[11-32]

An X-band HBT Harmonic Differential MMIC VCO using High Side Band Rejection Tripler.

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Abstract – *In this paper, the fully integrated x-band tripler differential voltage controlled oscillator (VCO) is designed and fabricated by the high linearity InGaP/GaAs HBT MMIC technology. The harmonic differential VCO consists of a differential VCO and two triplers. The VCO is designed for high oscillation frequency with the low phase noise using the tripler. The differential VCO generates the oscillation frequency of 3.583 GHz, the output power of 3.65 dBm and the phase noise of -96.7 dBc/Hz at 100 kHz offset with 2.9 V and 30 mA bias condition. The tripler shows the excellent side band rejection of 23 dBc using miniaturized open stub technique with 3 V and 12 mA. The harmonic diferential VCO achieves the oscillation frequency of 10.75 GHz, the output power of -13 dBm and the phase noise of -89.35 dBc/Hz at 100 kHz offset.*

1. Introduction

As increasing demand for high speed data rate, the operation frequency of satellite communication system moves to high in order to achieve more wide bandwidth. In accordance with this, for down conversion from RF band to IF band, high local oscillation (LO) frequency is required. However, as the oscillation frequency is increased, the quality factor of resonator is rapidly decreased and phase noise is increased. In this case signal to noise ratio is decreased and causes to data transmission error.

In order to solve this problem, oscillator using multiplier is proposed. It makes high oscillation frequency with low phase noise, because it uses the harmonics of oscillation signal with good phase noise. Phase noise is increased in the ratio of 20log N as increasing harmonic index (N) [1]. If the index is 3, the phase noise is increased to 9.4 dB. Therefore, as the higher frequency application, the increment of phase noise by harmonic index is lower than the increment by the Q factor of resonator. So oscillator structure using multiplier is necessary for high frequency band communication system.

This harmonic differential voltge controlled oscillator is fabricated by InGaP/GaAs HBT process. The flicker noise of InGaP/GaAs HBT process is lower than GaAs MESFET and GaAs HEMT. Low flicker noise issue is meaning of good phase noise of oscillator. So InGaP/GaAs HBT process is suitable to the oscillator [2].

2. Circuit Design

The harmonic differential VCO consists of a differential VCO and two triplers. The differential VCO is designed for the oscillation frequency of 3.583 GHz, which drives the tripler. The tripler converts the oscillation frequency of 3.583 GHz to the oscillation frequency of 10.75 GHz.

The differential VCO schematic is shown in Fig 1. The L1 and C1 constitute resonator. For frequency tuning varactor diode is implemented with base emitter connected transistor and it is allocated parallel to capacitor. Capacitor contributes 30.25 % of LC tank and capacitance variation ratio is 9.24 % in total capacitance. Thus, frequency tuning ratio by variable capacitor is 2.79 % of frequency 4.3 GHz which is the resonance frequency except for parasitic elements of strip line. So frequency tuning range is calculated around 120 MHz [3].

L2 and L3 control the phase of active block to satisfy Barkhausen criterion at the oscillation frequency. In order to control output power, the R2 and R3 are used. If these value increased, voltage signal swing at the collector of Q2 and Q3 is increased [4]. C1 and C2 are cross coupled capacitor and make positive feedback loop at the oscillation frequency. Q2 and Q3 generate balanced signal by switching operation. Q1and Q4 are composed of common emitter configuration enough power to provide for the tripler[8].

The tripler is composed of 2 stage amplifiers and it is depicted in Fig. 2.. First stage (Q5) and second stage (Q6) are common emitter topology and are optimized by class B operation mode to provide maximum power for third order harmonic, by the distortion of fundamental