ANALYSIS OF MICROWAVE NETWORK CIRCUITS BY TIME AND FREQUENCY-DOMAIN COMPARISONS

(Invited Paper Presentation)

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Abstract

The analysis of microwave network circuits by time and frequency-domain comparison will be demonstrated by actually producing theoretical time domain plots from their calculated frequency reflection response. In the time domain, the shape of an impulse and step response for different networks will be discussed.

Introduction

When actual microwave components are measured and the design goals are not achieved, the designer must make changes in order to improve performance. Many times these changes are experimentally derived and optimum results never achieved and the design is accepted as "good enough".

This new technique of analysis allows the designer to isolate and calculate the heretofore hidden reflection areas and get quickly the optimum designed results.

The description of the theory involved has been published[1] where frequency-domain measurements are translated into a time domain display. Examples of experimental data were published at the IMTT-74 Symposium at Atlanta, Georgia[2]. It is now possible to produce similar time-domain display from purely mathematical modeling programs[3] of the desired circuit. By comparing the theoretical and experimental time display analysis, the effects demonstrated by the impulse and step response show the location of undesired or not-accounted-for connector and junction reflections.

Oscillographic plots of various time-domain responses of microwave networks have been generated by computer simulation. In order to demonstrate one of the elements in the circuit, the value was varied and the output frequency responses translated to time and superimposed upon the others. Figure 1 shows the theoretical L, C, R circuit where each are separated by 2 cm in order that each may be seen as individual impulse responses. In this case, the resistor was varied from 5 to 10 to 15 ohms and located at 6 cm from the input terminal. Figure 2 shows the same three elements when the capacitor-to-resistor distance is zero and the resistor is varied. Figure 3 shows the resistor fixed at 15 ohms and the capacitor-to resistor distance varied from 0 to 2 cm in 1 cm steps. In this case, the step analysis is displayed showing the displacement in time of the change in impedance. It should be noted that when D = 0, the change of impedance is not exactly at 4 cm, but is displaced in time by the presence of the capacitor.

Figure 4 and 5 demonstrate the ability of the analysis program to separate as individual elements similar capacitive elements located 2 cm apart. The impulse and step domain is shown in Figure 4, while the scan from 1 to 3 cm is reconstructed into the VSWR-frequency domain and shown with the calculated VSWR of the two capacitors. Figure 6 shows the effect on both the impulse and step responses when the capacitors are only 1 cm apart (i.e. $\sim \lambda/2$ at 15 GHz).

Figure 7 shows the interactive impulse responses of a variable series inductance located 1 cm from a .05 pF shunt capacitor. Then in Figure 8, when they are adjacent to each other, their responses merge.

In Figure 7, the first dip produced by the capacitor is not affected by the inductor located 1 cm away, while in Figure 8, the capacitor is quickly reduced and disappears when the inductive impulse time display is increased. However, it is noted that the zero reflection magnitude crossing point is displaced approximately .1 cm by the capacitor location at the 2 cm mark.

When lumped circuit elements are located near each other they will compensate or if separated they may cancel each other only over a narrow band as in the case of Figure 5. It has been found with actual measured circuit components that these effects can be separated and when models which are ideal are compared with experiments that many junction effects are not considered. Several examples of such diagnostic interpretations will be explained in the oral presentation.

It is possible to do a partial frequency domain analysis using only the higher harmonics which eliminates the high VSWR effects produced by shorted stubs or series capacitors. When this partial frequency domain analysis is done to both experimental theoretical models the time domain picture may become distorted, but the most interesting portion of the circuit will not be time distorted. In this way it is also possible to make comparison of actual velocity and loss values to the theoretical desired lengths of line with assumed line losses.

Conclusions

It is possible for a circuit to be tested and a desired model that theoretically should work, to compare the time-impulse and time-step domain of both to determine quantitative differences and identify where to place compensation to correct the circuit. Actual measurements on accurately located capacitive tabs make it easy to identify velocity, effective dielectric permittivity and loss.

Acknowledgement

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References

1. MTT-22 Vol 3, March 1974 pp 276-282

2. 1974 IEEE S-MTT International Microwave Symposium, pp 266-267

3. MANAP, "Nodal Analysis Program"

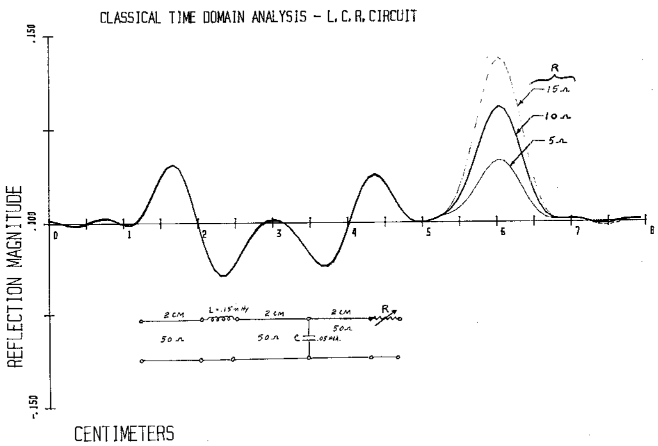

FIGURE 1 CAPACITOR-RESISTOR DISTANCE = 2 CM

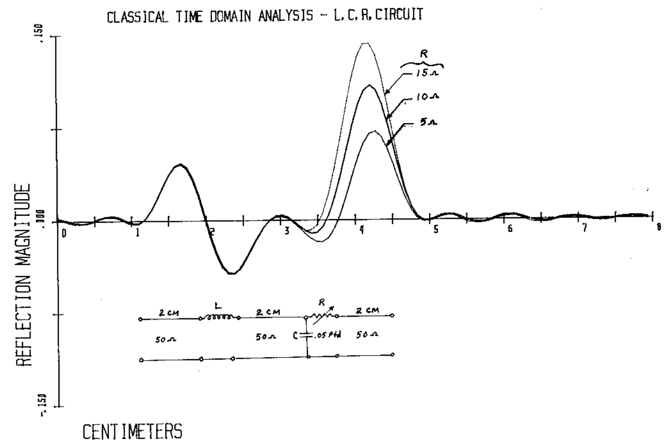

FIGURE 2 CAPACITOR-RESISTOR DISTANCE = 0

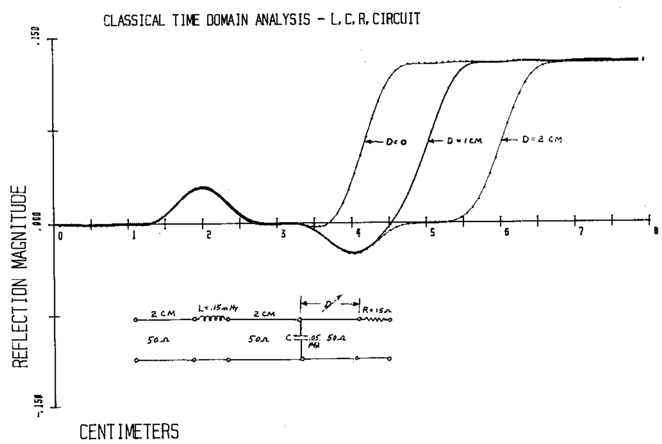

FIGURE 3 STEP ANALYSIS R = 15 OHMS D = 0 = 1 CM = 2 CM

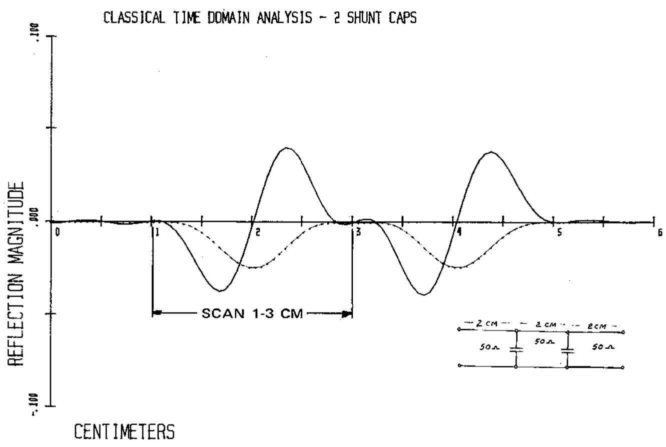

FIGURE 4 TWO SHUNT CAPACITORS .05 PFD 2 CM APART

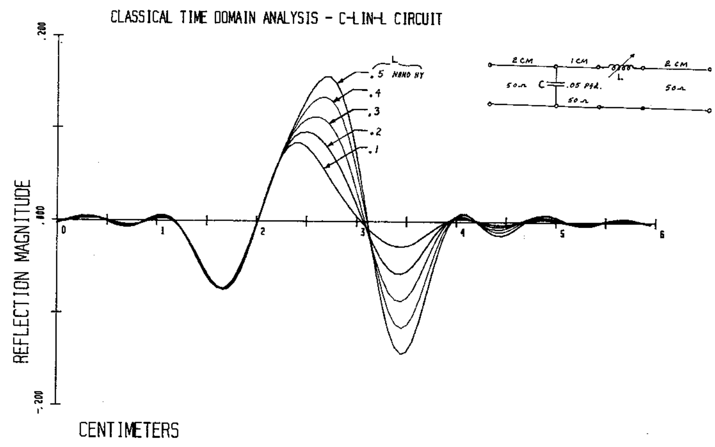

FIGURE 7 VARIABLE INDUCTANCE 1 CM FROM .05 PFD

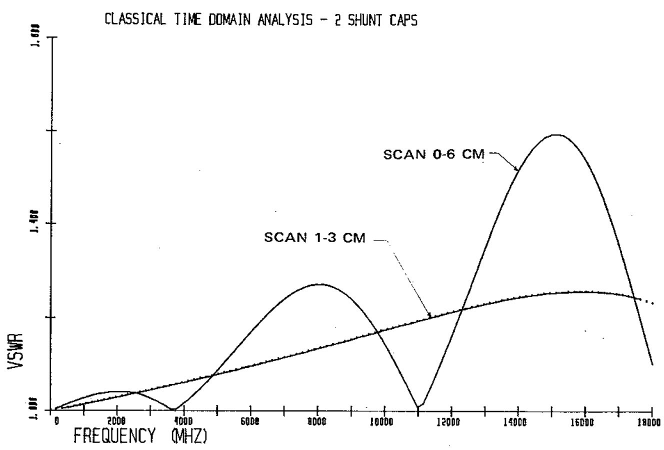

FIGURE 5 ORIGINAL AND RECONSTRUCTED SINGLE CAPACITOR

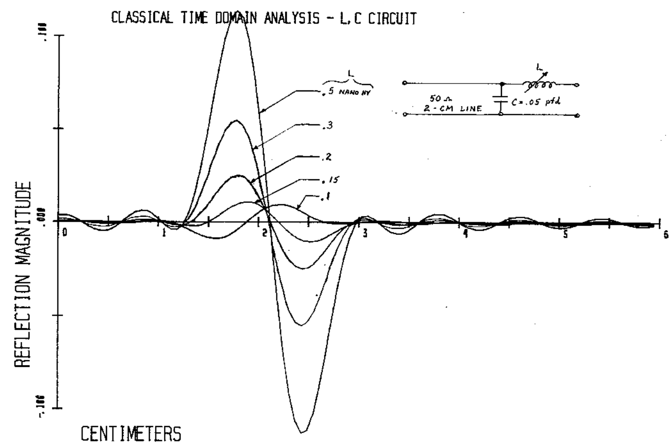

FIGURE 8 VARIABLE INDUCTANCE .1, .2, .3, .5 NANOHYS

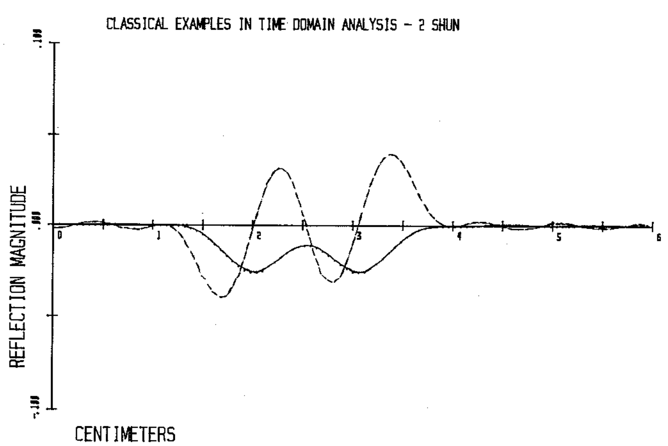

FIGURE 6 TWO CAPACITORS .05 PFD 1 CM APART