

## Characteristic Impedance Measurement of PC Board Circuit Patterns

- HP 4194A Application Information -

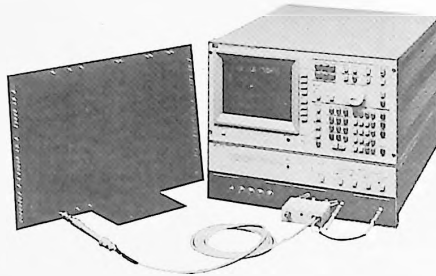


Figure 1

### INTRODUCTION

This article describes how to use the HP 4194A to measure the characteristic impedance of PC board circuit patterns. This information will be useful for PC board manufacturer (micro-processor, ECL, and other impedance sensitive circuits), PC board users, and manufacturers of PC board materials to improve the quality of PC boards.

### PROBLEM

Until 4 or 5 years ago, the characteristic impedance of PC board circuit patterns was not generally evaluated. Now, due to increased circuit complexity, density and speed, multilayer PC boards are commonly used. manufacturing tolerances and variations in materials (dielectric constant, insulation resistance, etc.) will cause the characteristic impedance of circuit patterns

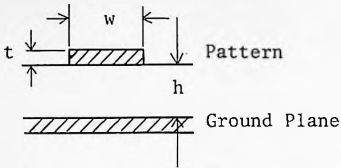
to vary from design values. If the characteristic impedance is different from designed value, and impedance miss-match will occur and the characteristics of circuit are changed.

### MEASUREMENT REQUIREMENTS - TRANSMISSION CHARACTERISTICS EVALUATION

There are several methods used to measure transmission characteristics but there is not an established measurement method for PC board patterns. The Time-Domain Reflectometer method could be used but this is not an easy method. The method that we present uses the HP 4194A Impedance/Gain-Phase Analyzer. Using the HP 4194A is the easiest method for obtaining characteristic impedance information and for comparing this measurement data to the ideal characteristic impedance value given by the following equation.

$$Z_0 = \frac{87}{\sqrt{E_r + 1.41}} \ln \frac{5.98h}{0.87w + t}$$

Er: Relative Dielectric Constant  
(Epoxy Glass: 4.8 - 5.0)



The characteristic impedance is determined using the open-short method, the same as is used for cables. Figure 1 shows the measurement setup. Characteristic impedance is calculated from the following equations.

$$|Z| = \sqrt{|Z_{open}| \times |Z_{short}|}$$

$$\theta = 1/2 (\theta_{open} + \theta_{short})$$

$|Z_{open}| - \theta_{open}$ : Measured valued  
from open measurement

$|Z_{short}| - \theta_{short}$ : Measured values  
from short measurement

#### SOLUTIONS OFFERED BY THE HP 4194A

\* High accuracy impedance measurement at frequencies up to 40MHz with the HP 4194A alone, and up to 100MHz when using the HP 4194A/B impedance probe.

\* Quick analysis using the HP 4194A's calculation function and color display.

... Evaluation of characteristic impedance requires calculation. The 4194A can perform these

calculations and can then display the results.

\* Automatic Evaluation  
... The HP 4194A's ASP (Auto Sequence Program) internal programming language can be used to automate evaluation, from compensating to displaying the measured and ideal value of characteristic impedance. (Figure 2,3)

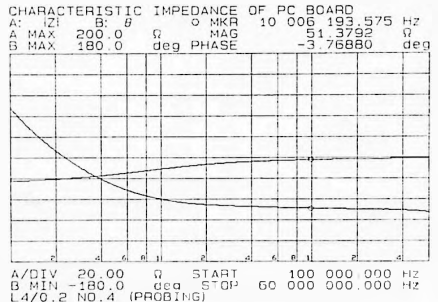


Figure 2

Figure 3

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