ROGERS CORPORATION
Advanced Circuit Materials

Advanced Circuit Materials Division
100 S. Roosevelt Avenue
Chandler, AZ 85226
Tel: 480-961-1382, Fax: 480-961-4533
www.rogerscorporation.com

RO4003C™ High Frequency Material Insertion Loss Comparison With Other Material Types

High Frequency circuits require substrate materials that have tight control of dielectric constant as well as low loss. Materials that meet these requirements traditionally have been priced much higher than conventional epoxy/glass boards. The emergence of the commercial high frequency market has brought about a strong need to balance performance, manufacturability and cost. Rogers RO4003C™ High Frequency Material bridges the gap by providing tight control on dielectric constant, and low loss, while processing the same as standard epoxy/glass at a fraction of the cost of conventional microwave laminates. RO4003C materials are proprietary woven glass reinforced hydrocarbon/ceramics with the electrical performance of PTFE/woven glass and the manufacturability of epoxy/glass.

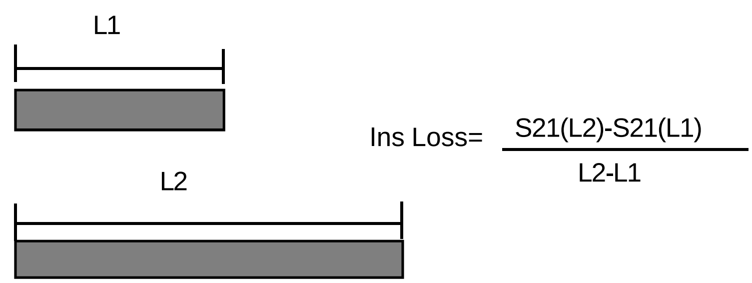


Figure 1. Calculation of Insertion Loss Data

An evaluation of insertion loss for a 50Ω microstrip transmission line was conducted on several materials. The materials selected range from standard FR4 (difunctional epoxy), to the more sophisticated PTFE based laminates (GX and RO3003™). The goal of the evaluation was to quantify the circuit losses on the various types of materials. This would enable one to better understand the frequency limitations of each material type. The selected materials and advertised ε_r are presented in Table I.

Table I. Commercial Grade Materials for Microwave Applications

Material	Advertised ε_r
RO3003™ (PTFE/ceramic)	3.0
GX (PTFE/woven glass)	2.4 - 2.6
RO4003C™ (Hydrocarbon/woven glass)	3.38
BT	3.7 - 3.9
Epoxy/PPO	3.95
BT/Epoxy	4.0
Difunctional Epoxy	4.5

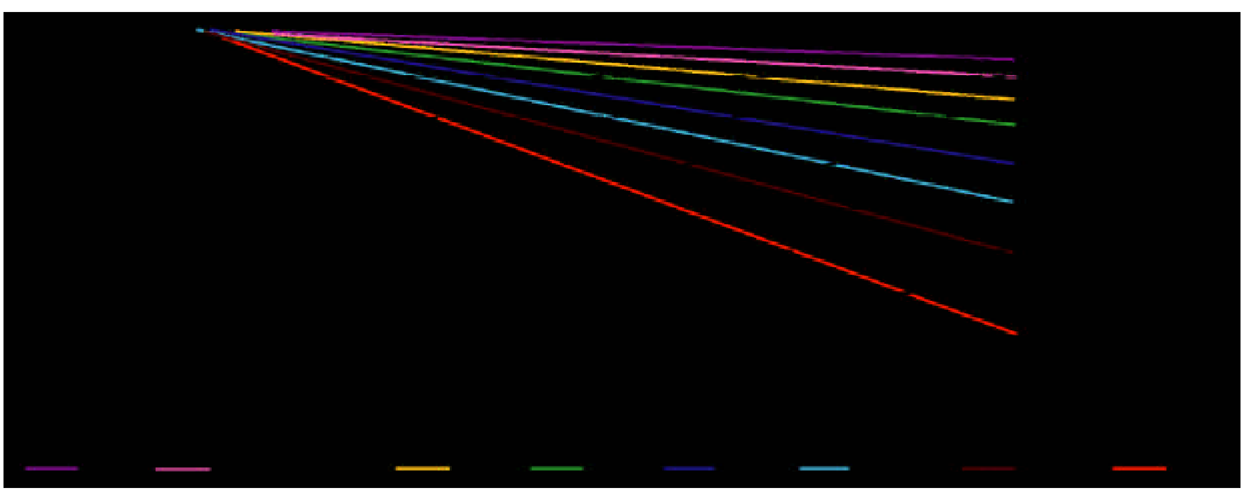
In order to obtain the insertion loss of the 50Ω lines, two different length lines, 3 and 7 inches long, were measured for S_{21} from 0.1 to 18 GHz on a network analyzer. The difference of the two measured values was divided by the difference in the length of the lines. The result of this operation would yield the insertion loss of the incremental length of the line thus eliminating most of the losses caused by reflections at the launch site. Figure I displays the method used for calculation. All circuits were fabricated on 0.030" material with 1 oz copper.

Regression analysis was conducted on the various resultant measurements to obtain a linear characterization of the insertion loss versus frequency. Figure II and Table II provide data based on the regression models for all six materials at various frequencies.

Table II. Insertion Loss vs. Frequency in dB/inch for 0.030" (0.762mm) material

Frequency	RO3003	GX	RO4003	BT Glass	Epoxy/ PPO	BT/Epoxy	Difunct Epoxy
0.5	-0.003	-0.006	-0.009	-0.017	-0.022	-0.027	-0.039
1	-0.007	-0.012	-0.018	-0.033	-0.043	-0.054	-0.078
2.5	-0.017	-0.031	-0.044	-0.082	-0.106	-0.132	-0.192
5	-0.036	-0.063	-0.088	-0.167	-0.216	-0.269	-0.391
10	-0.071	-0.126	-0.176	-0.334	-0.431	-0.538	-0.782
15	-0.107	-0.189	-0.265	-0.501	-0.647	-0.807	-1.174
18	-0.128	-0.226	-0.318	-0.602	-0.777	-0.969	-1.409

Figure II. Measured Microstrip Insertion Loss Data
(in order of least loss to most loss)



RO4003C material provides loss comparable to RO3003 and GX material. A large increase in loss is evident when going to the next material, BT glass. The lossiest material, difunctional epoxy, is 4.5 times lossier than the RO4003C laminate. Overall when selecting a material during the design stages, issues like;

- ε_r control
- material loss
- electrical and mechanical thermal stability
- manufacturability
- cost

need to be considered in order to reduce cycle time of the design.

There are many materials being evaluated for commercial high frequency applications, but once performance and cost are evaluated, the choices narrow down to a few, RO3003, GX and RO4003 among them. These remaining choices provide good ε_r control as well as low loss, critical for frequencies at C-band (4 to 8 GHz) and above. RO4003C materials not only provide the needed electrical characteristics, but can also be manufactured with standard epoxy/glass processes, bringing down fabrication costs. In general, RO4003C materials combine the best of electrical properties with ease of fabrication at a competitive cost for commercial applications.

CONTACT INFORMATION:

USA:	Rogers Advanced Circuit Materials Division, ISO 9002 Certified	Tel: 480-961-1382	Fax: 480-961-4533
Belgium:	Rogers Corporation - Gent	Tel: +32-9-2353611	Fax: +32-9-2353658
Japan:	Rogers Japan Inc.	Tel: 81-3-5200-2700	Fax: 81-3-5200-0571
Taiwan:	Rogers Taiwan Inc.	Tel: 886-2-86609056	Fax: 886-2-86609057
Korea:	Rogers Korea Inc.	Tel: 82-31-716-6112	Fax: 82-31-716-6208
Singapore:	Rogers Technologies Singapore Inc.	Tel: 65-747-3521	Fax: 65-747-7425

Revised 12/2002, -1202-0.5CC, **Publication** #92-