DESIGN & ANALYSIS OF AN X-BAND QPSK MODULATOR USING DIRECT CARRIER MODULATION TECHNIQUE

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Abstract—This paper presents the design & simulation of a QPSK Modulator (Quadrature Phase Shift Keying) based on Direct Carrier Modulation technique with a very simple circuitry. In this design, two double balanced mixers, Branch-line coupler & Wilkinson power combiner are used. The selection of a Double Balanced Mixer, being the main component of the design, is a critical issue. Specifications of mixer such as Conversion loss, Interport isolation etc are discussed. Branch-line coupler is used to produce in phase & quadrature signals & Wilkinson power combiner is used to combine the two modulated orthogonal signals at the output. These passive components are easy to fabricate, occupy reasonable area and provide satisfactory performance as compared to their counterparts. The simulated spectrum and static constellation diagrams of the modulator are presented. The circuit has been designed at 8.3 GHz X Band for 150Mbps bit rate.

I. INTRODUCTION

High performance & affordable transmitters for digital communication and radar systems are in demand. In traditional microwave transmitter systems, first modulation is carried out at an intermediate lower frequency and then the modulated signal is upconverted to the required transmitting frequency. To filter out the unwanted sidebands at the carrier frequency, a complex chain of filters and amplifiers are required [3]. The performance of the circuit is very good but due to the long chain of filters & amplifiers, hardware is bulky. Direct Modulation has attained considerable importance due to the minimal hardware complexity and cost especially for microwave wireless applications such as in satellites. Furthermore direct modulation eliminates the need of extra filters to reject the sidebands. Direct Modulators are widely used in cellular phones and wireless LAN communications.

Research has been done on direct modulation techniques based on Reflection Topology using FET(Field Effect Transistor), pHEMT (pseudomorphic High Electron Mobility Transistor) and PIN diodes as switches. Traditionally, current-controlled PIN diodes were used to realize a variable resistor. However, due to more expensive foundry processing & the significant control power required, PIN diodes are not often used in monolithic applications [3]. With MMIC technology, a tunable resistor can be realized using FET and pHEMT. However, there were amplitude & phase variations in the output signal dictated by the bias dependency of the intrinsic resistances & parasitic capacitances of these devices. These problems can be removed using passive double balanced mixers. The double balanced mixer having balanced diodes and transmission line transformers remove the spurious response of RF & LO frequencies. This eliminates the need of filters which makes the hardware bulky and complex [1]. The design and simulation of modulator is carried out using Harmonic Balance & Circuit Envelop Analysis.

II. QPSK DESIGN

Depending on the frequency of operation & performance criteria, there are various ways to implement the direct modulator. One of the microwave direct modulators is Tandem modulator also known as I-Q vector modulator which has the ability to control both amplitude and phase of the transmitted signal simultaneously [3]. Fig. 1 shows typical vector modulator with a 90° splitter, two mixers and an in-phase combiner.

Fig. 1. Typical QPSK Modulator

I-Q modulator consists of a quadrature 3dB power divider which creates two orthogonal channels. The two I (in-phase) & Q (90° out of phase), NRZ (non return to zero) data streams