A 2 - 18 GHz TRAVELLING WAVE LOSSLESS TWO-PORT COMBINER

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Summary

An extension of travelling wave amplifiers is applied to a lossless 2 - 18 GHz two-port combiner, realized in hybrid microstrip technology.

Its amplitude weighting capability allows its use in vector phase shifters for phased array applications ; it enables also to realize a lossless n-port combiner by cascading several identical modules.

Introduction

The principle of travelling wave amplifiers is particularly attractive for wide-band microwave applications, not only in MMIC technology but also in hybrid technology.

Among the possible applications of the distributed amplifier, signal combiners or dividers are to be found. They can be obtained by combining gate-lines or drain-lines in a particular way.

The purpose of this paper is to describe a lossless two-port combiner offering an amplitude weighting capability. This function is compatible with its use in vector phase shifters for phased array applications. The device acts in the 2 to 18 GHz frequency range and is realized in hybrid microstrip technology.

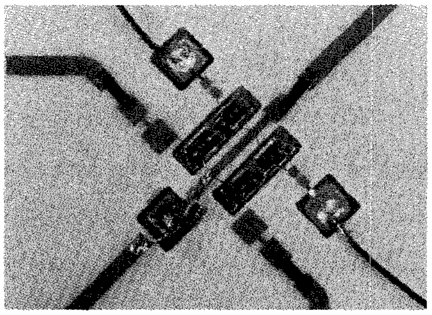


Fig.1 : Lossless two-port combiner

Principle of operation

The conventional distributed amplifier's equivalent structure consists of a gate-line and a drain-line actively coupled by FETs. A double gate-line and single drain-line amplifier leads to the block diagram in fig. 2.

This structure is basically equivalent to two independent distributed amplifiers linked by a common drain-line wich is the output of the combiner.

The two gate-lines are separately biased and the gain of each amplifier is controlled so that all possible signal combinations can be achieved at the output.

INN1, INN2, OUT, VGS1, VGS2, VDD

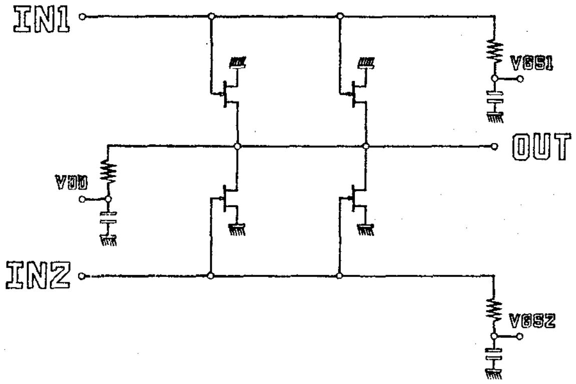


Fig. 2 : Block diagram

Among these combinations, the three principal states of the device are the following ones :

1. Combination of two signals (fig. 4a)

When all the FETs are biased at OV, the circuit acts as a conventional two-port combiner presenting neverthless 0 dB typical gain compared to the usual 3 dB losses.

2. Selection of one of the channels (fig. 4b and 4c)

When T_1 and T_2 are biased to the pinch off voltage $-V_p$, only the RF signal applied to the other access IN2 is transfered ; it is also modulated by the gate voltage applied to this channel.

3. No signal at all (fig. 4c)

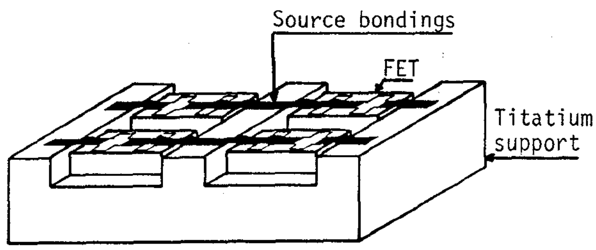
When all the FETs are biased at $-V_p$, there is no signal at the output. The isolation achieved is that of the drain-gate line of a distributed amplifier, i.e. about 20 dB.

The use of only two FETs on each channel was decided upon to obtain a 0 dB transmission gain. As a result, by cascading several identical modules, a n-port combiner presenting 0 dB gain in the 2 to 18 GHz frequency range is obtained.

Device fabrication

As an initial step in MMIC realisation, the circuit is achieved in hybrid microstrip technology, in a planar configuration without via-holes. In order to minimize the source parasitic inductances, the FETs are inserted between the ridges of a specially constructed titanium support. This enables the ground to be raised to the top level of the FETs. The microstrip alumina is also placed on the titanium support.

A diagram and a photo of the active area of the device are shown in fig. 3.



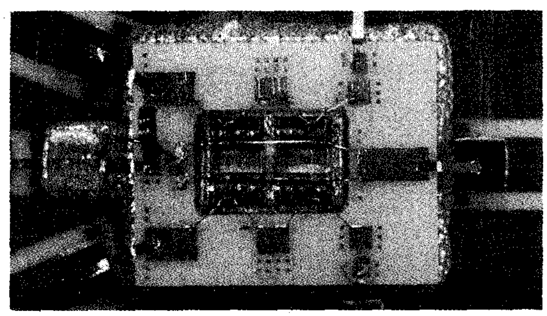


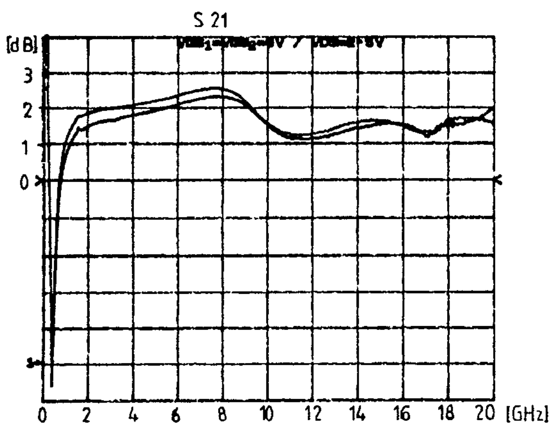
Fig. 3 : Diagram and photo of the active area ($3x3\ mm^2$)

Performance

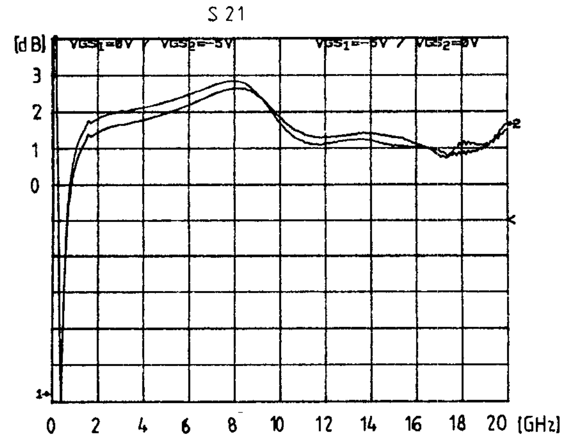
The device's essential characteristics are established by measuring the performance on one of the channels while the other channel is operating in both its possible states : on and off. In each case, transmission performance characteristics were observed for various gate bias conditions applied on the principal channel.

The transmission signal is controlled from + 1 dB to - 10 dB ; within this dynamic range, all the curves are flat and parallel to each other so that the circuit can be used as a tunable attenuator. A range of 10 dB is normally sufficient to obtain all the vector combinations from two orthogonal vectors in any sector (Fig. 4c).

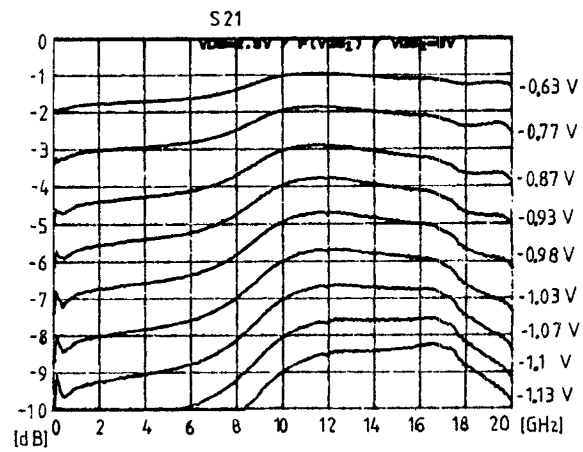
In all the gate bias configurations applied to each channel, the VSWR is better than 2 : 1, the isolation is about 20 dB, the isolation between inputs is better than 20 dB and the noise figure about 9 dB.



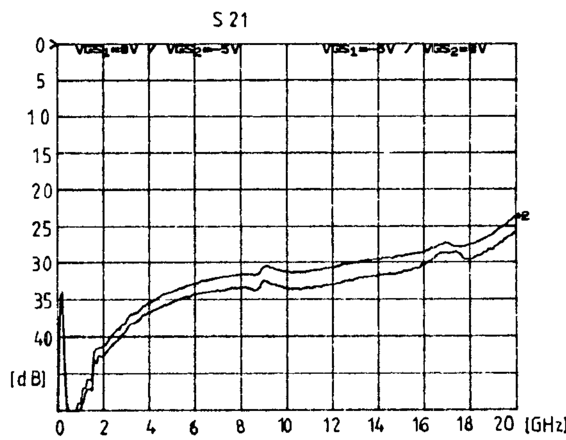
4a. State 1 : two channels on



4b. State 2 : one channel on / second channel off

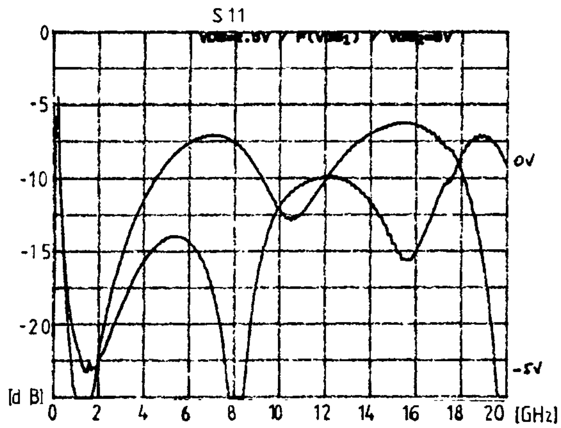


4c. State 3 : transmission control versus gate bias second channel off

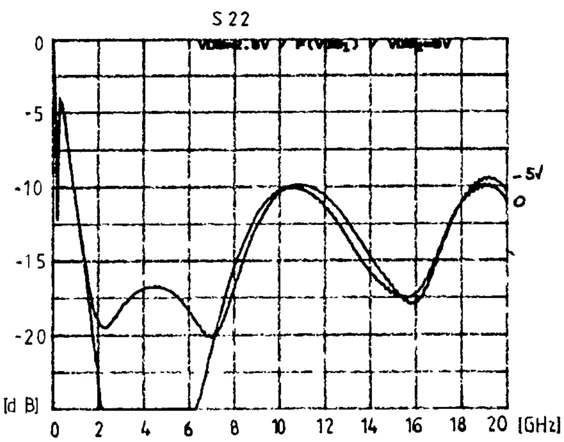


4d. Maximum isolation

Fig. 4 : Transmission performance



Input VSWR versus gate bias



Output VSWR versus gate bias

Fig. 5 : VSWR

Conclusion

This circuit illustrates perfectly the new possibilities of hybrid technology : it is not only to be considered as a preparating stage but also as a competitive alternative to Ga As MMICS.

The various extensions of the travelling wave amplifier theory led us to realize a lossless two-port combiner/modulator in the 2 to 18 GHz frequency range controlled by the gate bias applied to each channel.

By cascading several identical modules, a n-port combiner exhibiting 0 dB gain can be achieved whatever the number of inputs.

References

(1) U. CHRIST - "Optimised travelling - wave amplifier with two parallel gate transmission lines"

IEE Proceedings - vol 132 - PLI - N° 3 - June 1985

(2) W. STRID "A monolithic 10 GHz vector modulator" Ga As IC Symposium - 1983"