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Cascading of Two QPSK Modulators for Improving Bandwidth & Gain

N.Shivareddy
Asst.Professor,Dr.T.T.I.T
K.G.F,shivadrttit@gmail.com(09449757970)

Abstract: A QPSK Modulator has been designed to operate at X-band frequency and simulated using EESOF Software.The Modulator consists of 90ohybrid,BPSK Modulators in parallel,Wilkinson power combiner combine their outputs.The BPSK Modulator has been designed using a 90ohybrid coupler,beam lead PIN diodes for switching and Micro-strip radial stubs are used to achieve broad band.The measured phase and amplitude deviations are ±1oand ±0.15dB respectively,over 350-MHZ bandwidth.The phases can be improved with better approximation of PIN diode parameters during design.

Key words-QPSK and BPSK Modulators,Center frequency,bandwidth.

1.1 Introduction

The demand for faster and more efficient information access has necessitated the development of highly efficient communication systems.Transmitters that can handle increasing volumes of data,with an efficient usage of the available bandwidth,are the need of the hour,for space bound systems.keeping in view the future requirements of the Remote sensing Satellites,a QPSK modulator to be designed and implemented to achieve high data rates.

The QPSK modulator was designed using EESOF Software.The input carrier is divided into two quadratic phase carriers.Each carrier is BPSK modulated with data.The QPSK modulation is obtained by combining the output of the two parallel BPSK modulators through Wilkinson power combiner.The hybrid coupler must have a 3dB power split with a 90^{o}Phase difference between its output signals.The design will be on Alumina substrate is used for the design[3].

1.2 General Design Considerations

All designs for QPSK modulators at microwave frequencies have either a serial or a parallel configurations.The serial configurations consists of a 0^{o}/90^{o} binary phase shifter cascaded to a 0^{o}/180^{o} binary phase shifter.This circuit gives good amplitude balance but may have undesirable switching transients in the output[3].A more commonly use design is the parallel configuration[4] shown in **Figure-.1**

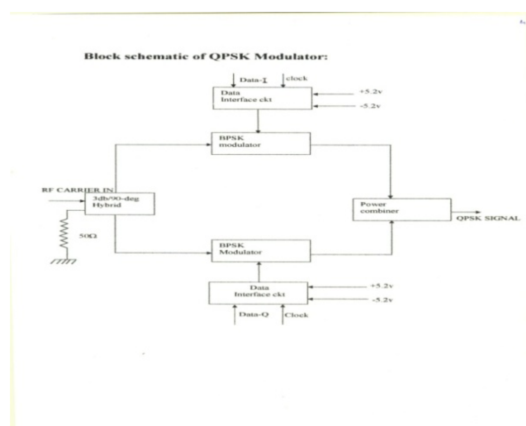

Figure1. Parallel configuration for design of a QPSK modulator.

Here, the RF carrier-In signal is divided by an in-phase,3dB hybrid and applied to identical BPSK modulators on both arms.The output of these modulators is combined by means of a Wilkinson power Combiner to produce the desired QPSK signal.

The BPSK modulators which determine the performance of the QPSK modulators have been realized at X-band by using various techniques.There are two categories of BPSK modulators: the transmission type and the reflection type. A reflection modulator consists of a hybrid with a matched pair of reflecting elements.Switching diodes are most frequently used to achieve strong reflections in forward and reverse bias modes.

Dual-gate FETs are well-suited as the switching elements for transmission modulators.The choice b/w an FET modulator and a diode modulator is based on such factors as size,weight,and power consumption.In most applications,high RF output power-handling capability can be traded off against amplitude and phase balance.For such applications,diode modulators appear to be a better choice when thermal stability of the circuit is a critical requirement[3].

A parallel configuration(Figure1) was adopted as the baseline design.First, balanced BPSK modulators were designed using PIN diodes and micro-strip radial stubs as reflecting elements at the arms of a 3dB/90^{o}hybrid(Branch line coupler).Then a BPSK modulator with excellent amplitude balance and a phase imbalance over 350-MHZ bandwidth was developed[5].

1.3 BPSK modulator design

Reflection Modulator Configuration

Refection modulators have been constructed by using 3-dB branchline coupler.The measured return loss of the BPSK modulator, designed and simulated using EESOF software,was 26 dB or more over a 350 MHZ bandwidth centered at 8.25GHZ.The underlying principle of the reflection modulator is to create reflections of equal amplitude and 180^{o}phase difference,by the two logic levels.These reflections are created by driving the diodes that are connected to the arms of the coupler into two distinct states.Theoretically, a strong forward bias or reverse bias can create a true short circuit or a true open circuit,respectively,there by achieving the required reflection coefficients.However, the finite values of the forward bias resistance(dynamic resistance) and the package capacitance could create an amplitude imbalance, and could also offset the phase in the two states.Additionally,the finite resistance affects the insertion loss(modulation loss) of the modulator.Because these effects worsen at higher frequencies,the choice of suitable diodes is a critical factor in the design of reflection modulators at microwave frequencies[3].

1.4 Characterization of PIN diode

Beam-lead PIN diodes(HPND 4050) were used in this modulator.The PIN diode is normally modulated by lumped element equivalent circuit for various bias conditions.Equivalent circuits of the PIN diode under forward and reverse bias are shown in **Figure 2.**The parasitic inductance and parasitic conductance are 0.02nH and 0.02pF respectively.The forward resistance R_f is 1.3Ω and junction capacitance under reverse biased C_j is 0.12pF and reverse series resistance R_r is 1.3KΩ.

The bandwidth of the BPSK modulator is governed by the bandwidth of coupler as well as the reflective network consists of microstrip radial stub.Microstrip radial stubs are used to achieve broad band.(The λ/4 impedance line is disconnected across biasing circuits).The BPSK is designed and simulated the phase difference between forward and reverse biased condition at 8.25 GHZ is 181^{o}[5].

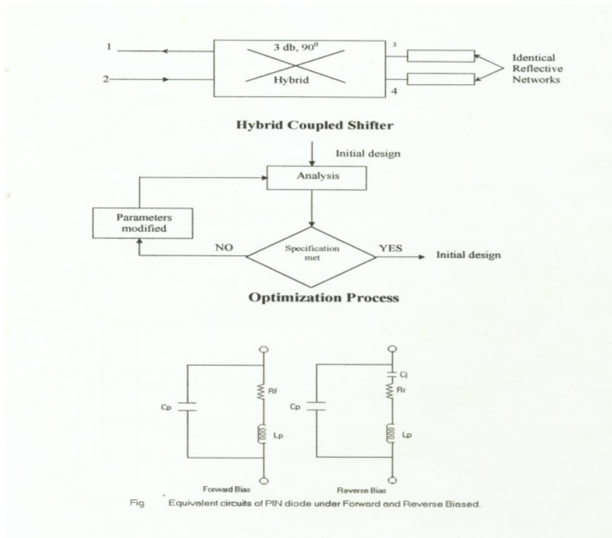

Figure 2.PIN diode models

1.5 Power Combiner

A power combiner is used to combine two modulated carriers which are in phase quadrature at its input ports.The combiner is required to have equal input and output impedances.The combiner must have enough isolation between the two input ports.These requirements may be achieved through use of series terminated,3-port,in-line power combiner first introduced by Wilkinson as in **Figure-3.**

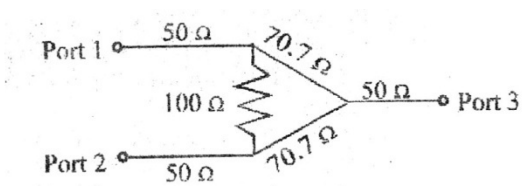

Figure3.Wilkinson power combiner.

This provides an isolation of about 20dB between the input ports.The power handling capability of the Wilkinson combiner design depends upon fabrication techniques and dissipation capabilities of the isolation resistors[5].

1.6 QPSK Modulator

The QPSK Modulator is designed and simulated using EESOF Software.The Performance Characteristics of the QPSK Modulator are given in **Table1.**

Center frequency	8.25GHZ
Bandwidth	350MHZ
Maximum RF input	-10dBm
Modulation loss	6dB
Phase imbalance	$\pm 1^{o}$
Amplitude imbalance	±0.15dB
Input return loss	≤ 26dB
Impedance	50Ω
Data compatibility	ECL
Power Supply	+5.2V/150mA - 5.2V/300mA

Table 1.

Performance Characteristics of the 8.25GHZ QPSK Modulator.

1.6 Conclusion:

A 8.25 GHZ QPSK modulator with high performance is required in a QPSK Regenerative modem for future communications Satellite pay loads.Designed modulator is to be fabricated on alumina substrate using thin film technology.Performance test results obtained from microwave integrated circuit are to be compared.The Phase of the modulator needs to be improved.

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