# R-6

## DE-EMBEDDING THE CAPACITANCE OF A RESONANT CIRCUIT USING TIME-DOMAIN REVERSAL AND SUBTRACTION

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### Abstract

A precision 50 ohm line 10 cm long was modified by a #4-40 screw at its center. The screw forms a capacitance to the center conductor and a resonant circuit at 17.7 GHz. Evaluating the data with the new MAMA program reveals parasitics of the screw which form the resonance response.

### Introduction

A screw in the outer conductor of a coaxial line forms a capacitance with the center conductor. At high frequencies, the length of the screw forms an inductance in series with the capacitance. The new "MAMA" program is used to create the time-domain and evaluate the capacitance and inductance formed by the screw in the coaxial line.

"MAMA" stands for "Measurement And Microwave Analysis" so it will be used also for the measurement of the data to be analyzed.

### Measurements

The MAMA program is used to make the measurements using the HP-8409B Automatic Network Analyzer. A full set of S-parameters are stored in a TEST file. These measured parameters are corrected for both generator and load (system) errors. Thus, the data stored is free from test set measurement errors. The analysis portion of the MAMA program can extract and plot from these measurements the data required to fully characterize the equivalent circuit.

The corrected S11 data is used to obtain the input VSWR vs frequency as shown in Figure 1. The resonant frequency is obtained from this plot using the "MARK" feature. The VSWR at this point and the frequency are printed below the graph.

The conversion of S11 data into the time-domain is shown in Figure 2 where the "RLC" function has displayed the estimation of the capacitance and its location. The location of this resonant screw is 4.66 cm and its capacitance is .1558 pfd. The "RLC" function has also estimated an impedance change of 50 to 52.88 ohms. This apparent impedance change is due to the resonant parasitics associated with the screw's capacitance. The ringing displayed beyond the location of the capacitance is due to the resonance of the screw.

Using the switch option #2, the time-domain can be reversed. This reverses both the parasitics beyond the capacitor as well as the capacitor, making the ringing reflections to appear before the capacitance. This reverse time-domain is shown in Figure 3. The evaluation by the "RLC" function gives the approximate same value for capacitance, but with the impedance change factor lower than 50 ohms and the location at 7.35 cm.

FIGURE 1

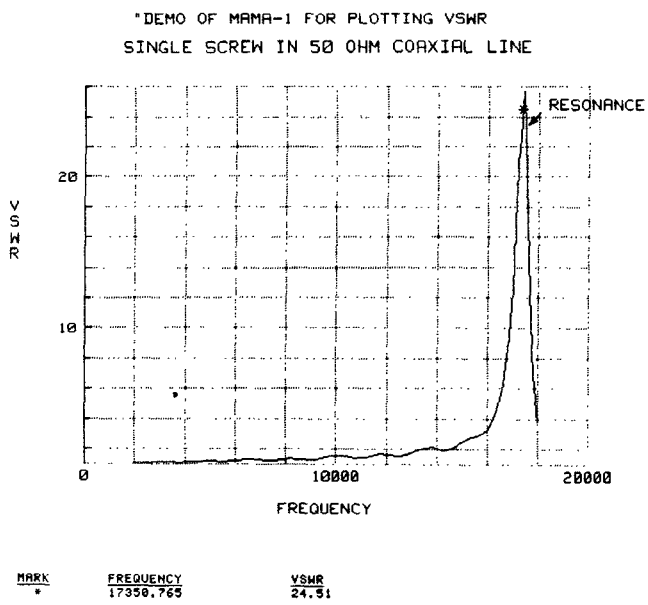


FIGURE 2

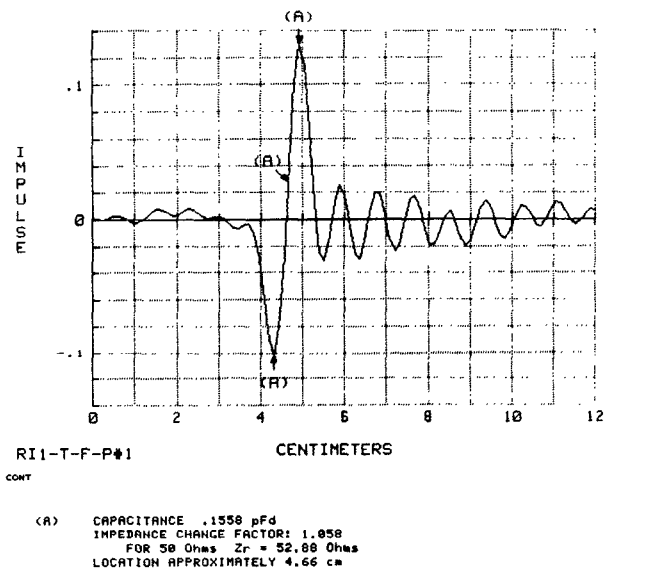


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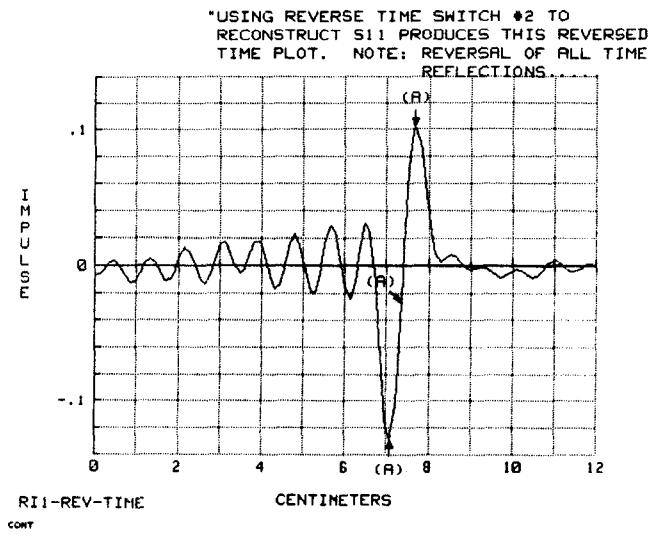
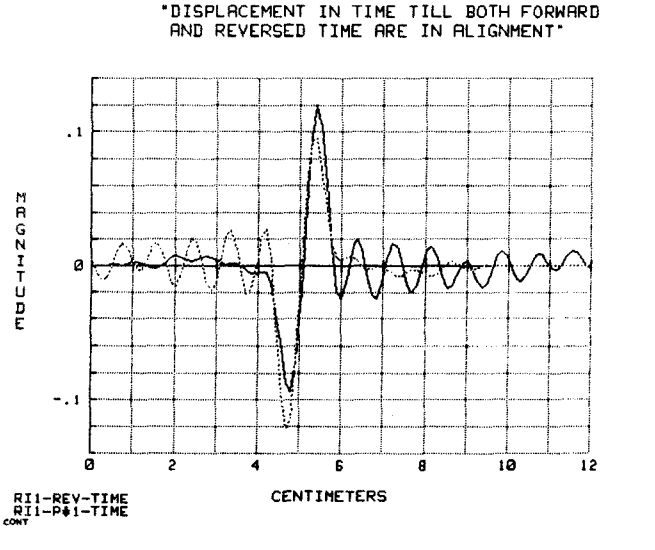
FIGURE 3




(A) CAPACITANCE .1562 pFd
IMPEDANCE CHANGE FACTOR: .948
FOR 50 Ohms Zr = 47.39 Ohms
LOCATION APPROXIMATELY 7.35 cm

FIGURE 4




RI1-P#1-TIME LINE CODE ═══
RI1-REV-TIME LINE CODE ------

FIGURE 5

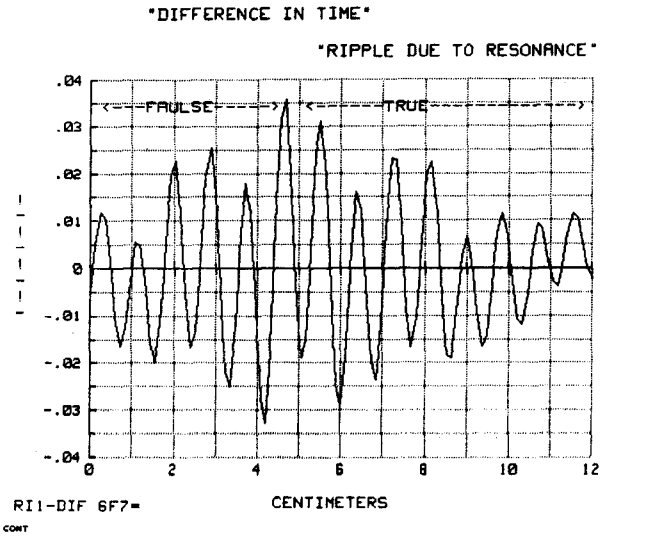
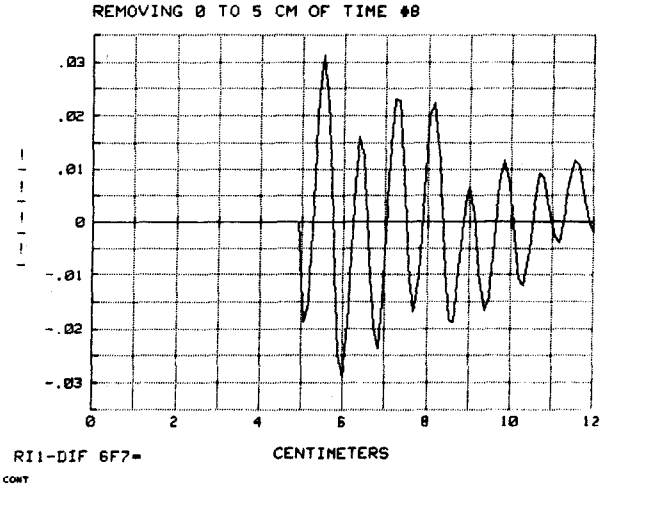



FIGURE 6



This reverse time-domain is next shifted until the capacitance is approximately at 5 cm. The original time frame shown in Figure 2 is also shifted to 5 cm and overlaid to form Figure 4. Thes two time-domains represent the same value of capacitance with the parasitics on the opposite sides. Subtracting these two time-domains gives the difference in time shown in Figure 5. The reflections which appear from 5 cm to 12 cm are the difference between parasitics and no parasitics. This represents the true parasitics without the capacitance. The reflections from zero to 5 cm are "FALSE" reflections and are the parasitic reflections beyond the screw which now appear before the screw when the time display is reversed.

These reflections from zero to 5 cm are erased as shown in Figure 6. The reflections which remain are now subtracted from the orginal measurements to obtain the capacitance without these parasitic reflections as shown in Figure 7. The capacitance value is now .1274 pfd and the impedance change factor is almost unity. This time frame, when de-convoluted, shows the admittance of the screw in Figure 8.

## Conclusions

By using the reversed time feature of the program, the parasitics produced by a discontinuity which appear after the discontinuity in time, can be removed. Aligning the forward and reversed time-domains and subtracting them removes the major discontinuity. This leaves the parasitics beyond the discontinutiy as reflections with false reflections before the discontinutiy. These false reflections are then erased and the true parasitics subtracted from the original measurements to obtain purified measurements without the parasitic parameters.

FIGURE 8

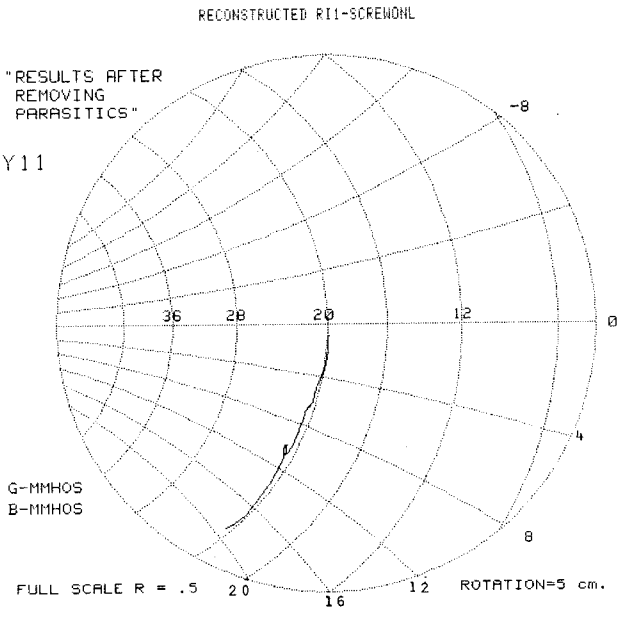



FIGURE 7