

# Connector Pin Recession and its Effect on Network Analyzer Accuracy

## White Paper

The apparent effect of a recessed connector upon network analyzer measurements is often talked about, but without any quantitative measurements it is very hard to either predict or correct for the resulting errors. This article outlines an experiment undertaken to assess the impact on the measurement of reflection coefficient when using 3.5 mm connectors.

### Why?

The ideal connector would not produce any discontinuities in the transmission line. In reality, as a result of their dimensional tolerances, there will normally be some small gap between mated connectors. This gap is often referred to as recession and it may be both or just one of the mated connectors which are recessed. The opposite of recession, protrusion, is likely to cause mechanical damage to 3.5 mm devices unless the mating connector is at least equally recessed and is undesirable. The electrical effect of recession is to produce a very short section of line having different impedance characteristics due to the difference in diameter of the center conductor and the exposed part of the connecting male pin. The theoretical effect of this change in diameter could be calculated but because there are many more effects in operation with such a short length of line, it is simpler to assess practically.

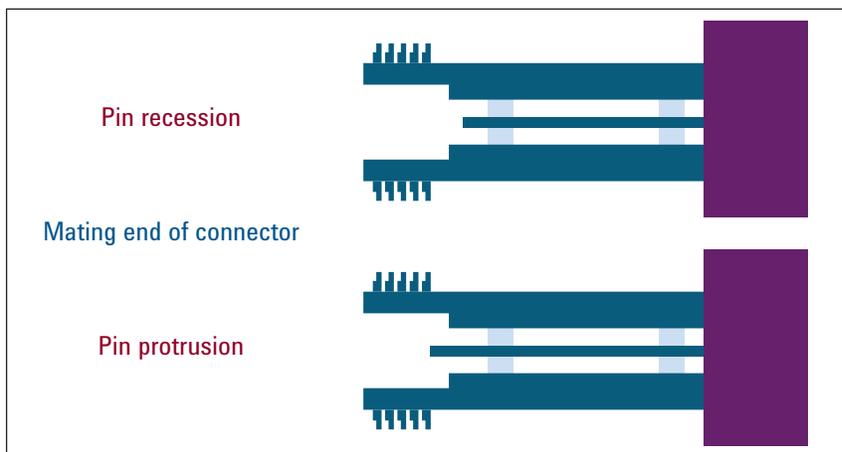


Figure 1. Connector recession defined

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## Procedure

The measurements were performed using an HP8722D Vector Network Analyzer over the range 3 GHz to 27 GHz at 1601 trace points and with the bandwidth set to 300 Hz. Calibration (network analyzer error correction) was performed using an HP85052B Precision-grade Calibration Kit. Three separate calibrations were performed; first with the sliding load set to zero recession, another with it locked at 2.5 thousandths of an inch (0.0025") recession, and finally with 0.005" recession.

It was important that the characteristics of the item to be measured remained stable throughout the test, even though the connector's pin recession was to be varied. The item selected for this task was another 3.5 mm sliding load (HP911D); the type where the connector recession can be adjusted using a small screwdriver. This enabled the connector recession to be precisely incremented from zero to 0.005" in steps of one thousandth of an inch without damaging any of the components involved in the tests.

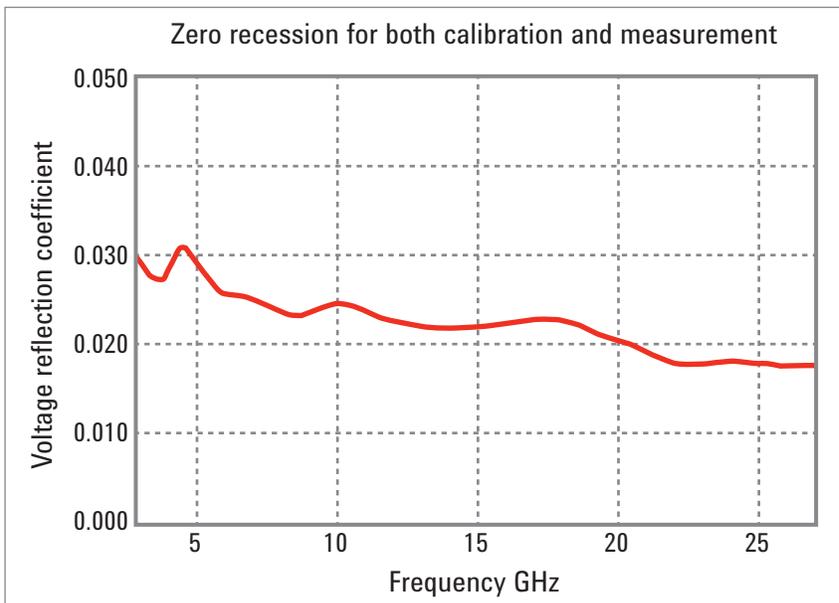


Figure 2.

**Figure 2** forms the reference for the following measurements and is shown on all plots as the red line. It was performed with both the calibrating and measured sliding load set to zero recession. This is considered to be the correct representation of the voltage reflection coefficient (VRC) of the tested sliding load.

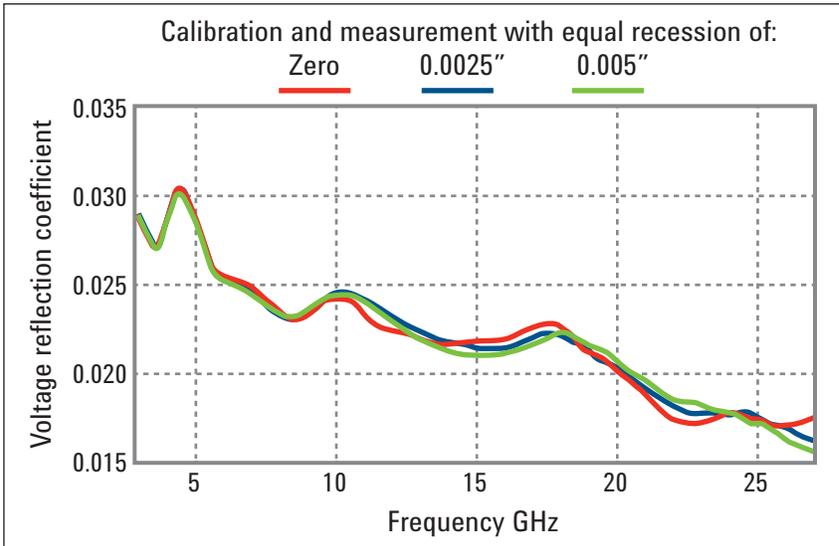


Figure 3.

When the significance of recessed connectors was more generally recognized, it was suggested that if the test port of the network analyzer were also recessed and the calibrating and measured devices had equal recession, then a "good" measurement could still be performed. Whilst it is no easy task to recess the network analyzer's test port connector, it is possible to recess the calibration and measured devices. **Figure 3** seems to prove that as long as the recession is the same during calibration and measurement, the results are very similar. The small deviations seen (in the order of 0.0025 VRC) could be accounted for by the unrepeatability of the connectors and possibly because the reference short and open circuits were not recessed by the same amount as the sliding load.

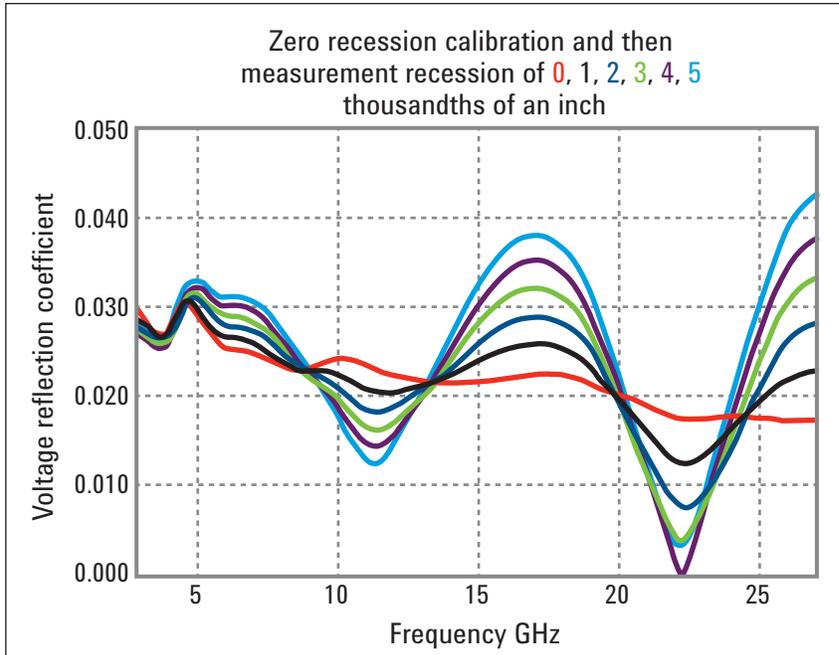


Figure 4.

**Figure 4** shows an ideal calibration performed with no recession and the measured load adjusted in 0.001" increments from zero to 0.005". At approximately 22 GHz it is apparent that the predictability of the results changes. As the recession continues to increase, the VRC reaches a minimum and starts to return towards its original value.

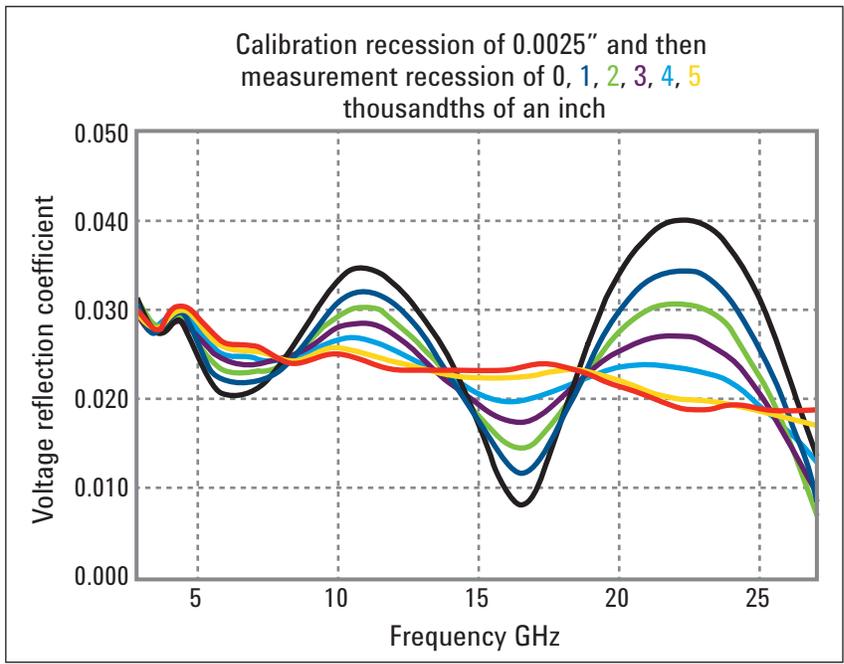


Figure 5.

**Figure 5** is similar to **Figure 4** but with the errors "reversed". With 0.005" recession during calibration then zero recession during measurement, the effect is similar to that for a connector with protrusion (providing the test port has sufficient recession to avoid damage). However, the peaks occur where the troughs were positioned in the previous chart.

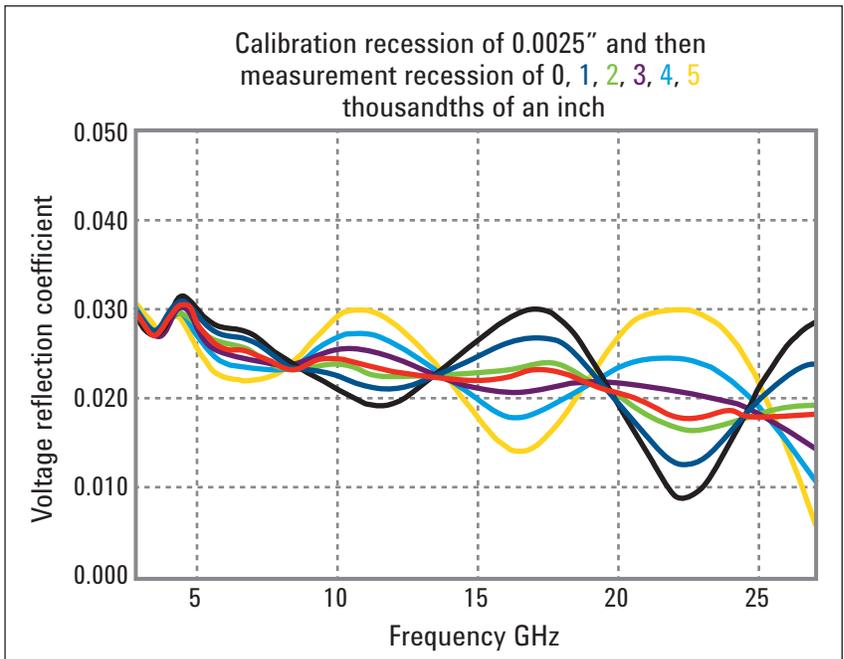


Figure 6.

In **Figure 6**, recession during calibration was set midway between the extremes of recession for measurement. This produced a plot that resembles an amplitude-modulated signal and clearly shows the combination of the plots from **Figures 4/5**.



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## Conclusions

The results are modified by approximately the same degree but in the opposite direction depending whether the calibrating, or measured, sliding load connector was recessed. The small differences are possibly due to the open and short not being recessed. In addition, the uncertainty due to use of the connector dial indicator gauge to set the recession has an effect on measured values.

### A Rule-of-Thumb:

- Recession reduces effective directivity by about 0.005 VRC per 0.001 inch.
- That is equivalent to a typical directivity of 46 dB being reduced to 40 dB with 0.001 inch recession, or to 30 dB with 0.005" recession.

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