Verification of 2015 and 2017 Parameters of the Low-Band 1 Front-End Network

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Here we present the s-parameters of the Low-Band 1 front-end network computed in 2015, at 15°C, 25°C, and at 35°C, as well as the parameters measured in 2017-05 and 2017-07 at 25°C, when the receiver was back from the field. We also show (1) verification of the math of the method by calibrating the measurements of the external Keysight 85033E standards, used for the computation of the parameters, and (2) verification of the calibration performance using measurements of attenuators, compared with expectations from their DC resistance. An initial comparison of the 2015 and 2017 s-parameters was presented in report #91[1]. That report shows the effect on several DUTs, of using the 2017 parameters when the true parameters are those from 2015.

Measurements from 2015

In 2015, the front-end s-parameters were computed with the receiver at nominal temperatures 15°C, 25°C, and at 35°C. The actual temperatures measured with the internal thermistor attached to the 4-position switch, after stabilization, were 18.67°C, 27.16°C, and 35.31°C, respectively. The resistance of the Keysight 50 Ω calibration load was previously measured at the three temperatures that it achieved while connected to the receiver, obtaining 50.13 Ω, 50.12 Ω, and 50.11 Ω, respectively. These values were used in the computation of the s-parameters. Two attenuators, of 10 dB and 20 dB, were measured at the receiver input, for verification of the calibration. Unfortunately, due to time constraints, it was not possible to measure their resistance at the three temperatures. We only have the values at ambient temperature, which are 60.934 Ω, and 50.883 Ω, respectively. The VNA used was the Keysight E5072A. The settings were:

- power: 0 dBm
- frequency range: 50-100 MHz
- frequency resolution: 250 kHz
- IFBW: 100 Hz
- averaging: 10 traces

[1] http://loco.lab.asu.edu/loco-memos/edges_reports/report_20170527.pdf

Measurements from 2017

In 2017, measurements were done in May and July at $25°C$. Measurements at other temperatures are currently in progress. The measured resistance of the calibration load is $50.11\ \Omega$. Note that in 2015 we used the value $50.12\ \Omega$. In a future report we will explore the effect of errors of $\sim 0.01\ \Omega$ in the calibration load resistance.

Two attenuators, of 6 dB and 10 dB, were used for verification. Their resistance is 85.78 and $60.66\ \Omega$. In July, two measurement repetitions were conducted, using two approaches. In the first approach, for each switch position the reflection was measured only after the switch temperature stabilized. The temperature does not stabilize necessarily to the same value for each switch position. Here, the reflection measurement used 10-trace averaging. In the second approach, the switching and measurements were done as fast as possible, with no trace averaging, to operate the switch at about the same temperature for all positions. The VNA used was the Agilent E5061A. The settings were:

- power: 0 dBm
- frequency range: 40-120 MHz
- frequency resolution: 250 kHz
- IFBW: 100 Hz
- averaging: 10 traces (May and July Rep 1), and off (July Rep 2)

Figures

The following figures summarize the measurements.

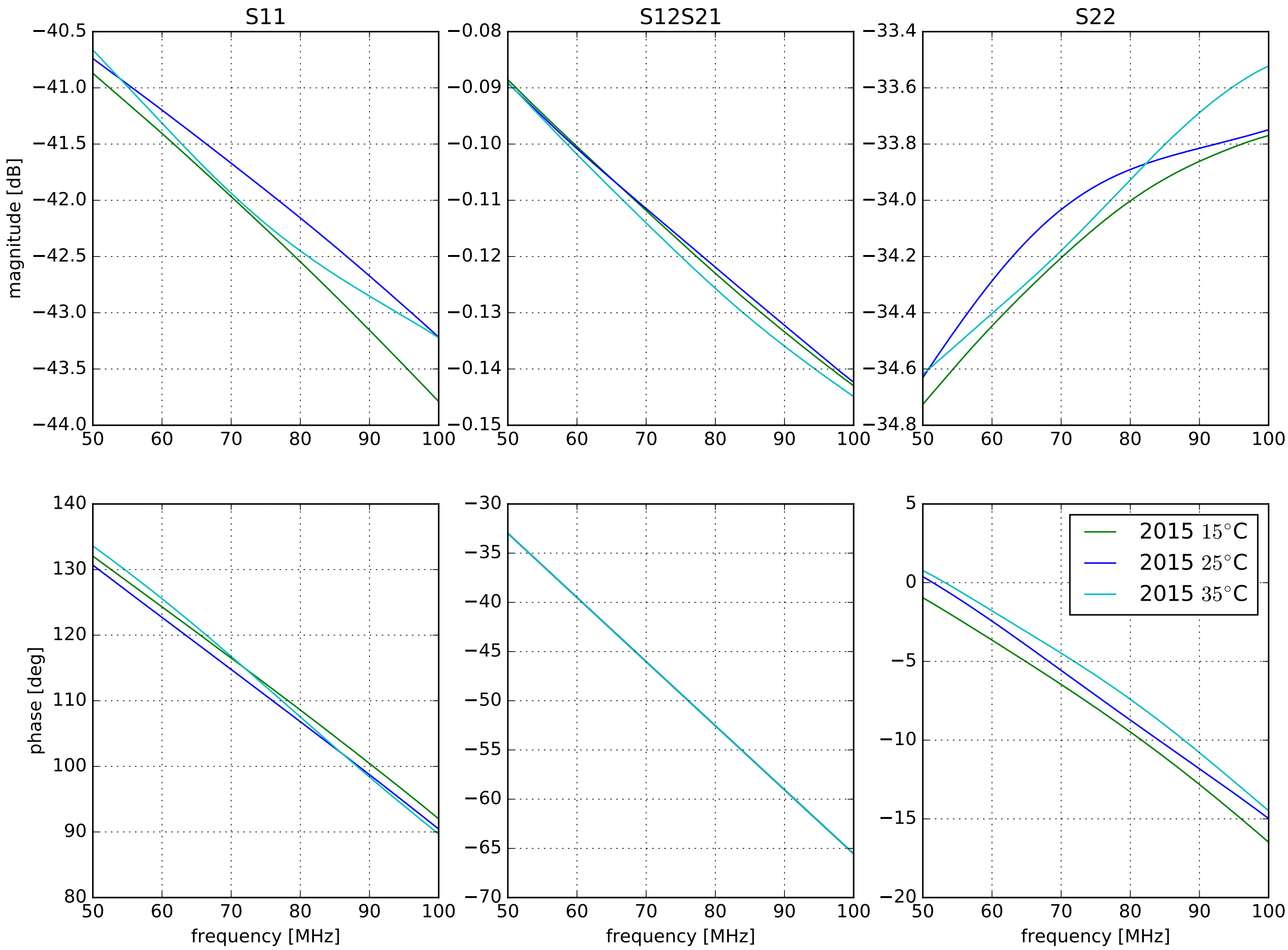

Figure 1: S-parameters measured in 2015 at three temperatures. There is no clear pattern in the parameters as a function of temperature. However, see Figure 8.

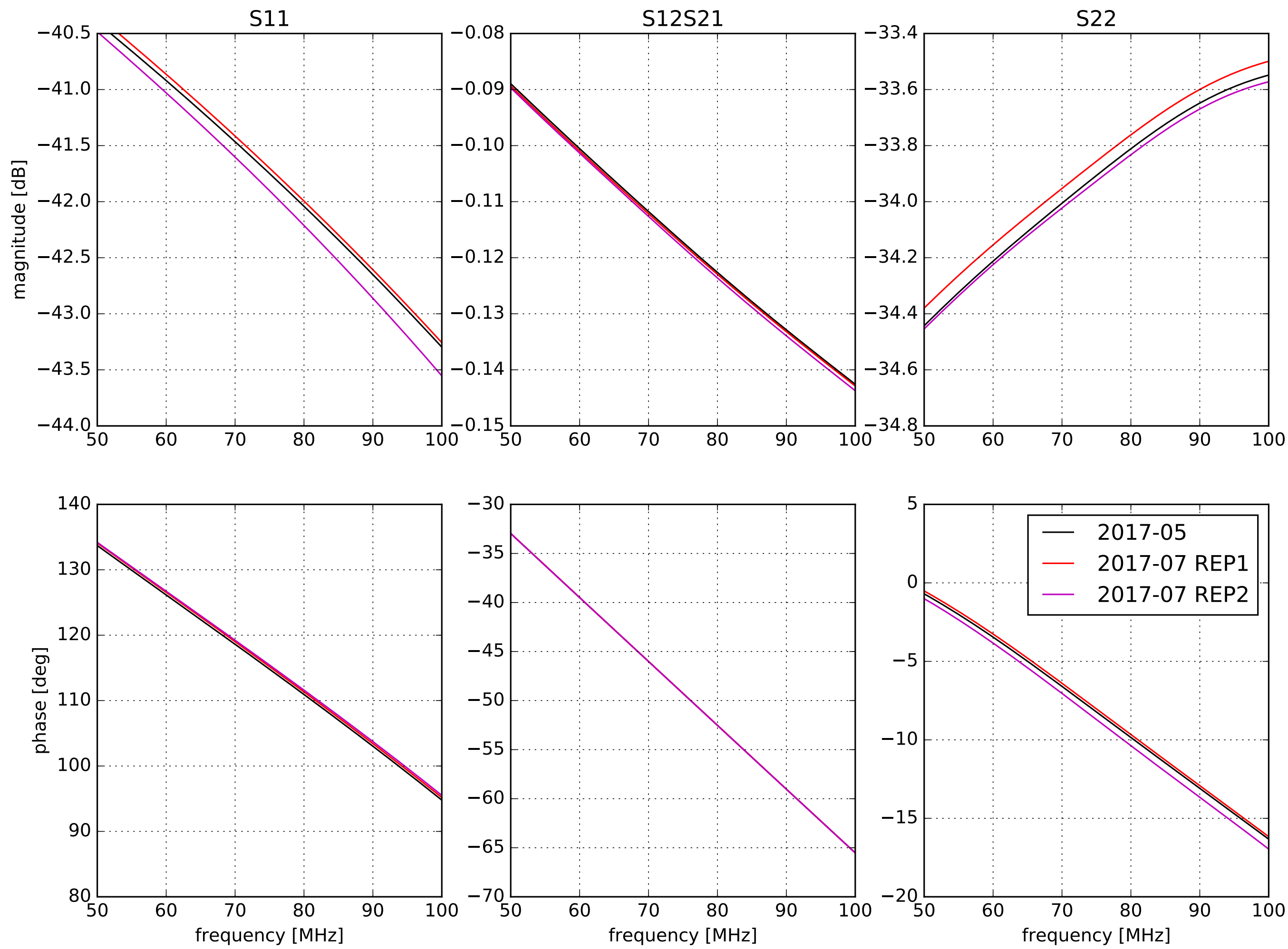

Figure 2: S-parameters measured in 2017 at 25°C.

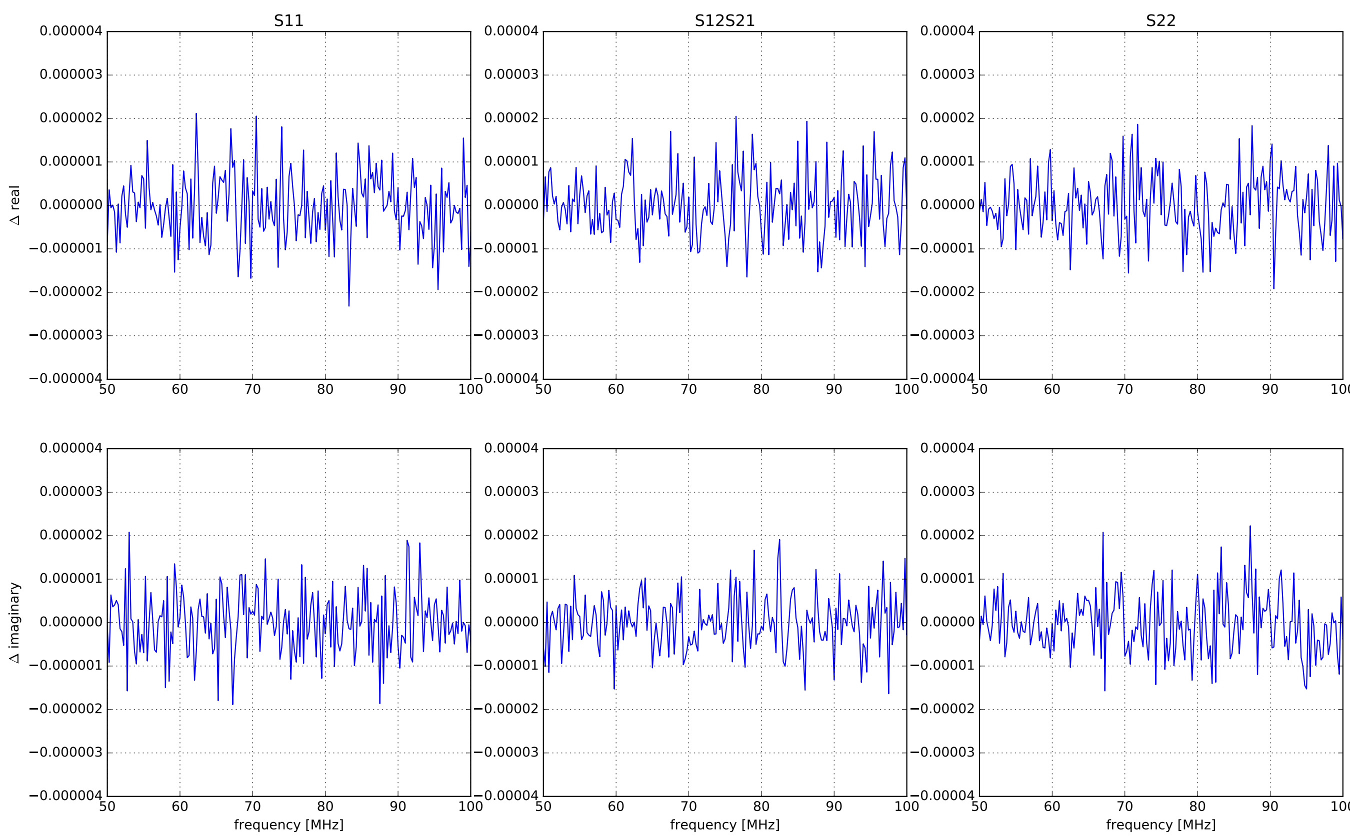

Figure 3: Noise-like residuals for the 2017-05 25°C s-parameters after fitting and removing 10-term polynomials for interpolation. The residuals for all sets of s-parameters are noise-like.

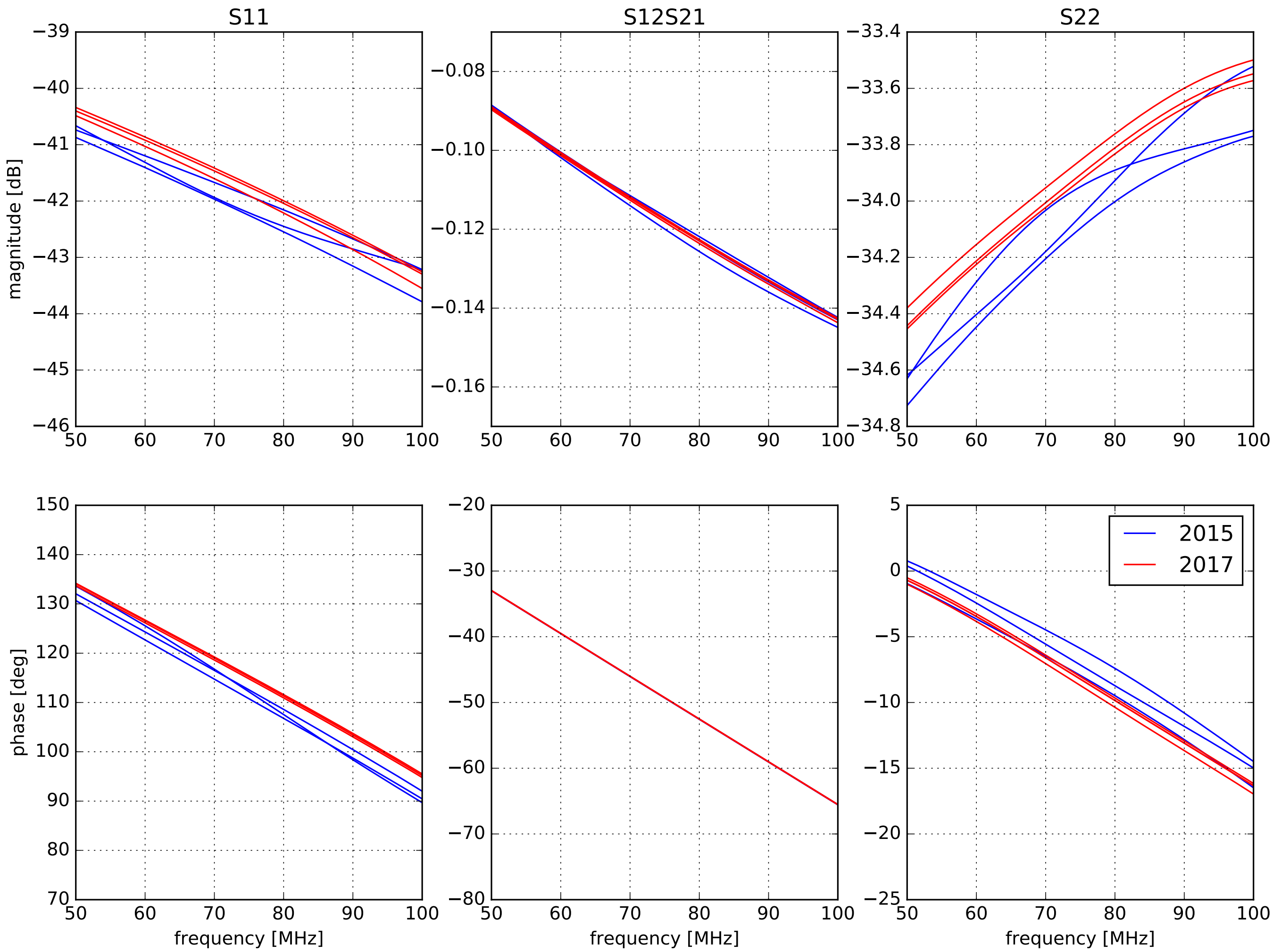

Figure 4: Comparison between 2015 and 2017 s-parameters, shown in Figures 1 and 2, respectively.

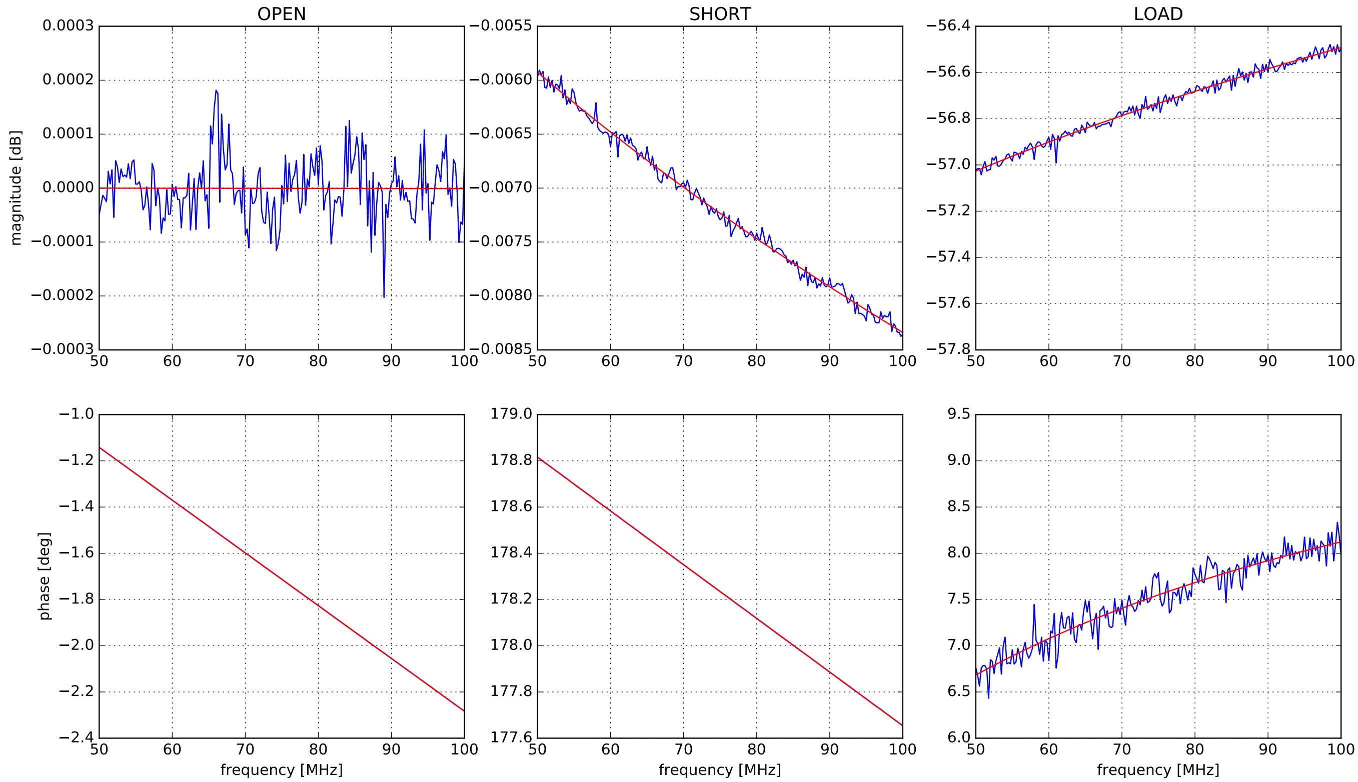

Figure 5: Comparison between models (red) and calibrated Keysight OSL standards measured (blue) at the receiver input in 2015 at 25°C.

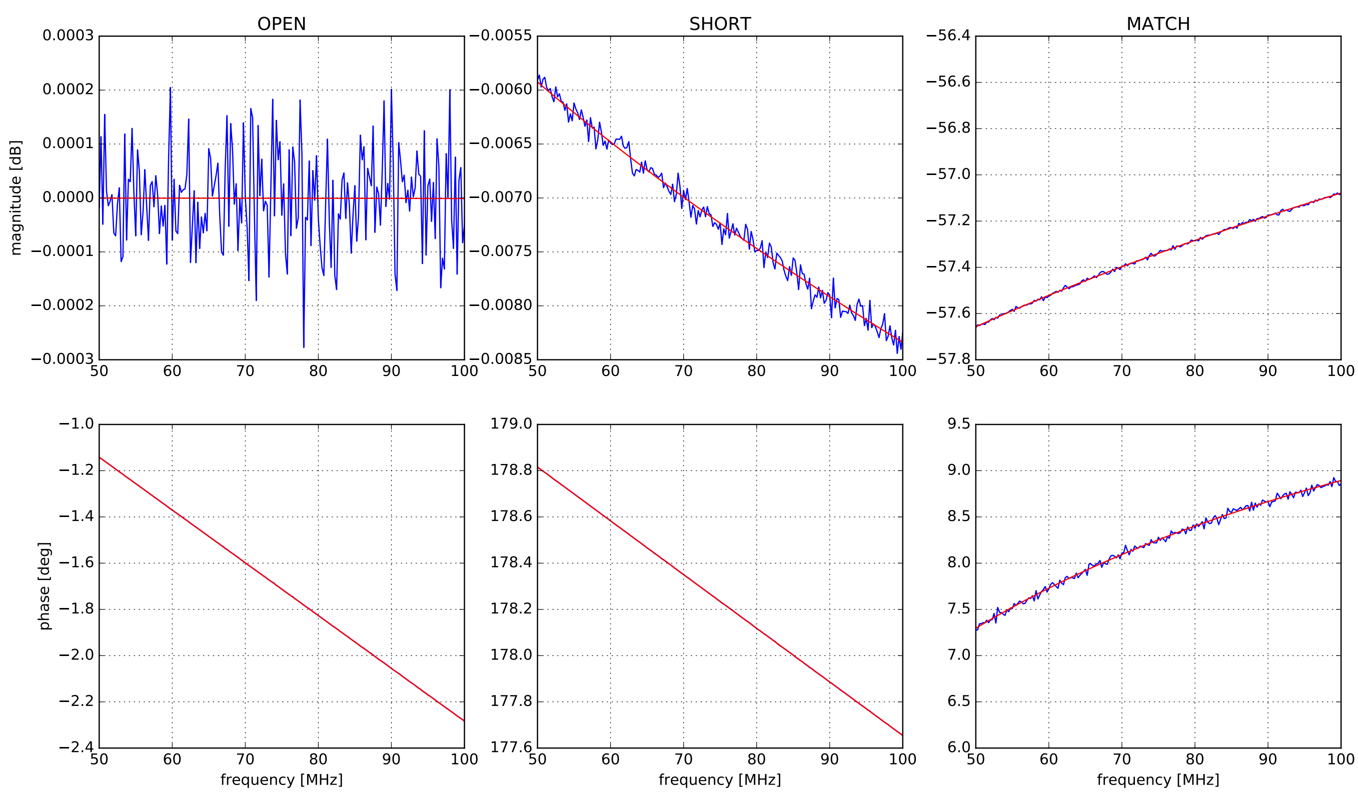

Figure 6: Comparison between models (red) and calibrated Keysight OSL standards measured (blue) at the receiver input in 2017-05 at 25°C.

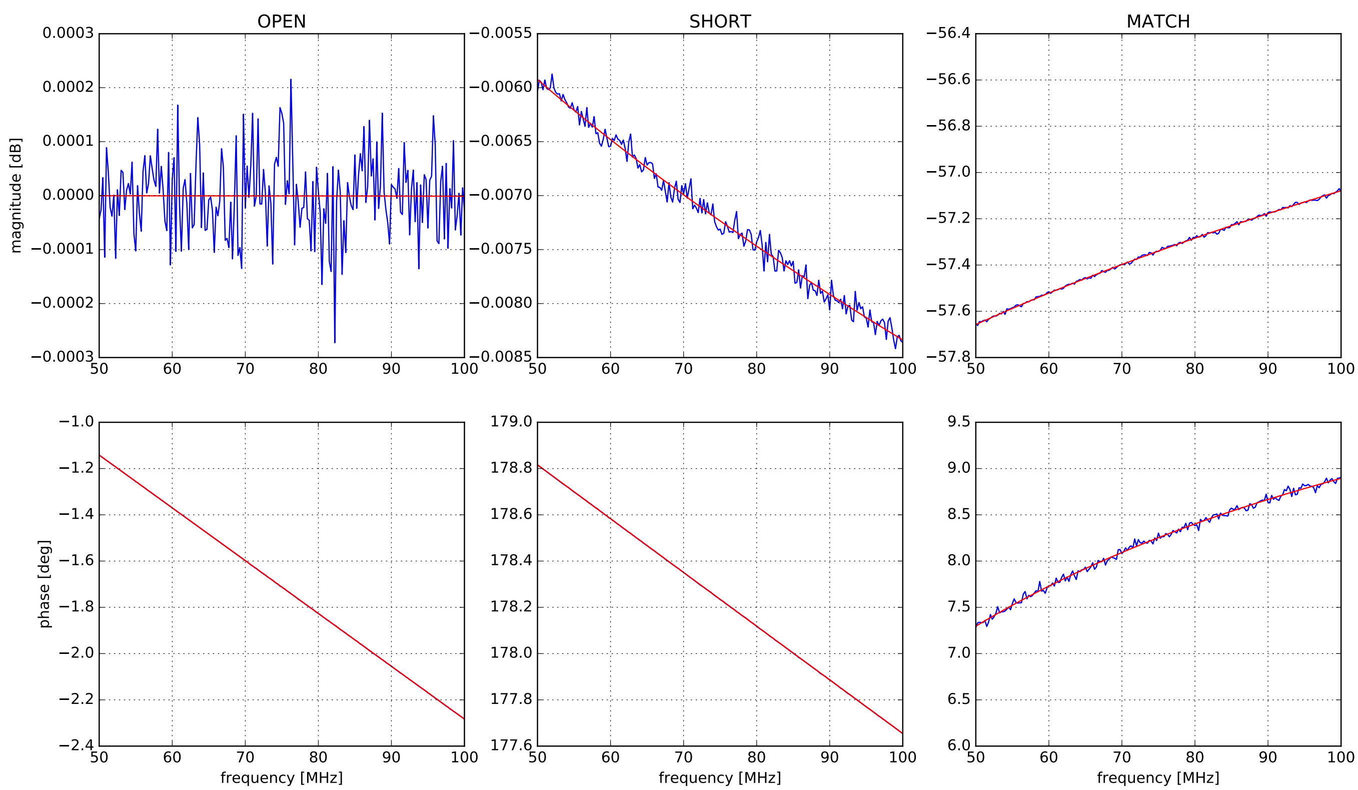

Figure 7: Comparison between models (red) and calibrated Keysight OSL standards measured (red) at the receiver input in 2017-07-Rep1 at 25°C.

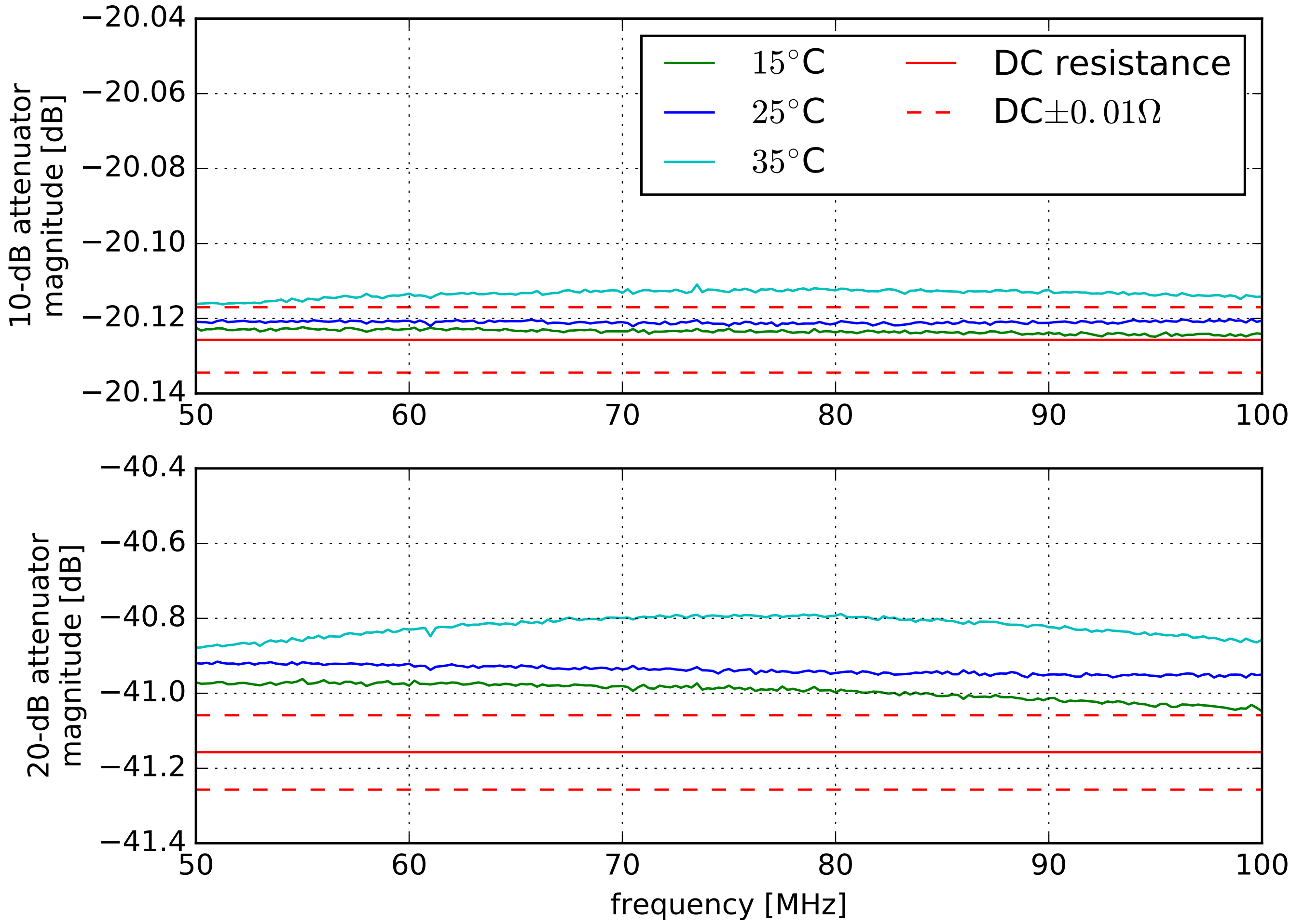

Figure 8: Comparison between DC predictions and calibrated measurements of 10-dB and 20-dB attenuators at the receiver input in 2015, at 15°C, 25°C, and 35°C. The s-parameters of the receiver front-end network are those in Figure 1. Since the same resistance value is used for the attenuators at the three temperatures, only one DC prediction is shown. It is interesting that, although the s-parameters in Figure 1 do not show a clear pattern with temperature, the measurements shown here do, after calibrating with the corresponding s-parameters.

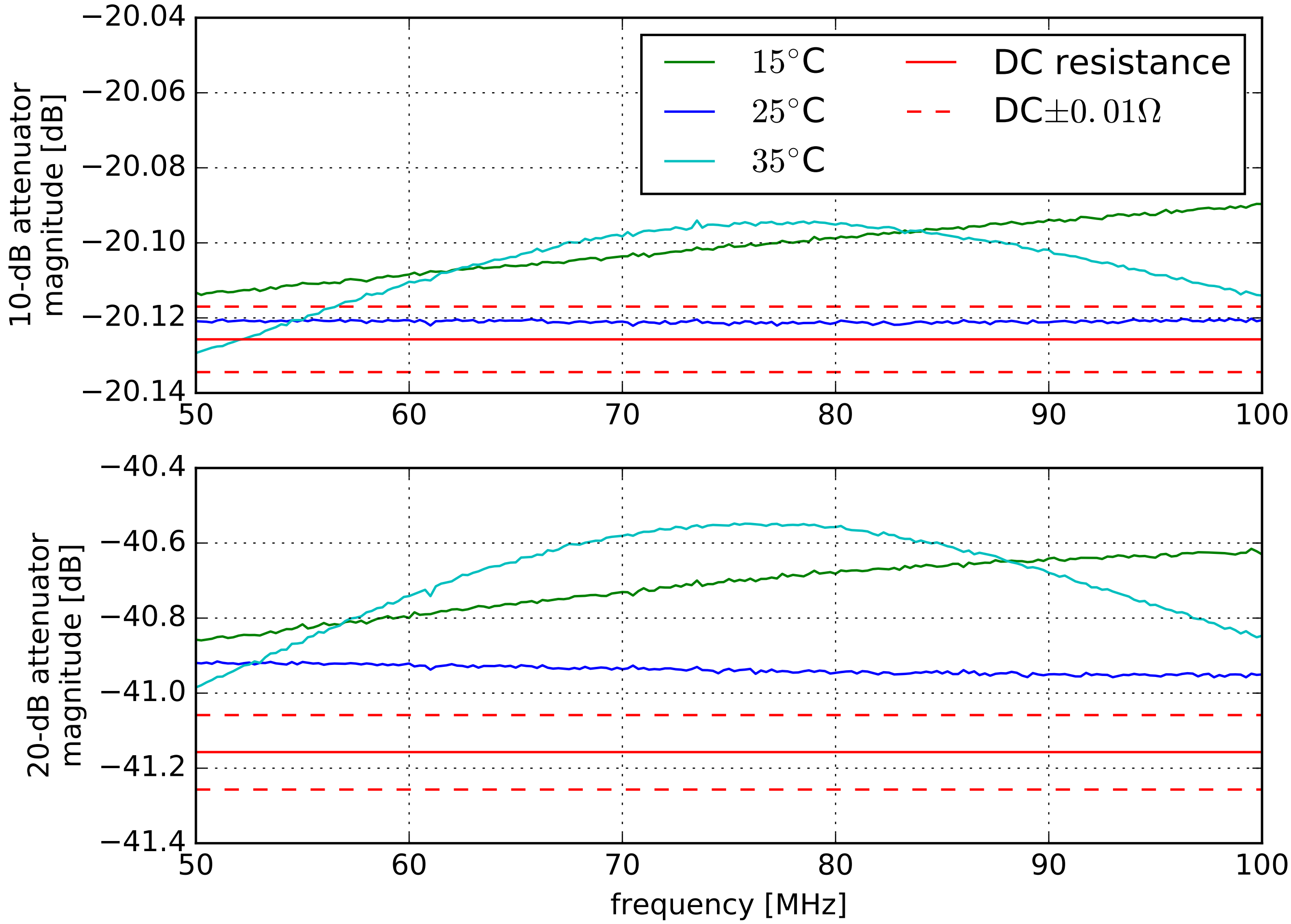

Figure 9: Same as Figure 8, but after calibrating all the attenuator measurements (done at different receiver temperatures), with the s-parameters computed at 25°C. This is done as a test. Clearly, the agreement between the 15°C and 35°C cases and the DC prediction is degraded, which suggests that the variability of the 2015 s-parameters could represent real changes in the front-end network.

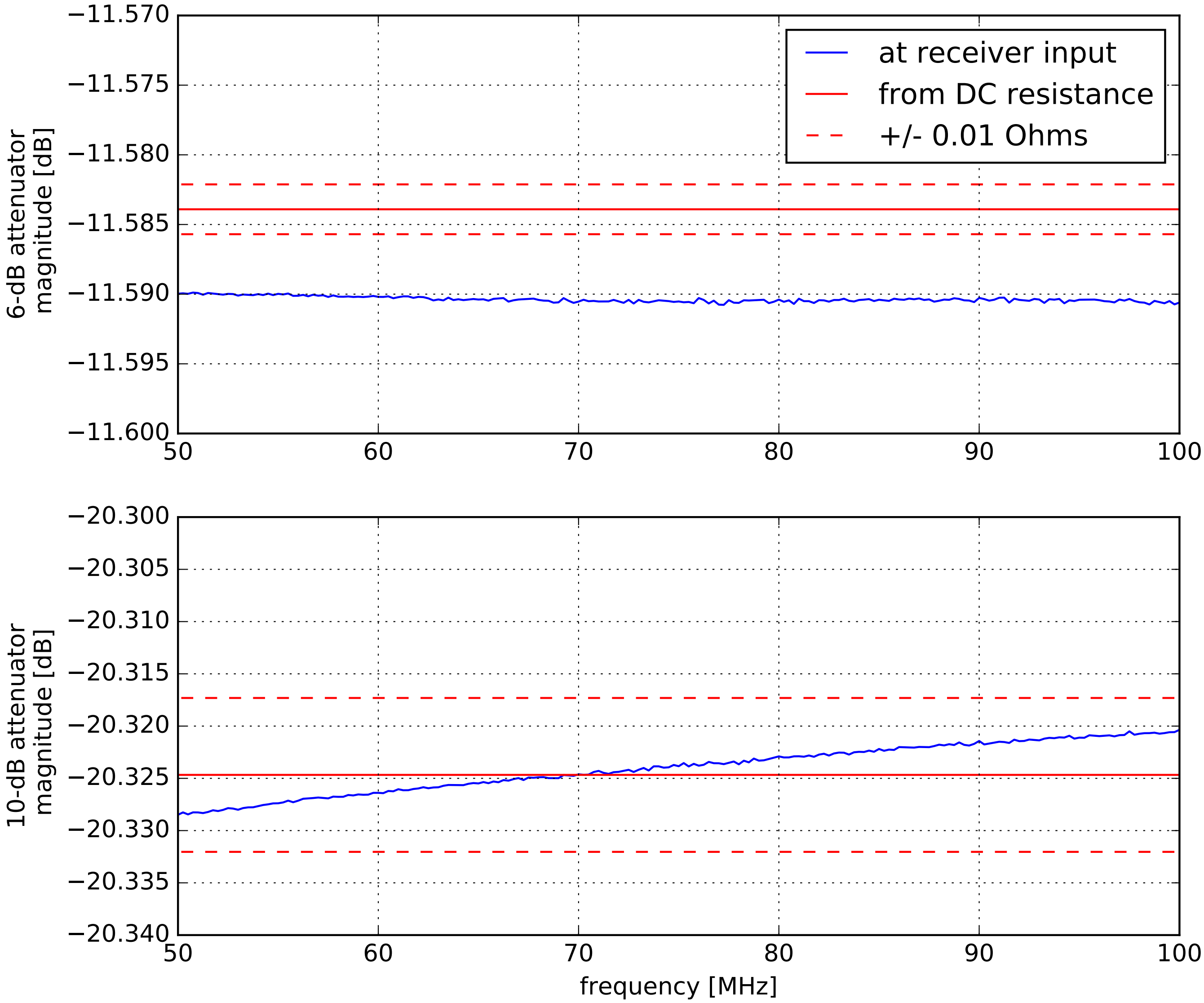

Figure 10: Comparison between DC predictions and calibrated measurements of 6-dB and 10-dB attenuators at the receiver input in 2017-05, at 25°C.

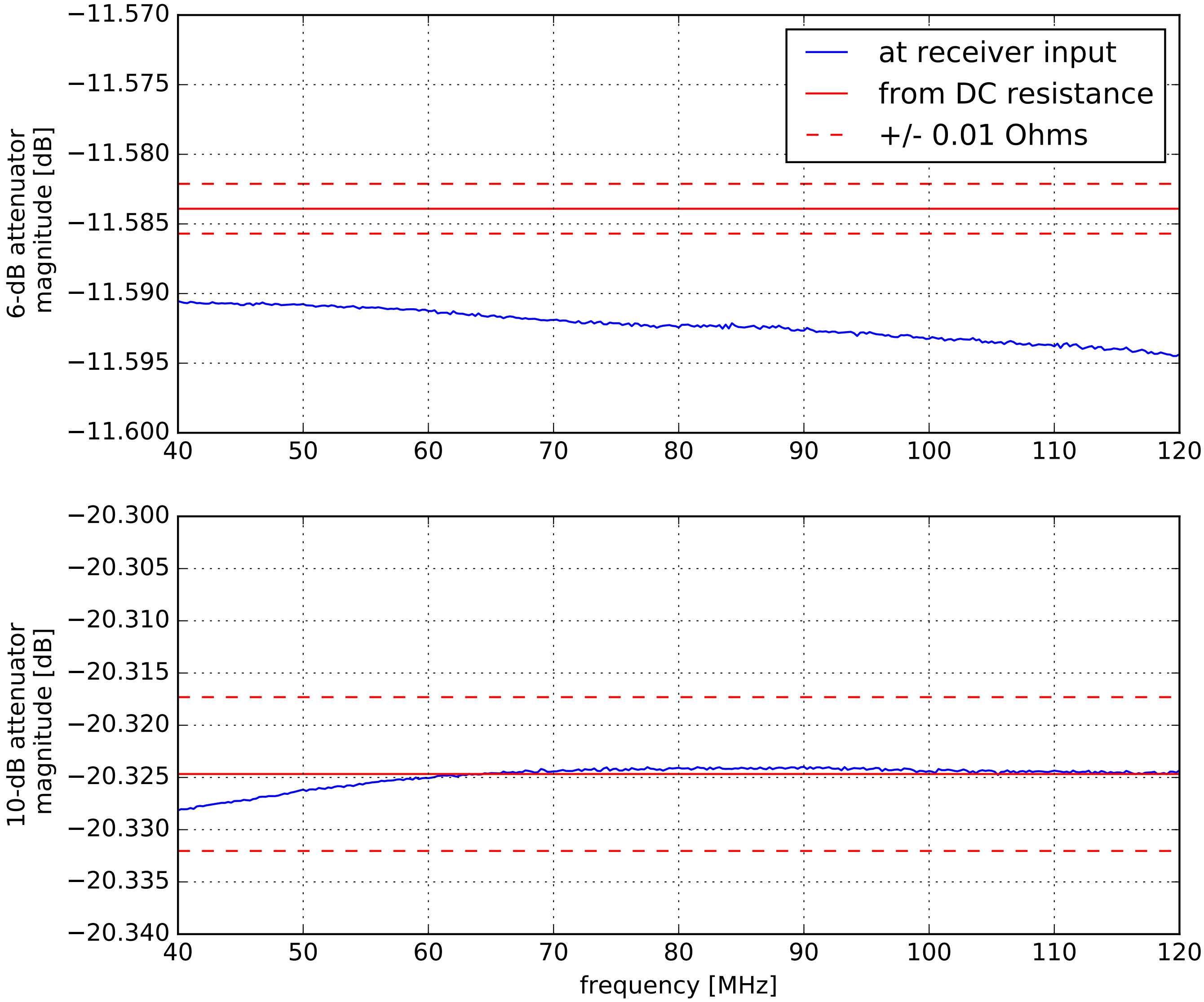

Figure 11: Comparison between DC predictions and calibrated measurements of 6-dB and 10-dB attenuators at the receiver input in 2017-07, Rep 1, at 25°C.

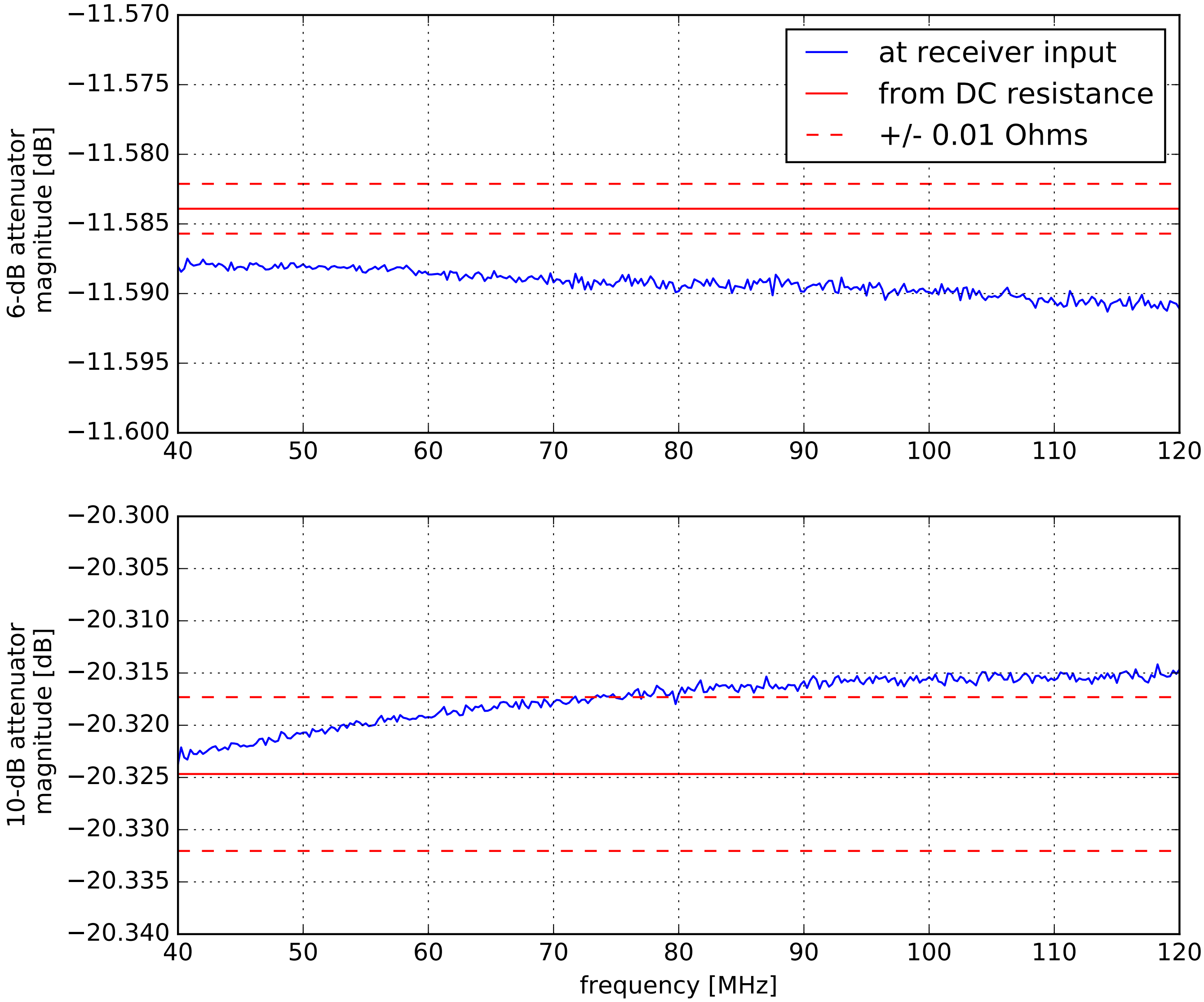

Figure 12: Comparison between DC predictions and calibrated measurements of 6-dB and 10-dB attenuators at the receiver input in 2017-07, Rep 2, at 25°C.