EDGES MEMO #394

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To: EDGES Group

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Subject: Simulations of the length and loss of the cables used in noise wave calibration

In EDGES-2 30 ft long low loss open and shorted cables were used for the noise wave calibration while for EDGES-3 10 ft Molex temp-flex cables are used. The temp-flex cables have a PFA/FEP dielectric which eliminates the phase knee of polytetrafluoroethylene (PTFE) at room temperature, which means the cable's performance is more phase stable during temperature swings. The details of some tests on various cables are in memos 84, 85, 104, 109, 111 and 269.

In EDGES-3 a single cable 10 ft Molex cable is used with a switch on the end to make it open or shorted.

However even the 10ft Molex cable used in EDGES-3 is too bulky for some applications so some simulations using the circuit theory modeling of the LNA in memo 334 have been made to test the effects of using a shorter and thinner cable to reduce the size of the "open and shorted" cable needed to solve for the receiver noise waves.

Table 1 shows the results for different cables

Cable type	Length ft	Weight lbs	Loss at 100 MHz	rms1 mK	rms2 mK
Molex WM10479-nd	10	0.8	0.5 dB	4.3	18.1
PE-047SR	10	0.05	2.0 dB	4.0	17.6
PE-047SR	5	0.025	1.0 dB	37	262
PE-047SR	5			312	309
open/short				2137	

Table 1. Comparison of Molex and 047 semi-rigid cable. rms2 and rms1 are the residuals with and without added VNA measurement noise. The fourth entry has noise added to the spectra.

The comparison is made using a simulation of EDGES using a circuit model as in memo 334. The results of the calibration and simulation of the sky are shown in Figure 1 for the Molex cable without any added noise to the S11 measurements. The rms residual to a one term fit to the sky of rms1 = 4.3 mK is shown in the plot labeled "calibrated sky spectrum". Figure 2 shows the result of adding Gaussian noise of 1e-4 to the real and imaginary components of s11 for the LNA as well as shorted and open cables along with hot and ambient loads. The effect of using cables with smaller diameter (0.15" for the Molex and 0.01" for the PE-047) is very small. Reducing the cable length results in a larger effect of noise and using the open and short of the VNA SOL calibration to make extremely short cables requires constraints on the noise waves and even more extreme sensitivity to noise. Figure 3

shows case of using a 5 ft PE-047 cable with 1e-4 added S11 noise plus the theoretical Gaussian noise for an integration time of 10 minutes on each spectrum. In summary if the size of cable is a problem these simulations show that a coil of a much thinner cable be used with significant loss of performance. TF4 SiO2 dielectric cables, including 047 are becoming available and should be used to avoid the Teflon knee. Tests of automated calibration cross-checks using EDGES-3 are described in memo 361.

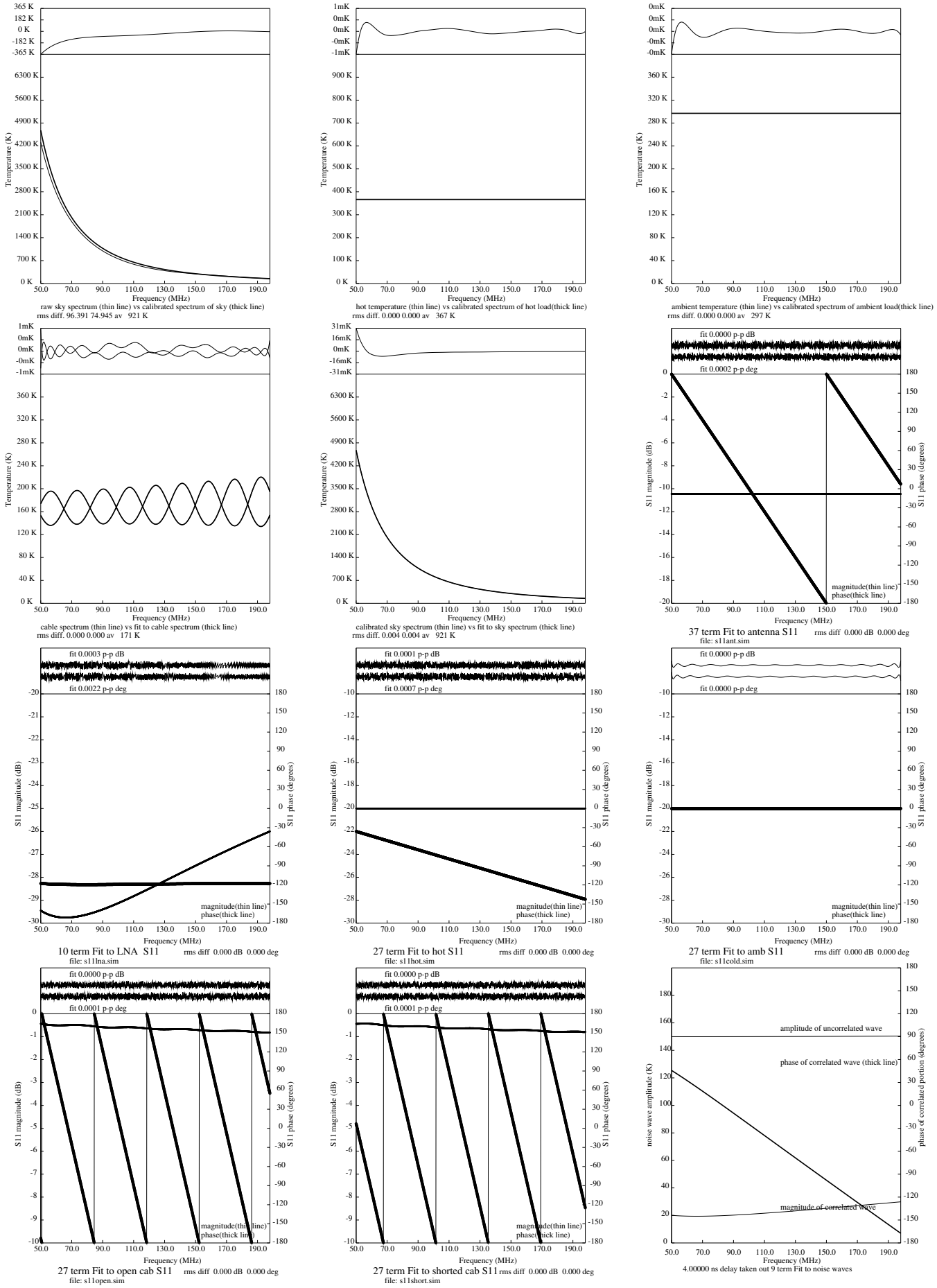

Figure 1. Simulated calibration solution using 10ft Molex open/shorted cables

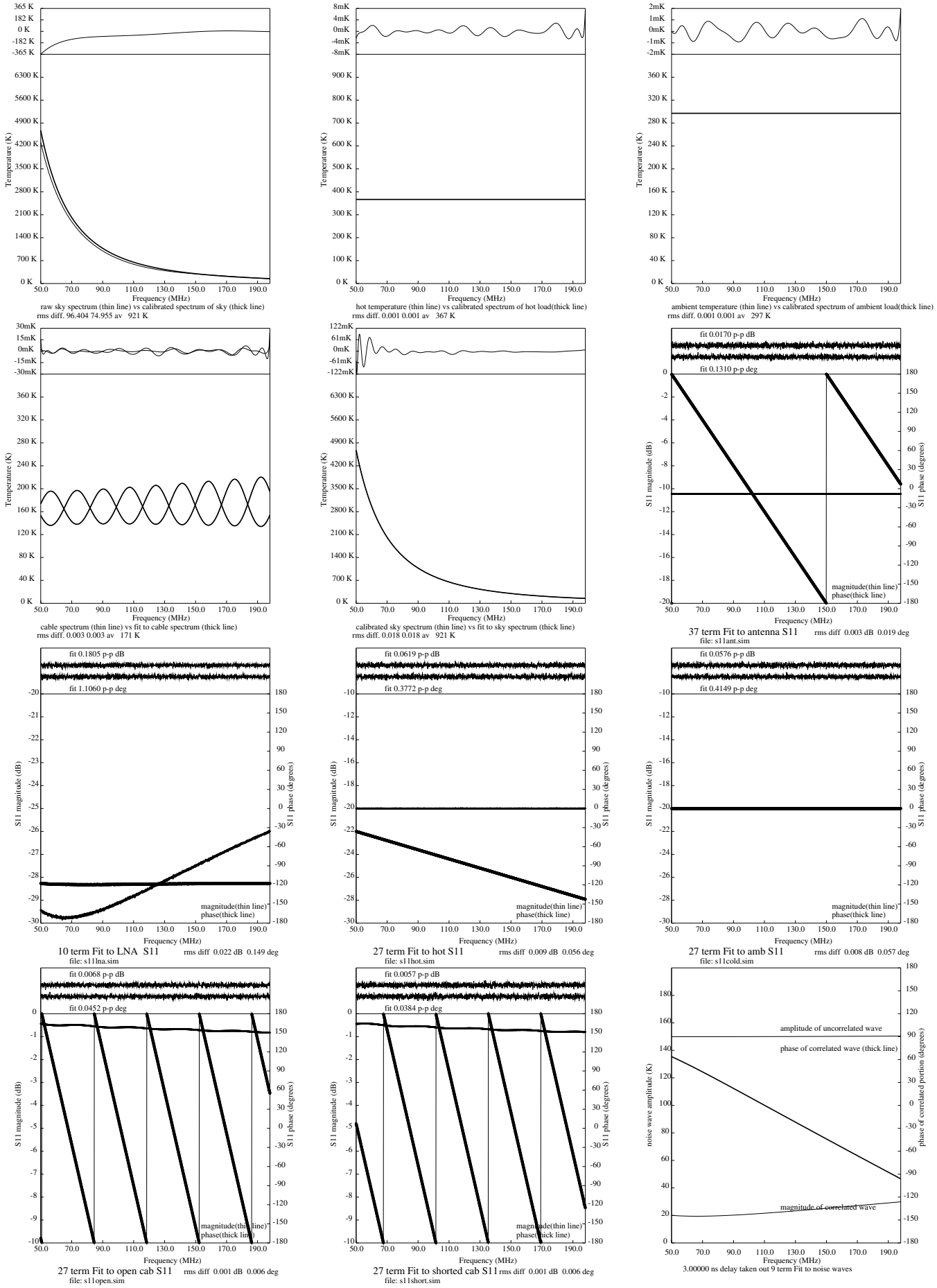

Figure 2. Calibration solution with 10ft Molex cable with added VNA noise

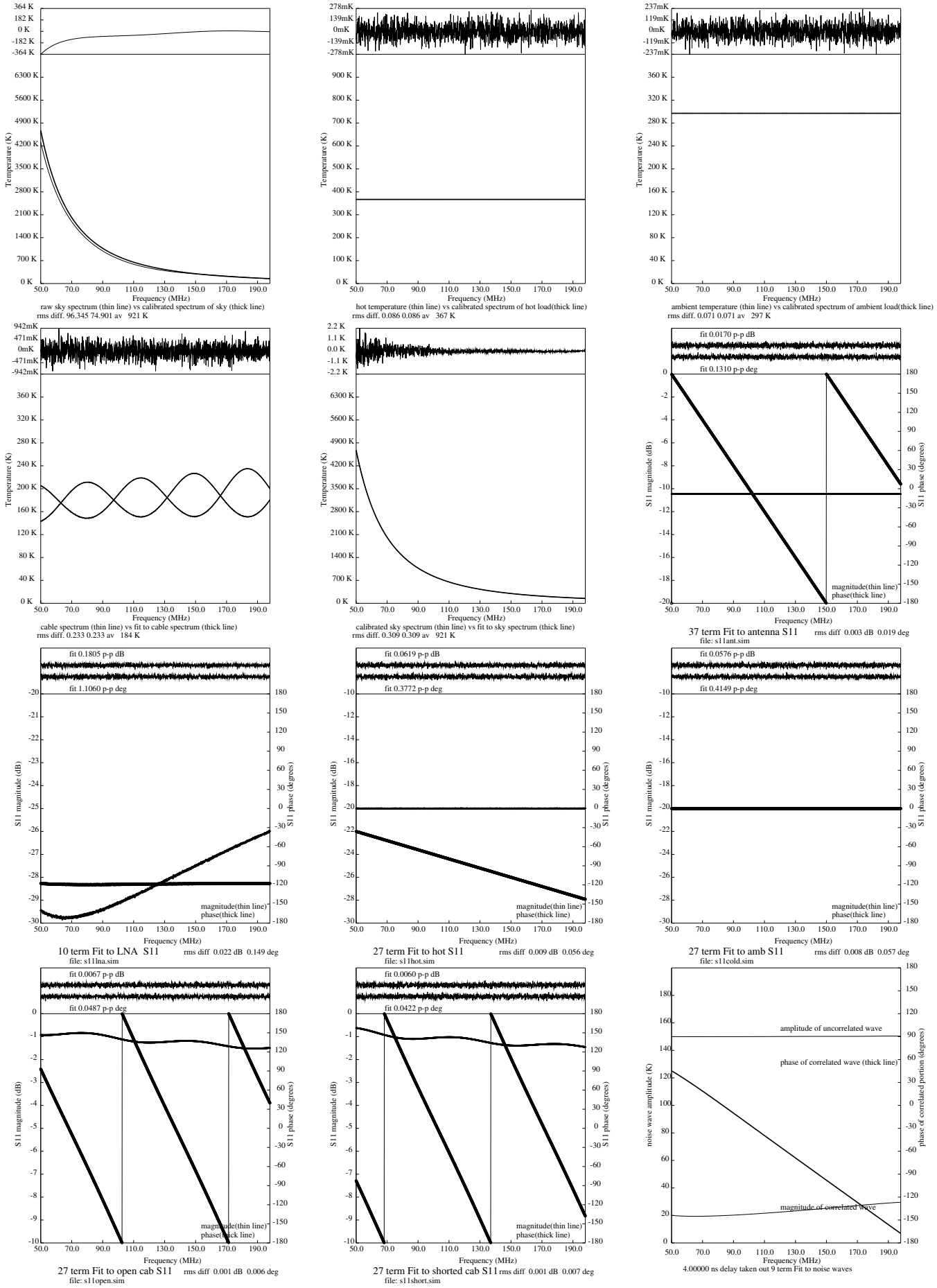

Figure 3. Calibration solution with added VNA and spectrum noise for 5ft PE-047 cable