MMIC Local Oscillator’s Chains for mm-Wave Bands

Rumen Kozhuharov* Toru Masuda+ Herbert Zirath*^ Vesa Löwenmark*

*Chalmers University of technology, Gothenburg , Fysikgränd 3, Sweden
^Ericsson Microwave Systems, Mölndal, Sweden
+Hitachi, Central Research Laboratory, Tokyo, Japan
rumen.kozhuharov@mc2.chalmers.se
tmasuda@crl.hitachi.co.jp
herbert.zirath@mc2.chalmers.se

Abstract

Three LO chains consisting VCO and active multiplier at 24, 32 and 54 GHz are described. The MMIC are developed on the base of GaAs pHEMT technology.

INTRODUCTION

The signal generation in the mm-wave bands can be realized either directly by an oscillator or by multiplication from a lower frequency. The use of frequency multipliers can be a practical and quick solution to generate high quality local oscillators (LO). That way the flexibility of the system design increases and gives the possibility of using high quality oscillator at lower frequencies in combination with high effective multiplier with HEMT technology.

MMIC VCO

A voltage –controlled oscillator at 8 GHz is implemented as a microwave source for further frequency multiplying by 3 and by 4 to obtain a signal at 24 and 32 GHz. Oscillator is based on a circuit topology shown on Fig.1. This is a single device negative resistance oscillator. Its design and operation has been described elsewhere [1].Commercial PHEMT-process with 0.2 µm gate length, 60 GHz ft, offered by Philips Microwave Limeil is used for fabrication of MMIC VCO.

The output characteristics of the VCO versus varactor control voltage are shown on Fig.2a. Three different bias voltages 2.4, 3.0 and 4.2 V are used. Dissipation power is between 75 and 110 mW. A frequency range of more than 300 MHz linear tuning can be covered with fairly constant output power. The measured phase noise at 1 MHz offset from the carrier versus the control voltage is depicted on Fig 2b.
MULTIPLIER TOPOLOGY

The schematic diagram of the implemented multipliers is shown at Fig. 3. The used transistors have an area of 4x15 µm size. Both – multipliers by 3 and by 4, are based on two-stage configuration. The process used for multiplier’s fabrication is a standard 0.14 µm gate length, 95 GHz \( f_t \), double delta-doped PHEMT process – offered by the OMMIC.

The first stage is grounded gate transistor, designed to achieve an active input impedance matching in a small chip area.

At the output 2-pole high pass filter is used for matching at the output frequency. This way a high rejection of the unwanted harmonics is achieved. (Fig. 4)

OSCILLATOR CHAINS

The photograph of the connected VCO and quadrupler is shown on Fig. 5. The size of both VCO multiplied by 3 and by 4 are similar - 3.5x2 mm. The output characteristics of the chains – power, frequency and phase noise are measured by using HP 8565E spectrum analyzer of Agilent.

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The power level of the unwanted harmonics is also evaluated. The measured output performances of LO chain at 24 GHz are shown on fig. 6. The bias voltages are $V_{d(vco)}=3\text{V}; V_{d1(trpl)}=2\text{V}; V_{g2(trpl)}=-0.9\text{V}$. $V_{d2(trpl)}=2\text{V}$. Dissipated power is mainly due to VCO and is 89 mW. The chain demonstrates an output power of 0 dBm at 24 GHz with almost constant level in a band width of 4%. The suppression of the fundamental, the second and the forth harmonic is 36 dB, 38 dB and 18 dB respectively.

The measured phase noise at 1 MHz offset from the carrier versus controlled voltage is depicted on fig. 7. According to the phase noise of the VCO (Fig. 2b) degradation of 10 dB is observed due to the multiplier noise degradation of $20\log (N)$, where N is the multiplication order [2] In the case of a frequency tripler the theoretical value is 9.5 dB. The output characteristics of LO chain at 32 GHz are depicted on fig. 8 and 9. A tuning range of 1.5 GHz and output power -6dBm is obtained. The rejection of the third harmonic is more than 10 dB. The total dissipation power is 92 mW.

Fig. 5 Photomicrograph of 8 GHz VCO with active quadrupler connected. Common size of chips is 3.5x2 mm

Fig. 6 Output power and frequency vs. varactor voltage of 24 GHz LO chain.

Fig. 7 Measured phase noise at 1 MHz offset from the carrier vs. varactor voltage

Fig. 8 Output power and frequency vs. varactor voltage of 32 GHz LO chain

Fig. 9 Measured phase noise at 1 MHz offset from the carrier vs. varactor voltage for 32 GHz output
A 28 GHz VCO with further multiplication of the output signal by an active frequency doubler was designed and implemented in the LO chain at 55 GHz (Fig 10).

Frequency tuning in 1.3 GHz bandwidth at 28 GHz is obtained with a drain DC-biased HEMT implemented as a varactor.[3] The doubler consists of two active cascaded HEMT- stages. It has been described elsewhere [4]. The output characteristics measurement has been performed using HP 8565E spectrum analyzer and HP 11974 pre-mixer. The VCO output power is 10 dBm and is enough to drive the multiplier into saturation. This explains the flatness of the output power characteristics, which is shown on Fig.11.

With small excess of the dissipation power of 48 mW related to fundamental frequency VCO (Pdiss=120mW), an output power of 5dBm in a 2.6 GHz tuning range is reached at 55 GHz. The suppression ratio of fundamental frequency component is more than 20dB.

SUMMARY

LO chains for three different bandwidths of the mm-wave range are described and characterized. The output characteristics indicate the feasibility of MMIC LO sources which are adequate for multi-circuit integration with mixer and PLL implementation.

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References


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