An X-band HBT Tripler 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 developed using the high linearity InGaP/GaAs HBT MMIC technology. The tripler differential VCO consists of a differential VCO core and two triplers. The VCO core 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 30 mA from the supply voltage of 2.9 V. The tripler shows the excellent side band rejection of 23 dBc using miniaturized open stub technique with 3 V and 12 mA. The tripler differential MMIC 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 demands for high speed data rate, the operation frequency of satellite communication system moves to high in order to achieve more wide bandwidth. Accordingly, the high local oscillation (LO) frequency is required for down conversion from RF band to IF band. However, as the oscillation frequency is increased, the quality factor of resonator is rapidly decreased and phase noise is increased. Consequently, signal to noise ratio is decreased and data transmission error is increased.

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. Therefore, oscillator structure using multiplier is necessary for high frequency band communication system.

This tripler differential VCO is fabricated by InGaP/GaAs HBT process. Low flicker noise pulls down the phase noise of oscillator. The flicker noise of InGaP/GaAs HBT process is lower than GaAs MESFET, GaAs HEMT and other devices[2].

2. Circuit Design

The tripler differential VCO consists of a differential VCO core and two triplers. The differential VCO core is designed for the oscillation frequency of 3,583 GHz, which drives the tripler. The tripler converts the oscillation frequency of 3,583 GHz into the oscillation frequency of 10,75 GHz.

The differential VCO core schematic is shown in Fig 1. The L3 and C3 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].

L1 and L2 control the phase of active block to satisfy Barkhausen criterion at the oscillation frequency. In order to control output power, the R1 and R2 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. Common emitter drive stage (Q1 and Q4) are composed for enough power to provide for the tripler[8].

The tripler employs 2 stage amplifiers as shown in Fig. 2. The first stage (Q5) and second stage (Q6) are common emitter configuration and optimized to provide maximum power for the third order harmonic in class B operation mode.