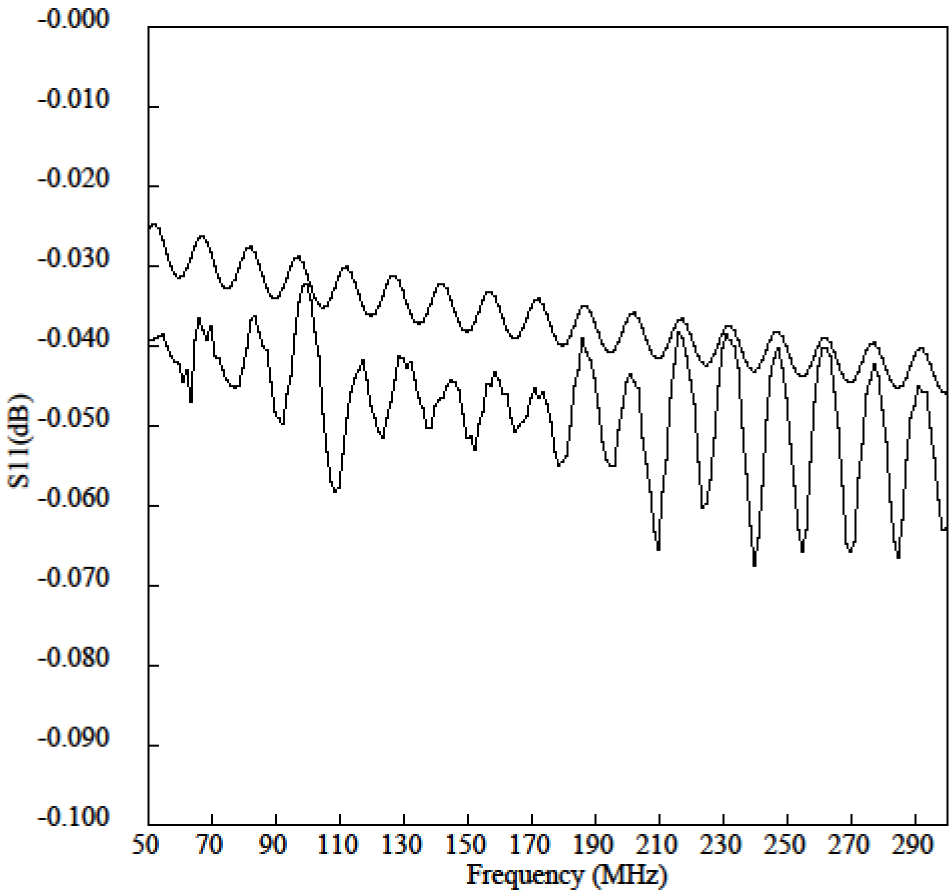

Figure 1. Change in S11 for a 15 K increase in temperature. [The end of the cable was connected to a 6 dB attenuator open at the far end. A small correction was made for the change of impedance of the attenuator.]