Application Note

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Performing Sequential Peeling Extraction and De-Embedding with an Anritsu ShockLine™ Vector Network Analyzer

Sequential peeling is a network extraction tool used for identifying and removing subsets of a structure that behave as localized pseudo-lumped-element reflection centers. It is particularly useful for electrically small structures with runs of transmission line, such as PC boards with isolated vias in the transmission lines. Sequential peeling identifies time domain elements and then fits a shunt admittance or series impedance model to the isolated data. For each lumped element, an .s2p file is generated that can be de-embedded to get between lumped defect areas. Once a series of these elements are identified, a more complete composite model of the structure can be obtained and de-embedded. This application note will examine some of the steps in the sequential peeling process.

For this application note, a ShockLine MS46524B 43.5 GHz (option 43) vector network analyzer (VNA) with time domain (option 002) and universal fixture extraction (option 024) was used. The example is based on a Wildriver Technology demo board CMP-28 2.4 mm connector with four vias, as shown in Figure 1.

Procedure

1. Connect K-V adaptor on each test cable
2. A full two-port SOLT calibration is performed by the 3654D V calibration kit on a ShockLine MS46524B using the V(F)-V(F) (34733) barrel with 24.15 mm as a thru
3. Frequency is from 50 MHz – 40 GHz with 800 points

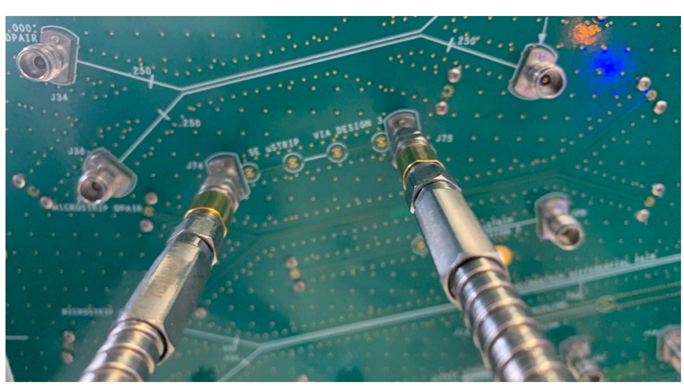

Figure 1: Picture of the transmission line with vias showing the cable connections. A V coaxial calibration was performed at the end of the cables

If one looks at the initial time domain representation (Tr3 as shown in the second plot in Figure 2), one can see the first via appearing near 76.22 ps. The frequency domain response shows a complex standing wave pattern due to all of the reflection centers and a worst-case reflection coefficient of about -1.6 dB (see Tr1 as shown in the first plot in Figure 2).

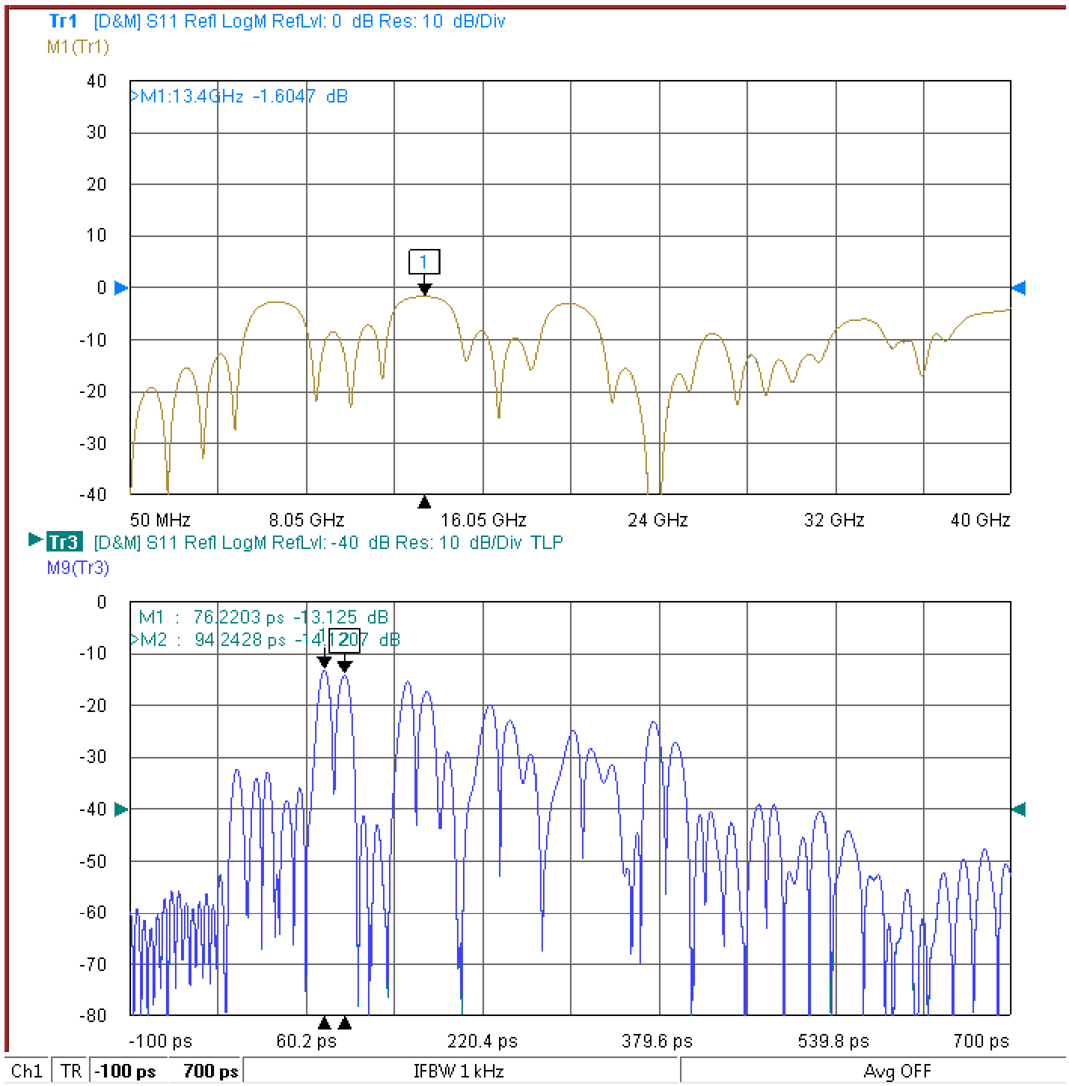

Figure 2: Original frequency and time domain responses of the transmission line with vias under study

The peeling process was initiated with a series-Z selection (since the defect was known to be inductive) and the 76.22 ps location was entered (while this choice is clearly dominant, 0 could have been entered to trigger the auto-selection routine). The resulting .s2p file and lead-in transmission line (76.22 ps converted to air-equivalent length = 22.8 mm) was de-embedded by selecting **Calibration Menu > De-embedding Tools > Sequential Extraction (Peeling)** (Figure 3). (Note: delay * speed of light = electrical length.)

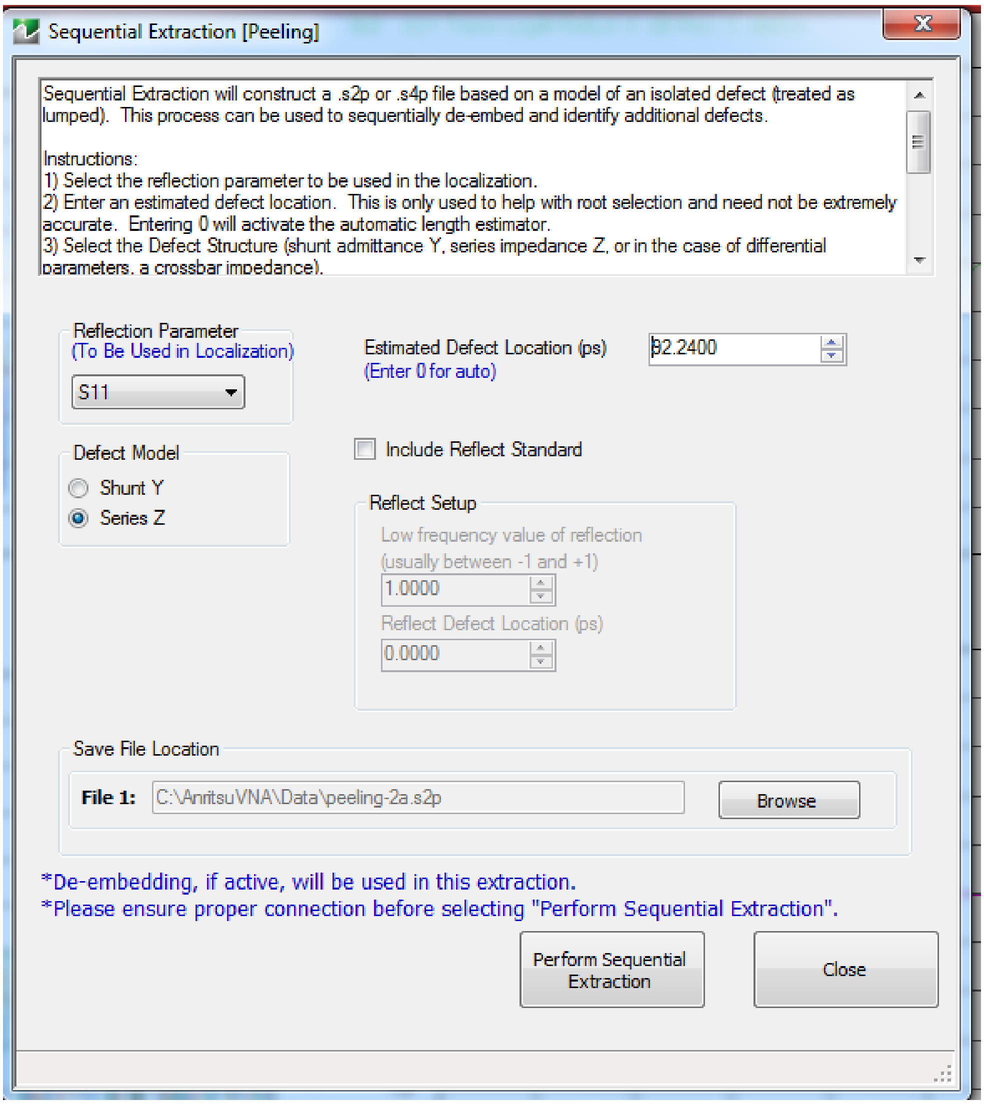

Figure 3: Dialog for the peeling extraction

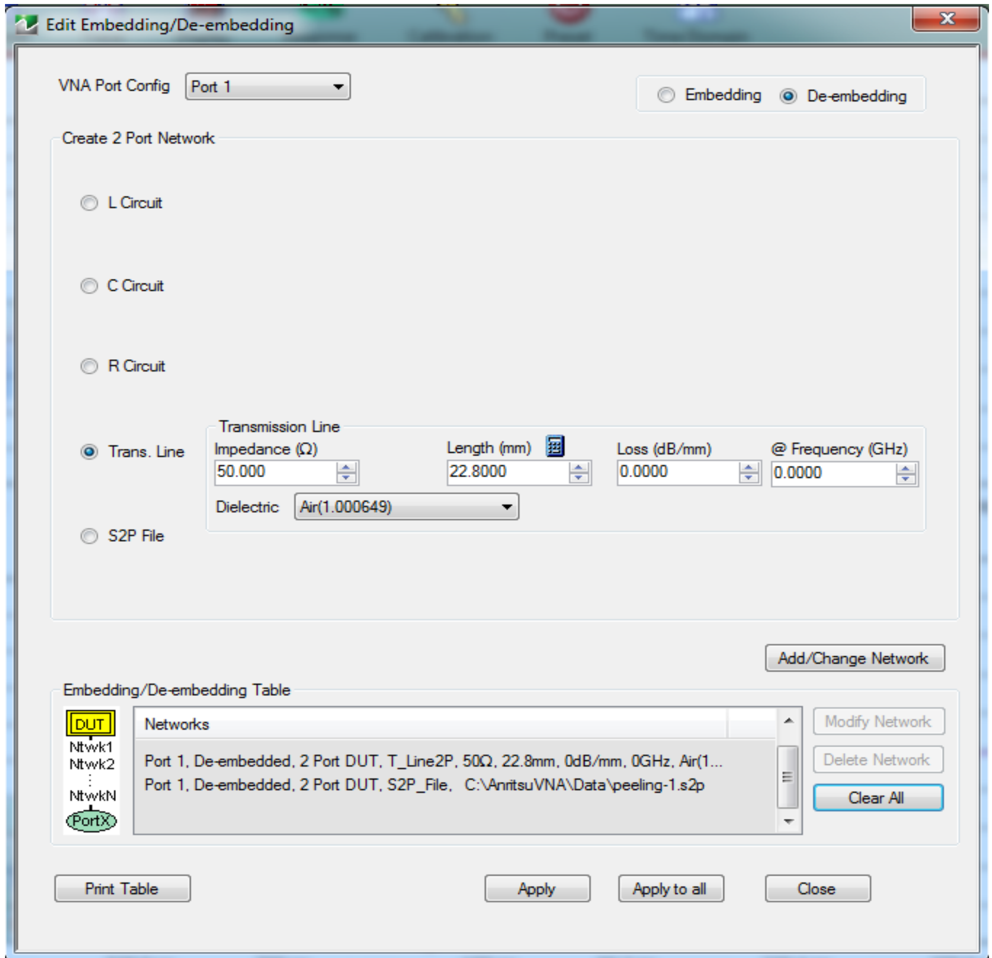

Figure 4: De-embedding dialog to remove the first peeling step

Figure 4 shows the dialog for de-embedding the .s2p file generated using the Figure 3 dialog. Note in particular that the .s2p files that are saved do not include positional information. It is important to move the reference plane to where the defect is (see Figure 4 for the check on “Trans. Line” where the reference plane has moved to 22.8 mm location). The .s2p file just characterizes the reflection center. Now if de-embedding is applied, the responses seen in Figure 5 appear as live traces (with the original data in memory). The frequency domain reflection peaks have dropped by at least 7 dB and the initial time domain impulse response is suppressed.

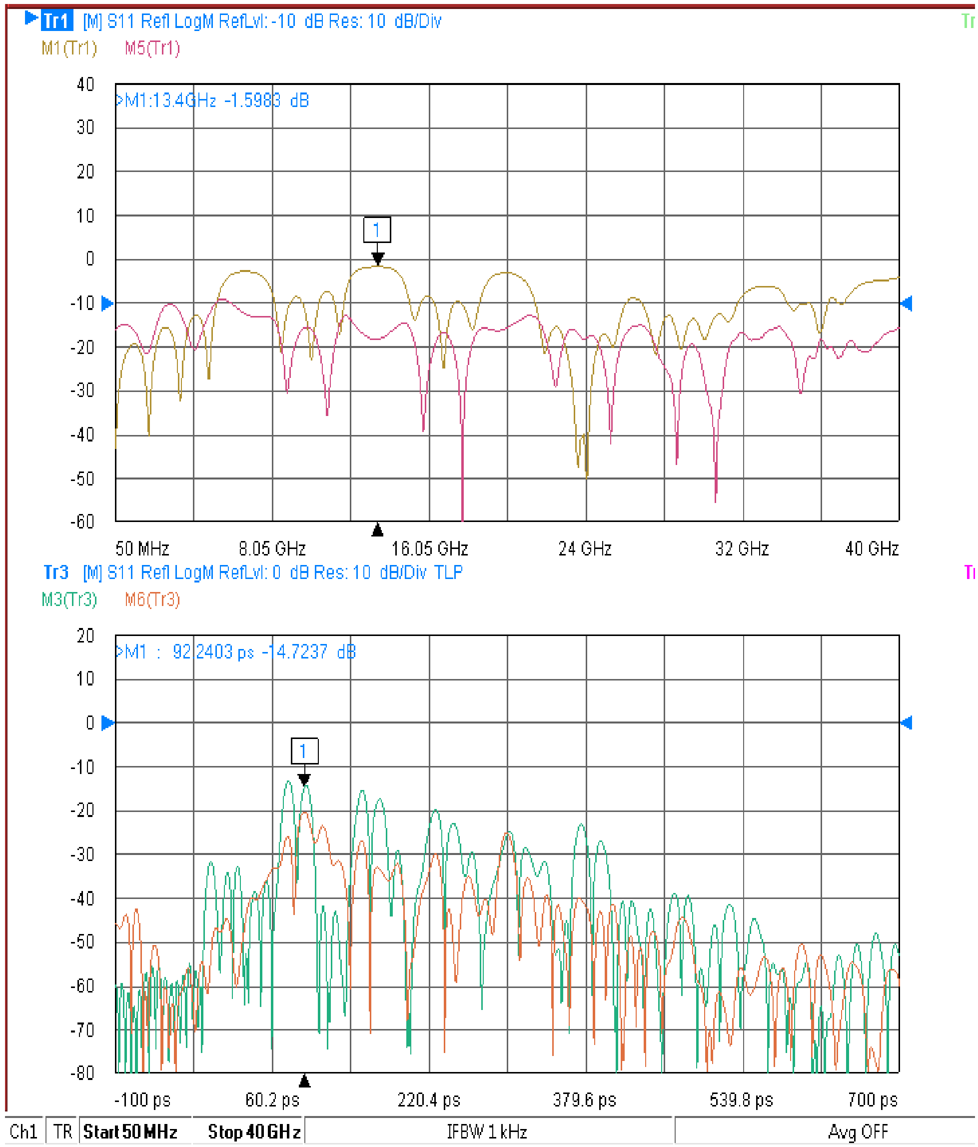

Figure 5: Frequency and time domain responses of the original structure (brown and olive green, respectively) and after de-embedding the first peeling step (orange-red and orange,

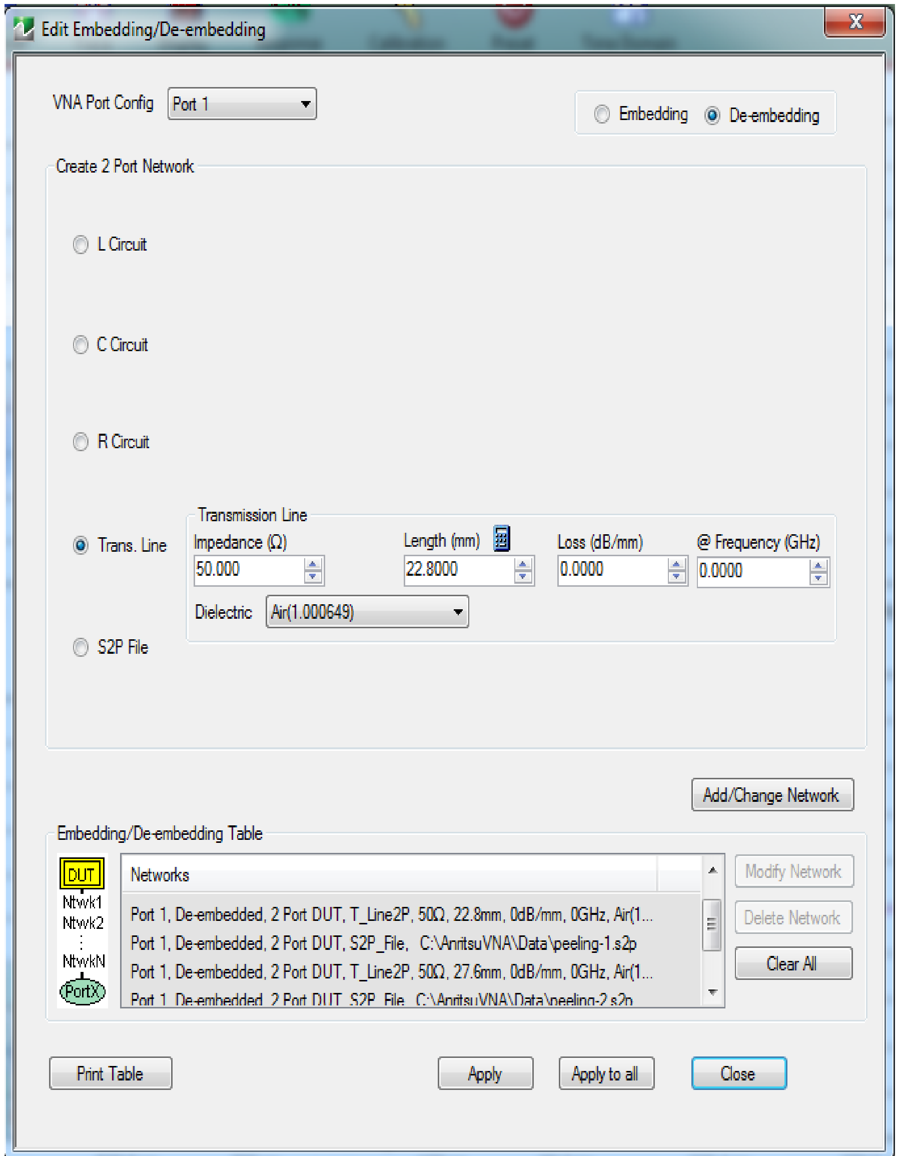

Figure 6: De-embedding dialog with both first and second steps applied

De-embedding was applied and the frequency domain responses for all three configurations are shown in Figures 7 and 8. The main reflection peaks have been heavily suppressed (in Figure 7, the blue curve on both Tr1 in the upper plot and Tr3 in the lower plot) as we have de-embedded some dominant reflection centers. In Figure 8 (the impedance profile), the vias have been de-embedded after the sequential peeling method (purple vs. brown curves). Certain other responses do increase in value since now reflections deeper in the structure are interacting with the launch reflection thus altering the frequency distribution. Also the extraction is not perfect since the vias likely have some distributed characteristics and thus cannot be completely described by the simple series-Z model used in this exercise. For fixtures with very distributed reflection centers, the peeling method will be less successful.

Finally, the impedance measurement after peeling clearly shows the impedance for the vias has been de-embedded.

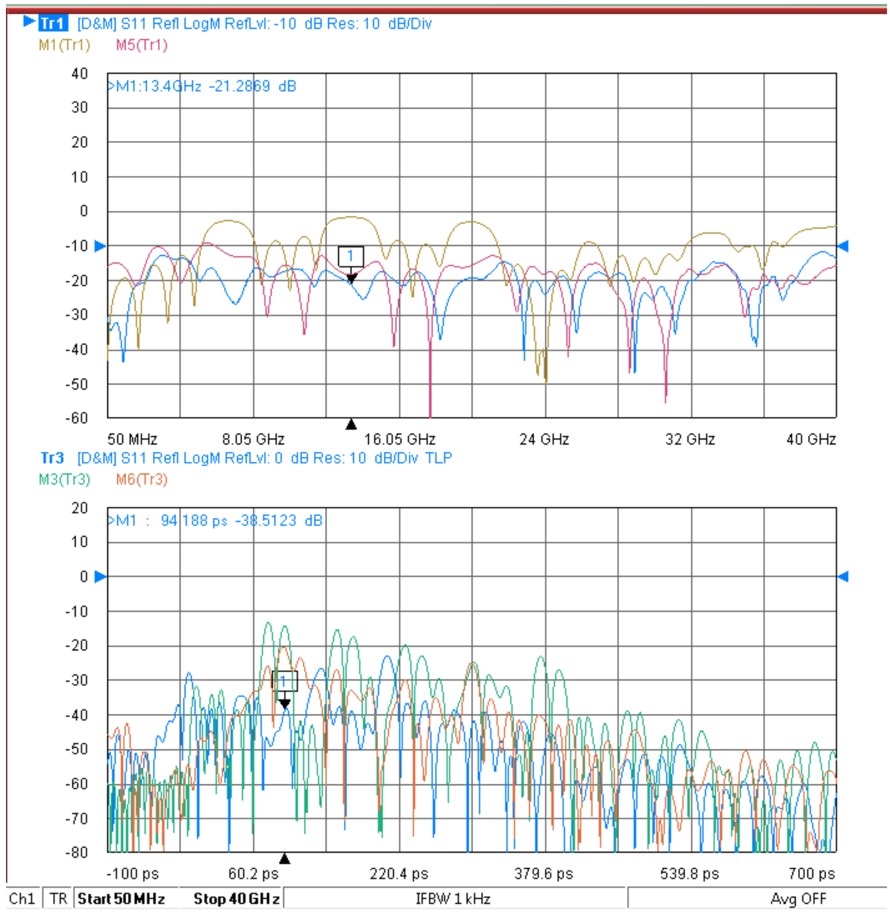

Figure 7: Results of the frequency domain response of the original structure (brown), with the first peeling step de-embedded (orange), and with both first and second steps de-embedded (blue).

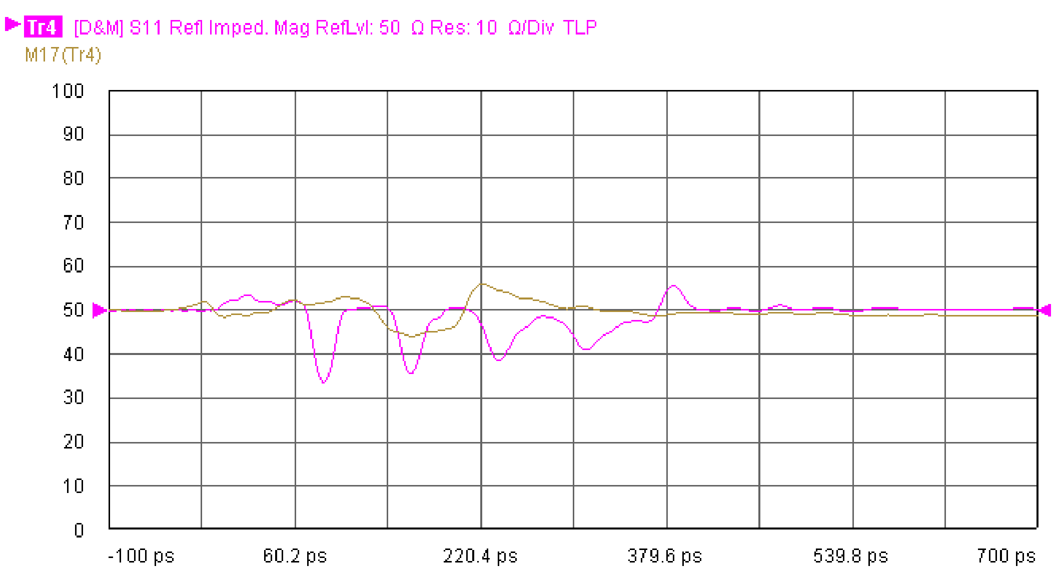

Figure 8: Impedance measurement after peeling (purple is before peeling and brown is after)

Summary

The sequential peeling network extraction tool is an effective and simple solution that enables users to de-embed subsets of structure that behave as localized pseudo-lumped-element reflection centers. This is particularly popular for electrically small structures (e.g., on-wafer) of those with runs of transmission line punctuated by electrically small structures (e.g., PC boards with isolated vias or studs in transmission lines). This process is based on reflection measurements only and does not work well with insertion loss measurements.

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