



International Journal of Emerging Technologies in Computational and Applied Sciences (IJETCAS)

www.iasir.net

ULTRA WIDE BAND VCO USING CMOS TECHNOLOGY

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Abstract: Ultra wideband (UWB) wireless technology has promoted designing devices covering wide bandwidth over several GHz. UWB oscillators that should achieve very wide tuning range along with low phase noise performance. Wideband (Ultra Wideband) oscillators can be realized by carefully designing passive and active devices. The techniques for sizing and layout design of active and passive elements are discussed to optimize the phase noise performance of oscillators. We will design and simulate CMOS VCO capable of multi-GHz and wide tuning range. The VCO will be based on inductive tuning, realized by the tunable active inductor (TAI) using CMOS technology that can provide a tuning range between 0.5–2.5 GHz using Hartley structures. The project also deals with some phase noise reduction techniques such as PLL-based feedback and harmonic tuning.

Keywords: CMOS Technology, Colpits VCO, Noise Analysis, PLL.

I. Introduction

Voltage Controlled Oscillators (VCOs) are perhaps the most ubiquitous element in all communication systems, wired or wireless. They appear in many analog and RF signal processing systems. Wireless and optical communication systems have shown an explosive growth during the last few years. This exponential growth has driven the need for more compact, more cost-effective, fully integrated, low noise, low power voltage controlled oscillator (VCO). Apart from communication systems, VCOs are integral part of biomedical applications. As the feature size getting smaller, CMOS technologies became attractive for the realization of high speed and high frequency ICs [1],[2],[6].

II. Simple LC Oscillator

It is a simple LC oscillator that consists of an inductor and a capacitor as shown in Figure 1. It is used to generate the sustained oscillations. The value of capacitor used in it is 4pF and inductor is of value 10mH. The resistance of inductor is very high which results in damped oscillations. In order to avoid these damped oscillation we have to use a resistor of same value but of negative amplitude is applied in series with inductor. It results in the sustained oscillations [6],[7]. The frequency of the oscillator is obtained by using the formula that is

$$F=1/(2\pi\sqrt{LC})$$

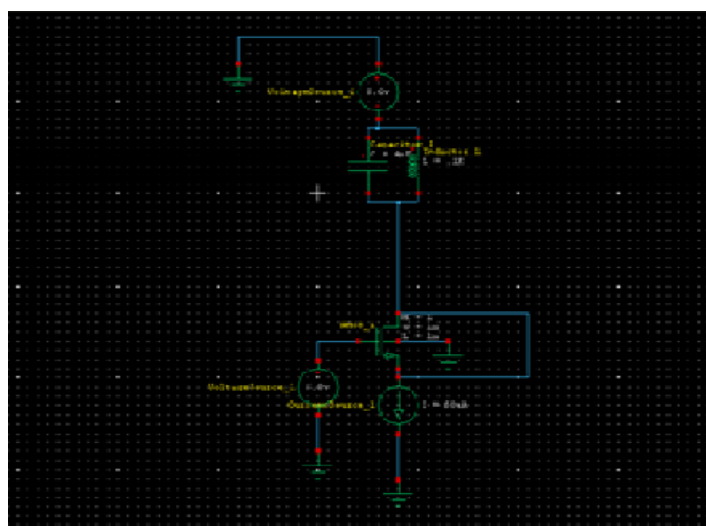


Figure 1 Simple LC Oscillator

Coding

***** Simulation Settings - General section *****

```
.probe
.option probev
.option probei
.option probeq
.lib "C:\Documents and Settings\user\My Documents\Tanner EDA\Tanner Tools
v12.6\Libraries\Models\Generic_025.lib" TT

***** Simulation Settings - Parameters and SPICE Options *****

*----- Devices: SPICE.ORDER > 0 -----
CCapacitor_1 N_2 N_1 4p
LInductor_1 N_2 N_1 L=10m
NMNOS_1 N_1 N_3 N_1 Gnd NMOS W=10u L=1u AS=9p PS=21.8u AD=9p PD=21.8u
VVoltageSource_1 N_3 Gnd DC 5
VVoltageSource_2 Gnd N_2 DC 5
ICurrentSource_1 N_1 Gnd DC 60u
***** Simulation Settings - Analysis section *****
.tran/Powerup 1u 10u
***** Simulation Settings - Additional SPICE commands *****
.end
```

In this we are improving the performance of simple LC oscillator by providing transconductance in feedback path. It is shown in Figure 2.

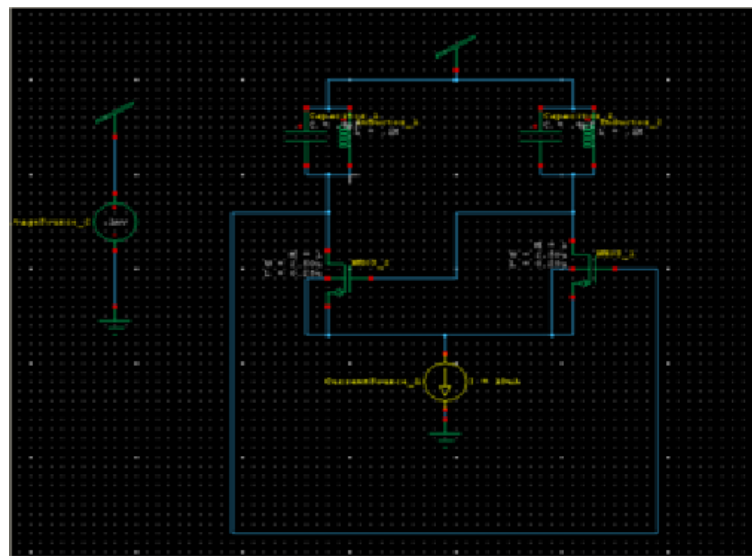


Figure 2 LC tank circuit with a transistor in feedback

Coding

```
***** Simulation Settings - General section *****

.probe
.option probev
.option probei
.option probeq
.lib "C:\Documents and Settings\user\My Documents\Tanner EDA\Tanner Tools
v12.6\Libraries\Models\Generic_025.lib" TT

***** Simulation Settings - Parameters and SPICE Options *****

*----- Devices: SPICE.ORDER > 0 -----
CCapacitor_1 Vdd N_1 400f
```

```
CCapacitor_2 Vdd N_2 400f
LInductor_1 Vdd N_1 L=100m
LInductor_2 Vdd N_2 L=100m
NMOS_1 N_2 N_1 N_3 N_3 NMOS W=2.5u L=250n AS=2.25p PS=6.8u AD=2.25p PD=6.8u
NMOS_2 N_1 N_2 N_3 N_3 NMOS W=2.5u L=250n AS=2.25p PS=6.8u AD=2.25p PD=6.8u
VVoltageSource_2 Vdd Gnd DC 100u
ICurrentSource_1 N_3 Gnd DC 10u
```

***** Simulation Settings - Analysis section *****

```
.tran 1us 20us start=60u UIC
```

***** Simulation Settings - Additional SPICE commands *****

```
.end
```

III. TAI –based Hartley UWB VCO

UWB VCO demands for extending the tunability bandwidth to multi GHz range. TAI is a good method of achieving noise and non linearity [5]. Since there are major advantages of passive inductors in terms of area, tunability and higher Q factor [3],[4]. The basic structure of Hartley oscillator with a common source amplifier and passive inductor is shown in Figure 3. This circuit is implemented on S-edit with advancement of replacing passive inductors with active tunable inductor using CMOS .25nm technology as shown in Figure 4.

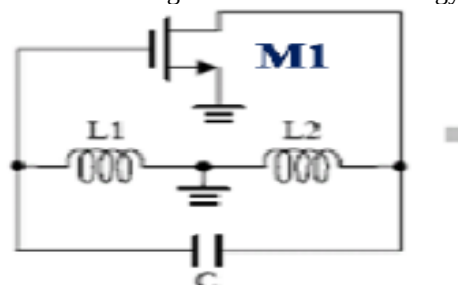


Figure 3 Simple Hartley Oscillator [4]

Hartley Oscillator with active inductor

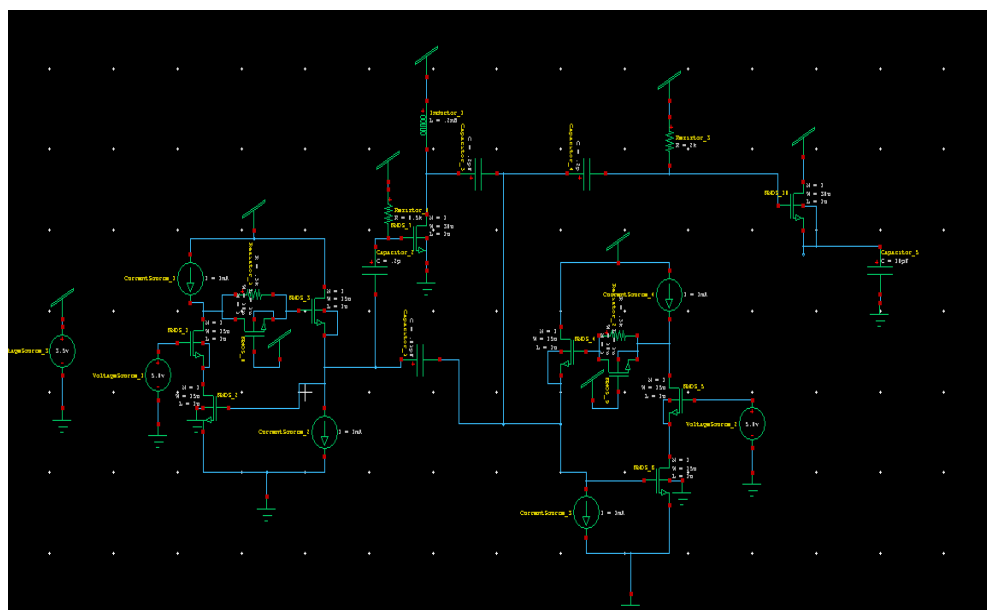


Figure 4 Hartley Oscillator with active inductor

Coding

*----- Devices: SPICE.ORDER > 0 -----

```
CCapacitor_5 N_15 Gnd 10p
CCapacitor_1 N_4 N_13 10f
CCapacitor_2 N_12 N_4 20f
```

```
CCapacitor_3 N_5 N_13 200f
CCapacitor_4 N_13 N_8 200f
RResistor_1 N_1 N_6 R=30k
RResistor_2 N_7 N_9 R=30k
RResistor_3 Vdd N_8 R=2k
RResistor_4 Vdd N_12 R=500
LInductor_1 Vdd N_5 L=100p
MNMOS_3 Vdd N_6 N_4 N_4 NMOS W=15u L=1u AS=13.5p PS=31.8u AD=13.5p PD=31.8u
MNMOS_4 Vdd N_7 N_13 N_13 NMOS W=15u L=1u AS=13.5p PS=31.8u AD=13.5p PD=31.8u
MNMOS_5 N_9 N_10 N_11 N_11 NMOS W=15u L=1u AS=13.5p PS=31.8u AD=13.5p PD=31.8u
MNMOS_6 N_11 N_13 Gnd Gnd NMOS W=15u L=1u AS=13.5p PS=31.8u AD=13.5p PD=31.8u
MNMOS_7 N_5 N_12 Gnd Gnd NMOS W=38u L=1u AS=34.2p PS=77.8u AD=34.2p PD=77.8u
MNMOS_8 N_1 Vdd N_6 N_6 NMOS W=10u L=1u AS=9p PS=21.8u AD=9p PD=21.8u
MNMOS_9 N_7 Vdd N_9 N_9 NMOS W=10u L=1u AS=9p PS=21.8u AD=9p PD=21.8u
MNMOS_10 Vdd N_8 N_15 N_15 NMOS W=30u L=1u AS=27p PS=61.8u AD=27p PD=61.8u
MNMOS_1 N_1 N_2 N_3 N_3 NMOS W=15u L=1u AS=13.5p PS=31.8u AD=13.5p PD=31.8u
MNMOS_2 N_3 N_4 Gnd Gnd NMOS W=15u L=1u AS=13.5p PS=31.8u AD=13.5p PD=31.8u
MNMOS_11 N_15 N_14 Gnd Gnd NMOS W=30u L=1u AS=27p PS=61.8u AD=27p PD=61.8u
VVoltageSource_1 N_2 Gnd DC 2.5
VVoltageSource_2 N_10 Gnd DC 2.5
VVoltageSource_3 Vdd Gnd DC 5
VVoltageSource_4 N_14 Gnd DC 5
ICurrentSource_1 Vdd N_1 DC 1m
ICurrentSource_2 N_4 Gnd DC 1m
ICurrentSource_3 N_13 Gnd DC 1m
ICurrentSource_4 Vdd N_9 DC 1m
```

***** Simulation Settings - Analysis section *****

.tran/Powerup .1n 1n

***** Simulation Settings - Additional SPICE commands *****

.end

IV. Simulation Results

The simulation result of simple LC oscillator is shown in Figure 5.

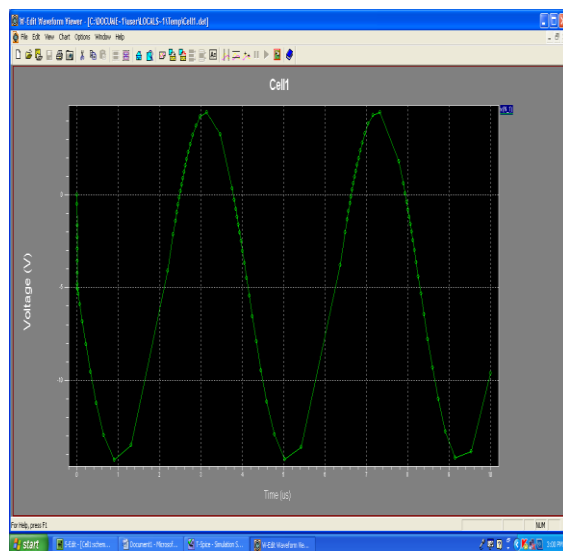


Figure 5 waveform of LC oscillator

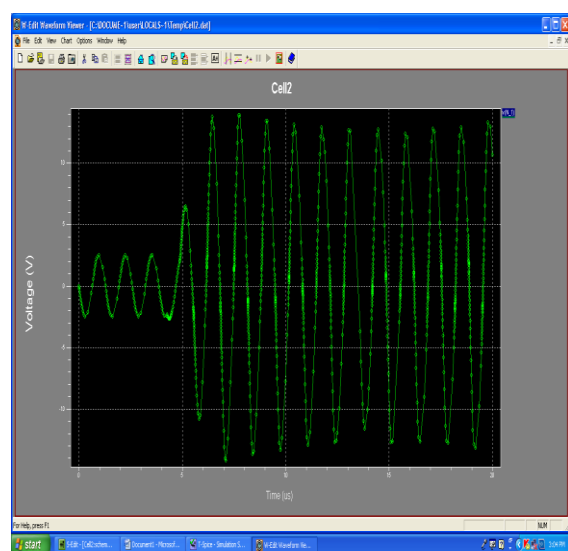


Figure 6 Waveform of LC tank circuit with a transistor in feedback

The simulation result of simple LC oscillator with a transistor in feedback path is shown in Figure 6. After simulation we get this oscillation and we get the oscillation of 2.5GHz as shown in Figure 7.

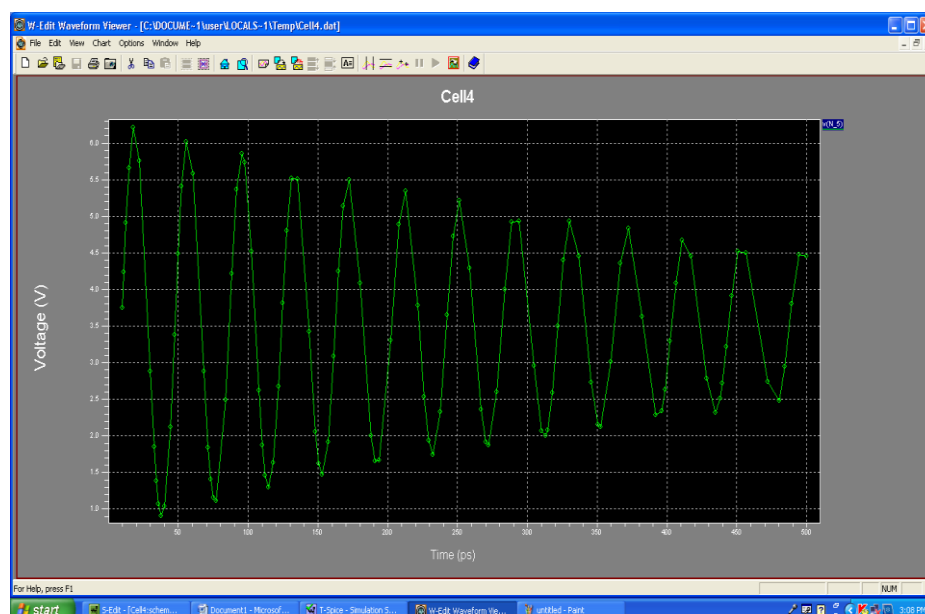


Figure 7 Waveform of Hartley Oscillator with active inductor

V Conclusion

In this paper, the transient response of TAI Based Hartley VCO is obtained. In this different frequencies at different voltages are obtained. It means that frequency is varied in accordance with the variation in voltage. It is measured by drawing voltage- time plot for VCO and from plot we observe that with the change in voltage frequency is also changed. In this project we get the frequency of the range (0.5GHz-2.5GHz).

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