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Low Power Low Phase Noise LC VCO To Reduce Start Up Time OF RF Transmitter

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Abstract

Voltage controlled oscillator (VCO) is one of the key components of a phase locked loop (PLL), which is used in various synchronization schemes.In this paper,a 2.4GHz low phase noise LC tank VCO is designed and implemented in 0.18 um CMOS process to reduce the start up time of RF transmitter.After comparing measurement results of Differential cross coupled LC tank VCO and Complimentary cross coupled LC tank VCO using PMOS current mirror,Differential VCO provides minimum phase noise at low supply voltage which means that -126.5 dbc at 1.2 V as well as it provides low power and best FOM.

Index terms- *LC tank Voltage-controlled oscillator(VCO),CMOS,phase noise, supply voltage*

1. Introduction

Integrated voltage-controlled oscillators (VCOs) are important building elements in the implementation of a single-chip radio in today's communication systems[16] .The VCO performance in terms of phase noise, tuning range, and power dissipation determines many of the basic performance characteristics of a transceiver[17].

A typical transmitter requires maximum start up time.This maximum start up time consumes maximum energy.

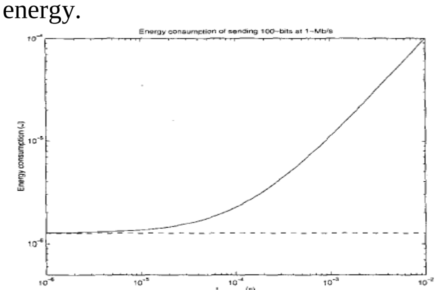

Figure 1: Effect of start-up transient

The solid line shows that as the start up time increases,energy consumption also increases and this energy consumption is reduced by lowering the phase noise of LC VCO[12].

2. NEGATIVE RESISTANCE MODEL OF OSCILLATORS

A typical LC tank VCO consists of LC resonator tank to provide oscillation.This oscillation phenomenon employs the concept of "negative resistance"[2]. The resonator can be equivalent to a parallel *RLC* tank circuit, whose *Rp* (parallel resistance) captures the energy loss inevitable in any practical system. If a resistor equal to *-Rp* is placed in parallel with *Rp* , as shown in Figure 1, since *Rp* // (*-Rp*) = ∞, the tank oscillates at wo indefinitely. Thus, if a one-port circuit exhibiting a negative resistance is placed in parallel with a tank, the combination may oscillate. This topology is called as negative resistance model.

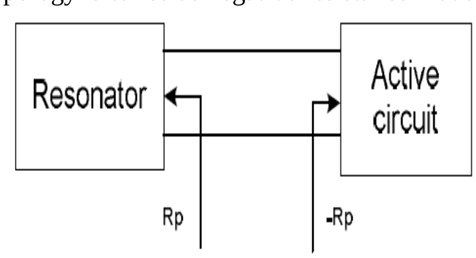

Figure 2: a simple negative gm oscillator block diagram

3. TOPOLOGIES OF LC TANK VCO

There are four different topologies of LC tank VCO such as differential cross coupled LC tank VCO, Complimentary cross coupled LC tank VCO,cross coupled LC tank VCO with pseudo resistance and Quadrature VCO with reconfigurable LC tank.

3.1 Differential cross coupled LC tank VCO

In[7] Differential cross coupled VCO is used to obtain the performance of low power and low phase noise. The resistor Rs controls the DC current as well as the peak dynamic current of the VCO. The P-MOSFET used in the cross-connected pair helps to reduce phase noise due to less flicker noise. Rs is a poly silicon resistor which is almost 1/f noise-free.

3.2 Complimentary cross coupled LC tank VCO

LC resonation tank has active power loss. The loss can be compensated by negative impedance. Usually active device is used to compensate the active power loss caused by the resonation tank. In this design[8], complementary cross coupled MOS transistors are used. To provide a DC bias for MOS transistors and to avoid strong dependency of output swing on supply voltage, a current mirror is employed. The complimentary cross coupled LC tank is designed by using PMOS current mirror which provides minimum phase noise as compared to the circuit designed by using NMOS current mirror.

3.3 Cross coupled LC tank VCO with pseudo resistance

Basic goal in this technique[9] is to decrease the power consumption of VCO In order to decrease the power consumption of VCO two PMOS and NMOS pairs are placed in tail of conventional VCO [9]. Each of these NMOS and PMOS transistors works in triode region .In triode region transistors work as resistor.These two resistances are added to the VCO in the path of power supply in order to decrease the power consumption. But since these resistances were used in differential mode, the overall transconductance of the cross-coupled transistors was reduced and hence the amplitude of the oscillator output waveform was decreased and the phase noise was destroyed.

3.4 Quadrature VCO with reconfigurable LC tank VCO

Quadrature VCO is used in multi band and multi standard transceiver system. For dual band operation reconfigurable LC tank[10] is connected which simply adjust oscillation frequency of VCO by the combination of inductors and/or capacitors.

Desirable requirement of low noise in order to reduce start up time of RF transmitter. This low noise and low power are provided by proposed design of differential cross coupled LC tank VCO and complimentary cross coupled VCO using PMOS current mirror .

4. SCHEMATIC DESIGN AND SIMULATION RESULT

In this paper we have designed 2.4GHz low power and low phase noise LC tank VCOs based based on the technology of TSMC 180 nm, we use the ADS tool Spectra to do simulation.

4.1 Differential cross coupled LC tank VCO

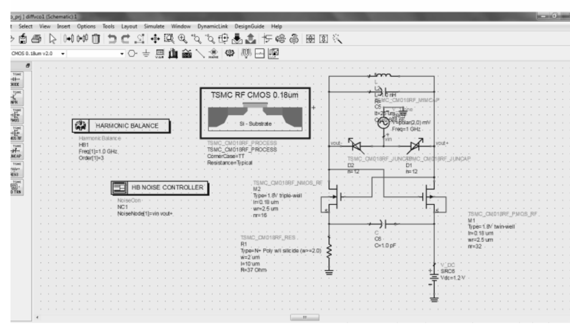

Figure 2.Schematic design of differential cross coupled VCO

Table 1:Relationship between Noise Frequency with Phase noise

Noise frequency (MHz)at 1.2 V	Phase noise(dbc)
1	-124.69219
2	-124.69220
4	-124.69224
6	-124.69227
8	-124.69230
10	-124.69234
200	-124.690
400	-124.699
600	-124.6707
800	-124.716
1000	-124.726
2000	-126
2400	-126.5
4000	-128.8
6000	-131.4
8000	-133.8

10000	-136.4

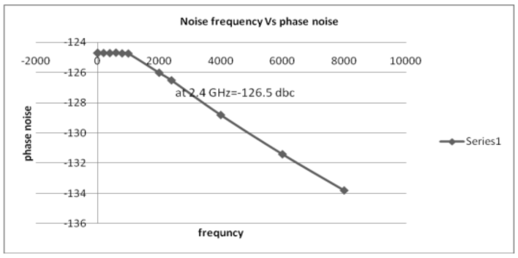

Figure 3.Relation between noise frequency with Phase noise

From this graph it is seen that as the noise frequency increases, phase noise decreases. Phase noise of given differential cross coupled LC tank VCO is -126.5 dbc at 2.4 GHz central frequency.

4.2 Complimentary cross coupled LC tank VCO using PMOS current mirror

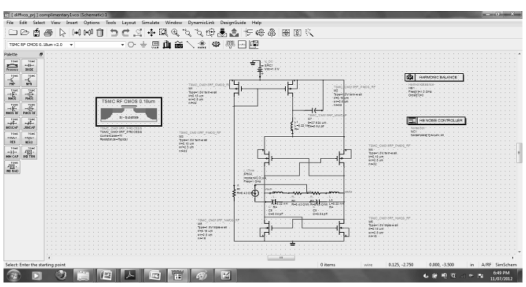

Figure 4:Schematic of complimentary cross coupled LC tank VCO using PMOS current mirror

Table 2:Relationship between Noise frequency with Phase noise

Noise Frequency (MHz)at 1.8 V	Phase noise(dbc)
1	-120.04419
2	-120.04422
4	-120.04431
6	-120.04439
8	-120.04447
10	-120.04454
200	-129.25
400	-120.55
600	-120.85
800	-121.2
1000	-121.5
2000	-122
2400	-122.2
4000	-123.3
6000	-124.4
8000	-125.5
10000	-126.6

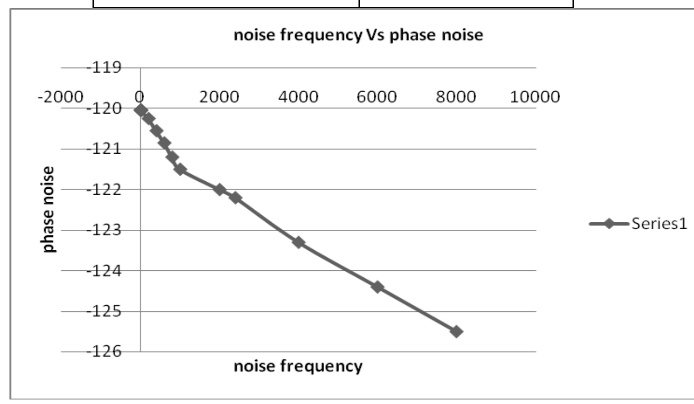

Figure 5:Relationship between Noise Frequency with Phase noise

Phase noise of given complimentary cross coupled LC tank VCO using PMOS current mirror is -122.2 dbc at 2.4 GHz central frequency.

By using transient analysis, the current has been calculated .After that the measured power is 0.499 mW for Differential cross coupled LC tank VCO and 48.6 mW for complimentary cross coupled LC tank VCO using PMOS current mirror.

A widely used figure of merit (FOM) to compare VCOs is defined as follow:

$$FOM=L\{fm\} +10\log [(fm/fo)^{2} Pdc] \qquad (1)$$

where L{fm} is the phase noise at the offset frequency f m from the carrier fo and PDC is the consumed DC power.

5. COMPARISON AND DISCUSSION

The VCOs are designed with TSMC 0.18um CMOS process. After comparing given schematic design of Differential cross coupled LC tank VCO with complimentary cross coupled LC tank VCO using PMOS current mirror, we note that phase noise is about -126 dbc at 1.2 supply voltage for differential cross coupled LC tank VCO and phase noise is about -122.2 dbc at 1.8 supply voltage for complimentary cross coupled LC tank VCO using PMOS current mirror. Proposed design of differential cross coupled LC tank VCO provides low power as well as best FOM. From the comparison table ,it is seen that for low supply voltage we will get lower phase noise as we got in case of proposed design of differential cross coupled LC tank VCO.

Table 3:Comparison between Differential and Complimentary cross coupled VCO

Mode	Differential VCO	Complimentary VCO
Technology	0.18um	0.18um
Supply voltage	1.2V	1.8V
Oscillation frequency	2.4GHz	2.4GHz
Phase noise	-126.5 dbc	-122.2 dbc
Power	0.499mW	48.6mW
FOM	-285db	-265db

6. CONCLUSION

In this paper we have compared differential cross coupled VCO and complimentary cross coupled VCO in term of phase noise,power and FOM.The proposed design of differential LC tank VCO provides low phase noise,low power as well as best FOM as tank VCO using PMOS current mirror.We have concluded that the start up time of transmitter will reduce which uses differential cross coupled LC tank VCO because of its lower phase noise and as the start up time reduces ,energy conserved by that system also reduces.

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