

Correspondence

Coaxial Isolator Utilizing Yttrium-Iron Garnet*

The inherently narrow ferromagnetic resonance line width attainable with yttrium-iron garnet (YIG) material permits building isolators with greatly improved characteristics at the lower microwave frequencies. An isolator utilizing YIG designed for operation in the UHF range has been reported.¹ This letter describes a coaxial isolator designed to operate at 2250 ± 50 mc employing yttrium-iron garnet.

A $\frac{5}{8}$ -inch diameter, 50-ohm coaxial line was half filled with a high dielectric constant material (Stycast Hi-K-15) with $2\frac{1}{2}$ -inch tapers on the ends and the YIG rods of square cross section ($0.070 = 0.070 \times 2.450$ inches long with $\frac{1}{4}$ -inch tapers on the ends) were located on both sides of the inner conductor. With a permanent magnet biasing field adjusted for resonance at 2250 mc, isolator characteristics as shown in Fig. 1 were obtained.

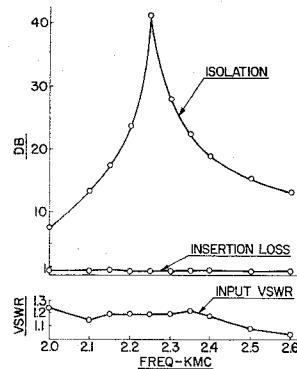


Fig. 1—Characteristics of yttrium-iron garnet coaxial isolator.

By replacing the permanent magnet with an electromagnet and adjusting the biasing field for maximum reverse attenuation at each frequency, the maximum reverse attenuation as a function of frequency was obtained as shown in Fig. 2. All measurements were made in the milliwatt power range. Since this material evidenced such reasonable isolation-to-insertion loss ratios in the 1-kmc region, additional work was initiated and is presently in progress to develop an isolator for this frequency range.

This material was prepared by the Magnetics Research Group of the Solid State Electronics Department of Lockheed Missile Systems Division, and had a measured

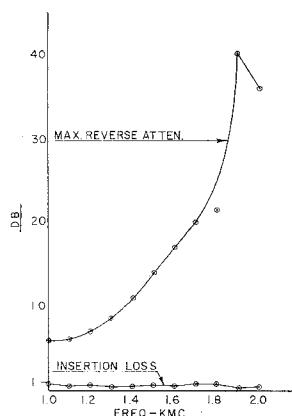


Fig. 2—Maximum reverse attenuation of coaxial isolator vs frequency by varying biasing field.

density of 98 per cent of theoretical maximum, a Curie temperature of 318°C , and a measured X-band line width of 60 oersteds.

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dielectric constant. From 1.5 to 10 kmc the connector has less than 3 db insertion loss and a VSWR less than 1.5. The dc current rating of the resistance wire is 100 ma and the dc voltage breakdown between two faces of capacitance is greater than 1500 volts.

PHYSICAL PROPERTIES

The center conductor of a type N(UG29 B/U) connector is severed and insulated with dielectric material to form a blocking condenser which will pass RF but not direct current. The capacitance should be made as large as possible for low impedance at the operating frequency. Various materials were tested and the best results were obtained by inserting a piece of ceramic obtained from an ordinary Erie 0.001 μf disk ceramic condenser. It was estimated that the dielectric constant of this type ceramic was in the order of 100, which greatly exceeds the dielectric constant of the usual construction materials. With a piece of ceramic having a diameter of 0.168 inch and a thickness of 0.040 inch the inserted capacitance was 7 to $12 \mu\text{f}$ at 1 mc and the dc working voltage was greater than 1500 volts. The dc path was formed by placing a fine Karma alloy resistance wire inside a small teflon tubing and feeding this unit through a $\frac{1}{16}$ -inch diameter hole in the outer conductor in such a way that the Karma wire overlapped the teflon tubing and was pressed against the center conductor by screwing on a bakelite cap. With this arrangement the insulation between the Karma wire and the outside conductor was also greater than 1500 volts. The bakelite cap also formed the terminal for the dc connection. A drawing of the modified connector is shown in Fig. 1.

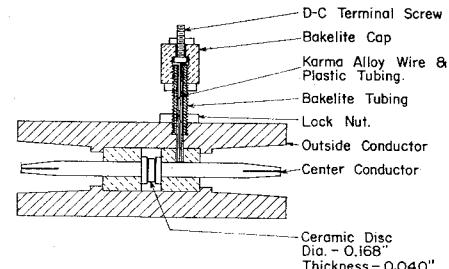


Fig. 1—Microwave coaxial capacitance using an N-type connector fitted with dc connection and a series capacitance in the center conductor.

The Karma alloy wire was used because it was readily available in small sizes and has excellent mechanical properties. Its physical properties were as follows:

Karma alloy wire	0.0012 inch diameter
Resistivity of wire	521.5 ohms per foot
Resistance of dc path	30-40 ohms
Current carrying capacity	100 ma

The specifications of the unit were selected to satisfy our own requirements but could be suitably modified to allow for a different breakdown voltage or frequency bandwidth for other applications.

* Received by the PGM TT, June 27, 1958.

¹ F. R. Morgenthaler and D. L. Fye, "Yttrium garnet UHF isolator," Proc. IRE, vol. 45, pp. 1551-1552; November, 1957.

² B. J. Duncan, L. Swern, K. Tomiyasu, and J. Hannwacker, "Design considerations for broad-band ferrite coaxial line isolators," Proc. IRE, vol. 45, pp. 483-490; April, 1957.

* Received by the PGM TT, July 18, 1958.

¹ J. W. McLaughlin and D. A. Dunn, "Wide band dc return connector," IRE TRANS. ON ELECTRON DEVICES, vol. ED-4, pp. 310-311; October, 1957.