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To: EDGES Group  
From: Alan E.E. Rogers  
Subject: Test of 100 ps error in VNA calibration measurement

The high sensitivity of an error in VNA delay calibration discussed in memo 319 using a circuit model of the LNA is extended to a test using lowband data “H2” data in the Nature paper. Figure 1 shows a signature search using a 5-term LinLog fit to the foreground and the standard calibration.

Figure 2 and 3 show a signature search for a +100 ps and –100 ps error in all S11 measurements respectively. The positive error increases the depth of the absorption and the negative error fails to find a significant absorption. Figure 4 shows a signature search with –50 ps error in all VNA S11 measurements. Figures 5, 6 and 7 show the antenna S11, LNA S11 and noise waves obtained without S11 errors.

Sensitivity tests in memo 319 using simulations show that the sensitivity to VNA S11 delay error increases in approximate proportion to the magnitude of the LNA correlated noise wave and is independent of the LNA uncorrelated noise.

The phase delay of the S11 of a calibration open or short is approximately the 2-way propagation to the open or shorted end whereas, by convention, the calibration “offset delay” is the 1-way delay so that a 50 ps S11 delay of 50 ps is a 25 ps “offset delay” or about 7.5 mm.

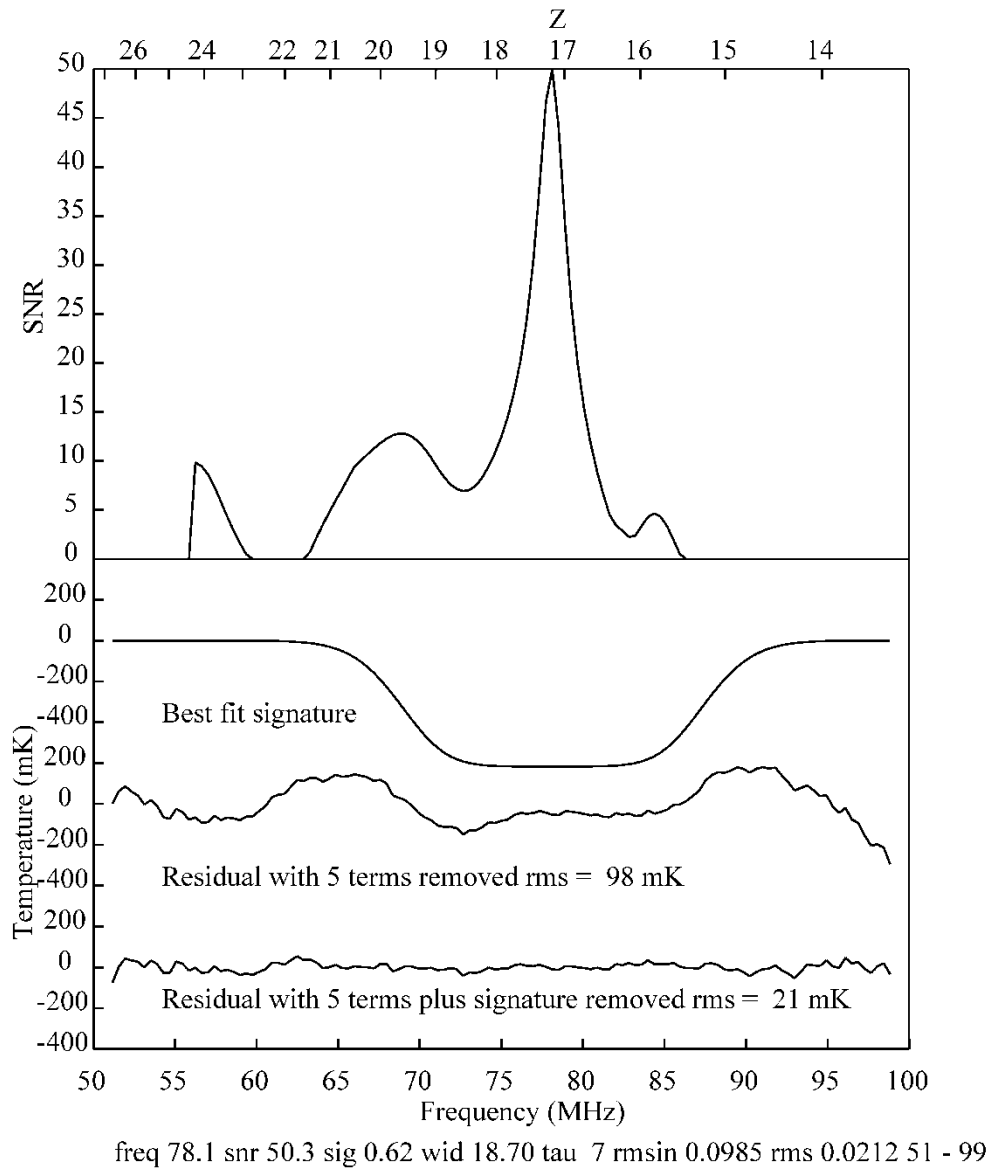


Figure 1. Signature search without VNA error.

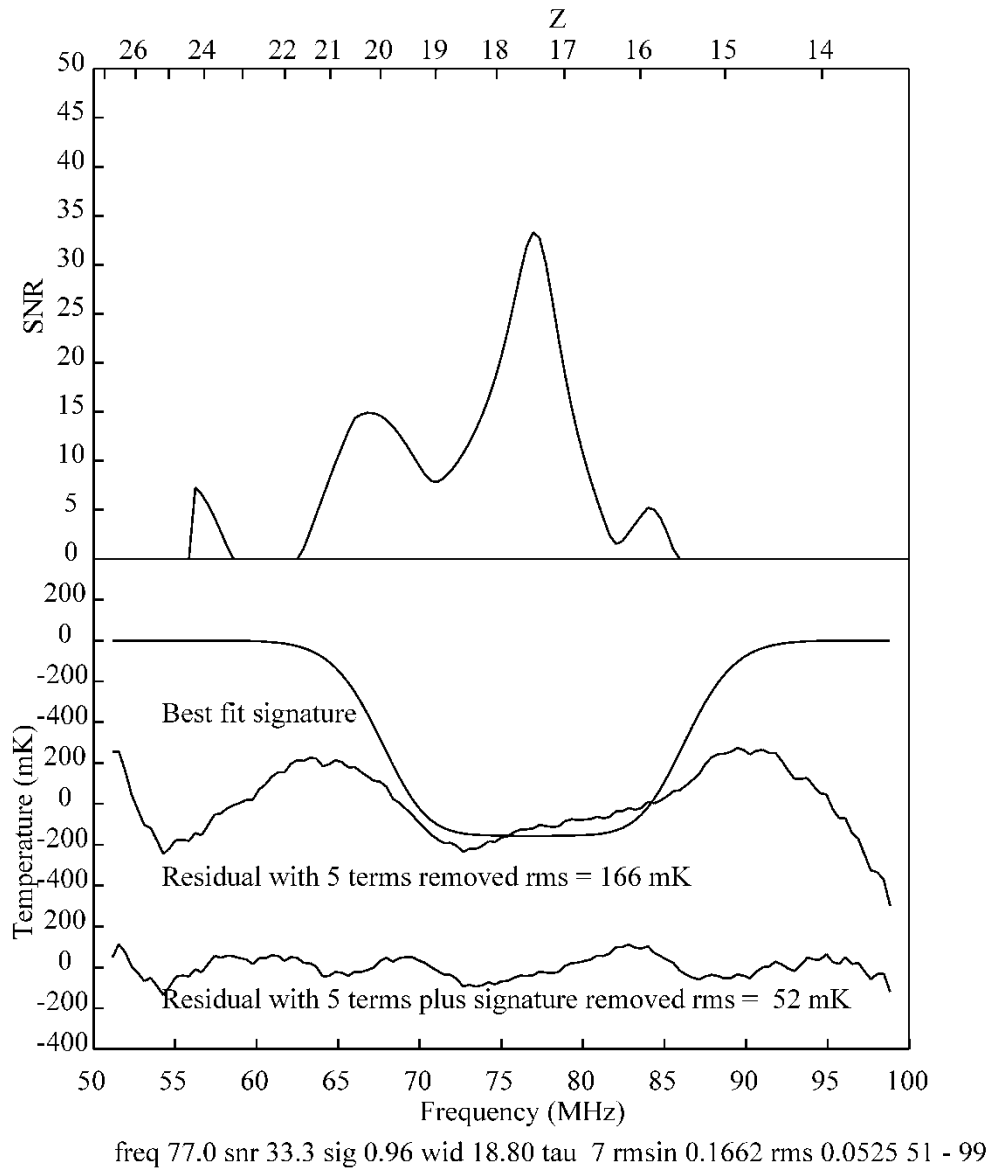


Figure 2. Signature search with +100 ps error in S11 measurements.

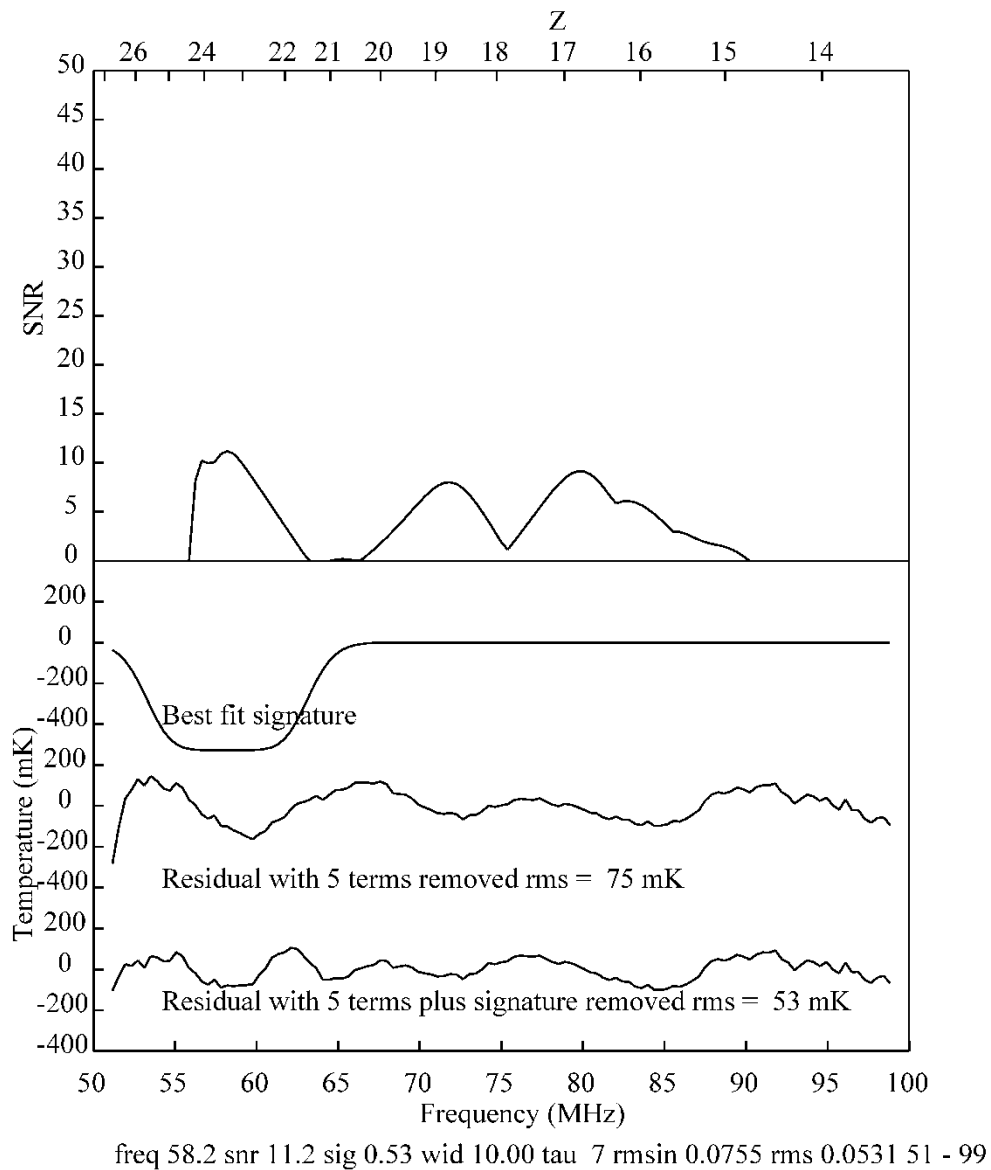


Figure 3. Signature search with  $-100$  ps error in S11 measurements.

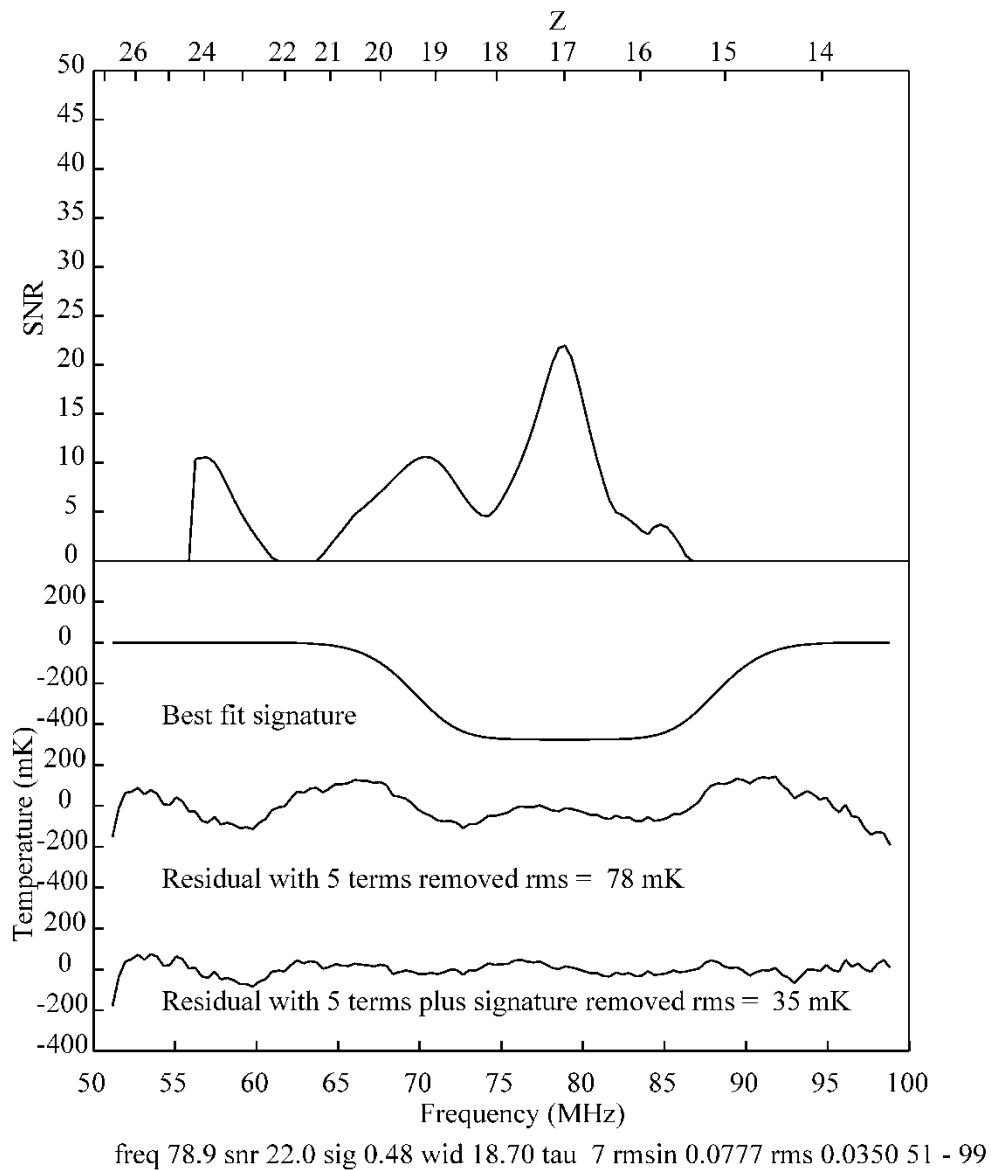


Figure 4. Signature search with  $-50$  ps error in S11 measurements.

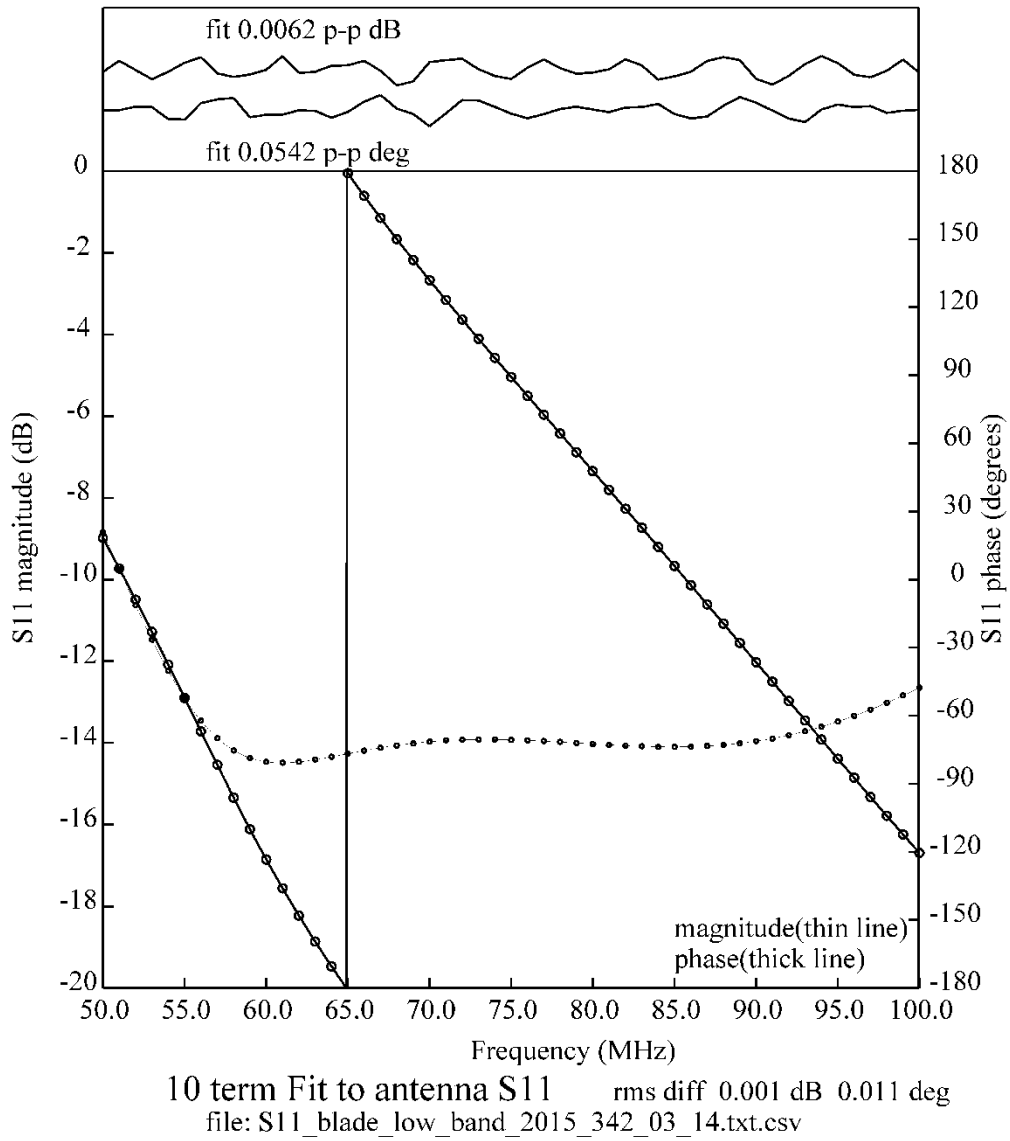
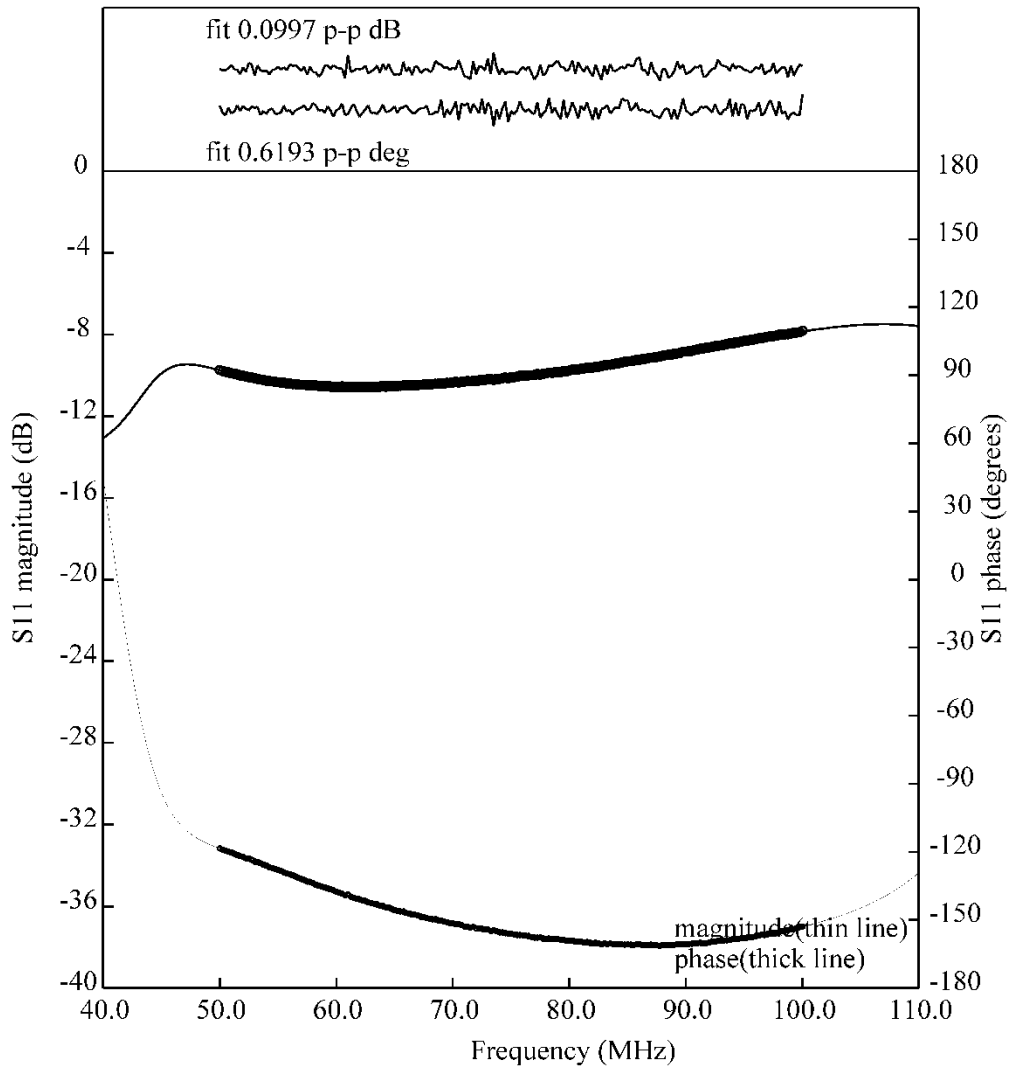


Figure 5. Antenna S11.



11 term Fit to LNA S11 rms diff 0.014 dB 0.098 deg  
 file: s11\_calibration\_low\_band\_LNA25degC\_2015-09-16-12-30-29\_simulator2\_long

Figure 6. LNA S11.

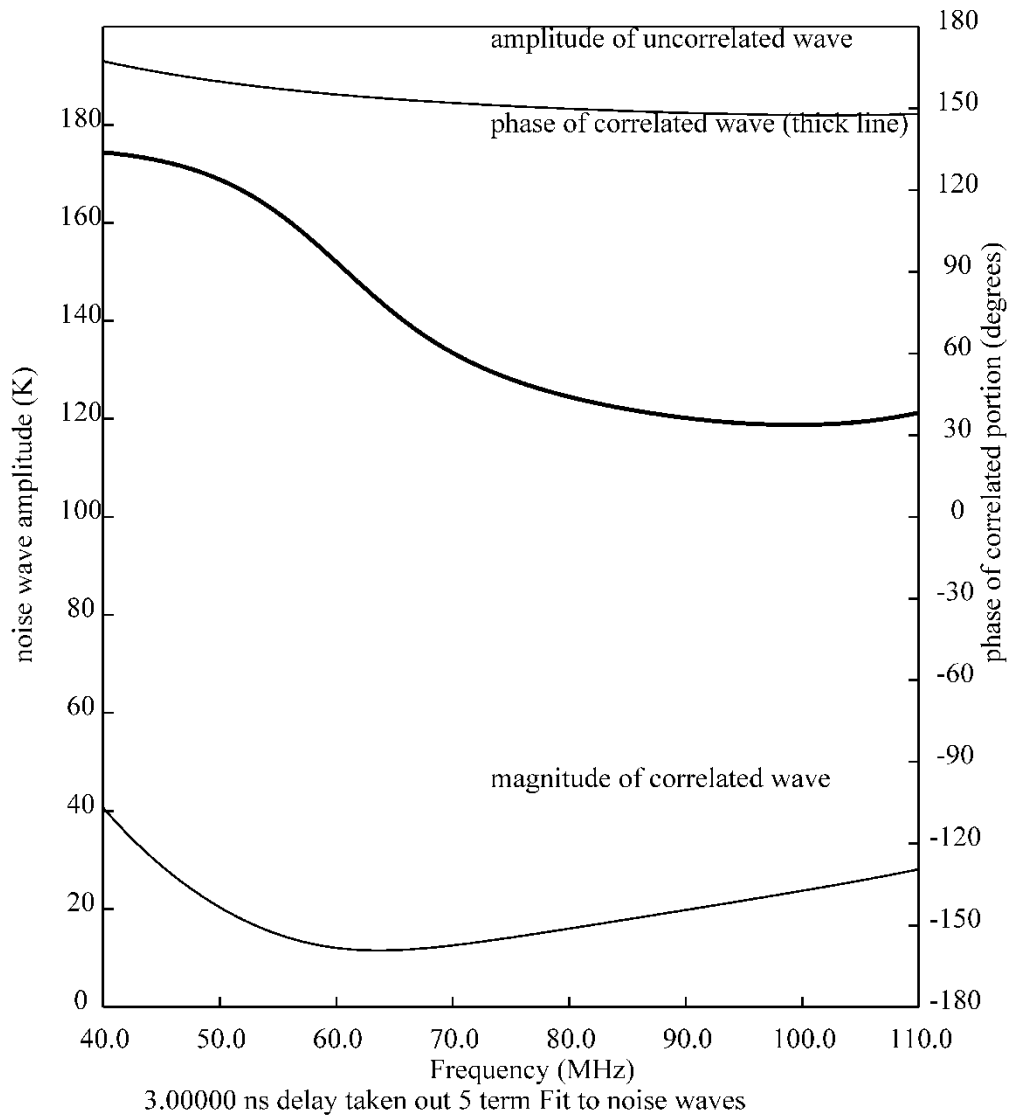


Figure 7. LNA noise waves for calibration without S11 error.