Estimation of the Reflection Magnitude Accuracy with the Agilent E5061A VNA: Part 2

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This document is a continuation of Report #85 (http://loco.lab.asu.edu/loco-memos/edges_reports/report_20170227.pdf). Here we take a deeper look at the accuracy of the Agilent E5061A VNA, which is one of the main benchtop VNAs used to calibrate the EDGES receivers.

In report #85 we estimated the accuracy of the reflection magnitude at a VNA power of -30 dBm using open-ended attenuators (-3, -6, -10, and -15 dB). Here we keep the original set, and add a second set of attenuators of same nominal values. We start by measuring the devices at 0 dBm. Then, we repeat their measurement at -30 dBm. Finally, we do the -30 dBm again after turnig off the VNA, turning it back on, and waiting for about 1 day. In every case, every attenuator is measured twice, after disconnecting and reconnecting it to the VNA port. The reflection measurements were done in the range 50-100 MHz, with a frequency resolution of 250 kHz and averaging of 30 traces. The measurements are calibrated using measurements of the VNA standards done at the two powers. The calibrated reflections measurements are then compared to the reflections predicted from the DC resistances of the attenuators.

The results can be summarized as:

1. The predictions from the DC resistance are only valid to first order. Given that, the calibrated VNA measurements yield lower magnitudes than the DC predictions, in all cases.

2. There is no significant difference between the measurements at 0 and -30 dBm, to within the scatter observed due to a combination of 1) noise, 2) VNA calibration uncertainty, 3) connection repeatability, and 4) repeatability after VNA restart.

3. The magnitude accuracies are:

Approx. Reflection Magnitude [dB]	Accuracy Limit [dB]
-5.6	< 0.01
-11.6	< 0.02
-20.3	< 0.07
-30.0	< 0.17

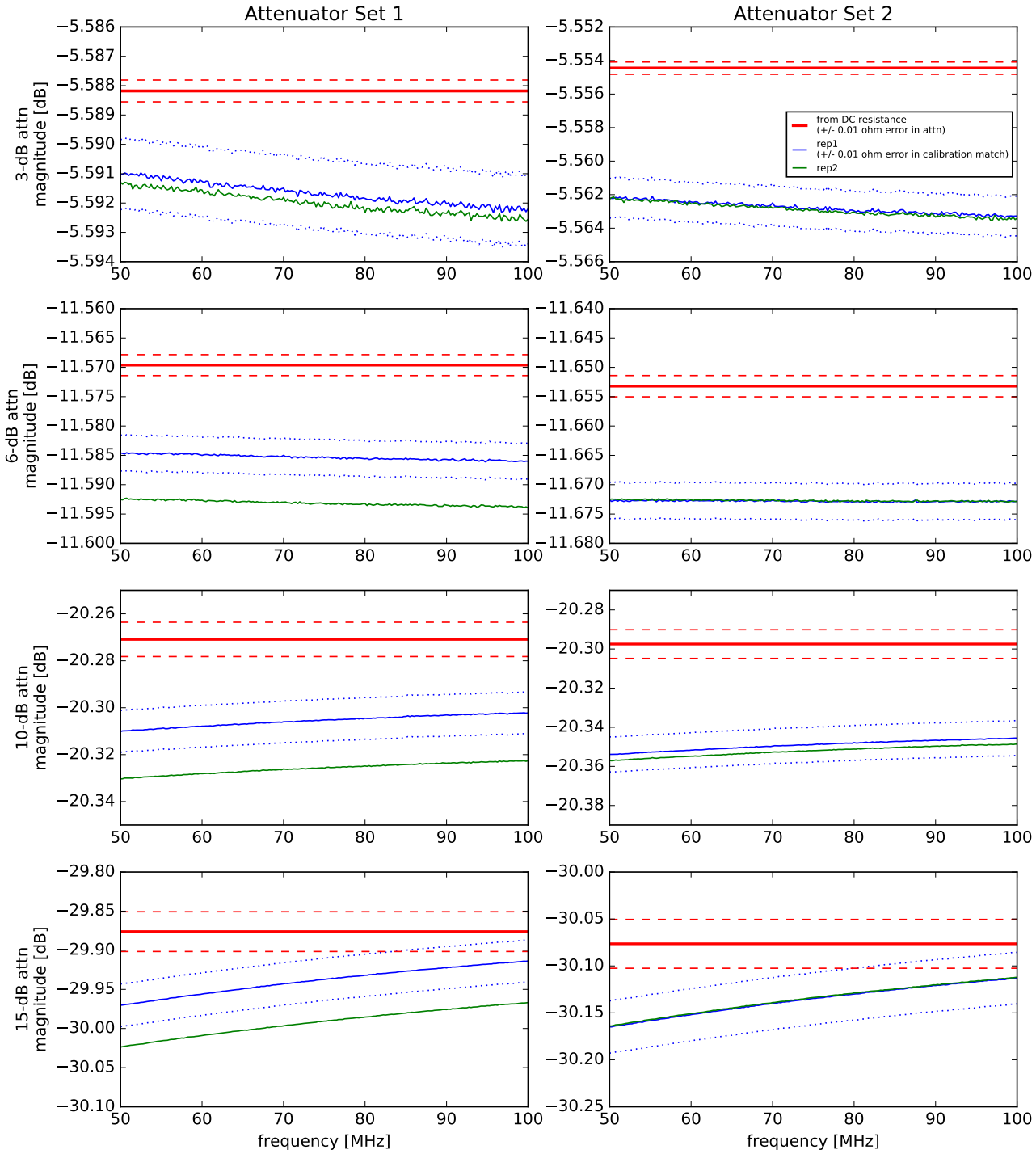

Figure 1: Comparison of the calibrated VNA measurements at a power of 0 dBm, with the reflection reference from the DC resistance of the attenuators. Dashed and dotted lines represent uncertainty bands from realistic uncertainties ($\pm 0.01\Omega$) in the measured resistances of the attenuators and the 50-Ω calibration load, respectively.

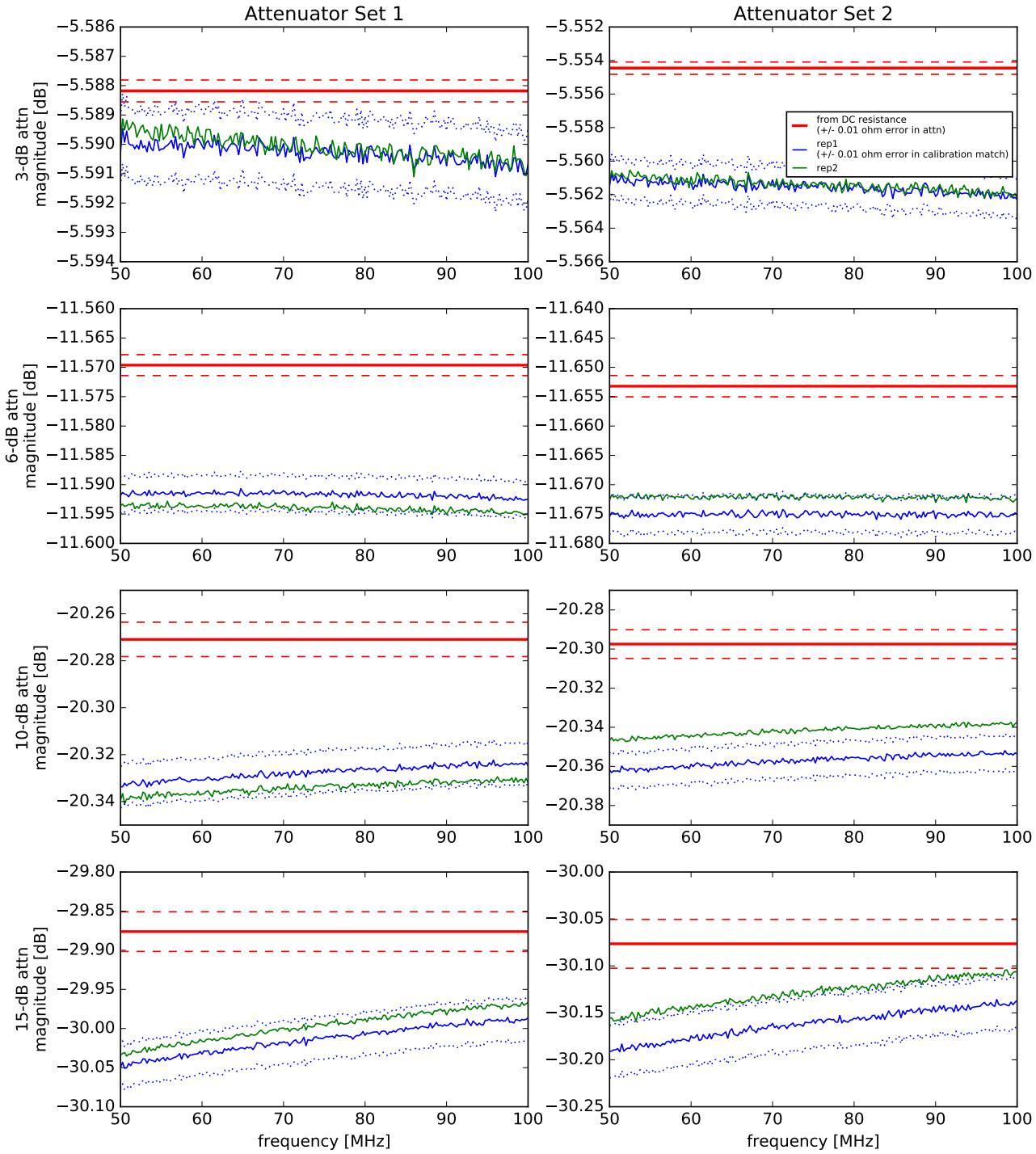

Figure 2: Comparison of the calibrated VNA measurements at a power of -30 dBm, with the reflection reference from the DC resistance of the attenuators. Dashed and dotted lines represent uncertainty bands from realistic uncertainties ($\pm 0.01\Omega$) in the measured resistances of the attenuators and the 50-Ω calibration load, respectively.

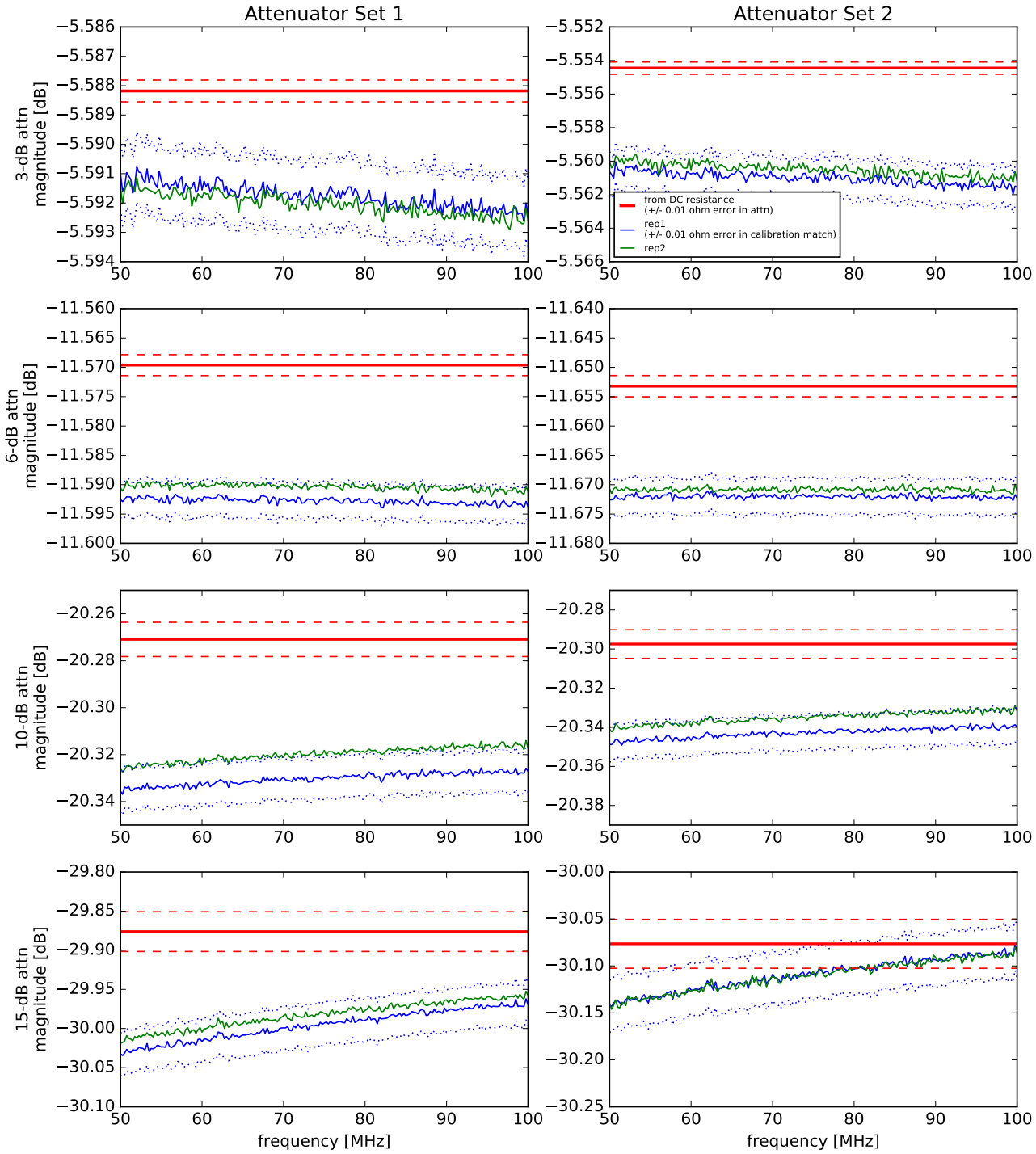

Figure 3: Comparison of the calibrated VNA measurements at a power of -30 dBm, measured after restarting the VNA, with the reflection reference from the DC resistance of the attenuators. Dashed and dotted lines represent uncertainty bands from realistic uncertainties ($\pm 0.01\Omega$) in the measured resistances of the attenuators and the 50-Ω calibration load, respectively.