DOI: 10.15439/2017R02
ACSIS, Vol. 10 ISSN 2300-5963

Realization of Colpitts Oscillator using second generation current controlled current conveyor

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***Abstract*—An inductor-less tunable Colpitts oscillator using second generation current controlled current conveyor (CCCII) is implemented. The circuit uses a CCCII and three grounded capacitors. The passive inductor has been replaced by an active inductor [14] connected to the ground. Thus the absence of external resistor and an inductor in the circuit makes it more complacent for IC Design. The frequency of oscillation can easily be electronically adjusted. The PSPICE simulation results have been deduced. The theoretical results are verified with the parameters of BJT PR100N (PNP) and NR100N (NPN) using PSPICE simulation tool.**

***Index Terms*—Inductor-less tunable, Colpitts oscillator, active inductor, CCCII**

I. Introduction

An oscillator circuit is an electronic circuit that produces signal of repetitive oscillations, often a sine wave or a square wave [1] . Over the last three decades or so various schemes of the design of the R-C oscillator, based on various current conveyors have been developed [2-4]. The generation of oscillation was invented by Edwin Henry Colpitt's (1872-1949) [6]. The Colpitts oscillator is mostly designed for generation of high frequency oscillations. The Colpitts oscillator is the exact opposite of the Hartley; instead of using a tapped inductance, Colpitts oscillator uses a tapped capacitor. In 1966 [7] introduces, a new analog building block for high frequency application named as current controlled current conveyor. The most important advantage of current conveyor, compared to the operational amplifier provides high electronic tunablility, wide bandwidth, and low power [8] etc. Colpitts oscillator design is available in various forms like: RF Chaotic Colpitts oscillator [9], BJT transistors based oscillator [10-12], Colpitts oscillator using ICCII [13], complementary Colpitts oscillator in CMOS technology [14].

The purpose of presenting work is to analyze and exploit the CCCII based current mode oscillator circuit [2-6] which uses only three CCCIIs and two grounded capacitors. The previously introduced concepts were partly reflected and extended, especially in the following points:

- Inductor has been replaced by the CCCII based Active Inductor [15].
- No resistance and inductor have been used in proposed circuit.
- Minimum number of components (only three capacitors) has been used.
- The frequency of oscillations for active mode inductor-less Colpitts oscillator has been adjusted by bias current I0 and capacitor values individually.

Also a simulation and experimental implementation of the Colpitts oscillator circuits performed using commercially available IC AD844AN.

II. Circuit description

A. *Second generation current controlled current conveyor (CCCII)*

Active block CCCII [8] can provide electronic control in various circuits like in filter [16], sinusoidal oscillator [17] etc. The circuit symbol of the CCCII and its trans-linear circuit is shown in Fig.1. Further use I_X and I_Y to denote current and V_X and V_Y to denote the voltage at terminal X and Y, respectively, and $R_x = \frac{V_T}{2I_o}$ to denote intrinsic series input resistance of a trans-linear mixed loop (Q1 to Q4) at the X port has electronically tunable via I_0 and V_T = 26 mV is the thermal voltage at room temperature.

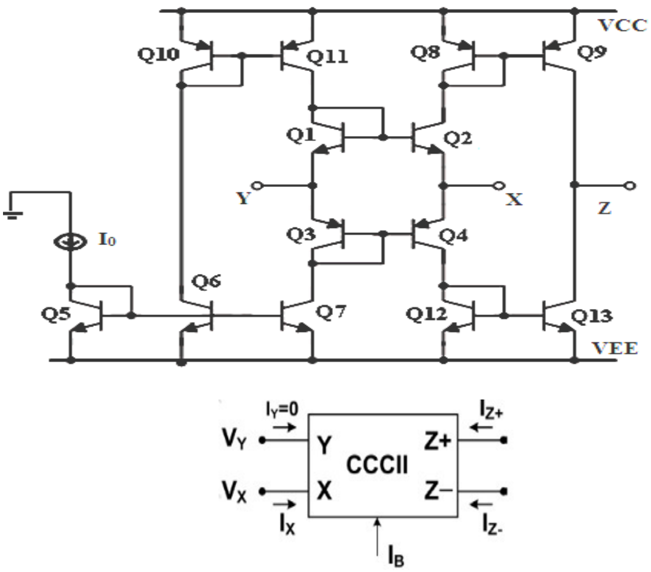

Fig.1. Symbol of CCCII and its trans-linear circuit

The Standard port relationships of CCCII are given below:

$$I_Y = 0$$
$$V_X = V_Y + I_X R_X \quad (1)$$
$$I_Z = I_X$$

B. Active Inductor connected to ground [15]

An inductor based on two current conveyors and a capacitor [15] has been realized.

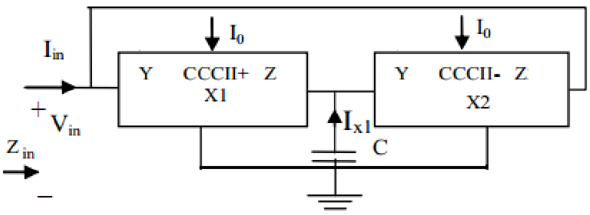

Fig. 2. The realization of an inductor connected to ground [15]

Fig.2 depicts the realization of inductor design by taking into account the presence of both parasitic resistors $R_{x1}= R_{x2}=R_x$ Here we have considered input impedance which is the ratio of input voltage V_{in} and input current I_{in} as given by the equation below:

$$Z_{in} = \frac{V_{in}}{I_{in}} = s(\mathrm{R}_{\mathrm{X}})^2\,\mathrm{C} \quad (2)$$

Which is equivalent to the standard form of reactive inductance (sL):

$$L = \mathrm{R}_{x1}\mathrm{R}_{x2}\mathrm{C} \quad (3)$$

C. Inductor-less Colpitts oscillator circuit and tunable frequency

The inductor-less active mode Colpitts oscillator has well designed using two grounded capacitors and tunable active mode inductor with analog building block CCCII as the active device shown in Fig.3.

The CCCII based active mode amplifier's X terminal has been connected to the junction of capacitors i.e. series connection of C_1 and C_2 (center of the two grounded capacitors) which are placed across a common inductor L acting as a simple voltage divider. The characteristic equation of active mode inductor less Colpitts oscillator is written as:

$$s^2 + \frac{1}{R_X C_1 \mathrm{R}_{x2}\,\mathrm{R}_{x3} C_3} s + \frac{C_1 + C_2}{C_1 C_2 R_{x2}\,R_{x3} C_3} = 0 \quad (4)$$

C_{eq} is the equivalent capacitor of C_1 and C_2 which are connected in series and is given as.

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} \text{ or } C_{eq} = \frac{C_1 C_2}{C_1 + C_2} \quad (5)$$

The frequency of oscillations for active mode inductor-less Colpitts oscillator is determined by the resonant tunable frequency which is given as:

$$f_r = \frac{1}{2\pi\sqrt{R_{x2}\,R_{x3} C_3\, C_{eq}}} \quad (6)$$

Where, R_{X2}, R_{X3} represents the intrinsic resistance of the conveyor at the X terminal of CCCII which is adjustable via I_0, which gives the tunable active inductance value. If $R_{X2} = R_{X3} = R_X$ ($R_X = \frac{V_T}{2I_o}$), resonant tunable frequency f_r given as:

$$f_r = \frac{1}{2\pi R_x \sqrt{C_3\, C_{eq}}} \quad (7)$$

Also written as:

$$f_r = \frac{I_0}{\pi V_T \sqrt{C_3\, C_{eq}}} \quad (8)$$

Here, (8) show that frequency of oscillations for active mode inductor-less Colpitts oscillator is directly adjusted by bias current I_0 and grounded capacitances of equivalent capacitor. The concept of grounding of capacitor and absence of passive resistance provides advantage of monolithic IC implementation [18]. This fact is also supported by the Fig.4 which shows the variations of frequency of oscillation w.r.t capacitor, when bias current is constant and fixed at I_0 = 100µA, here value of frequencies are decreasing as the capacitor values are increased and further Fig.5 shows the variation of the frequency of oscillation with bias current I_0 for two different fixed values of capacitances i.e for 1pF and 10pF respectively. Here frequency has been increased by the value of bias current.

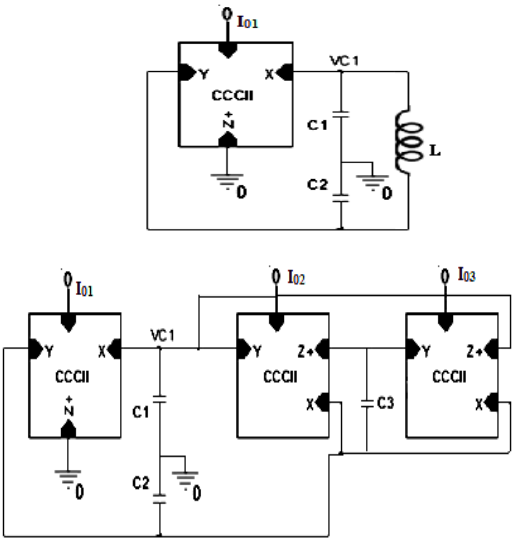

Fig.3.Inductor-less active mode Colpitts oscillator using CCCII

III. Simulation

The proposed active mode inductor-less Colpitts oscillator circuit is simulated with ORCAD 10.5 in which the circuit is implemented with CCCII using the model parameter [19] with power supply voltages fixed at $V_{ss} = -V_{ss} = 2.5\,\text{Vdc}$ and bias current I_0.

The active mode inductor less Colpitts oscillator circuit has been designed with capacitor values of C_1 = C_2 = C_3= 5.6 nF.

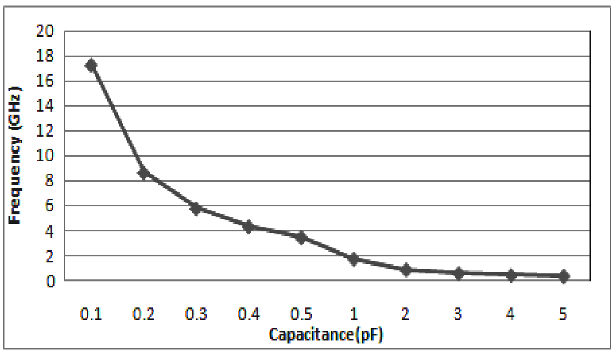

Fig.4. Variations of the frequency of oscillation with capacitor, when bias current is constant (I_0 = 100µA)

Finally, after simulation, practical realization is performed using AD844AN and three capacitors to confirm theoretical analysis. The DC power supply voltages were taken as ±12V and $C1$ = $C2$= C_3 = 5.6 nF ±5%. The main advantage of the proposed structure is that no resistance is required in the design. The observed frequency of 38.76 MHz is closer to in the simulated value of 40.22 MHz. The obtained experimental results in DSO are depicted in Fig.6.

IV. Comparison

The literature survey reveals that a wide variety of circuits have been studied by researchers. In this research work an effort has been made to study and improvement has been achieved. Proposed active mode tunnel diode has several advantages over earlier reported circuits [9-14]. Oscillator circuit has been designed using second generation current controlled current conveyor (CCCII) as active block. The frequency of oscillations for active mode inductor-less Colpitts oscillator has been adjusted by bias current I_0 and capacitor values individually as shown in fig.4 and fig.5.Also a practical and experimental implementation of Colpitts oscillator circuit has been performed using commercially available IC AD844AN.

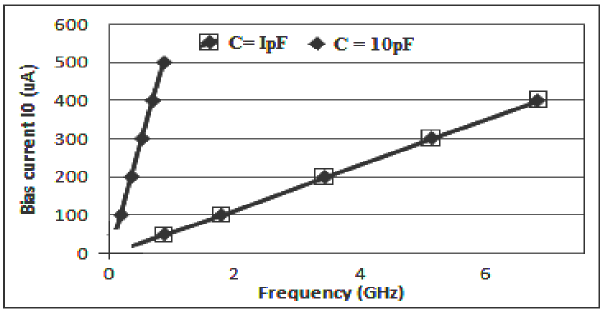

Fig.5. Variations of the frequency of oscillation with bias current I0 when capacitor values is constant (1pF and 10pF)

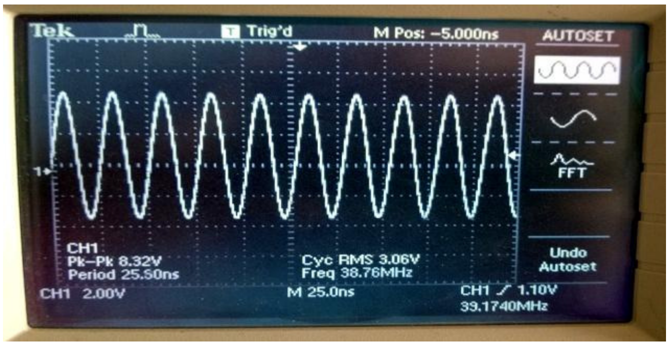

Fig.6. Experimental results: transient response at 38.78 MHz

Conclusion

A new active mode inductor-less tunable Colpitts oscillator circuit using CCCII (38.78 MHz) was proposed with apart from offering almost all the advantage like less number of hardware only capacitor are used no inductor and resistor is used for simulation which is the best for IC fabrication. The proposed approach is verified through PSPICE simulations and commercially available IC AD844AN.

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