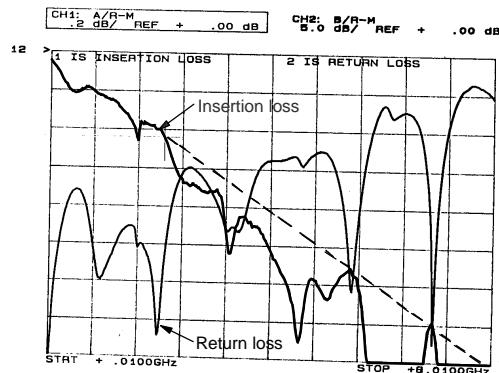


## Loss characteristics of microstrip board materials

- Losses in microstrip lines are the sum of conductor and dielectric losses.
- When dielectric losses are larger than conductor losses, insertion loss vs. frequency is a straight-line function, or loss is constant in terms of dB/wavelength.



Insertion loss of a cyanate ester microstrip board 91 mm long

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## An equation for losses in the substrate's dielectric

- For open microstrip line, it can be shown\* that this equation will predict the insertion loss, given guide wavelength and material characteristics.
- Note that the loss is constant when expressed as dB/ $\lambda$ .
- Use loss data (previous slide) to compute  $\tan\delta$ .

$$L = \frac{8.69 \pi \epsilon_r}{\epsilon_r - 1} \frac{\epsilon_{\text{eff}} - 1}{\epsilon_{\text{eff}}} \frac{\tan\delta}{\lambda_g}$$

where...

$L$  = insertion loss in dB/wavelength

$\epsilon_r$  = bulk dielectric constant

$\epsilon_{\text{eff}}$  = effective dielectric constant

$\lambda_g$  = guide wavelength

$\tan\delta$  = dielectric loss tangent

\* M.V. Schneider, "Dielectric loss in integrated microwave circuits," Bell System Technical Journal, vol 48, pp. 225 - 2332, Sept. 1969.  
B. Ramo Rao, "Effect of loss and frequency dispersion on the performance of microstrip directional couplers and coupled line filters," IEEE Trans. Microwave Theory Tech., vol. MTT-22, pp. 747 - 750, July 1974

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## Measurements were made on four low-cost materials

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Insertion loss measurements were made on microstrip lines, from which loss/wavelength was obtained. These data were used to compute loss tangent. Materials are listed in increasing order of cost.

Material	Thickness	$\epsilon$	$\epsilon_{\text{eff}}^*$	loss, dB/I measured	tand calculated	tand mfg. claim
FR4 (G10)	0.81mm	4.8	3.65	0.75	0.030	0.023 @ 1 MHz
cyanate ester**	0.81mm	4.5	3.40	0.45	0.018	0.009 @ 1 MHz
G-Tech	0.71mm	3.8	3.00	0.35 ***	0.014	0.018 @ 1 MHz
Rogers 4003	0.51mm	3.4	2.70	0.20 ***	0.008	0.002 @ 10 GHz

\* in a microstrip line

\*\* available from International Circuits, Visalia, California. Telephone: 209-741-1154; Web address <http://www.intlcircuits.com/>

\*\*\* measurements made by D.G. Swanson of Watkins-Johnson

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