VNA Accuracy Test 3

Raul Monsalve

SESE, Arizona State University

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Description

This test intends show that the measurements with the Agilent E5072A VNA are indeed very accurate.

In order to have a good reference when measuring the certain loads with our Agilent VNA, four attenuators were measured with a VNA that belongs to one of the Electrical Engineering labs, model HP8510C.

Sadly, due to certain restrictions in that lab, I could not operate the VNA myself and did not have enough freedom or time to perform all the tests I wanted with that unit. I was told that it was calibrated before I got there, and the measurements were done at the end of a cable.

The same loads were measured with the Agilent and then compared (Figure 1). The smoothness and flatness with the Agilent is better in general. The dubious behavior of the HP can be attributed to cable instability and use of a match standard not so close to 50 Ω. Also, there are obvious spikes on the trace that are due to the setup HP and not the loads.

However, this test was still useful since it allows to verify that good flatness can indeed be achieved with the Agilent VNA, and therefore the slopes or curvature that some loads evidence are real features.

Figures 2, 3, 4, and 5 show the reflection coefficient of several attenuators of different levels, along with a correction due an actual resistance of 50.01 Ω for the calibration match. The expectations at DC for these loads are also plotted, obtained from resistance measurements.

The VNA settings were:

- frequency range: 50 - 200 MHz
- resolution: 801 points
- power: 0 dBm
- bandwidth: 100 Hz
- averaging: no

The trace of most of these loads has a slope, but not much additional curvature. Some are very flat, which suggests that the measurement is being conducted properly.

VNA comparison

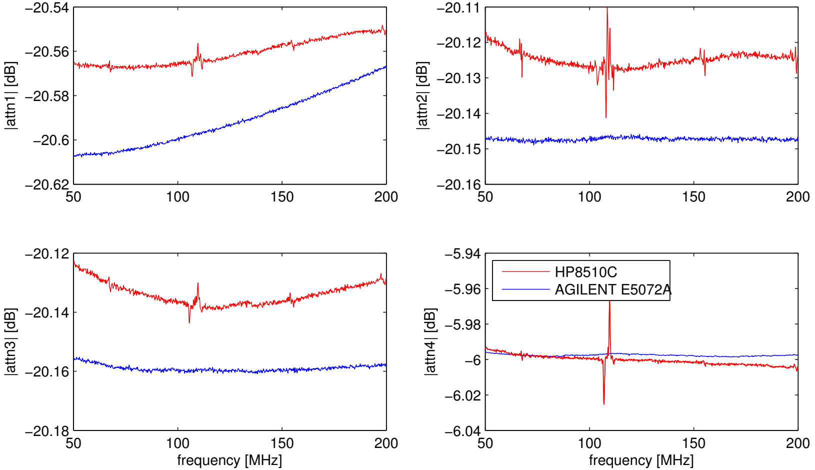

Figure: (1): The measurements with the HP8510C are worse than those with the Agilent. They were done at the end of a cable, which could have introduced error. I did not participate in the calibration and therefore cannot comment on its quality. There are notorious spikes introduced by the instrumentation. An any case, the Agilent is capable of reporting very good flatness for some loads, which suggests that the curvature we see in the other cases is probably real.

New Measurements

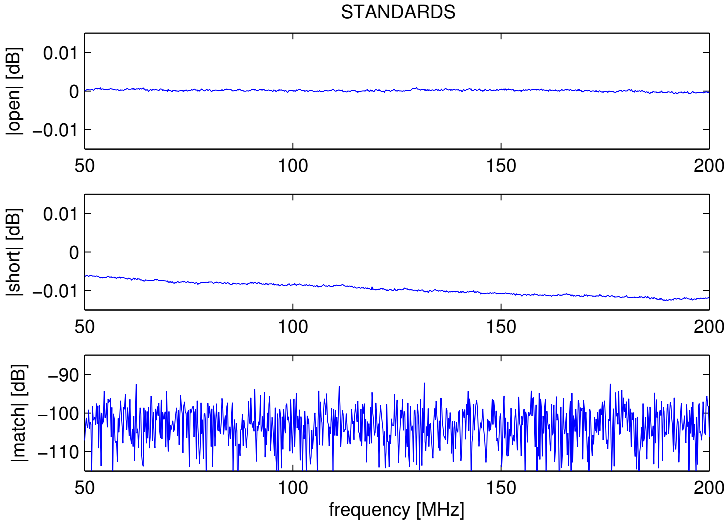

Figure: (1): After verifying that the Agilent VNA is capable of reporting good flatness, a new set of measurements was performed. The VNA was calibrated with the Agilent 85033E calkit and the settings on page 2. Afterwards, the same standards were measured. In this occasion, the magnitude of the *match* is very flat. Its DC resistance was 50.01 Ω.

New Measurements (Low Attenuation)

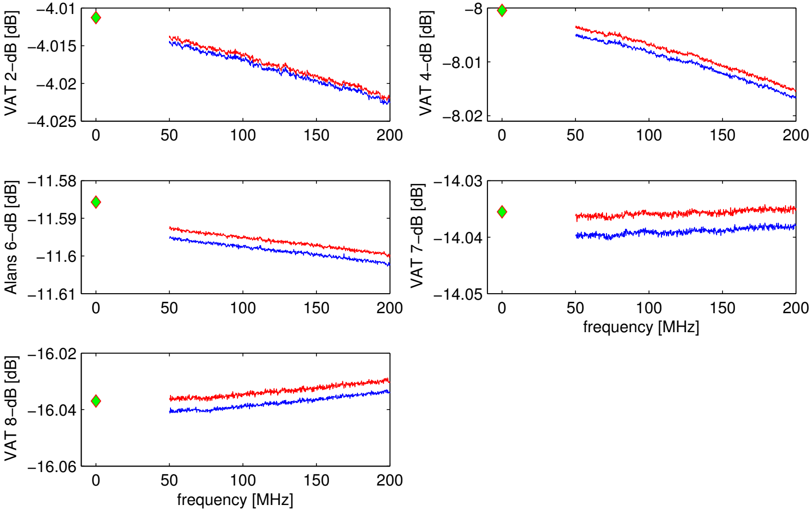

Figure: (1): Attenuators measured with the Agilent VNA (low attenuation). Their magnitudes have different slopes in frequency. The blue trace is the raw measurement and the red trace is after correcting for imperfect match. The green diamond is the expectation at DC. Visual inspection indicates that the correction improves the accuracy if the traces were projected to DC. Vertical label corresponds to the model of the attenuator.

New Measurements (10-dB Attenuators)

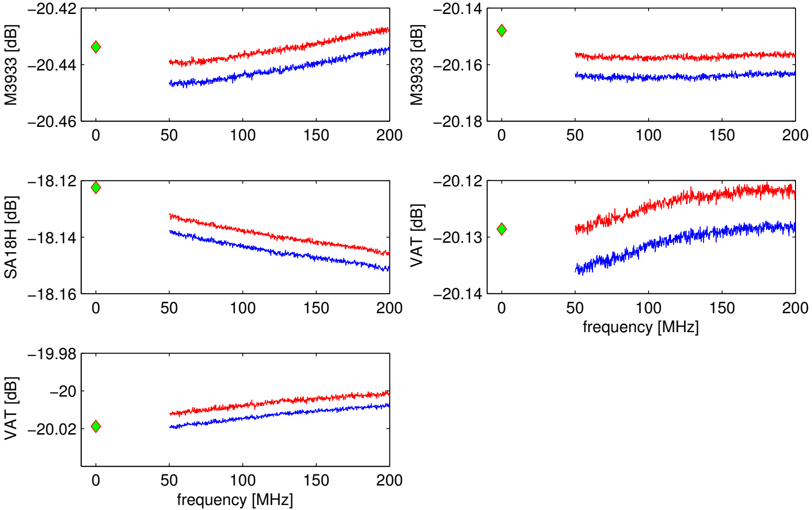

Figure: (1): Attenuators measured with the Agilent VNA (10-dB). Their magnitudes have different slopes in frequency. The blue trace is the raw measurement and the red trace is after correcting for imperfect match. The green diamond is the expectation at DC. Visual inspection indicates that the correction improves the accuracy if the traces were projected to DC. Vertical label corresponds to the model of the attenuator.

New Measurements (20-dB Attenuators)

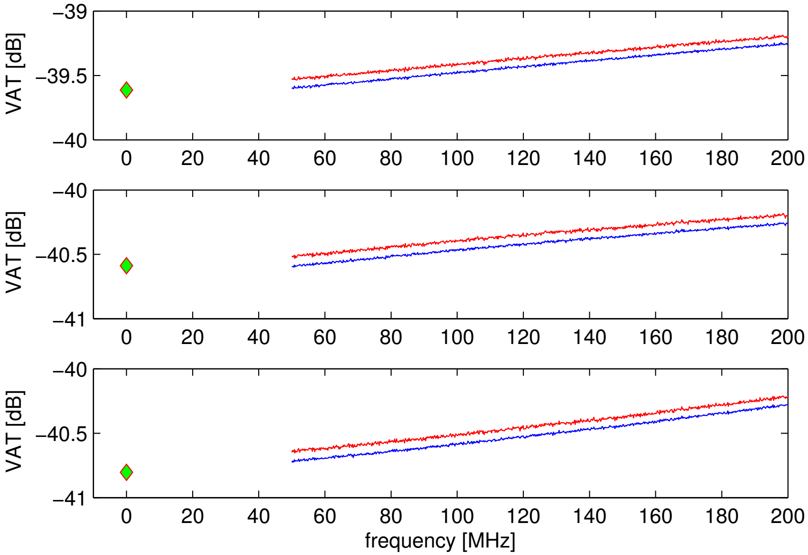

Figure: (1): Attenuators measured with the Agilent VNA (20-dB). The blue trace is the raw measurement and the red trace is after correcting for imperfect match. The green diamond is the expectation at DC. Vertical label corresponds to the model of the attenuator.

Conclusion

The shape of the trace measured with the Agilent VNA is representative of the load, at the very least with the settings presented here. Therefore, this unit can be used to demonstrate the method of frequent calibration at the end of a long cable with standards/loads whose temperature is varying.

The accuracy obtained with this VNA needs to be transfered to the measurement with the R&S portable unit we use for measuring the antenna, whose intrinsic accuracy is worse.