The TRL Calibration Method

What do we mean by TRL??

Most engineers understand what TRL means and what it is for...Through - Reflect - Line: network analyzer calibration method. In other words, we use three calibration standards, connect them successively to the VNA and its software computes the error model, which allows us to measure at the coaxial, or wafer probe reference plane.
The TRL of Network Analyzers

First there are still some rumors about this method: that we can calibrate only for a fmax/fmin ratio of up to 8:1, i.e. the range for which the delay (line) has a transmission phase between about 15 and 170 degrees: This is not accurate any more!

There is no minimum frequency for the TRL equations to be solved. The above recommendation originates from the 70's where TRL was first introduced and most people used frequency sweepers, instead of synthesizers, as VNA sources.. in this case the phase of the signal had a jitter and could not be kept stable, so, in order to be on the safe side, a high minimum frequency had to be used, in order to avoid a negative transmission phase of the delay line "minus" the phase of the through line, due to frequency drifts of the sweeper... Since that time very stable synthesizers have been introduced as signal sources in Network Analyzers and this requirement is not valid any more. So, there is no need for fmin. We at Focus have been verifying this experimentally since the end of the 80's and use this fact to calibrate any Anritsu, Rohde&Schwarz or Agilent VNA from 0.03 to 65 GHz respectively using a single delay line. The only limitation is the fmax: When the transmission phase of the delay line exceeds 180° we normally get an erroneous phase jump of 180°. But this condition can easily be respected if we choose the length of the delay line to be lambda quarter at the center frequency of operation.

The TRL of Focus

There is also the TRL method developed and used by Focus. This technique is more generic than the "VNA" TRL algorithm. It does not need any information about the nature of the delay line, its mechanical or electrical dimensions etc. The only information needed (which is also needed by the Network Analyzers) is its characteristic impedance Zo. This impedance can, by the way, be different from the remaining parts of the network, those being microstrip sections of a fixture or wafer probes with characteristic impedances of 50 Ohm OR NOT. In other words Focus' TRL method will compute the network S-parameters of any test fixture, using input and output sections with different characteristic impedances among themselves and different from the characteristic impedance of the delay line. As an example Focus TRL method will determine exactly the S-parameters of a structure using: One 50 Ohm microstrip, one 20 Ohm transformer and one 30 Ohm delay line (=Zo), just to name the most general case. In this case the S-parameters will be calculated normalized on 30 Ohms.

Once this Focus TRL has been used to characterize the probes the data can be used for S-parameter measurements at the probe ref. plane or for Load Pull de-embedding.