United Kingdom - Malaysia - Ireland
Engineering Science Conference 2011
(UMIES 2011), Kuala Lumpur, 12-14 July 2011

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Assembly of Low Phase noise Sub-Millimeter Wave Local Oscillator in Ku Band Frequency

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Abstract - A design and fabrication of a dual-band synthesizer device is presented in this paper. The noise analysis in synthesizer loop block component is modeled individually. The Design methodology is elaborated along with the test results. The initial frequency synthesizer in 1.8-2.4GHz frequency range (L and S-band) is designed and it is multiplied by 8. Microstrip bandpass filters (LFCN) are used to filter out the spurious frequency contents; the final output frequency is 14-20GHz (Ku-band). Phase noise investigation, design steps, filter assembling of 14-20GHz synthesizer is presented in this paper.

Keywords: *frequency synthesizer, serial radio link, phase noise*

1 INTRODUCTION

Designing a low jitter and phase noise frequency synthesizers as an integrated CMOS trend usually demands proportionally larger die area and power dissipation. In high speed communication systems where the frequency coverage is large, the best strategy to satisfy the design parameters is assembling compatible synthesizer system blocks which exist in the market [1]. The VCO block contributes a large portion in the total noise. Recently, high quality LC oscillators have been presented which exhibit very low jitter and phase noise along with acceptable frequency bandwidth [2]. However the output frequency is limited to less than a few Giga-Hertz. The other technique is to use special ring oscillator topologies which have shown high phase noise performance without power dissipation increment [3]. Design and assembling of frequency synthesizers are intensively covered in various references. Some of them discuss about the synthesizers in general and some discuss the IC design of synthesizers, other resources discuss about the design steps of particular synthesizer modules [4].

As the key component of mm-wave system, the demand for mm-wave frequency synthesizer with high spectral purity and integrity is growing rapidly [5]. The most commonly used technique is PLL-based mm-wave frequency synthesizer [6]; hence phase-lock-loop (PLL) technology

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dictates the main design parameters such as phase noise, power consumption and frequency stability.

The mm-wave frequency synthesizer designed in this paper embodies PLL and frequency multiplying scheme. The band frequency synthesizer is designed with low cost chip and external VCO to provide very low phase noise with high frequency resolution [7]. The frequency doublers are from Mincircuit Company www.minicircuits.com. The L-band frequency synthesizer is composed of ADF4118 by analog devices www.analog.com as the frequency synthesizer chip. It is an integer-N synthesizer with highly integrated and low phase noise and maximum frequency of 3GHz. ROS-2432-119+ from Minicircuits is chosen as the VCO, which has an output frequency band of 1662-2432MHz. it has typical output power of +5.5 dBm and -100 dBc/Hz at 10KHz and -122dBc/Hz at 100KHz offset frequency. The frequency of crystal TXO200U TCXO from RAKON Company is 10MHz with phase noise of -150dBc/Hz in 10KHz offset frequency www.rakon.com.

2 System block diagram

After the fabricating of the 1.8-2.4GHz synthesizer, we proceed to our main design target which is 14.4-19.7GHz synthesizer diagram.

The topology is based on frequency multiplication, as expressed below:

$$\frac{14.4-19.7}{2^3} = 1.8 - 2.4 \qquad (12)$$

The step size of synthesizer is increased by multiplication factor.

$$\text{step size}_{\text{in 14.4−19.7GHz synthesizer}} = 10\text{KHz} \times 8 = 80\text{KHz} \qquad (13)$$

Also take note that additional phase noise due to frequency doublers is calculated by:

$$20\log 2^3 = 18\text{dB} \qquad (14)$$

Hence our Synthesizer phase noise will be [8]:

$$98 - 18 = 80 \ {}^{\text{dBc}}/_{\text{Hz}} \qquad (15)$$

3 Band-pass Filter specifications

The Band Pass filters in this synthesizer application are very important to be accurate in terms of lower and upper band frequencies. The main reason is that after each multiplication by two, so many spurs frequencies will appear. In order to avoid these spurs contents on desired frequencies we designed three band pass (LFCN) filters with Microwave Office software. These band pass filters are Micro-strip filters which their simulated results are shown in figures 1 to 3.

It is observed that each band pass filter has its own specific frequency bandwidth to pass.

4 Conclusion

The output of the synthesizer is 14-20 GHz while the frequency step is 80KHz with 6GHz bandwidth. To measure the phase noise and spur contents,. The SPAN, RBW, and VBW are set to 50 KHz, 1 KHz, and 30 Hz respectively. The 51.03 dB power different between carrier and 10 KHz offset frequency leads to the output phase noise of the signal to be:

$$\text{Phase noise}_{\text{at 2.1 GHz}} = -51.03 - 10\log\text{RBW} = -80\ \text{dBc/Hz} \qquad (17)$$

Phase noises in different frequencies are measured by frequency spectrum analyzer of HP H8560 and they agree with the predicted measurements.

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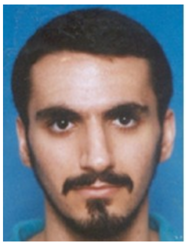

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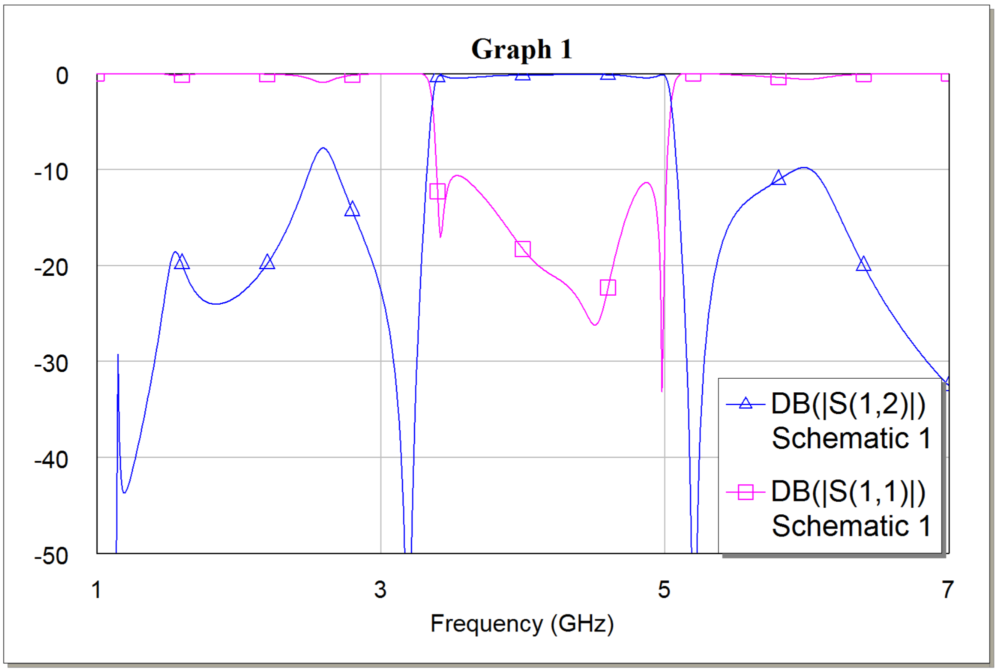

Figure 1. Frequency response of Filter from 3.6 to 4.8GHz

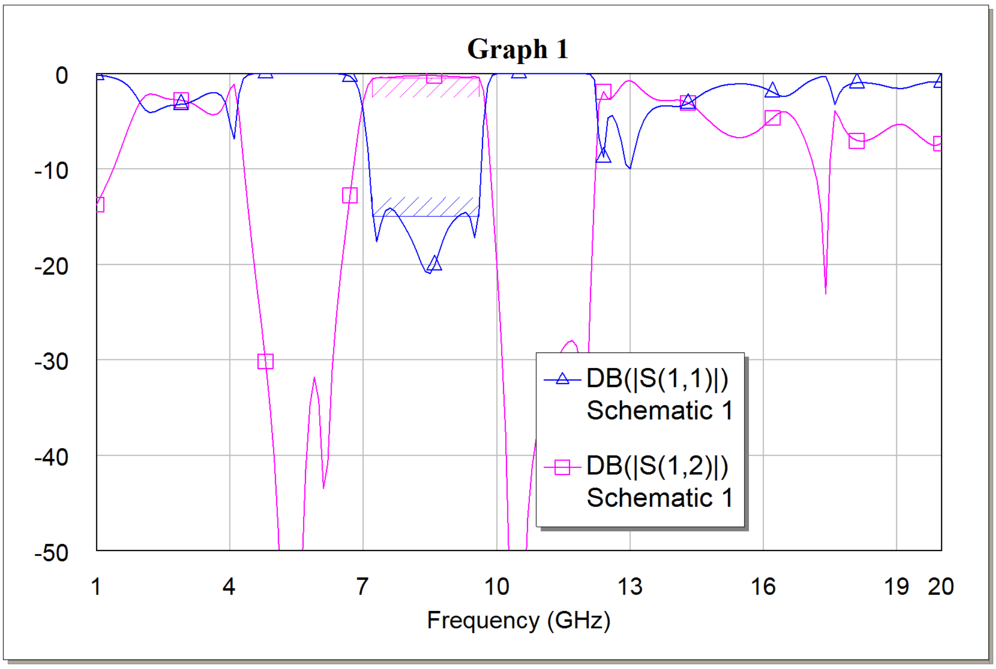

Figure 2. Frequency response of Filter from 7.2 to 9.6GHz

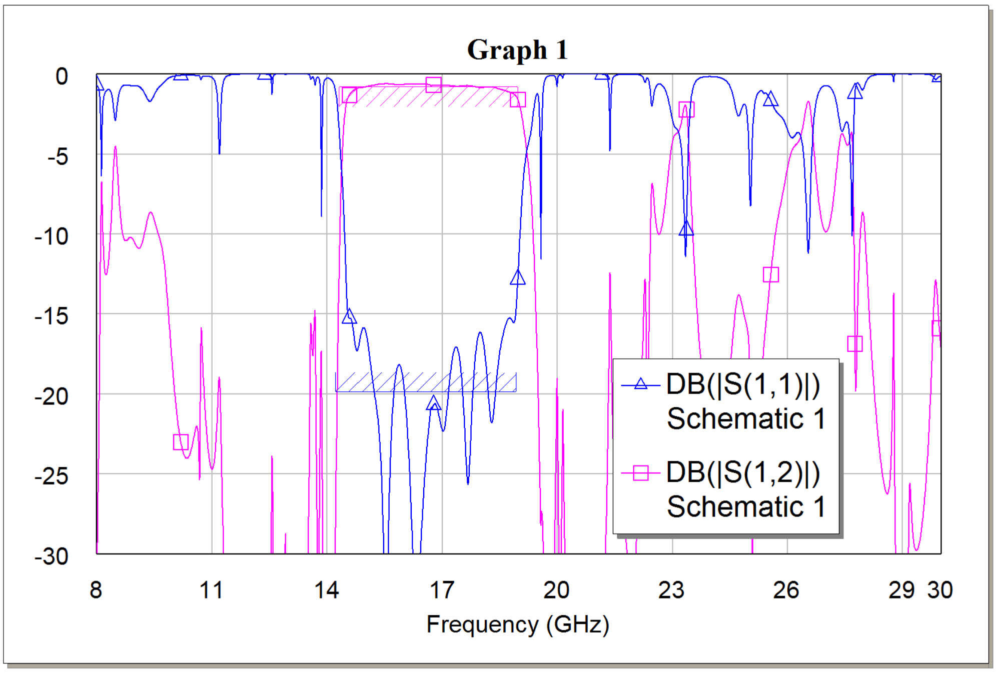

Figure 3. Frequency response of Filter from 14.4 to 19.7GHz