IEE

ELECTRONICS DIVISION

Colloquium on

THICK-FILM MICROWAVE INTEGRATED CIRCUITS

Organised by

Professional Group E12
(microwave devices and techniques)

Wednesday 7 May 1980

Digest No: 1980/26

A COMPARISON OF THE PERFORMANCE OF Au, Ag, Pd-Ag AND Cu THICK FILM MICROWAVE INTEGRATED CIRCUITS

M. E. Brinson, J. R. Forrest, A. J. Parsons and A. A. Salles

Fully filled active phased array radar systems rely on low cost transmit receive modules for their economic viability. It is likely that these modules would be of hybrid construction, employing discrete power devices and microstrip components. In such applications, thick film technology offers potential economies in the production of microstrip components. However, because of the high cost of gold thick film inks, alternative conductor materials must be used if the overall module costs are to be minimized.

In this paper an outline of X band and S band thick film active phas array modules, based on the phased locked loop principle, will be presente

In the work undertaken so far, Ag and Pd-Ag fritless inks were used for microstrip component development and Au fritless ink for the final module construction. Typical insertion loss values for test sections c 50 Ω microstrip transmission line are 0.25 dB per wavelength at 10 GHz (0.025 inch thick, 99.5 % alumina substrate) and 0.2 dB per inch at 3 GHz (on 0.04 inch thick, 99.5 % alumina substrate). These figures were obtained using conventional thick film printing techniques using 325 mes stainless steel screens.

The microstrip components developed for use in X and S band modules include

- Gunn diode matching networks
- 10 dB and 20 dB directional couplers (side coupled and wiggly line)
- Band pass interdigital filters
- Circulators
- 3 dB branch line couplers
- 3 dB power dividers
- Low pass filters
- Low V.S.W.R. 50 Ω loads (V.S.W.R. < 1.1 over design frequency band)

The measured performance characteristics of a number of these compo is illustrated in Figs. 1 to 3.

A ferrite circulator was employed in both the X and S band modules separate transmitted and received signals. A triangular shape has bee adopted for the central conductor pattern in order to achieve maximum possible bandwidth. Quarter wavelength transformer sections allow mat to the low impedance central region. Typical performance characterist for a 10 GHz ciculator, using 1" x 1" x 0.025" substrates mounted on a t jig with OSM connectors are shown in Fig. 1. The insertion loss is ju over 1 dB, some 0.5 dB of which is due to the connectors. A similar de at S band using 1.5" x 1.5" x 0.04" substrates has an insertion loss of 0.5 dB, including measurement connectors, and an isolation of better than 20 dB over the frequency band 2.7 GHz to 3.0 GHz.

At X band a balanced mixer design was chosen to provide good isolat between the signal and local oscillator inputs as well as to provide suppression of local oscillator a.m. noise. The 3 dB splitting action required in the balanced mixer was provided by a branch line coupler. Detailed performance curves for this component are shown in Fig. 2.

M. E. Brinson and A. J. Parsons are with the Department of Electronic a Communications Engineering, The Polytechnic of North London, Holloway, Lo
J. R. Forrest and A. A. Salles are with the Department of Electronic an Electrical Engineering, University College, London

Illustrated in Fig. 3 are the measured performance curves for an S band 3 dB power divider. This component comprises essentially a quarter-wave transformer section to match a 50-Ω line to two parallel lines, but some slight correction for the line section discontinuity is necessary.

In order to provide d.c. blocking between the transmit power source and the module output as well as to eliminate any harmonic or spurious signals, a band pass filter was provided in the output line before the circulator output. A maximally-flat response with two elements in the low pass prototype was chosen, the design at S band being for 2.85 GHz centre frequency, 14 % bandwidth and 50-Ω terminating impedances. Measurements on a test filter using 2" x 2" x 0.04" alumina substrates with OSM connectors indicate that at the design frequency the insertion loss is in the region of 0.5 dB, some 0.2 dB of which may be accounted for by the connectors. A family of comparative insertion loss curves for the band pass filter constructed from different conductor materials is shown in Fig. 4.

We conclude that thick film technology using fritless conductor inks allows construction of low cost high performance microstrip components of the form needed in active phased array applications.

Acknowledgements

The authors wish to thank the Procurement Executive, Ministry of Defence, ASWE and the European Office of Aerospace Research and Development, USAF, for their supprt in this work.

Fig. 1 Ferrite Circulator Performance

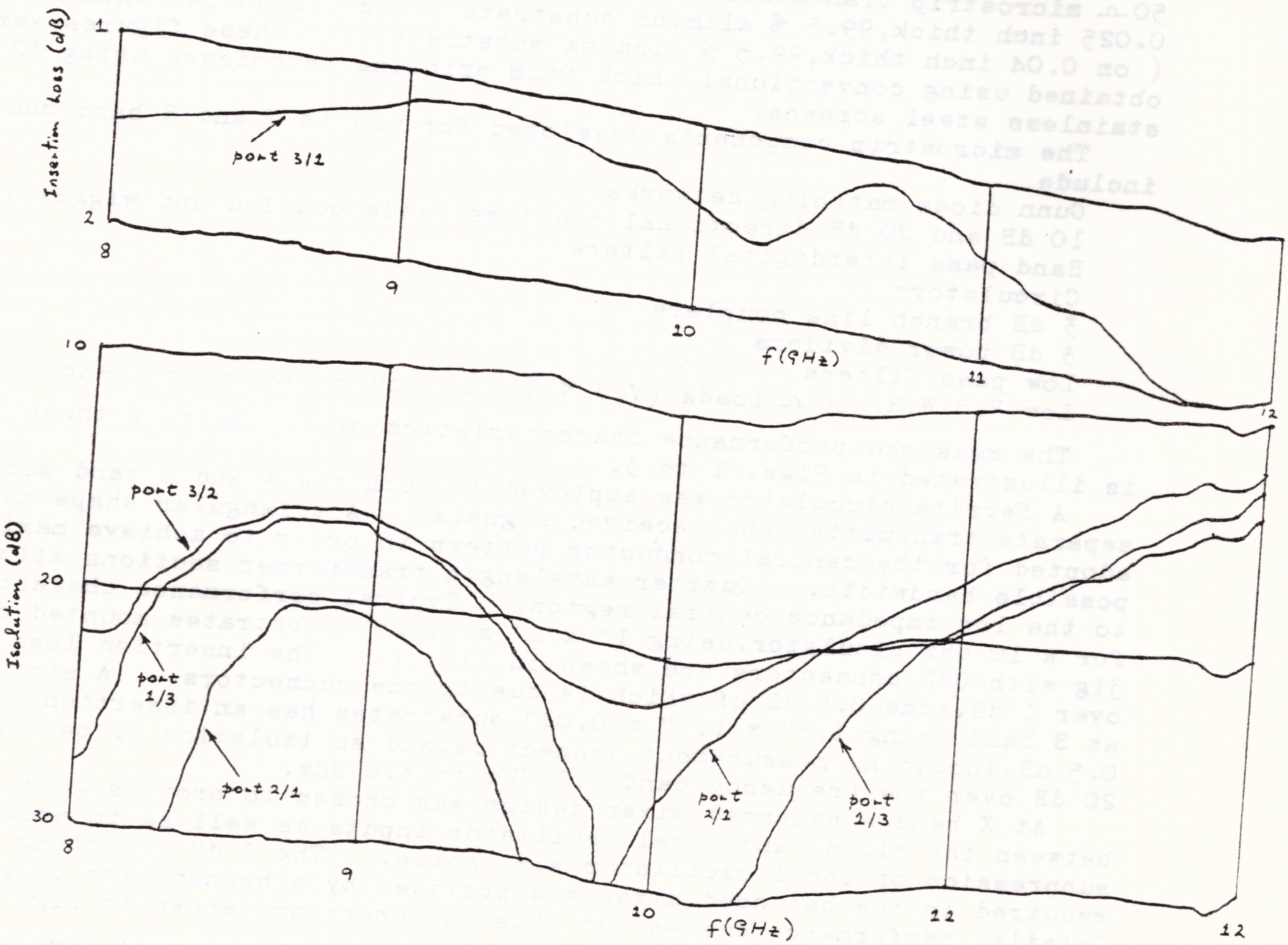

Fig. 2 Branch Line Coupler Performance

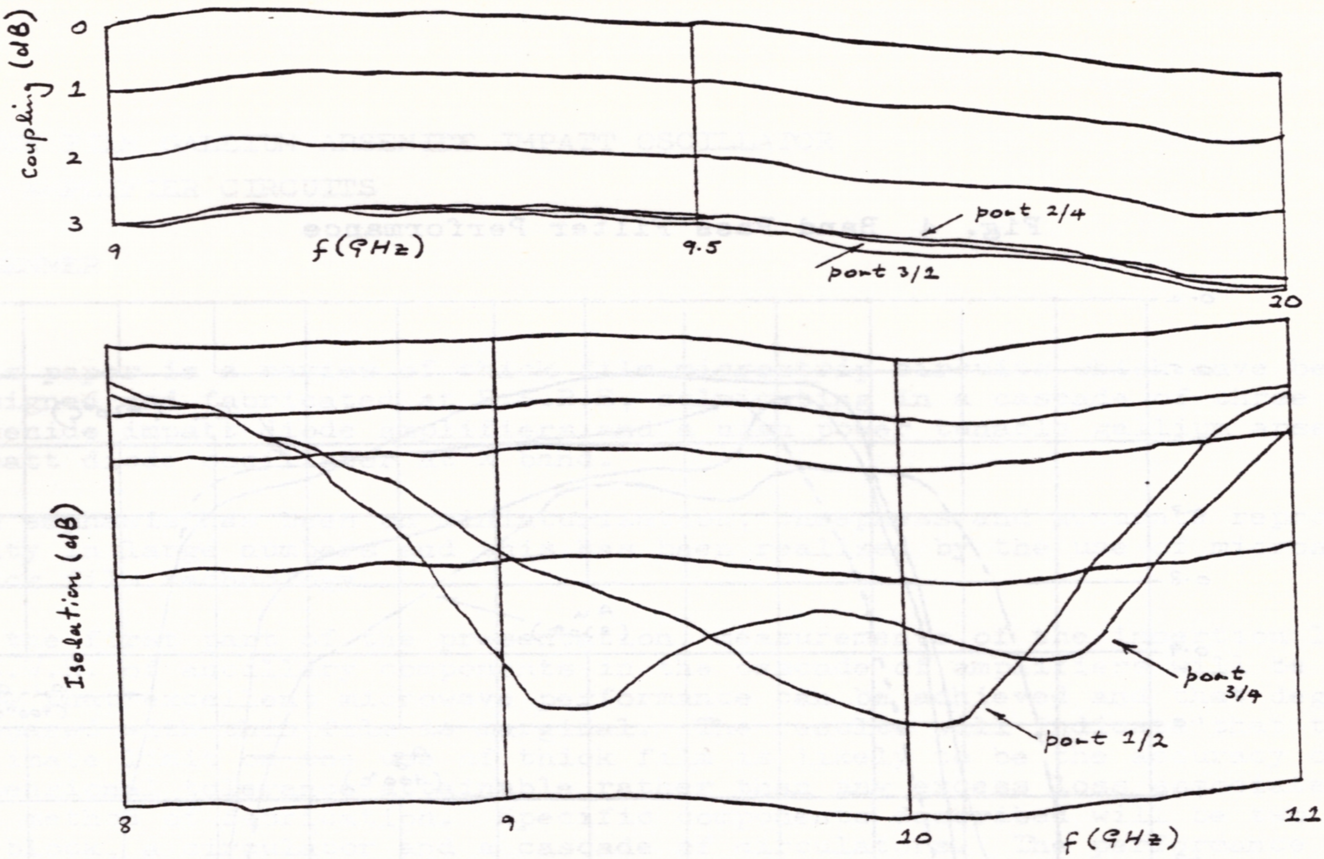

Fig. 3 3 dB Power Divider

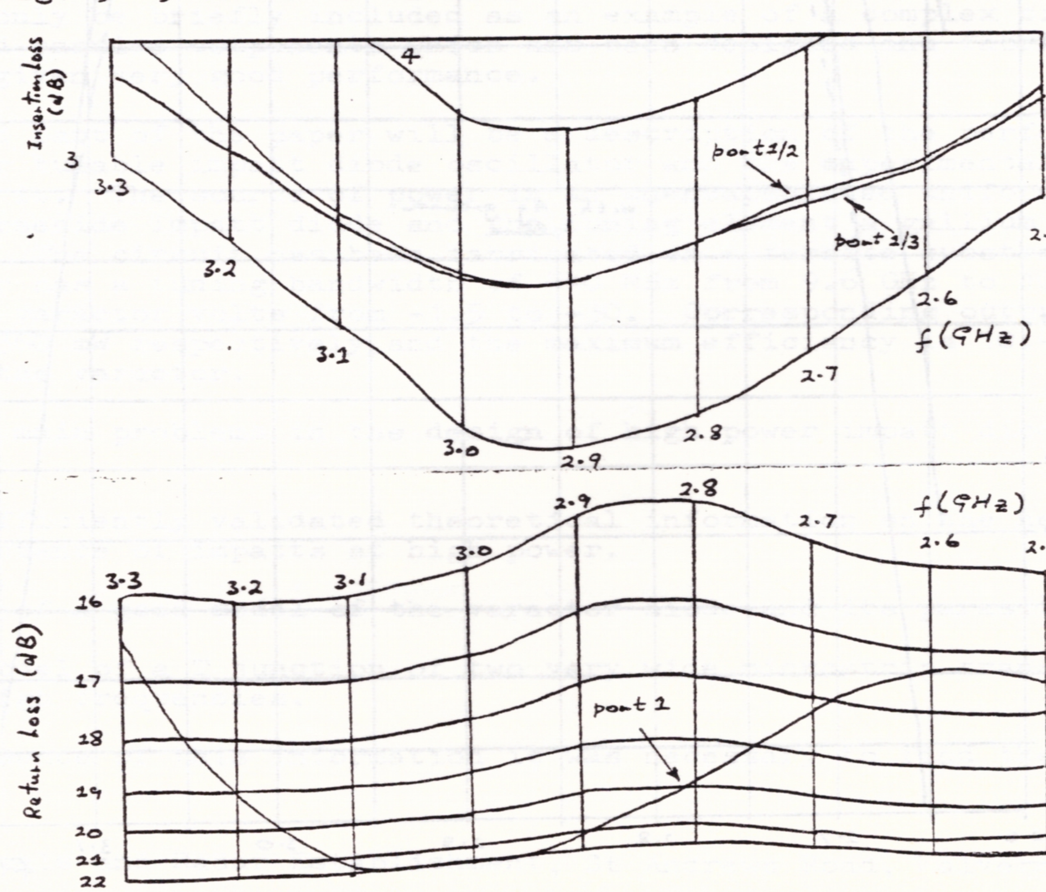

Fig. 4 Band Pass Filter Performance