DISTRIBUTED AND LOSSY MATCH ACTIVE POWER SPLITTERS USING BRIDGED-T LOW-PASS FILTER NETWORKS

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ABSTRACT

Wideband active power splitters using distributed or lossy match amplification have been designed and fabricated in hybrid form. These splitters use a bridged-T low-pass filter network. It provides a variable characteristic impedance without affecting a cutoff frequency, and thus, is powerful in an application to a multi-way power splitting/combining circuit which requires high impedance characteristics. A 2-way distributed active power splitter has achieved a gain of 1.8 $\pm$ 0.8 dB and input/output VSWR's of less than 2:1 over 0.5 to 26.5 GHz. A 2-way lossy match active power splitter has shown a loss of 1.3 $\pm$ 1.1 dB and input/output VSWR's of less than 2:1 across 0.5 to 26.5 GHz.

INTRODUCTION

During the past several years, a number of wideband monolithic distributed amplifiers have been reported in the literature [1],[2]. Associated with this development comes a wideband power splitter/combiner and mixer using a distributed-amplification approach [3],[4]. Wideband active power splitters are attractive in terms of gain, isolation and size over the conventional Wilkinson [5] or other planar power dividers [6],[7]. However, the previous distributed active power splitters have used a constant-K or m-derived low-pass filter network, showing a tradeoff between a characteristic impedance and cutoff frequency. To address this problem, a bridged-T low-pass filter network, which the author proposed in 1989 [8], is incorporated into the design of active power splitters using distributed or lossy match amplification. This papaer describes the design, fabrication and performance of hybrid distributed and lossy match active power splitters using a bridged-T low-pass filter network.

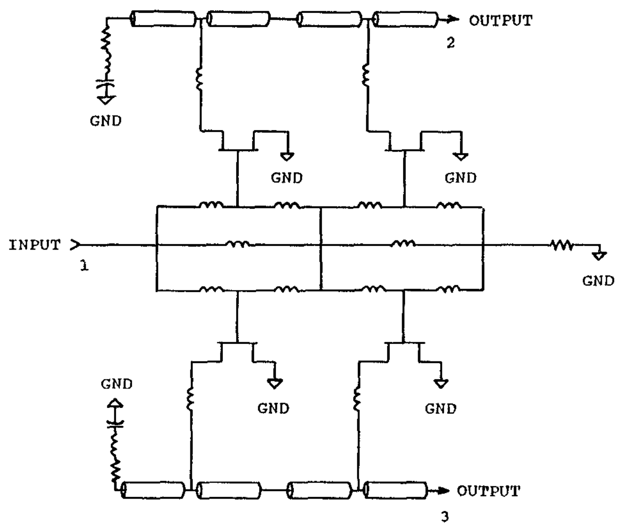

Fig.1 Schematic diagram of the 2-way distributed active power splitter

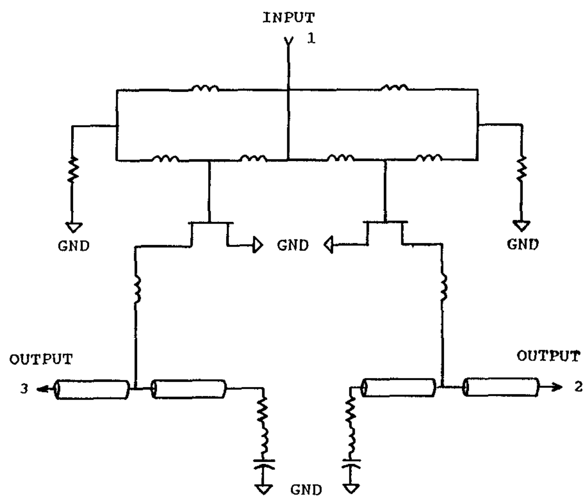

Fig.2 Schematic diagram of the 2-way lossy match active power splitter

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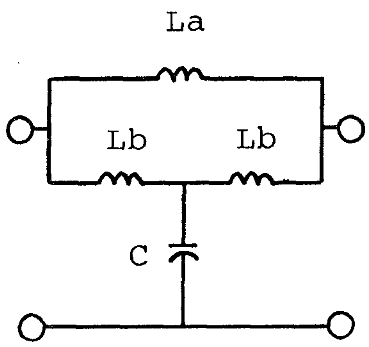

La : bridging inductance
Lb : bond-wire inductance
C : FET capacitance

CUTOFF FREQUENCY

$$\omega c = \sqrt{\frac{2}{LbC}}$$

CHARACTERISTIC IMPEDANCE

$$Zo \simeq \sqrt{\frac{2LaLb}{(La+2Lb)C}}$$

Fig.3 Bridged-T low-pass filter network

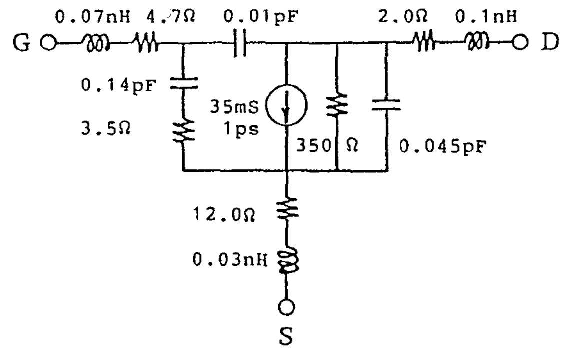

Fig.4 Equivalent circuit of 0.25 X 100 micron AlGaAs/GaAs HEMT

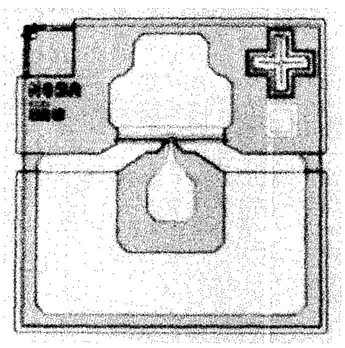

Fig.5 Microphotograph of 0.25 X 100 micron AlGaAs/GaAs HEMT (SONY SGH5501C)

CIRCUIT DESIGN

Schematic diagrams of the 2-way distributed and lossy match active power splitters are shown in Figs.1 and 2, respectively. The distributed power splitter can be seen as two independent distributed amplifiers whose input networks are linked commonly. The lossy match power splitter is equivalent to two independent lossy match amplifiers linked at the input port. The circuit was designed to minimize the number of FET's employed in the distributed or lossy match power splitter for the purpose of reducing power consumption. Each channel of the distributed power splitter uses only two FET's which is the minimum number of FET's for realizing a distributed amplifier. The lossy match power splitter uses only two FET's, which is the minimum number of FET's employed in the wideband active power splitters ever reported.

The input networks of both active power splitters were designed by using a bridged-T low-pass filter network whose equivalent circuit is shown in Fig.3. The bridged-T low-pass filter network contains four circuit elements that need to be implemented: bridging inductance (La), two bond-wire inductances (Lb) and FET capacitance (C). The outstanding feature of this network is that it can provide a variable characteristic impedance (Zo) without affecting a cutoff frequency (Wc) by changing a bridging inductance (La). This means that, when applied to a multi-way active power splitter, the bridged-T low-pass filter network improves gain and input VSWR without degrading bandwidth. The output networks of both active power splitters were designed by using a conventional m-derived low-pass filter network which has been used in the design of hybrid distributed or lossy match amplifiers [9],[10].

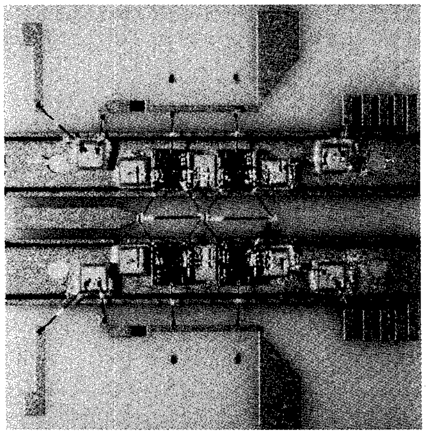

Fig.6 Photograph of the distributed active power splitter

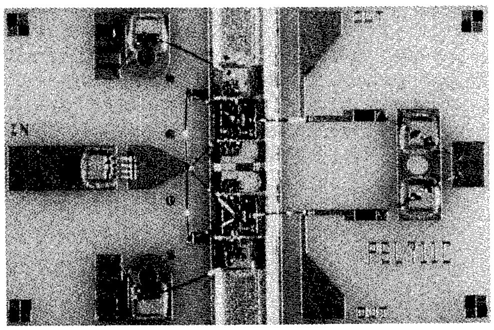

Fig.7 Photograph of the lossy match active power splitter

FABRICATION

Photographs of the 2-way distributed and lossy match power splitters appear in Figs.6 and 7, respectively. Thin film circuit is fabricated on 0.38 mm thick alumina substrate with TaN/Cr/Au microstrip lines. Both substrates have a narrow hollow with a depth of 0.12 mm and a width of 0.5 mm, where several via holes with a diameter of about 0.18 mm are drilled. This narrow hollow was made not only for heat sink but also for minimizing the gate bond-wire inductances. Considering the operating frequency above Ku-band, AlGaAs/GaAs HEMT with 0.25 X 100 micron gate was chosen, whose equivalent circuit and microphotograph are shown in Figs.4 and 5, respectively. The circuit size of the distributed and lossy match power splitters is 3.9 X 3.9 mm (Fig.6) and 2.9 X 4.5 mm (Fig.7), respectively.

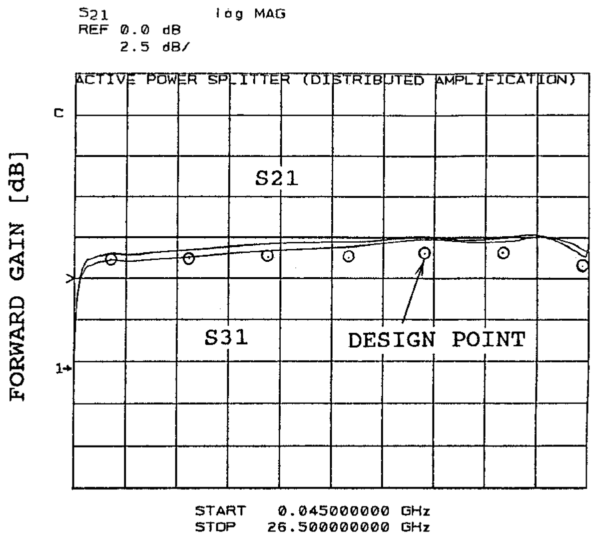

Fig.8 Predicted/measured forward gains of the distributed power splitter

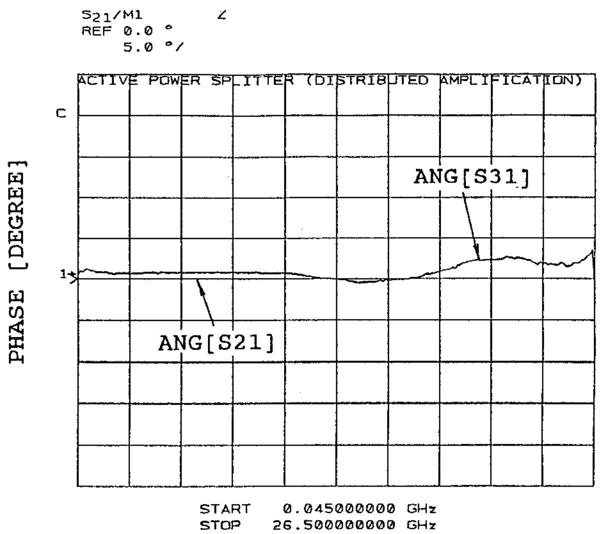

Fig.9 Measured phase match of the distributed power splitter

PERFORMANCE

Measured forward gains and phase match of the 2-way distributed power splitter are shown in Figs.8 and 9. Predicted forward gain as simulated for the circuit shown in Fig.1 is also plotted in Fig.8. The distributed power splitter shows forward gains of 1.8 $\pm$ 0.8 dB, amplitude match of less than 0.5 dB and phase match of less than 4 degrees over the 0.5 to 26.5 GHz band.

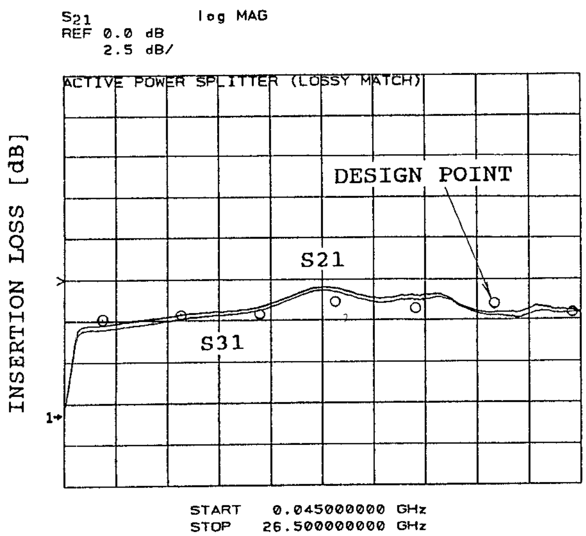

Fig.10 Predicted/measured insertion losses of the lossy match power splitter

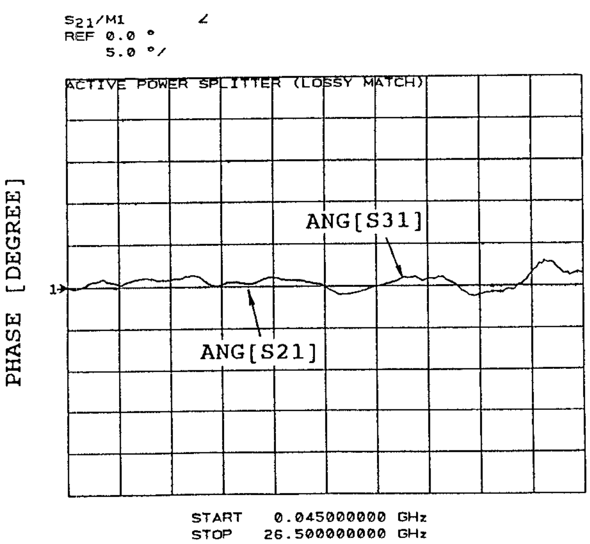

Fig.11 Measured phase match of the lossy match power splitter

Measured insertion losses and phase match of the 2-way lossy match power splitter are shown in Figs.10 and 11. Predicted insertion loss as simulated for the circuit shown in Fig.2 is also plotted in Fig.10. The lossy match power splitter exhibits insertion losses of 1.3 ± 1.1 dB, amplitude match of less than 0.3 dB and phase match of less than 4 degrees across the 0.5 to 26.5 GHz band. The predicted and measured insertion losses are in good agreement for both active power splitters. The amplitude and phase matches are also quite good. Other measured performance for both active power splitters are summarized in Table 1.

Table 1 Performance

	DISTRIBUTED	LOSSY MATCH
FREQUENCY	0.5-26.5GHz	0.5-26.5GHz
GAIN	1.8 ± 0.8dB	-1.3 ± 1.1dB
GAIN MATCHING	< 0.5 dB	< 0.3 dB
PHASE MATCHING	< 4 deg.	< 4 deg.
VSWR	2 : 1	2 : 1
ISOLATION	> 20 dB	> 26 dB
CURRENT	2 V, 24 mA	2 V, 12 mA

CONCLUSIONS

Wideband active power splitters using distributed or lossy match amplification have been designed and fabricated by using a bridged-T low-pass filter network. It has been demonstrated that the distributed or lossy match power splitter can achieve high gain or low insertion loss performance over decade bandwidths with the use of a bridged-T low-pass filter network.

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