Performance Analysis of a Partitioned Via

Background

As a consequence of the difficulty, expense, and unrepeatable nature of backdrilling vias a manufacturing process of partitioning a via has been proposed. The via has a plating resist applied just below the must not cut layer and this prevents galvanic conduction of current through the stub. The stub will however be capacitively coupled to the pad. This is an analysis of the Signal Integrity of such a system

Analysis

The system will take the following form. The system is a composition of transmission lines. The directions of the signal through reflection are noted

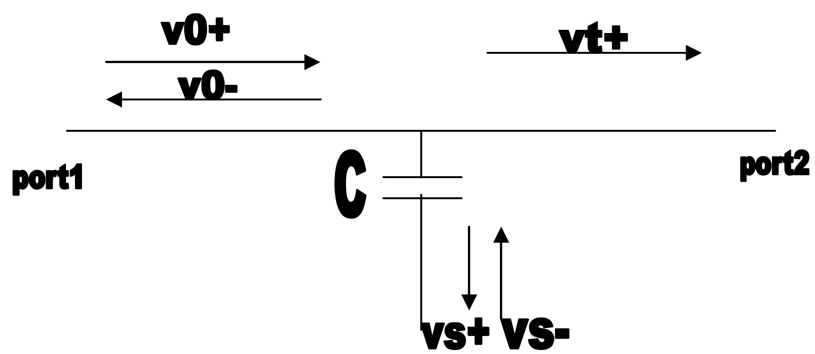

Fig. 1

Figure one shows the system. There is a transmission line feeding the trace. V0 is the signal in the feeding cable. vt is the signal propagating through the trace. Vs is the signal in the stub. The signal will reach the end of the stub and reflect. The trace is coupled at it's launch to the stub. Using the general solution to a transmission line the following expressions can be used to represent the voltage at any place along the signal length and in time.

$$v_0 = v_0^+ e^{-\gamma_0 x} e^{j\omega t} + v_0^- e^{+\gamma_0 x} e^{j\omega t}, i_0 = \frac{1}{z_0}\left(v_0^+ e^{-\gamma_0 x} e^{j\omega t} - v_0^- e^{+\gamma_0 x} e^{j\omega t}\right)$$

$$v_t = v_t^+ e^{-\gamma_0 x} e^{j\omega t} + v_t^- e^{+\gamma_0 x} e^{j\omega t}, i_t = \frac{1}{z_0}\left(v_t^+ e^{-\gamma_0 x} e^{j\omega t} - v_t^- e^{+\gamma_0 x} e^{j\omega t}\right)$$

$$v_s = v_s^+ e^{-\gamma_0 y} e^{j\omega t} + v_s^- e^{+\gamma_0 y} e^{j\omega t}, i_s = \frac{1}{z_0}\left(v_s^+ e^{-\gamma_0 y} e^{j\omega t} - v_s^- e^{+\gamma_0 y} e^{j\omega t}\right)$$

The linear coefficients can be determined using the boundary equations that follow

$$i_s(0) = C\frac{\partial}{\partial t}\left(v_t(0) - v_s(0)\right)$$

$$v_0(0) = v_t(0), i_0(0) = i_t(0) + i_s(0)$$

$$i_s(s) = 0$$

Substitution leads to the following linear system of equations

$$\begin{bmatrix} 0 & 1 + \dfrac{1}{j\omega C z_0} & 1 - \dfrac{1}{j\omega C z_0} & -1 \\ 1 & 0 & 0 & -1 \\ -1 & -1 & 1 & -1 \\ 0 & e^{-\gamma_0 s} & -e^{+\gamma_0 s} & 0 \end{bmatrix} \begin{bmatrix} v_0^- \\ v_{s0}^+ \\ v_{s0}^- \\ v_t^+ \end{bmatrix} = \begin{bmatrix} 0 \\ -v_0^+ \\ -v_0^+ \\ 0 \end{bmatrix}$$

Solving for vt and using the definition of s-parameters leads to the following expression

$$s_{21} = e^{-\gamma_0 L} \frac{tanh(\gamma_0 s) + j\omega C z_0}{tanh(\gamma_0 s) + j\omega C z_0 \left(\frac{1}{2} tanh(\gamma_0 s) + 1\right)}$$

With a trace length of 1meter a stub length of 5mm and sweeping the capacitance the following insertion loss is found.

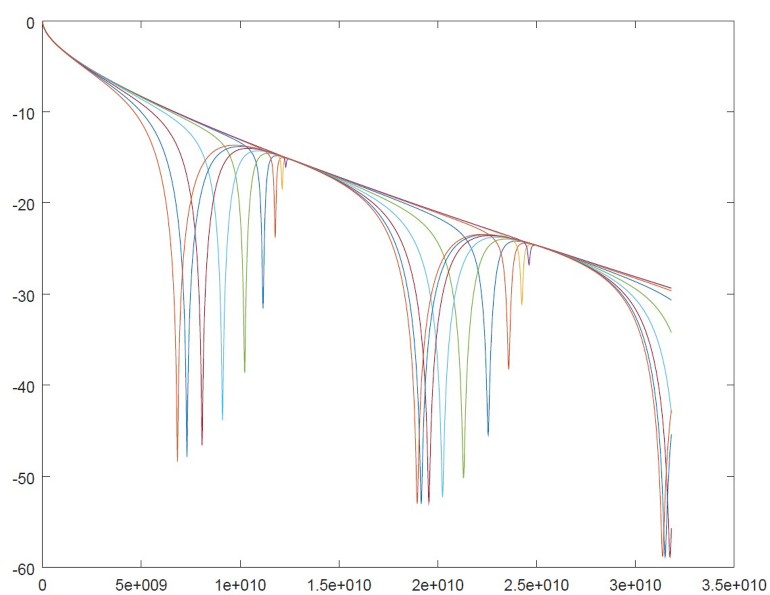

Fig. 2

Figure 2 has capacitance swept from 0.0125pF to 0.32pF. As the capacitance becomes very small the partitioned via effect vanishes.

Measurements

A coupon had a small length of wire inserted into its backdrill area. The bit of wire was left at different distances into the backdrill region and the insertion loss was measures with a VNA. The results follow.

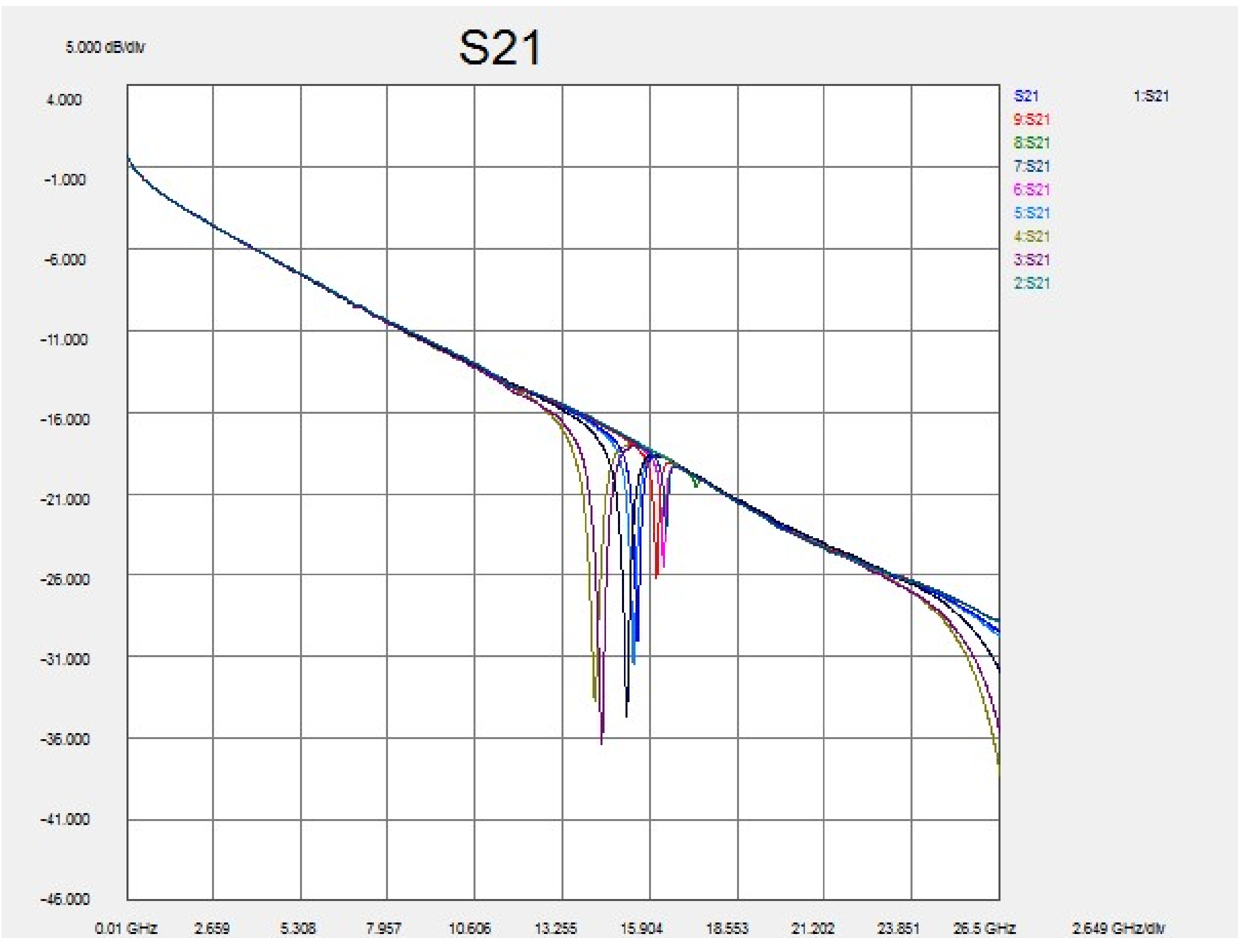

Fig. 3

Figure 3 shows measurements on the bench of a partioned via. The results are in good agreement with theory.

Conclusion

The response of a partitioned via in terms of insertion loss is well understood. The problem of relating the partition region features to capacitance is still an open problem. A 3D simulation would reveal this relationship.