VNA COMPARISON COPPER MOUNTAIN R60 (DEMO) VS ALIGELENT E5061A

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Description:

- ➢ There is a new VNA available in our lab, a Copper Mountain R60, and it was compared to the AGILENT E5072A, we have been using until now.
- ➢ The comparison consisted of the accuracy of the measurement of four attenuators (3dB-BW-S3W2+,6dB-BW-S6W2+,10dB-BW-S10W2+, and 15dB-BW-S15W2+), after correction using the expectations for the open, short, and match (Male,85033E). The temperature at all moments was23.5±0.5◦C
- ➢ With measurements specifications as follows:

i. Power: 0dBm
ii. bandwidth: 100 Hz
iii. Max Frequency: 200MHz
iv. Min Frequency: 40MHz
v. AVG: 10 traces
vi. Points: 641
vii. Frequency Step (MHz): 0.250

- ➢ The steps in the testing at each VNA are:

i. Calibrate the VNA at its SMA port (with open, short, & match).
ii. Measure the S11 of the open, short, & match, AGAIN after calibration.
iii. Measure the S11 of the four attenuators.
iv. Repeat steps ii and iii for repeatability.

- ➢ Perform uncalibrated VNA measurements to determine uncorrected S11 parameters.

i. Measure open STD using uncorrected VNA measurement and save S1p_open
ii. Measure Short STD and save S1p_short
iii. Measure Load STD and save S1p_load
iv. Using the calibration coefficients of the OPEN, Short and load standards (found on the VNA, called C0, C1..., L0, L1...), we can compute the S parameters of a 2-port network called the "error network" (it is a hypothetical 2 port network between the VNA and DUT)
v. Measure the S11 of the DUT (attenuator) and "de-embed" the error network from the measured data, you will be left only with the S11 (complex) of the DUT.
vi. The equation you will need is this: (it is the S11 of a [S_error] network terminated with Gamma_dut)
S11_Measured = S11_error + (S21_Error * Gamma_dut*S12_error) / (1 - S22_error * Gamma_dut)
vii. Solve for the S parameters of the error network [S_error]: S11_error, S12_error, S21_error and S22_error by solving the above 4 unknowns equation for:
Gamma_dut = Gamma_open_std
Gamma_dut = Gamma_short_std
Gamma_dut = Gamma_load_std
viii. assume reciprocity: S21_error = S12_error (reasonable assumption as the error network is reciprocal, meaning that S12=S21). The results will give 3 equations to solve for the 3 unknowns.

Images of VNA connections:

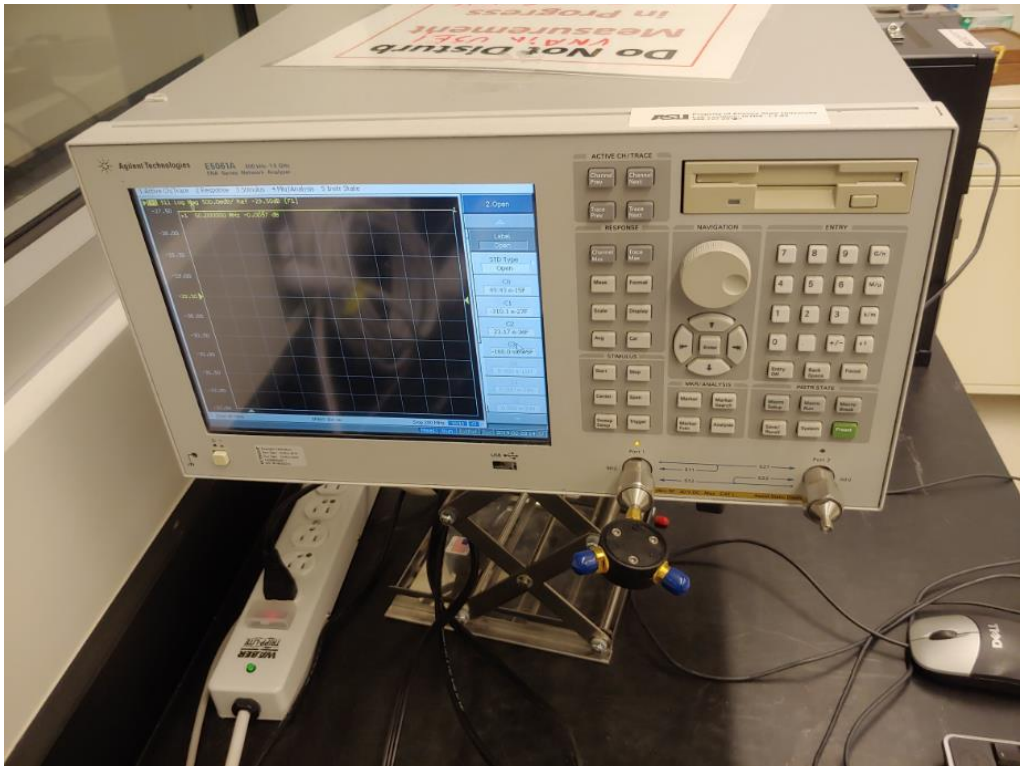

Figure1: Aligelent E5061A Calibration arrangement utilizing the male 85033E Calibration kit

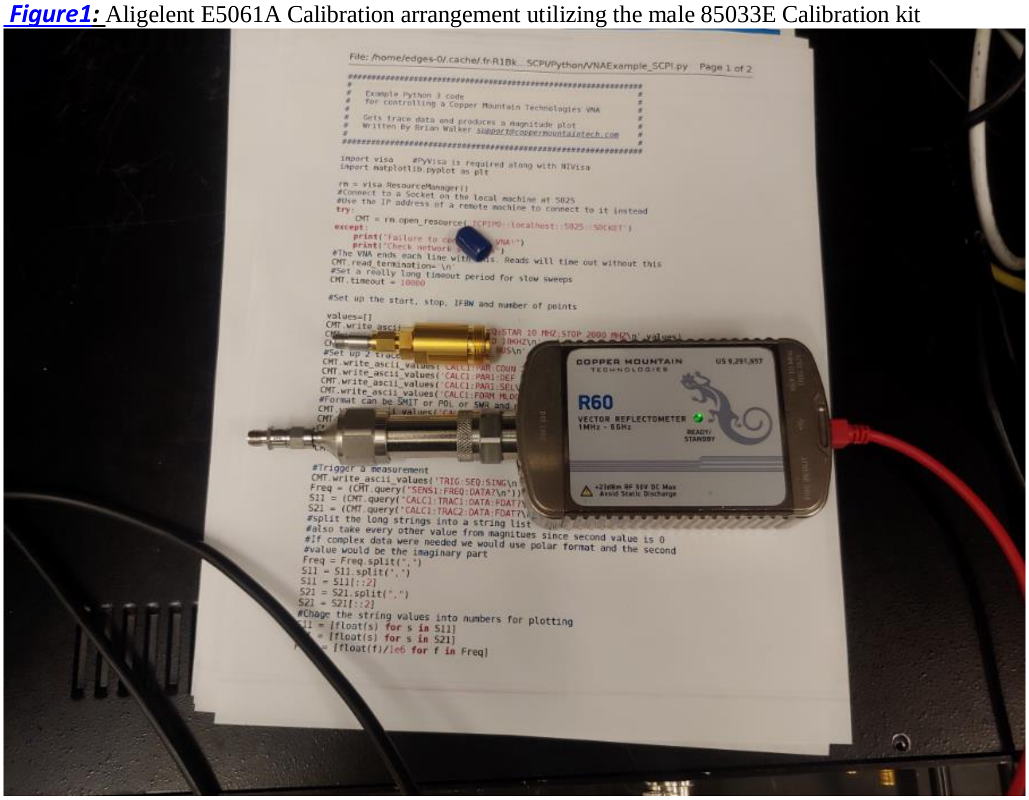

Figure2: Copper Mountain R60 Calibration arrangement with one-piece adapter attached (silver) and multi adapter above unit (Golden/Bronze). Performing attenuation measurement.

Results:

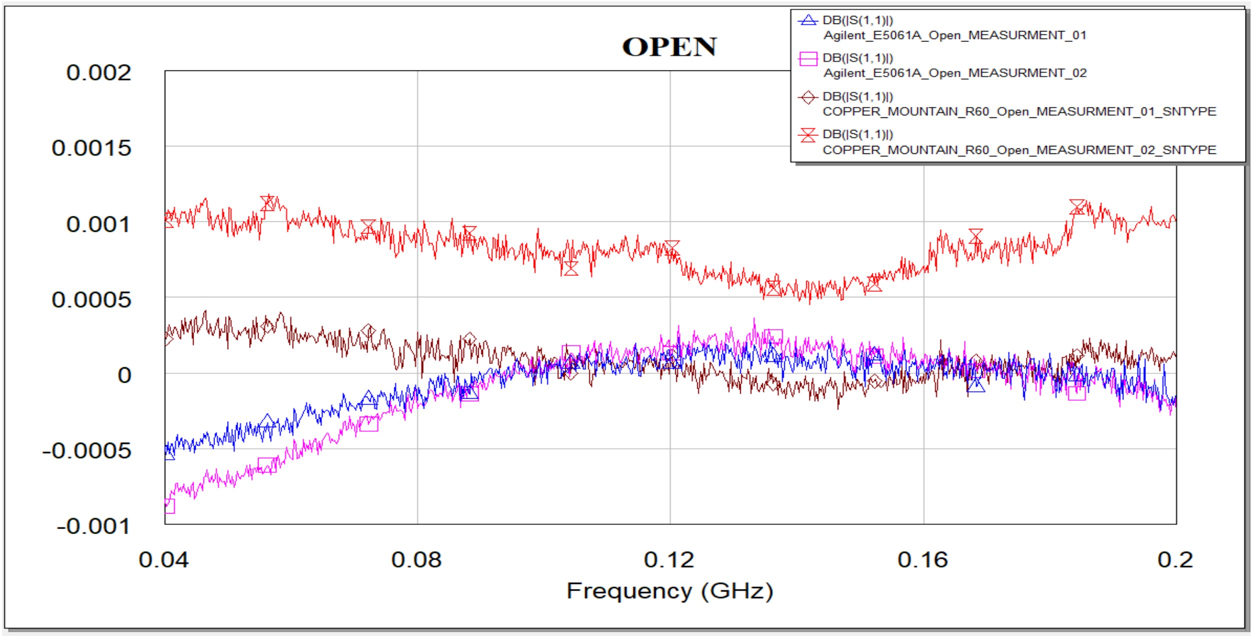

Figure3: Magnitude of the Open after calibration. Copper mountain R60 measurement one brown trace, Copper mountain R60 measurement two red trace, Agilent measurement one blue trace, Agilent measurement two pink trace. The difference in repeatability between the two VNAs with the same settings is favoring the Agilent E5061A VNA due to closer tolerances and consistent curvature.

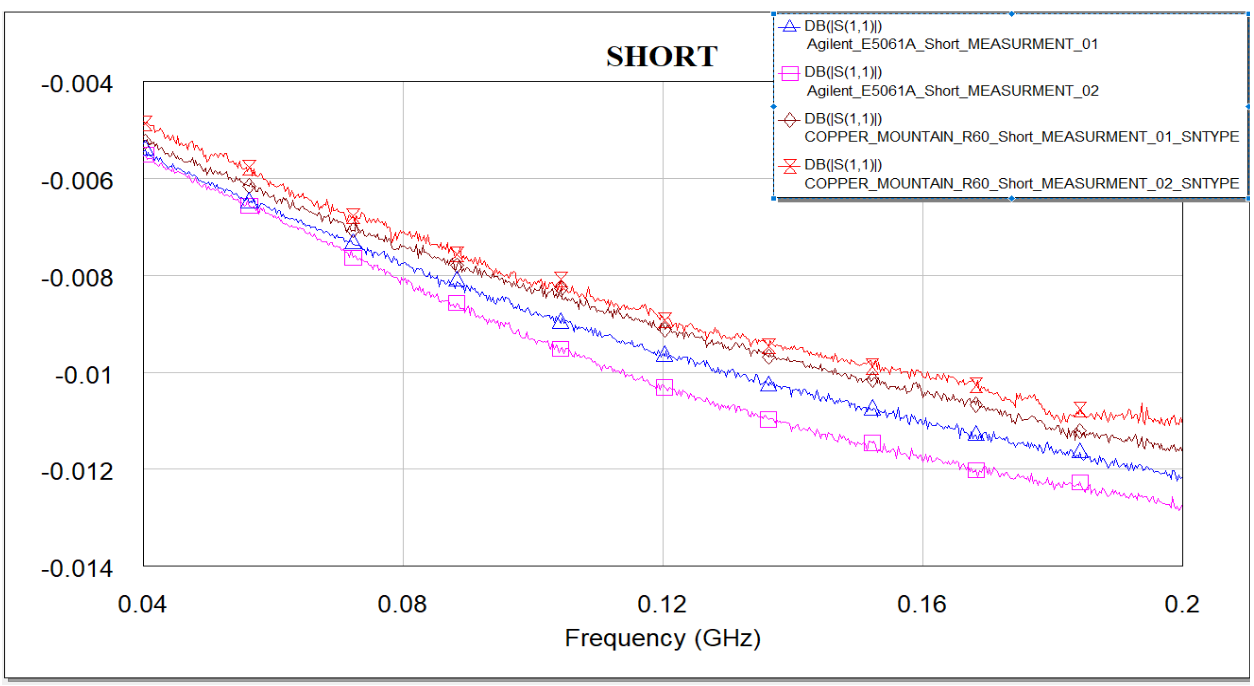

Figure4: Magnitude of the Short after calibration. Copper mountain R60 measurement one brown trace, Copper mountain R60 measurement two red trace, Agilent measurement one blue trace, Agilent measurement two pink trace. The difference in repeatability between the two VNAs with the same settings is favoring the Agilent E5061A VNA due to consistent curvature.

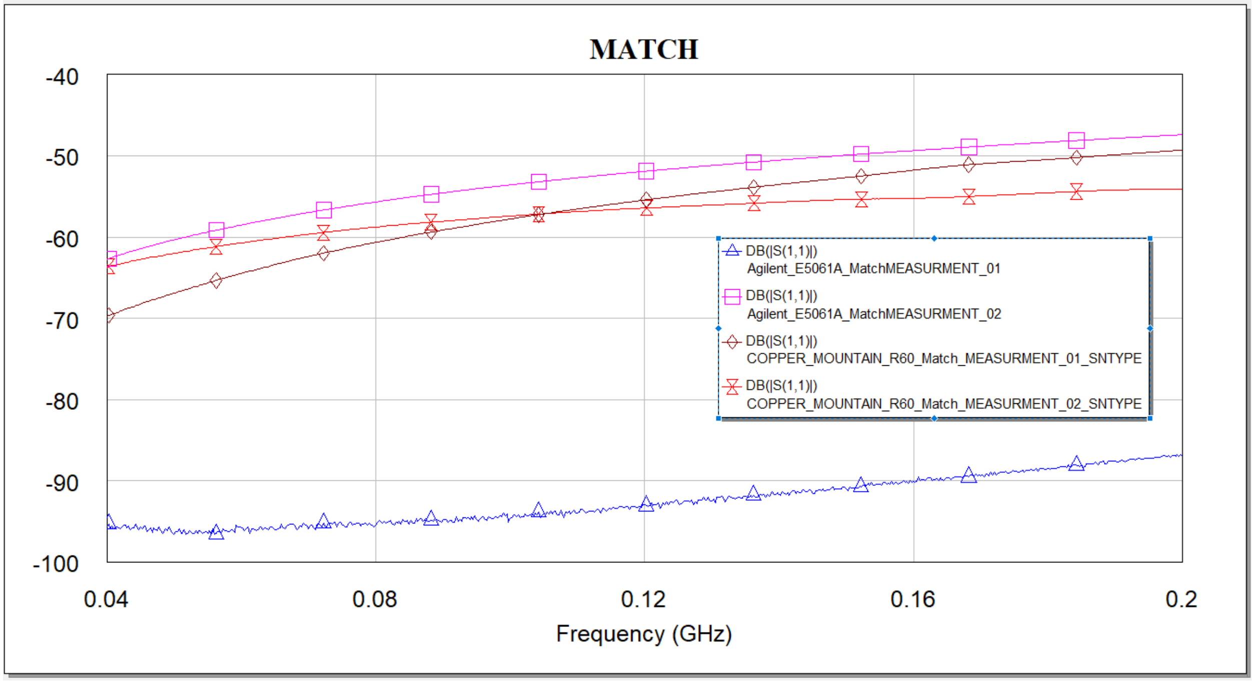

Figure5: Magnitude of the Match after calibration. Copper mountain R60 measurement one brown trace, Copper mountain R60 measurement two red trace, Agilent measurement one blue trace, Agilent measurement two pink trace. The difference in repeatability between the two VNAs with the same settings is favoring the Copper Mountain R60 VNA due to closer tolerances, better curvature and less ripples.

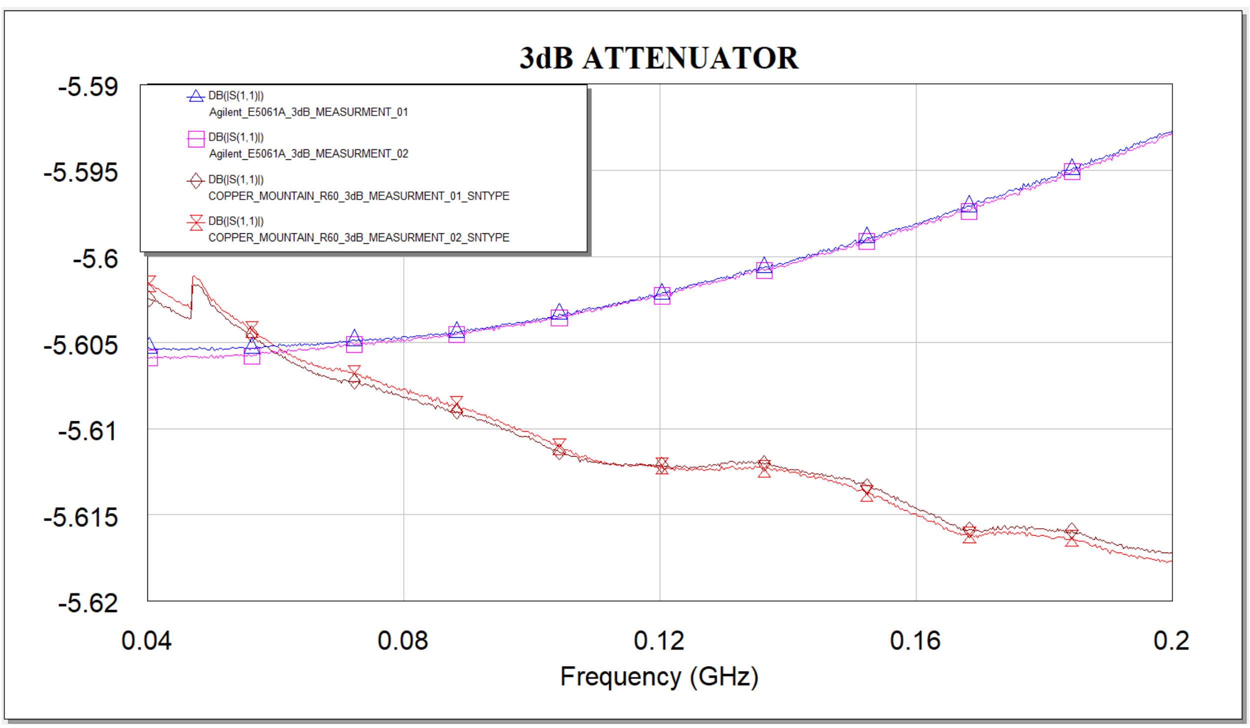

Figure6: Magnitude of the 3dB Attenuator after calibration. Copper mountain R60 measurement one brown trace, Copper mountain R60 measurement two red trace, Agilent measurement one blue trace, Agilent measurement two pink trace. The difference in repeatability between the two VNAs with the same settings is favoring the Agilent E5061A VNA due to closer tolerances and consistent curvature that is more predictable. Notice that the Copper Mountain VNA has an unusual feature at 48MHz and the trace of is non-leaner.

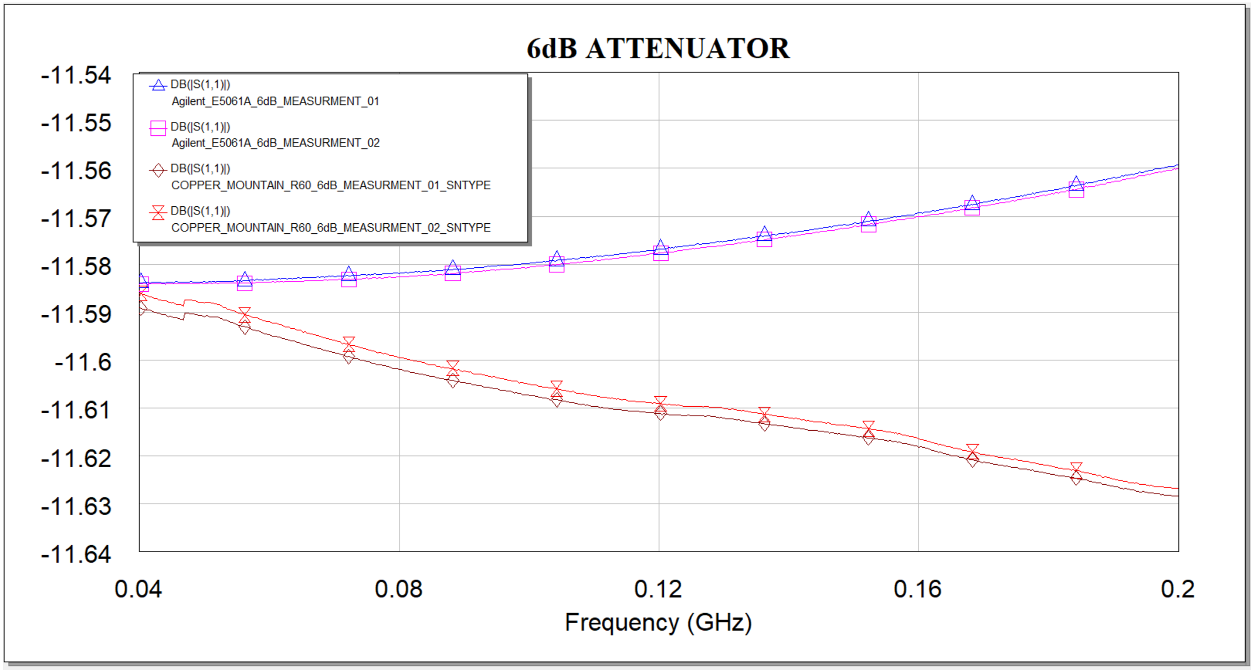

Figure7: Magnitude of the 6dB Attenuator after calibration. Copper mountain R60 measurement one brown trace, Copper mountain R60 measurement two red trace, Agilent measurement one blue trace, Agilent measurement two pink trace. The difference in repeatability between the two VNAs with the same settings is favoring the Agilent E5061A VNA due to closer tolerances and consistent curvature that is more predictable.

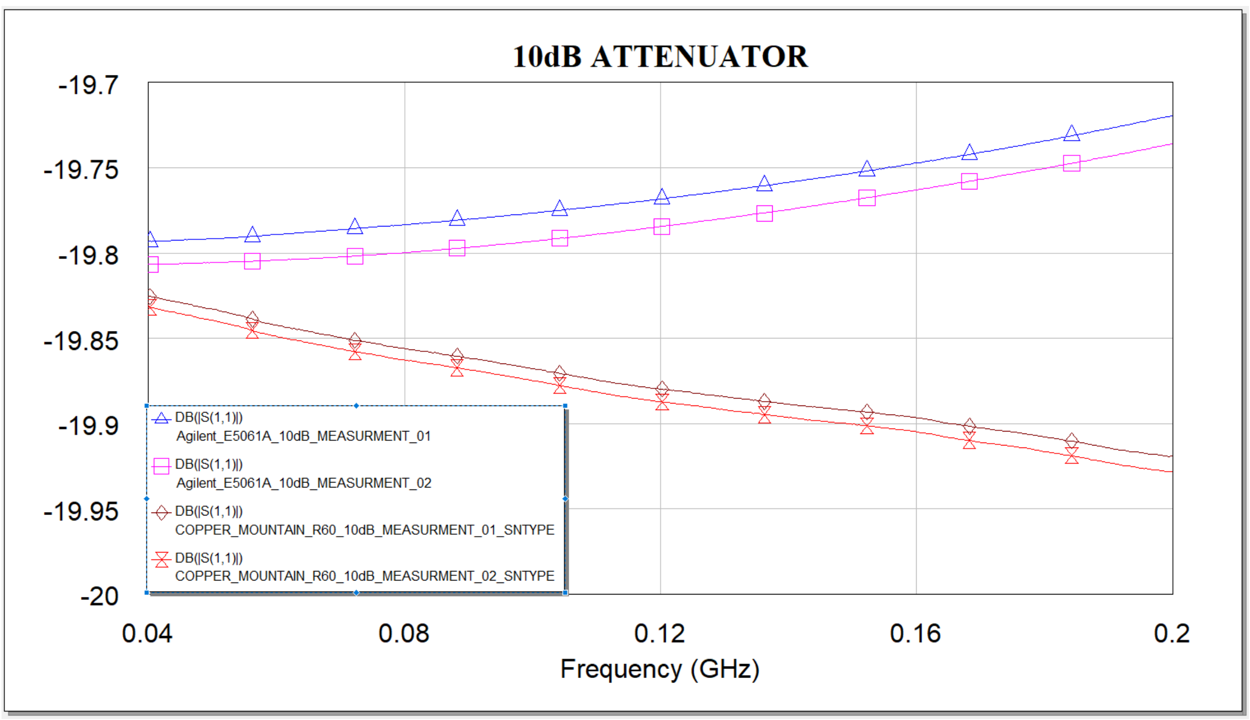

Figure8: Magnitude of the 10dB Attenuator after calibration. Copper mountain R60 measurement one brown trace, Copper mountain R60 measurement two red trace, Agilent measurement one blue trace, Agilent measurement two pink trace. The difference in repeatability between the two VNAs with the same settings is favoring the Agilent E5061A VNA due to consistent linear curvature that is more predictable.

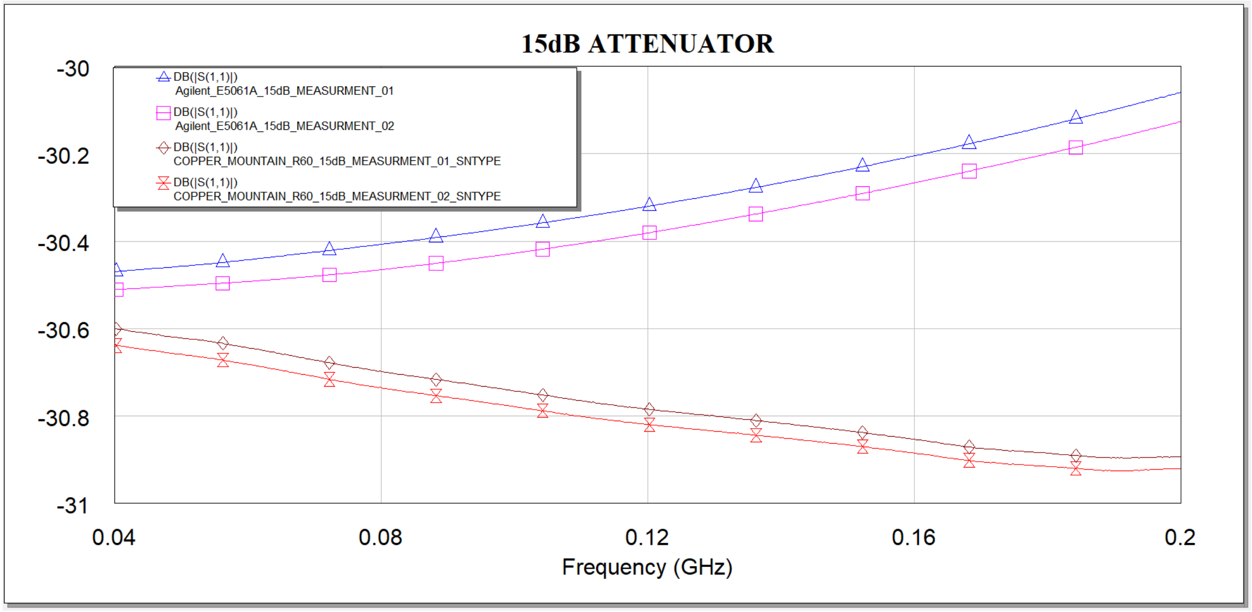

Figure9: Magnitude of the 15dB Attenuator after calibration. Copper mountain R60 measurement one brown trace, Copper mountain R60 measurement two red trace, Agilent measurement one blue trace, Agilent measurement two pink trace. The difference in repeatability between the two VNAs with the same settings is favoring the Agilent E5061A VNA due to consistent linear curvature that is more predictable.

Uncalibrated Measurements:

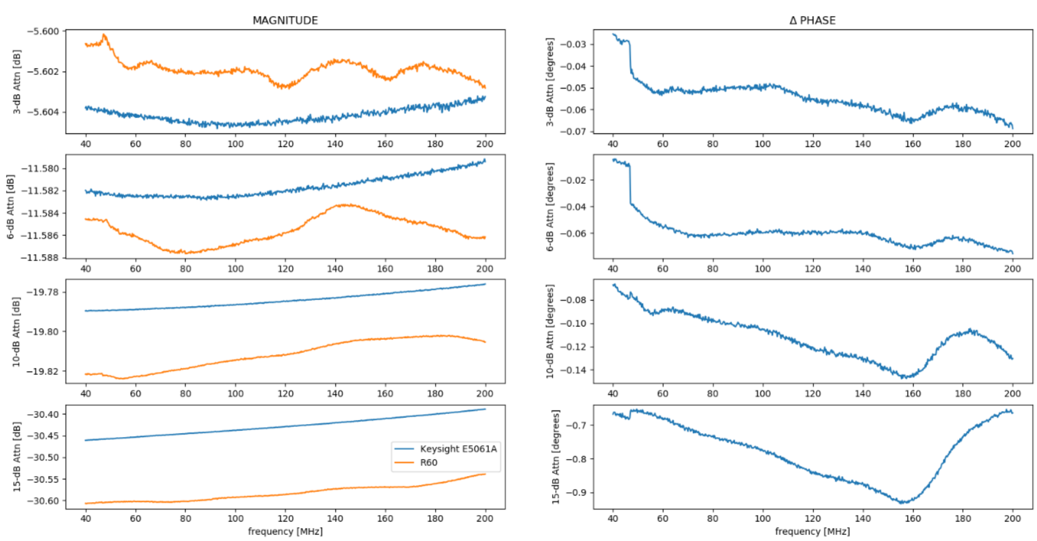

Figure10: Magnitude and Phase of Attenuators (3dB,6dB,10dB,15dB) Assuming coefficients (1, -1,0)

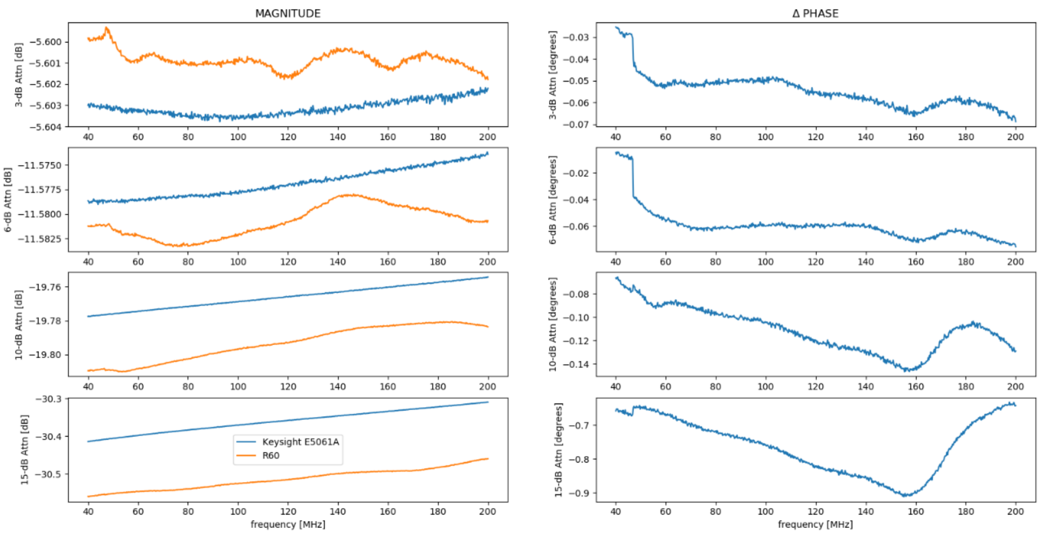

Figure11: Magnitude and Phase of Attenuators (3dB,6dB,10dB,15dB) Assuming coefficients of calibration kit 85033E

Discussion:

- After calibration, the measurements with the two VNAs show good agreement. For instance, for the 6-dB attenuator (-11.5 dB), the difference is at the 0.005 dB level. The differences in phase are also relatively low, although the devices measured have small values of phase. More tests could be done, with the attenuators at the end of a cable.

- The Copper Mountain (CM) VNA produces a difference with respect to the benchtop VNA, comparable to the largest difference I observed with the Field fox (about 0.02 dB at 100 MHz, and 0.07 dB at 200 MHz). With the Field fox this difference is reduced with averaging (to ~0.02 dB or less at 200 MHz).
  Some of the CM offset could be due to the fact that, as far as I can see, in the calibration, the two VNAs might not be using/applying the same parameters of the calibration OSL

- The sharp feature in the spectrum with the R60 at ~48 MHz is not completely removed with the calibration, which is more noticeable in the phase. But this residual effect is at a low level, and outside our "current" band. Again, I like a lot the low noise of the measurements with the R60.

- It is really just the spectral structure in the Copper Mountain measurement rather than the small offset with the Agilent that is most problematic or worrying. That little step is due to switching between a directly synthesized output and a mixed down output. Creating a broadband synthesized output requires switching between direct, divided and mixed down sources within the device. Factory calibration removes most of the amplitude variation but some small steps like this will remain. If you perform your own calibration this may disappear but keep in mind that our specification calls for +/- 0.4 dB accuracy in the range where the step occurs. That step is almost 100x smaller than our specification without any calibration.