# VHF- AND UHF-BAND STACKED-JUNCTION CIRCULATORS

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## 1. INTRODUCTION

A new type of junction circulators, in which two ordinary ferrite-loaded junctions are stacked and assembled in a common housing, is presented. The input power is divided into two junctions and the CW power rating doubled. The stacked circulator increases the freedom to choose the ferrite size, which must be optimized for a specific power level in each application because it affects closely the cost of the assembled circulator, and this design was proved to be very effective in improving the cost/power performance.

Recently VHF- and UHF-band circulators have really become practical and a variety of circulators, from high-power composite ferrite junction[1][2] to miniature lumped-element type,[3] have been reported. However VHF-band circulator appropriate for medium power of 300 W or so has not yet been obtained because ferrite discs 300 mm in diameter are needed to fabricate a stripline circulator at 100 MHz, which will be capable of handling 3 kW, quite a big figure.

First an experimental stripline stacked circulator was built to show the feasibility of the stacked-junction. Then a VHF-band lumped-element stacked circulator was constructed, which has the same physical size as a 700 MHz conventional stripline model and the comparable power rating to its 700 MHz counterpart.

## 2. STRIPLINE STACKED CIRCULATOR

Although adopting a composite junction can increase the power handling capability, it decreases the bandwidth due to decreased filling factor. Stacking on the other hand can double or triple the power rating without degrading the bandwidth if the corresponding number of junctions are stacked.

At the beginning an ordinary stripline junction is designed and the two center conductors are connected in parallel in a common enclosure which functions as the ground plane, as shown in Fig. 1. By this geometry the junction impedance becomes half and an additional matching scheme is necessary to insure good circulation characteristics. A quarter-wave transformer can

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be used for this purpose.

For the ferrite material, Gd-substituted YIG is used, which provides good temperature stability and is appropriate for high power applications.

Fig. 2 is a photograph of the experimental stripline stacked circulator. The performance for low power is shown in Fig. 3. Insertion loss was 0.3 dB minimum at 450 MHz and the bandwidth was 30 MHz. At 3 kW CW power the temperature rise reached 40°C under natural cooling but no deterioration of input VSWR was noticed.

## 3. LUMPED-ELEMENT STACKED CIRCULATOR

A lumped-element stacked circulator which can handle more than 150 W at 105 MHz was developed and it was verified that a circulator can be optimized for any power below the tested level. This originates from the essential nature of the lumped element, whose size may be arbitrary under the limitation that it is less than 1/8 wavelength. Therefore the ferrite size is also arbitrarily selected for a given power level.

The nonreciprocal junction structure of the lumped element circulator is shown in Fig. 4. As the impedance characteristics of the inductor can be approximated by a stripline whose end is short-circuited, the inductance is kept constant if the width and spacing of the center conductors are changed in proportion to the diameter of the ferrite discs.

In the experiments a considerably large diameter of 45 mm, which is still in the range smaller than 1/8 wavelength in its electrical length, was used and the ferrite thickness was 2.5 mm. The inductance for larger ferrite discs showed a tendency to increase, and two inductors were stacked in order to keep the inductance constant.

A 105 MHz model was constructed using Al-substituted YIG. This material was employed because Gd-YIG showed rather large loss at VHF-band. The insertion loss was 0.3 dB at the center frequency and the bandwidth was 5 MHz. CW power of 150 W was applied and no degradation of performance was observed. Only a small amount of biasing field adjustment was necessary.

## 4. ACKNOWLEDGEMENTS

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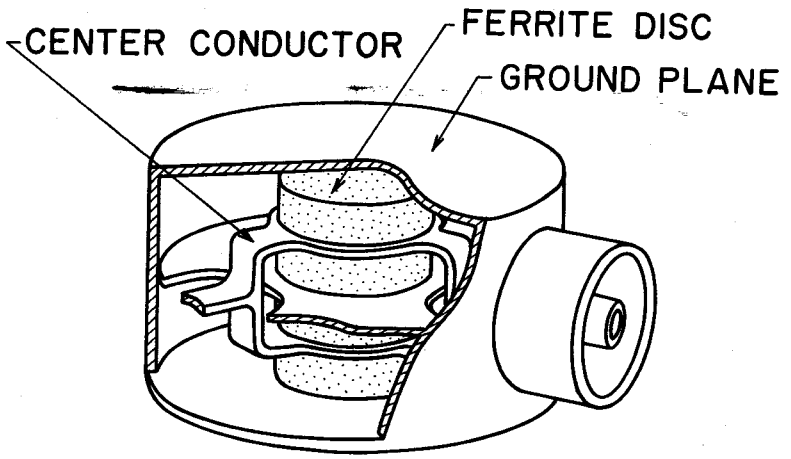


Fig. 1 Assembly of the stripline stacked circulator

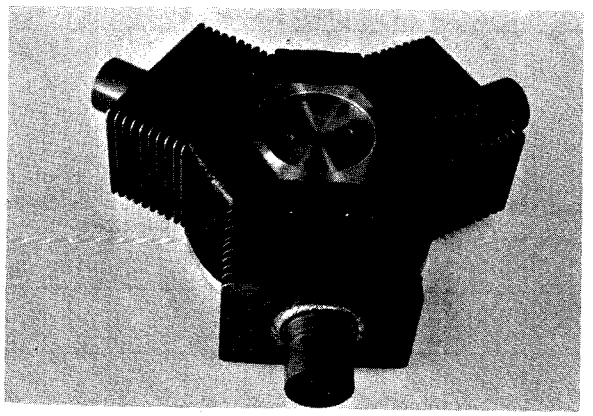

Fig. 2 UHF-band stripline stacked circulator

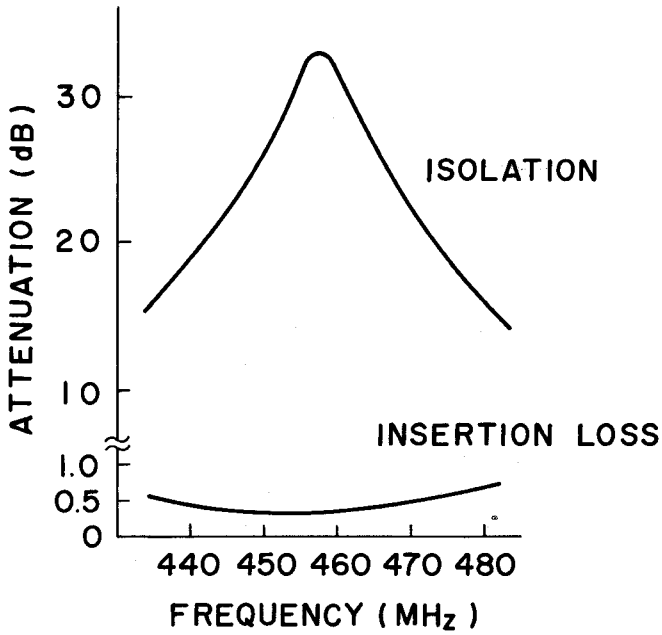


Fig. 3 Performance of the UHF-band stripline stacked circulator.

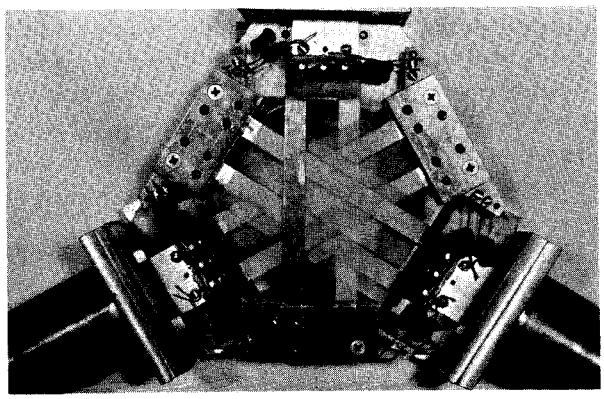

Fig. 4 Internal view of the lumped-element stacked circulator (upper ground plane and upper YIG disc have been removed to show the details)