[11-31] An Extremely Low Phase Noise X-band DRO using InGaP/GaAs HBT Technology

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Abstract A X band dielectric resonator oscillator (DRO) using InGaP/GaAs hetero junction bipolar transistor (HBT) technology is fabricated for Ku-band low noise block down-converter (LNB) system. The fabricated monolithic DRO achieves the output power of 1.73 dBm and the second harmonic suppression of 32 dB at 10.75 GHz oscillation frequency. The pushing figure of 7.17 MHz is measured by varying the supply voltage such as 3.3 ± 0.5 V. The extremely low phase noise performance of -109 dBc/Hz at 100 kHz offset and -131 dBc/Hz at 1MHz offset is obtained at the supply voltage of 3.25 V and the current consumption of 10.7 mA.

1. Introduction

With the rapid growth in X to Ku band satellite communication technologies, there is a great demand for the improved local oscillator (LO) performance. Because LO affects dynamic range, selectivity, and sensitivity of a receiver, the phase noise is a critical parameter of analysis [1].

The DRO is attractive and stable microwave source due to its high Q, low phase noise, good output power and high stability versus temperature. Because the bit error rate (BER) of the receiver in a digital system is directly affected by the level of the phase noise in the received signal, the DRO must exhibit low phase performance in order to satisfy the digital modulation scheme and BER requirements in a digital direct broadcast system (DDBS) [2]. Also, it must have the minimal frequency drift over temperature to lock the receiver into the selected channel, and provide enough power to directly drive the down-conversion mixer[3].

The HBT offers more efficient approach in many front-end signal processing functions than advanced Si homojunction bipolar transistor and III-V compound field effect transistor (FET) such as MESFET and HEMT technology. Phase noise in oscillators is dominated by low frequency $1/f$ noise up conversion, which is caused by mixing effects between the carrier and the noise near DC which follows $1/f$ behavior, the common one being $1/f$. Due to the low $1/f$ noise performance, HBT technology is more suitable for low phase noise performance than high efficiency applications. As HBTs have higher output power density compared to GaAs FETs as power amplifier [4], it can also generate a high oscillation output power [5].

In this paper, the InGaP/GaAs HBT based monolithic DRO as a LO of Ku-band low noise block down-converter (LNB) for a DDBS is fabricated. The measured phase noise characteristics is extremely low and much better than the phase noise specification of the LO for Ku-band LNB system [6].

2. Ku-band LNB System

The LNB is located in front of the dish and at the focal point of an antenna and performs the role of LNA. It converts the received electromagnetic signal fed from an antenna into an electrical signal and amplifies the signal during this conversion process [2].

The Ku-band LNB converts the radio frequency (RF) signal of 11.7 to 12.75 GHz to a lower intermediate frequency (IF) of 950 to 2000 MHz using the 10.75 GHz reference frequency of the X band local oscillator. The block diagram of the Ku-band LNB is shown in Fig. 1. The typical required phase noise specification of the DRO for Ku band LNB system is -95 dBc/Hz at 100 kHz offset and -115 dBc/Hz at 1 MHz offset from the 10.75 GHz oscillation frequency [6].

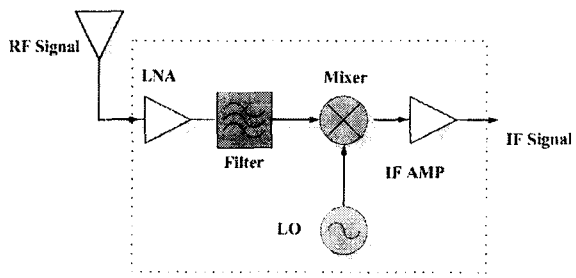

Fig. 1. Block diagram of the Ku-band LNB

3. Low Noise Characteristics of InGaP/GaAs HBT

The monolithic DRO is designed using 6-inch high linearity InGaP/GaAs HBT technology of Knowledge*on Inc. in Korea. Although the GaAs HBT has higher white noise than III-V FETs, its advantages include greater speeds with relaxed lithographic dimension, higher current per effective chip, better device matching, higher transconductance, low output conductance, and reduced trapping effects accompanied by low $1/f$ and phase noise [7].

Because the thermal conductivity of GaAs is lower than Silicon, the vertical bipolar inter-company (VBIC) model is used to consider self heating effect. The VBIC model extracts accurate large signal