# TIME DOMAIN OSCILLOGRAPHIC MICROWAVE NETWORK ANALYSIS USING FREQUENCY-DOMAIN DATA

(Invited Paper Presentation)

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## Abstract

Measurements taken in the frequency domain are translated into the time domain and plotted. Selected time slots are then reconstructed in the frequency domain revealing the VSWR of single connectors or circuit parameters without connector mismatch contribution.

## Introduction

The theory for the translation of frequency-domain data into the time domain has been published in Vol. MTT-22 No. 3, March 1974. This presentation will reveal the last six month's experience using this new technique on real problems.

Frequency-response data is obtained with a C.C.N.A.* The data is processed in an associated computer and selected time-domain responses are plotted immediately on an X-Y recorder. These displays then are interpretable as from a time-domain reflectometer. But now the resolution has been enhanced by having the original frequency data contain the network response to 18 GHz. Both reflection and transmission data may be displayed in the time domain revealing location of reflection points along the circuit and distortion in transmission caused by multi-path circuits. Using the impulse transformation to the time domain of the reflection parameters of a circuit, a selected time domain can be reconstructed into the frequency domain to obtain the VSWR versus frequency or impedance characteristic of that portion of the circuit.

Since the selected time-domain portion of the network can be rotated to any reference time position, the frequency-domain reconstruction data can be plotted on the usual Smith Chart displaying the actual impedance of just that portion of the circuit.

To illustrate the power of the method, a few experiments will be described. A classic example is the measurement of a precision capacitor across a 50 ohm line. Fig. 1 shows the original VSWR data from 200 MHz to 16 GHz of a capacitor of .08 pfds. A time-domain plot of this data is given in Fig. 2 for several settings of the precision 874B capacitor dial. This plot was obtained by constructing the time domain of repeated data files of complex reflection data measured by the network analyzer. When the 6-16 cm time display data is reconstructed for the .08 pfd setting into the frequency domain, the almost straight line occurs as expected and is also plotted on Fig. 2 along with original data. When this is rotated to 9 cm and plotted on the Smith Chart, it falls along the constant impedance circle as expected.

Another experiment is the measurement of a printed circuit illustrated in Fig. 3 with two pairs of open-circuit tabs, one pair on each side of a mitered right angle bend. The time domain picture for this circuit is shown in Fig. 4 where the two tabs are clearly shown as a capacitor. Fig. 5 shows the reconstructed frequency response of just one pair of tabs with the original data while Fig. 3 shows the reconstructed frequency response of the right angle bend located between the two large mismatches. Figs. 6 and 7 show reconstructed polar plots of one and both tab pairs at 20 cm the location of the first pair.

## Conclusions

Several other examples will be given in the oral presentation. It is impossible to give them in this summary. This new technique has a short time resolution, is highly sensitive and provides quantitative results useful in a variety of ways. A major application is in the analysis of impedance data at the input of transmission networks, where it serves as a quantitatively interpretable time-domain reflectometer. It may also be used to measure small reflection coefficients of individual parts of multiple-section networks which are physically inseparable, both in the time domain and the frequency domain.

## Acknowledgment

The speaker wishes to acknowledge the many helpful discussions with the co-author M. E. Hines on the interpretation of circuit responses and his major role in the writing of the original paper.

* Computer Controlled Network Analyzer

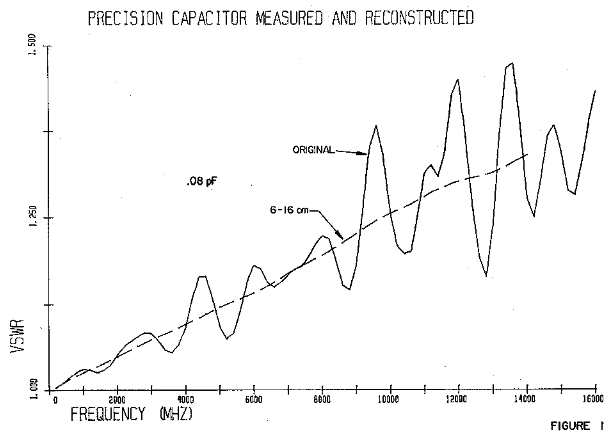


FIGURE 1

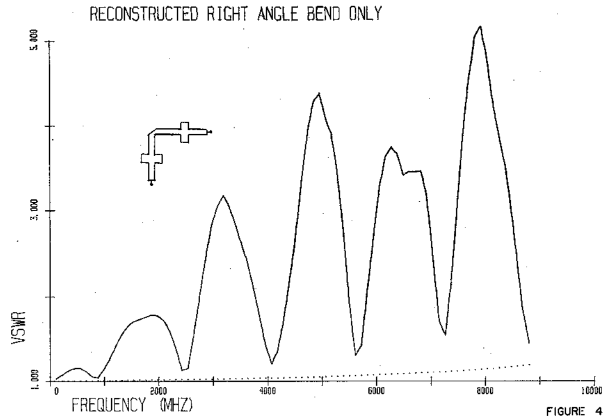


FIGURE 4

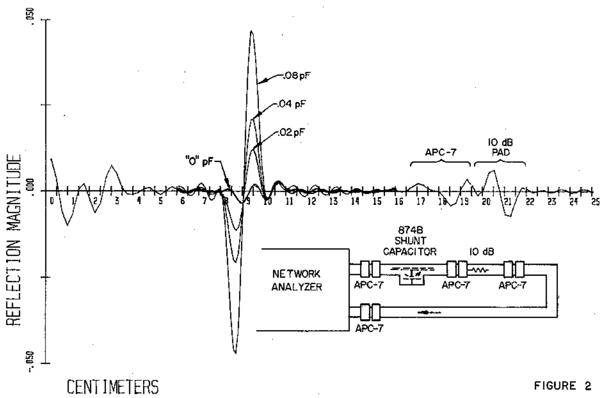


FIGURE 2

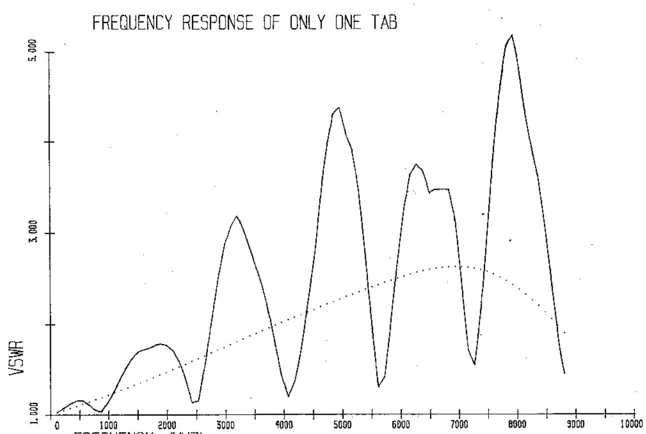


FIGURE 5

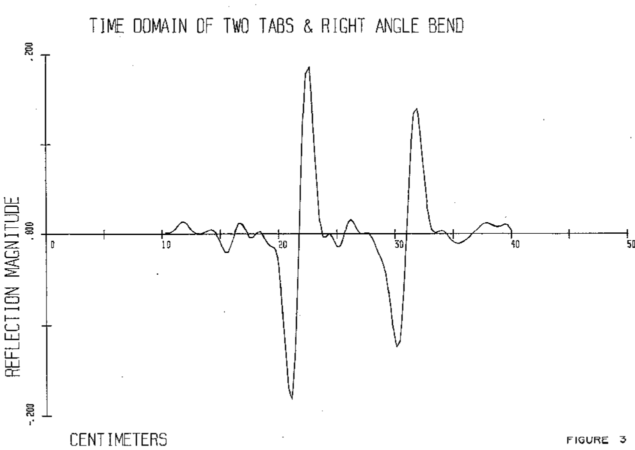


FIGURE 3

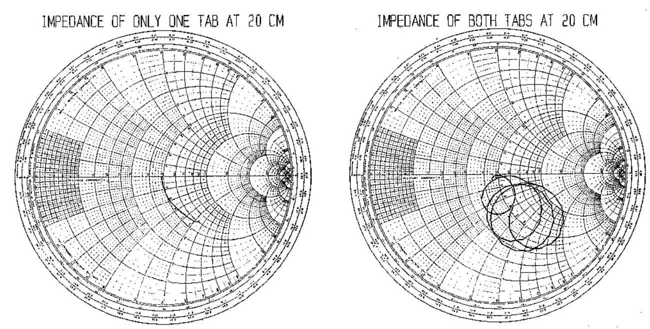


FIGURE 6