A NEW MICROWAVE VARIABLE POWER DIVIDER

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Abstract: A new variable power divider (VPD) has been developed without any phase shifter and only two diodes are needed and in a balanced circuit four diodes. The two varactor diodes are equally biased. The differential phase shift between the output is zero independent of the power dividing ratio. Measurements on an experimental VPD at L-band frequencies are presented.

Introduction

A new variable power divider (VPD) has been developed. The usual way to achieve a variable power dividing ratio is to split the incoming power into two parts with equal amplitude and phase. The two signals are then phase shifted α degrees and 90-α degrees, respectively, where α varies from 0 to 90 degrees. The signals are then added in a 3 dB hybrid which causes the power dividing ratio of the output signals to vary with α[1,2,3]. The new VPD has no phase shifter. The phase shifter is replaced by a 50Ω transmission line and a varactor diode.

The New VPD

The VPD consists of two 3 dB hybrids, two varactor diodes, and two 50Ω lines, each with an electric length of λ/4. All components are assumed to be lossless. Two diode arrangements are treated and the circuits are schematically shown in Fig 1a and 1b. The incoming power at port 1 is divided into two parts to the diodes. The capacitances of the varactor diodes are assumed equal and control the value of the reflection coefficients and the transmission coefficients. The two reflected signals are added at port 2, while the transmitted signals are added at port 3. Port 4 is isolated. The two output signals are isolated from each other and have the same phase shift from input to output. The phase shift of the output signals varies up to 90 degrees when the power dividing ratio is varied from minimum to maximum value.

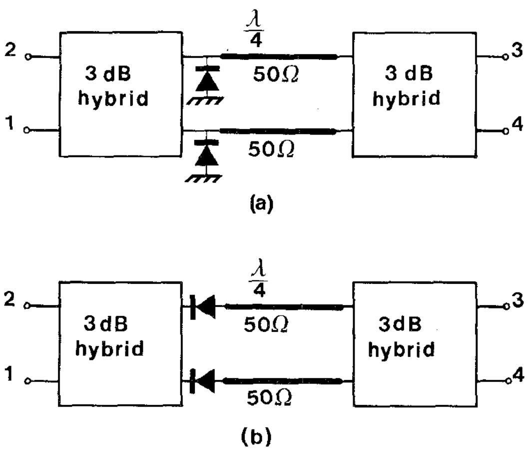

Figure 1 Variable power divider
a) with shunt diodes
b) with series diodes

The analysis is limited to the VPD in Fig 1a. If the reflection coefficients at the diodes are Γ and equal at the two diodes, then an incoming signal at port 1 gives a signal Γ at port 2 and nothing is reflected back to port 1. The same discussion can be used for the signal transmitted to port 3. If the 3 dB hybrid has greater bandwidth than the varactor diodes the VPD has the equivalent circuit in Fig 2.

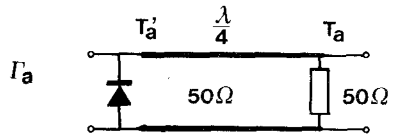

Figure 2 Equivalent circuit for the VPD

The reflected signal Γ_a is the signal at port 2, while the transmitted signal T_a is the signal at port 3. With the input impedance of 50Ω for the hybrids and the diode normalized susceptance equal to $j\bar{B}_d$

$$\Gamma_a = \frac{-j\bar{B}_d}{2 + j\bar{B}_d} \qquad (1)$$

$$T_a = \frac{2}{2 + j\bar{B}_d} e^{-\frac{j\pi f}{2f_o}} \qquad (2)$$

With a variation of $\bar{B}_d$ from 0 to infinity the amount of Γ_a and T_a is varied over the whole range. It is easily seen that Γ_a and T_a are in phase due to the λ/4 lines in the transmitted path. Thus the signals transmitted to port 2 and 3 have the same phase shift. The frequency response of the power dividing ratio is, within the range of the 3 dB hybrid, only dependent on the response of the susceptance $\bar{B}_d$. Since $\bar{B}_d$ is supposed to vary from 0 to infinity a matching network of the varactor must be used and this network will influence the bandwidth of the power dividing ratio.

Experimental Model at L-band

A VPD has been built at L-band in a three layer stripline circuit. See Fig 3.

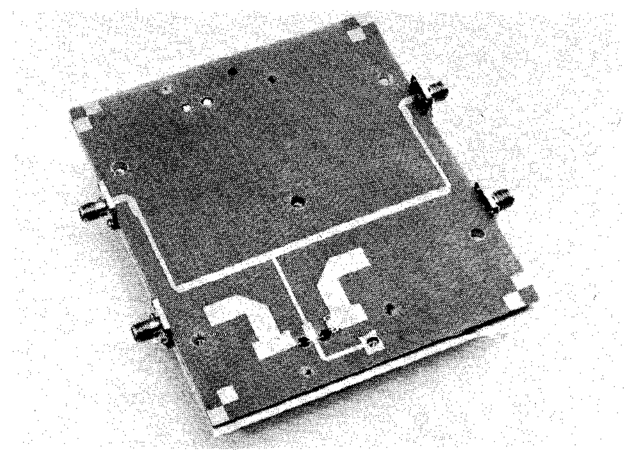

Figure 3 Stripline varactor diode VPD

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The VPD uses four diodes in a balanced circuit. The reason is that in many applications it is required to minimize the influence from the RF signal. The matching network consists of a $\lambda/4$ transformer and a short circuit stub. The broad stubs shown in Fig 3 are used to bias the diodes. The bandwidth of this matching network is not good. Another network has been found since this note was written. This network promises better bandwidth. The measured performance of the VPD at 1.6 GHz is shown in Fig 4. The differential phase shift in Fig 4 for very low or very high bias voltages is relatively big because one signal is very weak. The VSWR at the input is better than 1.3 and the isolation is greater than 28 dB over the frequency range 1.4-1.8 GHz.

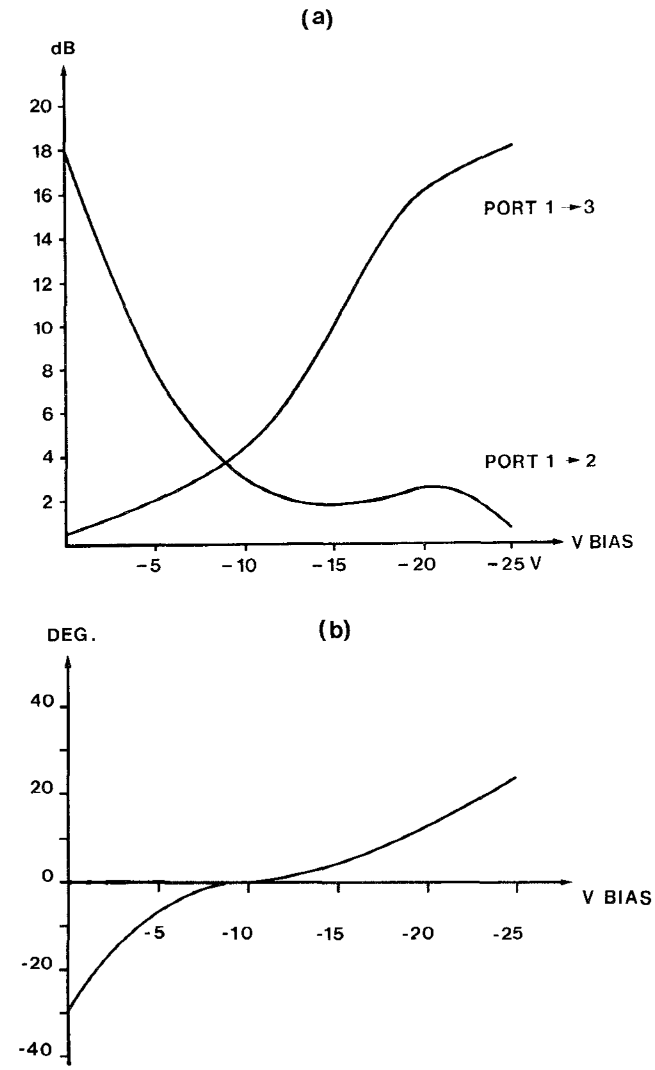

Figure 4 Measured curves at 1.6 GHz for the VPD in Fig 3
a) transmission loss
b) differential phase shift between outputs

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