VNA COMPARISON
PICO TECHNOLOGY VNA106 (DEMO) VS AGILENT E5061A

Leroy Johnson
Raul Monsalve

SESE, Arizona State University

May 20, 2019

Description:

- ➢ There is a new VNA available in our lab, a PICO TECHNOLOGY VNA106, and it was compared to the AGILENT E5061A, 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 (PICO TECHNOLOGY: 801 Points)
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:

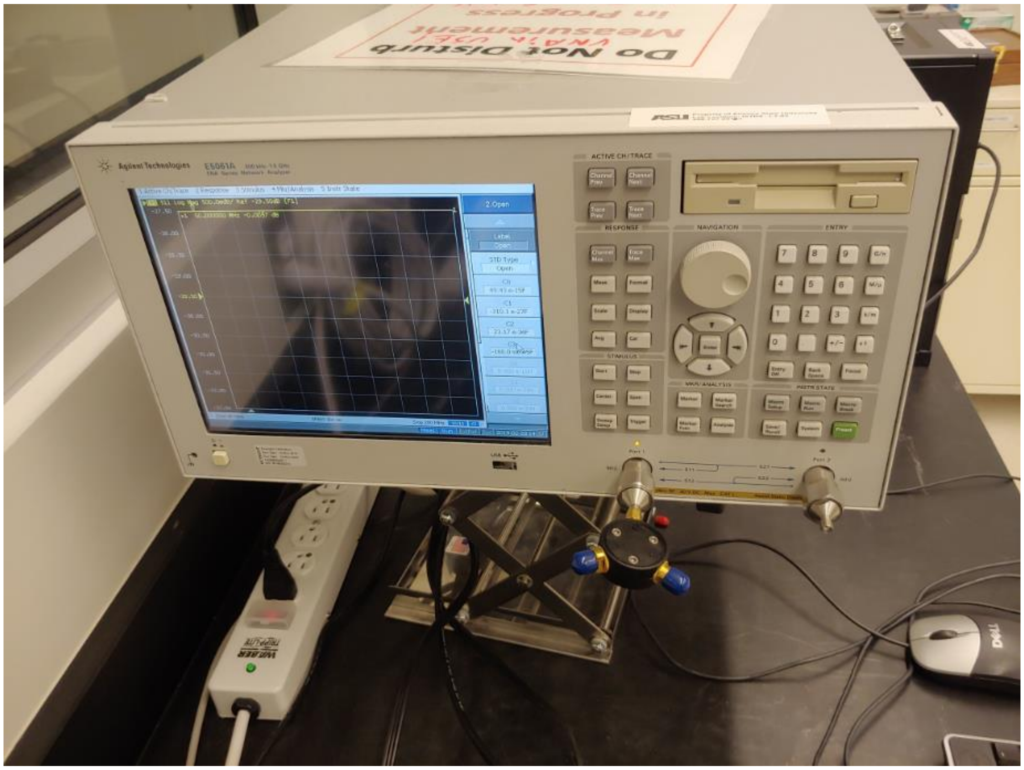

Figure1: AGILENT E5061A Calibration arrangement utilizing the male 85033E Calibration kit

Figure2: PICO TECHNOLOGY VNA106 Calibration arrangement utilizing the male 85033E Calibration kit

Results:

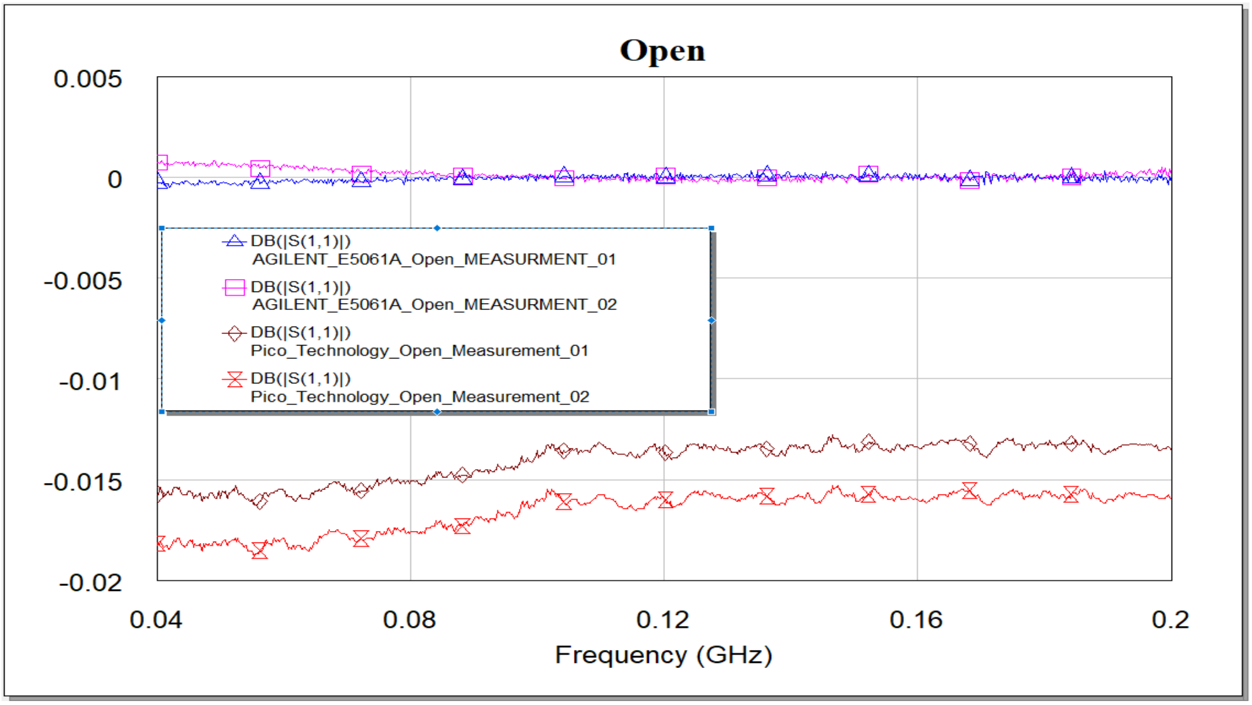

Figure3: Magnitude of the Open after calibration. PICO TECHNOLOGY VNA106 measurement one brown trace, PICO TECHNOLOGY VNA106 measurement two red trace, AGILENT E5061A measurement one blue trace, and AGILENT E5061A measurement two pink trace. The difference in repeatability between the two VNAs with the same settings is favoring the AGILENT E5061A VNA due to closer tolerances and consistent curvature.

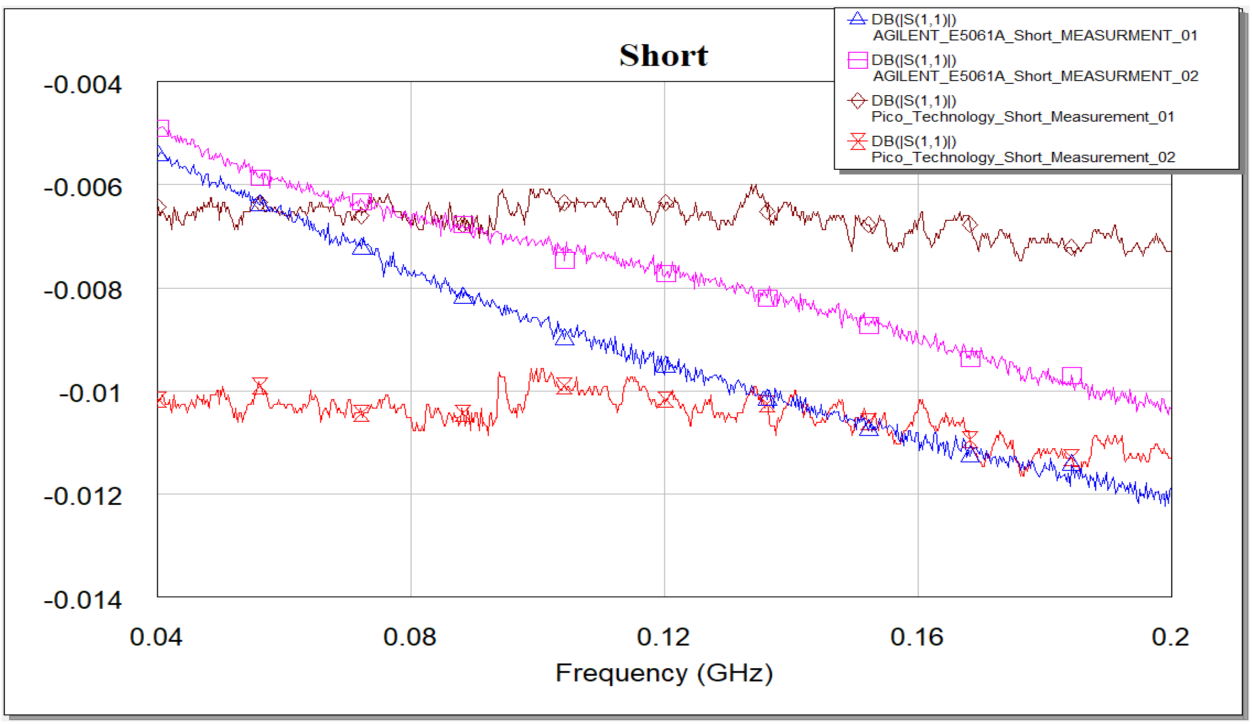

Figure4: Magnitude of the Short after calibration. PICO TECHNOLOGY VNA106 measurement one brown trace, PICO TECHNOLOGY VNA106 measurement two red trace, AGILENT E5061A measurement one blue trace, and AGILENT E5061A measurement two pink trace. The difference in repeatability between the two VNAs with the same settings is favoring the AGILENT E5061A VNA due to closer tolerances and less noise.

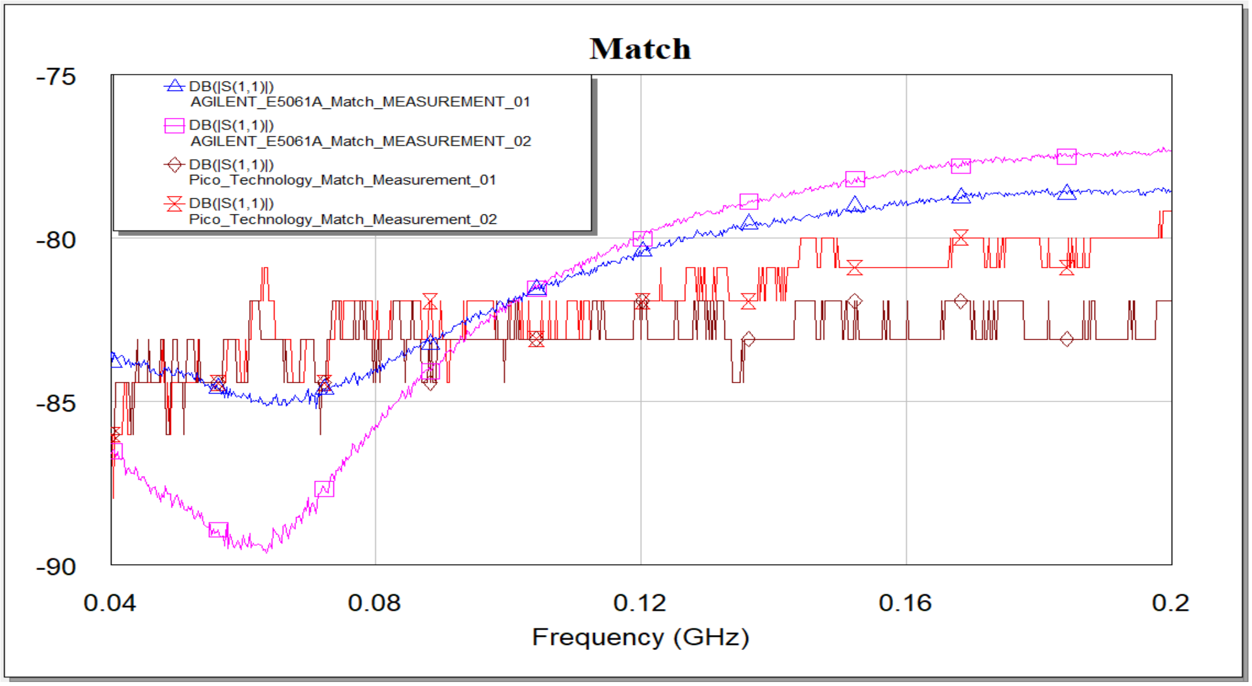

Figure5: Magnitude of the Match after calibration. PICO TECHNOLOGY VNA106 measurement one brown trace, PICO TECHNOLOGY VNA106 measurement two red trace, and AGILENT E5061A measurement one blue trace, AGILENT E5061A measurement two pink trace. The difference in repeatability between the two VNAs with the same settings is favoring the AGILENT E5061A VNA due to less ripples.

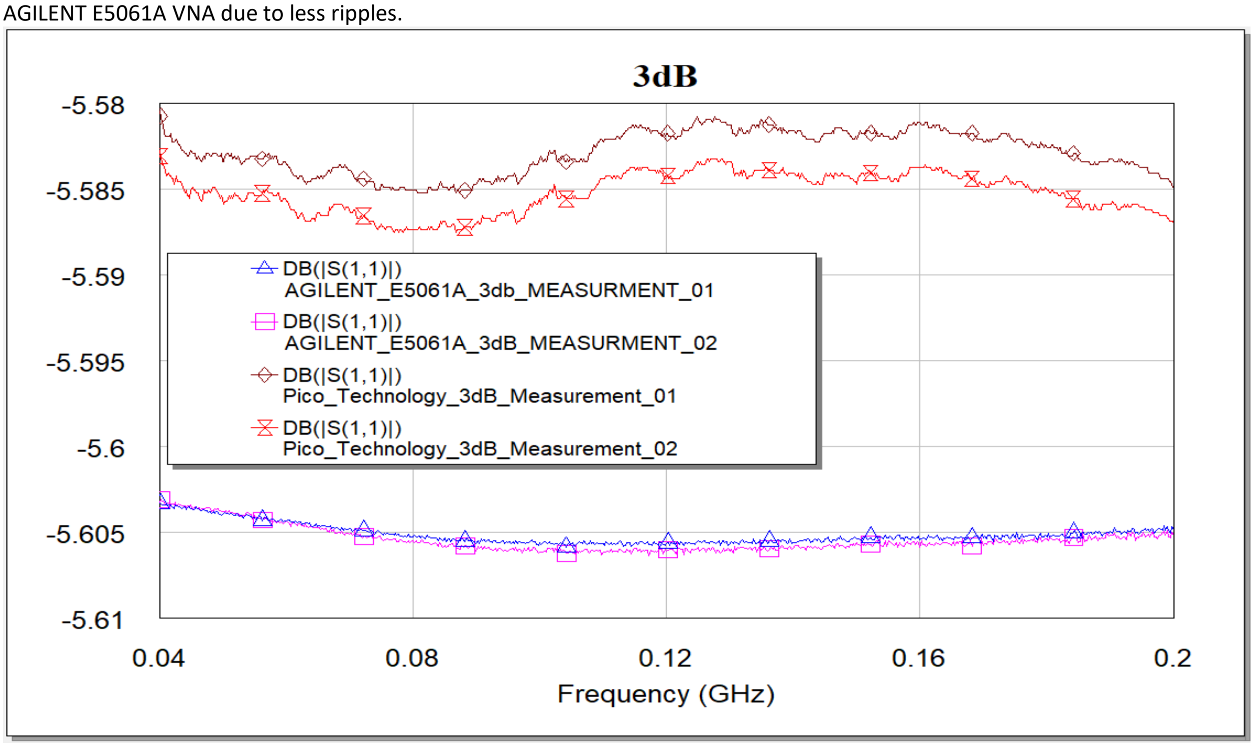

Figure6: Magnitude of the 3dB Attenuator after calibration. PICO TECHNOLOGY VNA106 measurement one brown trace, PICO TECHNOLOGY VNA106 measurement two red trace, and AGILENT E5061A measurement one blue trace, AGILENT E5061A measurement two pink trace. The difference in repeatability between the two VNAs with the same settings is favoring the AGILENT E5061A VNA due to closer tolerances and consistent curvature that is more predictable.

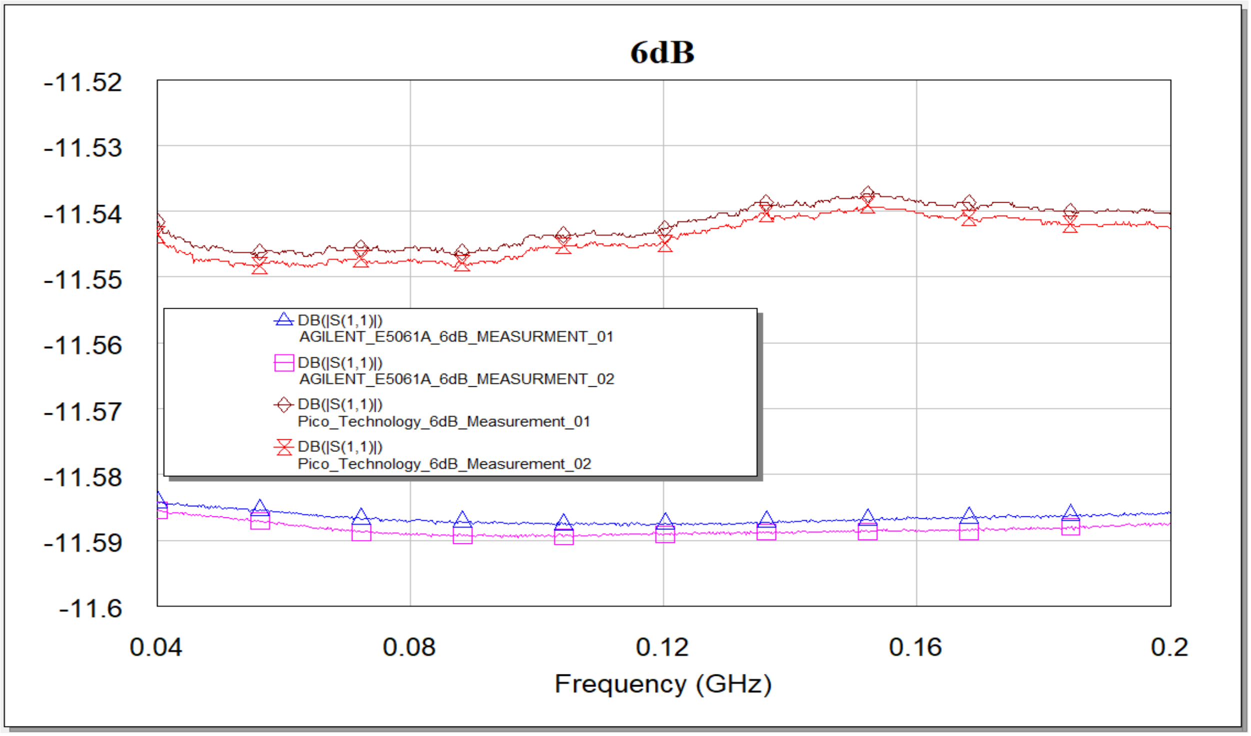

Figure7: Magnitude of the 6dB Attenuator after calibration. PICO TECHNOLOGY VNA106 measurement one brown trace, PICO TECHNOLOGY VNA106 measurement two red trace, AGILENT E5061A measurement one blue trace, and AGILENT E5061A measurement two pink trace. The difference in repeatability between the two VNAs with the same settings is favoring the AGILENT E5061A VNA due to closer tolerances, less noise, and consistent curvature that is more predictable.

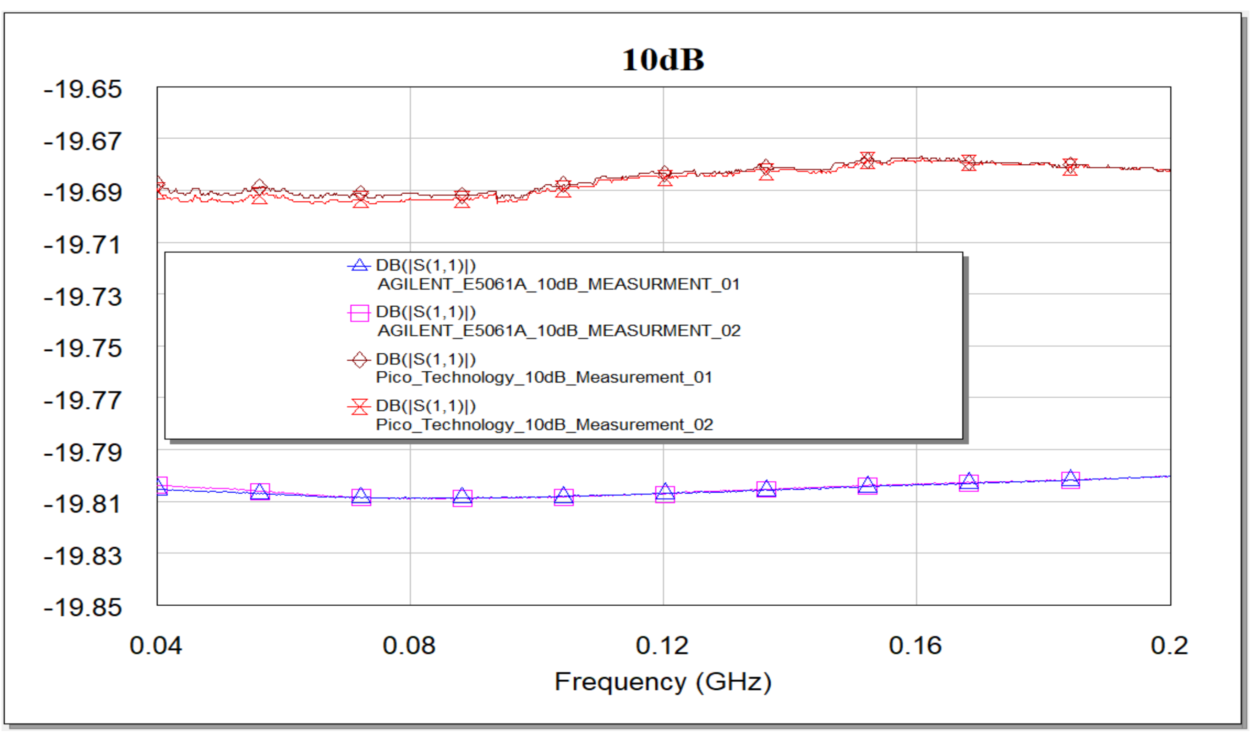

Figure8: Magnitude of the 10dB Attenuator after calibration. PICO TECHNOLOGY VNA106 measurement one brown trace, PICO TECHNOLOGY VNA106 measurement two red trace, and AGILENT E5061A measurement one blue trace, AGILENT E5061A measurement two pink trace. The difference in repeatability between the two VNAs with the same settings is favoring the AGILENT E5061A VNA due to consistent linear curvature that is more predictable.

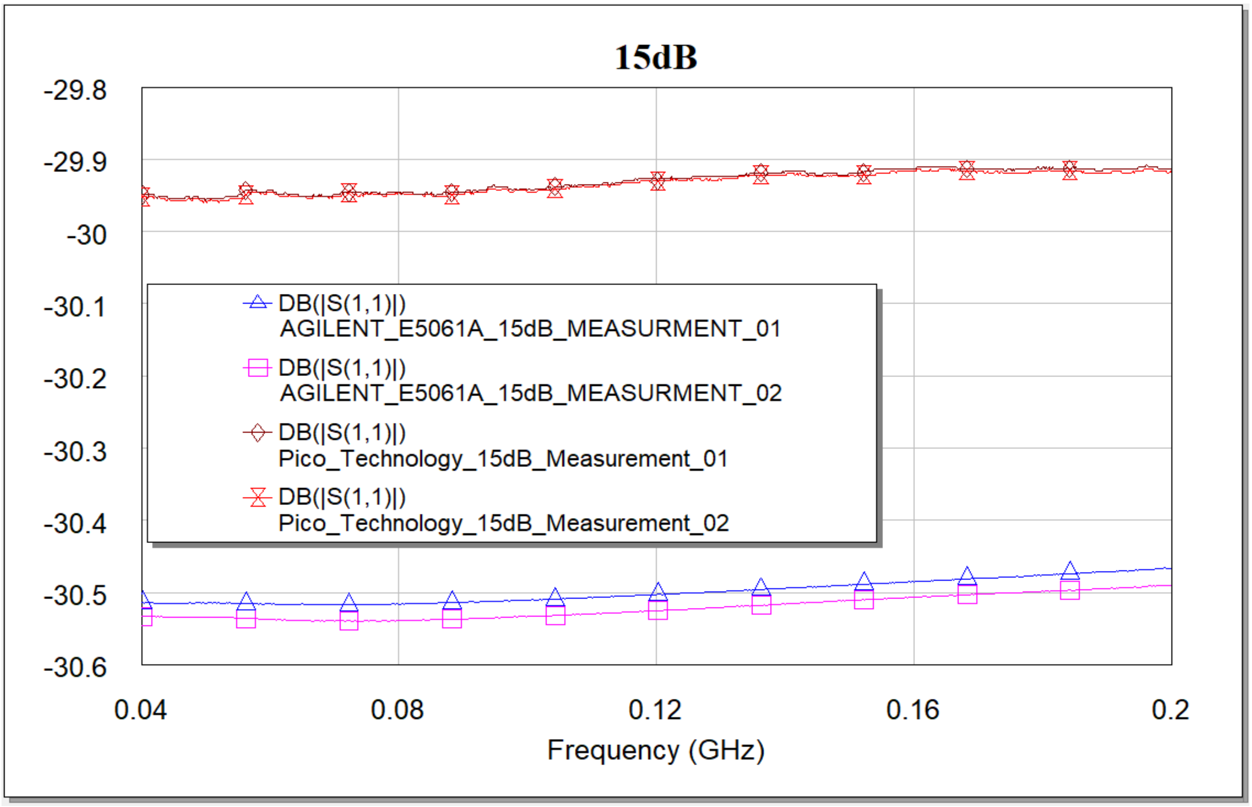

Figure9: Magnitude of the 15dB Attenuator after calibration. PICO TECHNOLOGY VNA106 measurement one brown trace, PICO TECHNOLOGY VNA106 measurement two red trace, AGILENT E5061A measurement one blue trace, AGILENT E5061A measurement two pink trace. The difference in repeatability between the two VNAs with the same settings is favoring the PICO TECHNOLOGY VNA106 VNA due to closer tolerances and consistent curvature that is more predictable.

Discussion:

- After calibration, the measurements with the two VNAs show good agreement not including the short and match measurements
- 3-dB attenuator (-5.581 dB), variance.018 dB
- 6-dB attenuator (-11.54 dB), variance 0.044 dB
- 10-dB attenuator (-19.69 dB), variance 0.11 dB
- 15-dB attenuator (-29.95 dB), variance 0.56 dB
- Overall, most measurements are precise to one another with slight variations.