Implementation of RC Oscillator with High-Q Frequency Selection using CCCII.

G. Appala Naidu, S. Mounika, B.T.Krishna

Abstract**: *This article given a second generation current controlled current conveyor positive (CCCII+), second generation current controlled current conveyor negative (CCCII-), Quadrature oscillator with high-Q frequency choosing network and implementing completely different phase oscillators by employing (CCCII+) positive and (CCCII-) negative, and high band pass filter network, the approach is predicted on the CMOS technology . The root of this concept is, considering a customary voltage mode oscillator which consists of band pass filter with prime quality issue (high-Q) and voltage mode amplifier is transfigure into current mode oscillator by replacing tans-conductance amplifier. Because the loop of the oscillator is has lavish selectivity, the oscillator process less distortion. In addition 3dB bandwidth, oscillating condition, oscillation frequency of the oscillator could linearly, independently and electronically be tuned by adjusting the bias current of the (CCCII±)[1], lastly different simulations have been carried out to verify the linearity between output and input ports, range of frequency operations. These results can justify that the designed circuits are workable.***

Keywords: CCCII+, CCCII-, ALC

I. INTRODUCTION

In the recent years, there has been a notable demand for chip driven VLSI products in electronics, medical electronics, communications, aero space computers etc. In the analog VLSI design field, second generation current controlled current conveyor (CCCII+) positive, (CCCII-) negative have established their own identity as an salient circuit design element and getting consequential recognition in current analog IC's design due to their higher band width , larger dynamic range, greater linearity , lower power consumption, simpler circuitry and less chip area[1]. In voltage mode to design oscillators we need BPF and voltage mode amplifier for this op-amp is used as an voltage amplifier. The op-amp experience to low slew rate at its output and less gain bandwidth product, so they remains deplorable at high frequencies.

Fabre first introduced CCCII in bipolar technology[2]. Since then different CCCII based active devices have been evolve [3-8]. Like current controlled current conveyor trans conductance amplifier(CCCCTA), current controlled current differencing buffered amplifier, current controlled current differing trans conductance amplifier, current backward trans conductance amplifier, current follower trans conductance amplifier(CFTA), current through trans conductance amplifier(CTTA) etc. [9-12] this implies that second generation current controlled current conveyor(CCCII) as operational trans conductance amplifier(OTA) which is a basic, general and flexible current mode device. The Current conveyors has been widely used in the realisation of analog filters, oscillators, and gyrator circuits[13-33]. Miserably, most of the oscillator design using CCCII do not satisfy high-Q frequency selecting network Then they have poor selectivity, producing more distortion. Although the oscillator in [13] employs only four CCCIIs and two grounded capacitor , the terminal z of the CCCII2 in the circuit is on the ground.

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The primary intention of this article is to make use of CMOS technology and design CCCII+/- and then using CCCII+/- and high band pass filter is presented to experience low distortion signal and 3db bandwidth, linearity, oscillating condition and oscillating frequency by adjusting bias current $I_{B1}, I_{B2}, I_{B3}, I_{B4}$. and implementing multiphase oscillators with CCCII's.

II. DESCRIPTION OF CCCII

Figure (1) block representation of second generation current controlled current conveyor(CCCII). It provides electronic tunability and wide tunable range of resistance at X-terminal for either positive or negative block [34]. Thereby it no need any external resistance, therefore it is much more suitable in the design of oscillators and integrate filters. The CCCII based circuits are more suitable for high frequencies because of its current source nature. These features was very attractive to circuits designers [35].

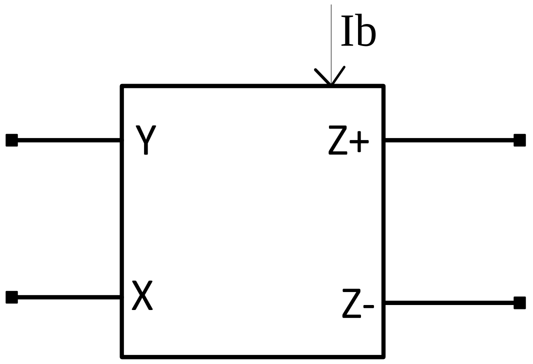

Fig1: CCCII block representation

The correspondence between the voltage and current variable at input and output ports X, Y, Z of CCCII can be expressed by the fallowing matrix [a]

$$\begin{bmatrix} Iy \\ Vx \\ Iz \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ Rx & 1 & 0 \\ \pm 1 & 0 & 0 \end{bmatrix} . \begin{bmatrix} Vy \\ Ix \\ Iz \end{bmatrix} \qquad (1)$$

Where the ± sign reefers to plus or minus mode of CCCII respectively [1] and at X terminal Rx implies the intrinsic resistance is adjustable by supplied bias current I_B . This can given through a trans-linear loop of class AB, which represent as input section.

$$I_{Z^+} = I_x \qquad (2)$$

$$I_{Z^-} = -I_x \qquad (3)$$

$$V_x = V_y + I_x R_x \qquad (4)$$

Resistance at X is given as

$$R_X = \frac{V_T}{2 I_B} \qquad (6)$$

Where V_T is thermal voltage V_T≈ 26mv at 27^0c and I_B is the bias current of CCCII [mf].

III. IMPLEMENTATION OF CCCII USING CMOS TECHNOLOGY

Figure(3) and figure(4) shows the common CMOS implementation of positive and negative current controlled current conveyor (CCCII+, CCCII-) schematics representation. We already perceive that metal oxide semiconductor transistors (MOS transistor) are best worthy to processing current rather than voltage type. Because of both common gate amplifier and common source configurations the current is represented as the output signal. Because of bulk-effect present in conventional CMOS process, at low supply voltage common drain amplifier configurations are ineffective. Furthermore, compare to bipolar current mirror which limits the accuracy because of the latter's base current. The MOS current mirrors are less sensitive to process the variations and more accurate, so metal oxide semiconductor-transistor circuits could be easier to do by using current signal than voltage signals. If the saturation region operation is assumed for devices the voltages in MOS transistor schematic are proportional to the square root of the signals when a signal is delivered as current [36,37]. Consequently, a concentrate of voltage signal swing and decrease of supply voltage is possible. The maximum useable frequency will reaches soon with high values for the drain current of the MOS transistor.

The schematic of figure(2) made up of PMOS and NMOS transistors. Mp1, Mp2, Mp3, Mp4, Mp5 & Mp6 are PMOS transistors and Mn1, Mn2, Mn3, Mn4, Mn5, Mn6 & Mn7 are NMOS transistors which consists of one mixed translinear loop i.e. Mn1, Mn2, Mp5 & Mp6 acts as input cell, and two current mirrors i.e. Mp1, Mp2 and Mn3, Mn5 allows the mixed loop to be dc biased by the current I_b,

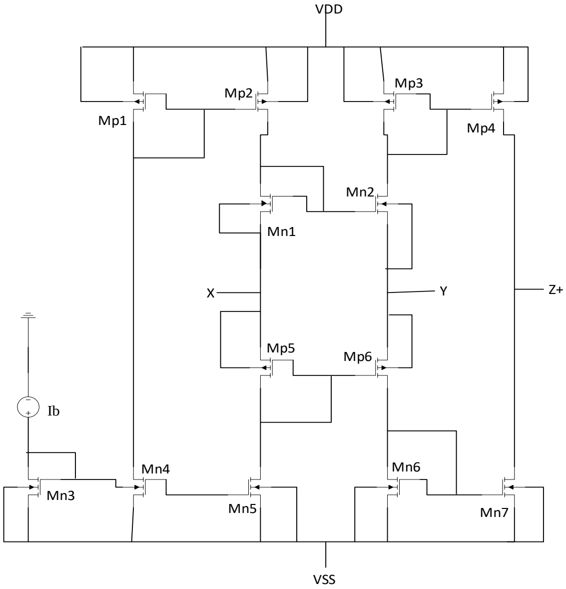

Fig2: CMOS based CCCII+.

The input cell consists of low impedance output port (X) and a high input impedance output port (Y). this mixed translinear loop cell act as a voltage follower. The current flowing across port X that copies by the output Z is conceive in the conventional manner using two complementary mirrors [35].

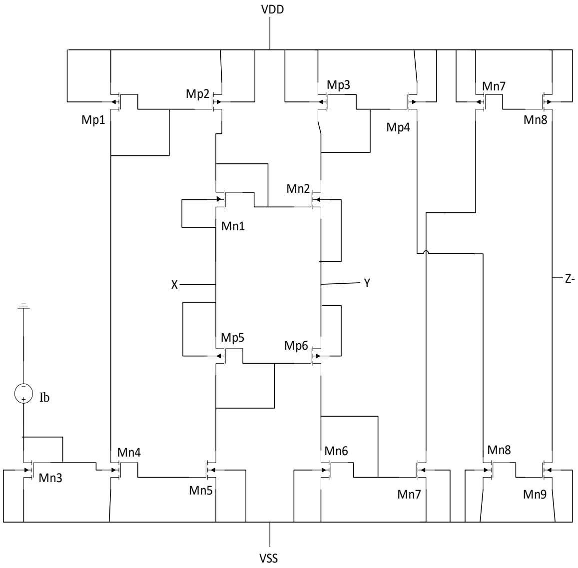

Fig3: CMOS based CCCII-.

IV. PROPOUND OSCILLATOR IMPLEMENTATION

Different types of RC oscillators can constructed by using high quality band pass filter of second order as feedback network. In figure(4a) is shown the basic circuit arrangement [38] the voltage mode amplifier is replaced by the trans conductance amplifier like CCCII to achieve the current type oscillator which represent in figure (4b). from figure 4 the oscillating condition is obtained from the characteristic equation which is convey in terms of loop gain(LG).

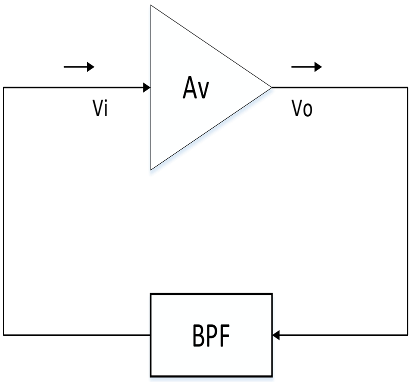

Fig 4a:employing voltage amplifier.

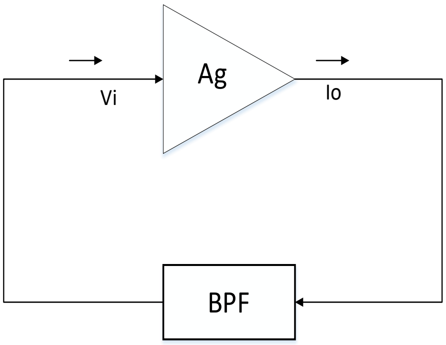

Fig 4b:employing trans-conductance amplifier.

$$1 - LG = 1 - A.BP$$

$$= 1 - A\,.\frac{F_S}{S^2 + \frac{s\omega_0}{Q} + \omega_0^2} = 0 \qquad (7)$$

$$S^2 + S\left(\frac{\omega_0}{Q} - A.F\right) + \omega_0^2 = 0 \qquad (8)$$

Here,

ω_0 is oscillating frequency.

In figure 4a $A = A_V$,

A_V - Voltage gain.

In figure 4b $A = A_g$,

A_g- trans conductance gain.

The oscillating condition is

$$A \geq \frac{\omega_0/Q}{F} = \frac{BW}{F} \qquad (9)$$

$$BW = \frac{\omega_0}{Q} \qquad (10)$$

Here, BW is the 3dB bandwidth of the band pass network, F is the scale factor. The band pass network may be LC network, RC network, RLC network. In this work we choose RC network such as, Twin T oscillator, wein bridge oscillator, which are best example of employing an RC band pass network.

The 3dB bandwidth which, governs selectivity is

$$BW = \left(\sqrt{\frac{G_2 C_1}{G_1 C_2}} + \sqrt{\frac{G_1 C_2}{G_2 C_1}} + \sqrt{\frac{G_1 C_1}{G_2 C_2}}\right)\omega_0 > 2\omega_0 \qquad \textbf{(11)}$$

Produce more distortion signal due to the circuit is having poor selectivity because of centre frequency is twicer than that of bandwidth; so that poor filtering carried out by the band pass network , yet the band pass network employs an RC network which is active type. The BP network can filtered if any distortion introduced by amplifier and bandwidth also quite narrow in nature, Figure 5 represents the propound oscillator with high-Q band pass network employing CCCIIs where CCCII 4 block serve as trans conductance amplifier, whose gain given as

$$A_g = \frac{I_o}{V_1} = G_4 \qquad (12)$$

Where block 1, 2, 3 of CCCIIs along with capacitors C1 and C2 form a feed back network then the transfer function can presented as fallows

$$V_1 = \frac{1}{C_1}\left(I_0 - G_3 V_1 - G_2 V_2\right) \quad ,$$

$$V_2 = \frac{1}{C_2}\, G_1 V_1 \qquad (13)$$

As long as G_3 is set to low value can achieve the high-Q frequency selecting network

The characteristic equation is

$$S^2 + S\left(\frac{G_3}{C_1} - \frac{G_4}{C_1}\right) + \frac{G_1 G_2}{C_1 C_2} = 0 \qquad (14)$$

The oscillating condition is

$$G_4 \geq G_3 \qquad (15)$$

The oscillating frequency is

$$\omega_0 = \sqrt{\frac{G_1 G_2}{C_1 C_2}} \qquad (16)$$

Then 3dB bandwidth is

$$BW = \frac{G_3}{C_1} = \sqrt{\frac{G_3^2 C_2}{G_1 G_2 C_1}}\ \omega_0 \qquad (17)$$

Equation (13) and figure(6) are combined for steady state sine signals to achieve the fallowing transfer function

$$\frac{I_{01}}{I_{02}} = j\sqrt{\frac{C_2 G_1}{C_1 G_2}},$$

$$\frac{V_1}{V_2} = j\sqrt{\frac{C_2 G_2}{C_1 G_1}} \qquad (18)$$

From this we can say that two sinusoidal signals with equal magnitude and phase difference of 90^0 is achieved.

The oscillator generally implemented with $C_1 = C_2 = C$ and $G_1 = G_2 = G$ and considering

$$G_d = \frac{2 I_{Bd}}{V_T} \qquad d = 1, 2, 3, 4 \qquad (19)$$

Rationalize as,

$$I_{B4} \geq I_{B3} \qquad (20)$$

$$f_0 = \frac{I_B}{\pi V_T C} \qquad (21)$$

$$BW = \frac{2 I_{B3}}{V_T C} \qquad (22)$$

Here

$$I_{B1} = I_{B2} = I_B \qquad (23)$$

The oscillator calibrate as fallows:

(a) To assure lower bandwidth adjust I_{B3} at block 3 i.e. CCCII3.

(b) To achieve the desired value of f_0 vary the oscillating frequency by adjusting I_B.

(c) To satisfy oscillating condition adjust I_{B4}.

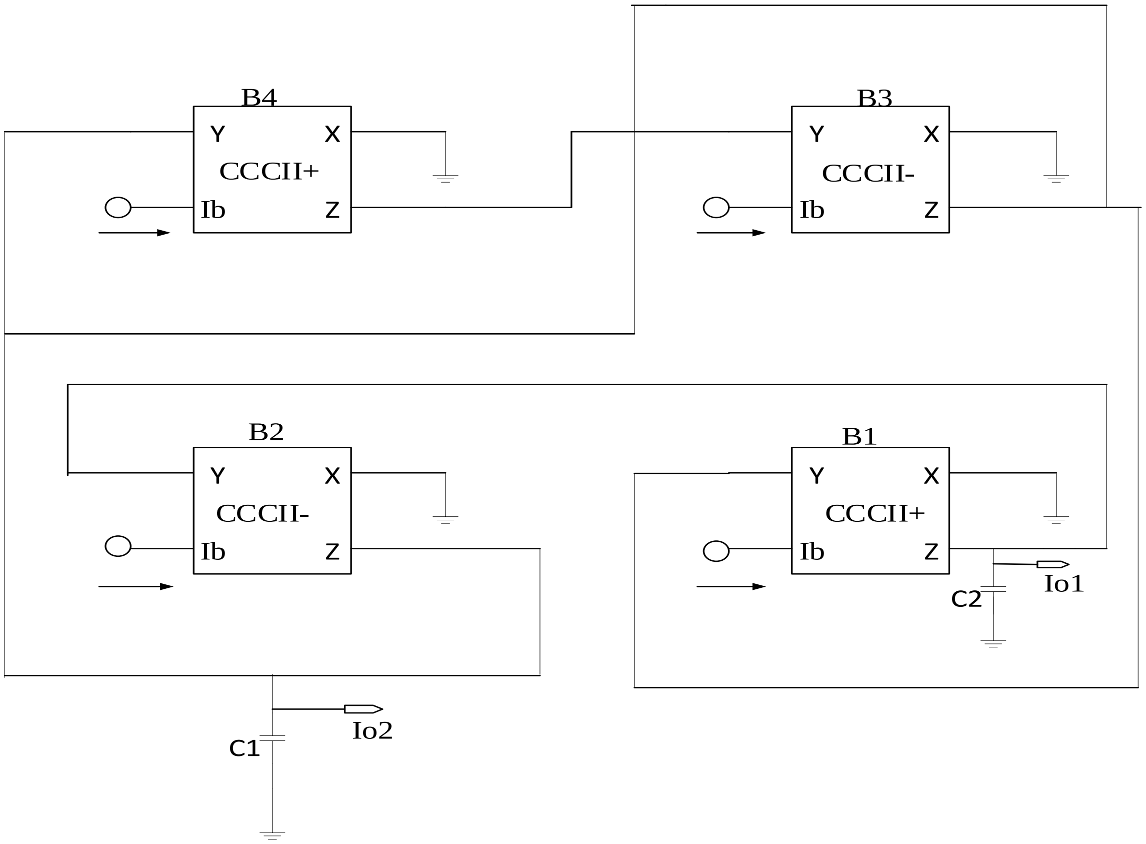

Fig5: propound oscillator with high-Q band pass filter, employing CCCCIIs

V. AUTOMATIC LEVEL CONTROL

It scrutiny that the oscillating frequency and oscillating condition can be independently tuned by adjusting the bias current I_{B4} and I_B and to satisfy the bandwidth to absolutely narrow. It can possible by adjusting I_{B3} at block3 i.e. CCCII3. To attain constant oscillations amplitude and low distortion for variable oscillators design, the Automatic Level Control (ALC) is extensively used[34-42]. The usual ALC circuit has been enclosed in figure6 that may be a changed counterpart of the CCCII block3 in figure5 and employs a straight forward diode resistor network to control the effective price of G_{eq} connected to the terminal X . ±0.5V bias offer makes 2 diodes. D1 & D2 in an exceedingly weak conducting state. D1 conducts and D2 shuts once the positive 0.5 cycle initially appears; D1 shuts and D2 conducts, once the negative 0.5 cycle appears. Also I_{B3} is choosen deliberately high (500µA) to confirm that the parasitic electrical phenomenon of the CCCII block3 is far beyond G_{eq} and it will so be neglected.

This means that the CCCII block 3 is employed as a CCII3, the G3; G_{eq}. At the start of the oscillation, R2 has no impact as a result of he diodes are off. We tend to so have R1= 1k ohm . let I_{B4} = 14µA, then G4 =1.08ms, indicating oscillating condition has stopped. However, before this limiting condition is reached, the amplitude can mechanically stabilize at some intermediate levels of diode physical phenomenon wherever equivalent G3=1.08ms precisely.

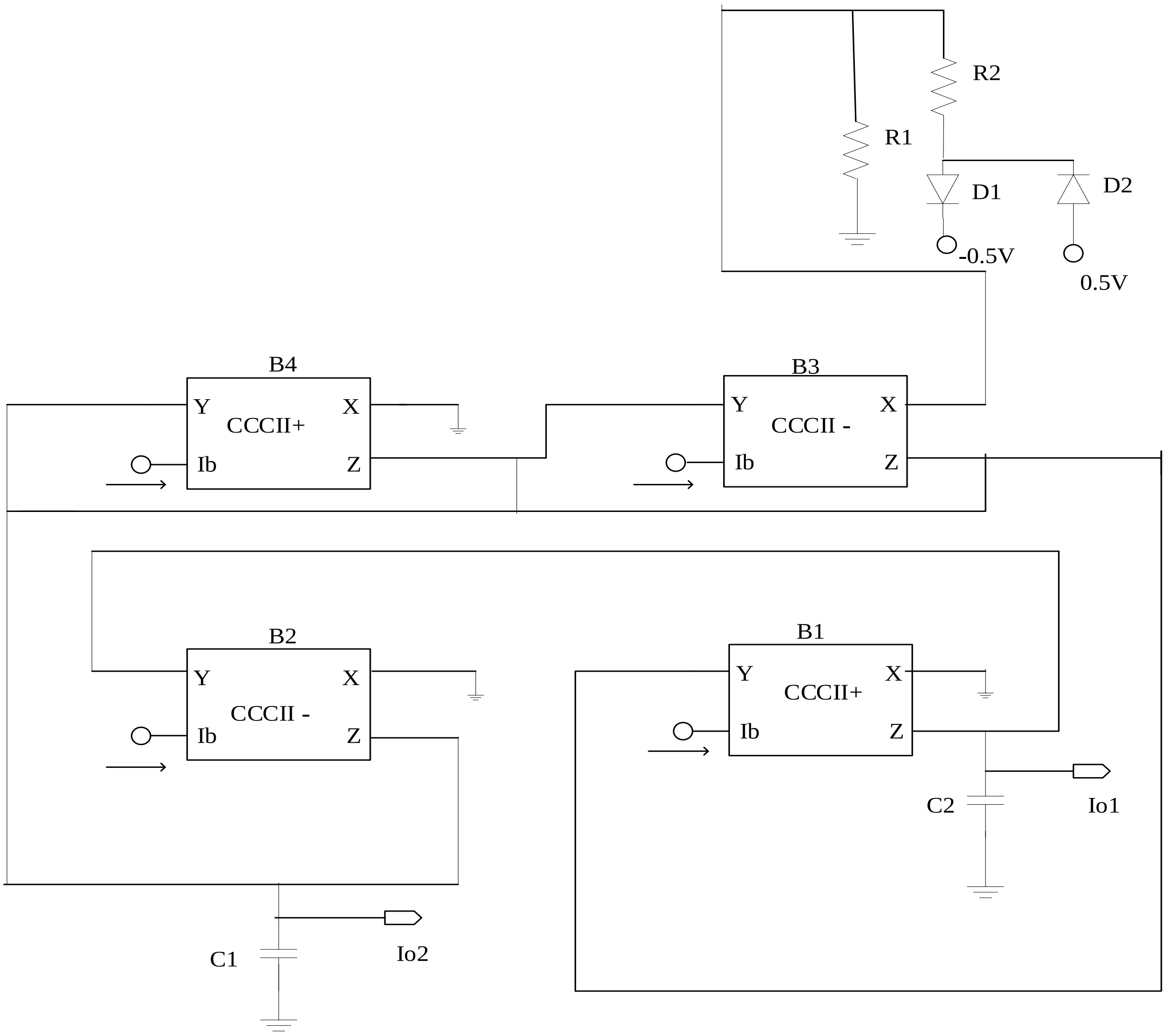

Fig 6: Quadrature oscillator using ALC circuit, taking R1=1Kohm, R2=1K ohm and D1 and D2 are IN4148.

VI. COMPUTER SIMULATION VERIFICATION

The circuits shown in Fig 2,3,5 & 6 has been simulated. The sub-circuit for the CCCII was created by the semiconductor device model of CMOS technology of the analogue device library from metallic element MULTISIM 13.0 software[39]. Then the circuit in fig.6 was simulated with ± pair of 0.5V power provides. Set C1=C2=1nF, G1=G2, particularly IB1=IB2=IB = 40.8µA. In theory, once IB4=14 µA, IB3=0.5mA. the G4=1.08ms > G3= Geq = 1ms. Then the circuit would oscillate. However, in follow once IB4 ≥ 16µA, the circuit might sustain oscillation result shown in fig 9 indicates that the particular price for fo is 498 k hz. To prove the soundness of the circuit in Fig6 Mote Carlo analysis and transient analysis for the output Io1 square measure performed with 5% tolerance of capacitances. The result illustrated in fig11. Indicates that the capacitance might slightly have an effect on the oscillating condition.

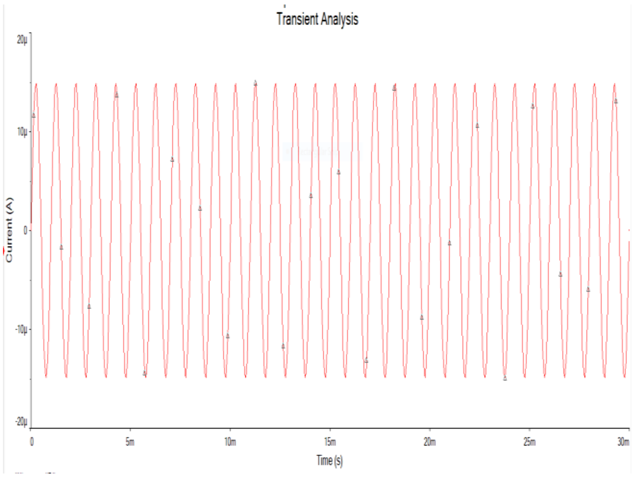

Fig7: transient response for CCCII+ block

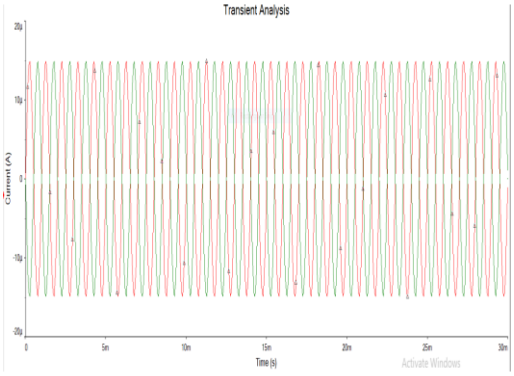

Fig8: transient response for CCCII- block

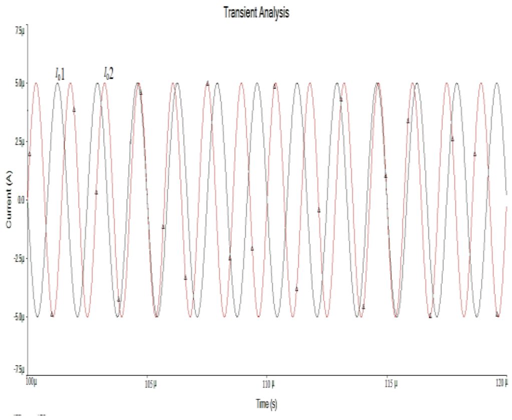

Fig9: transient response of oscillator for the design value of 0.5MHz.

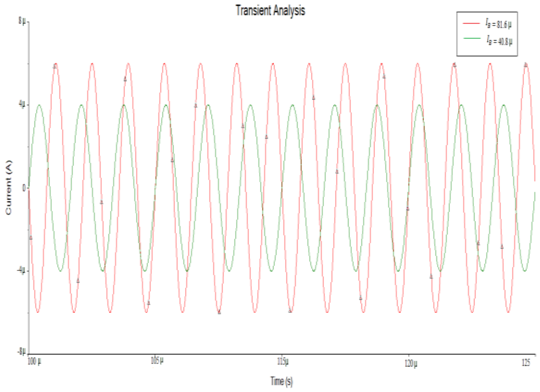

Fig10: transient response for Io1 where fo dependence on IB.

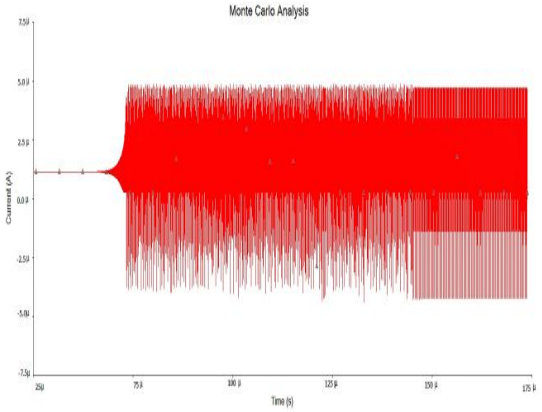

Fig11: Monte-carlo analysis for design value of 0.5MHz

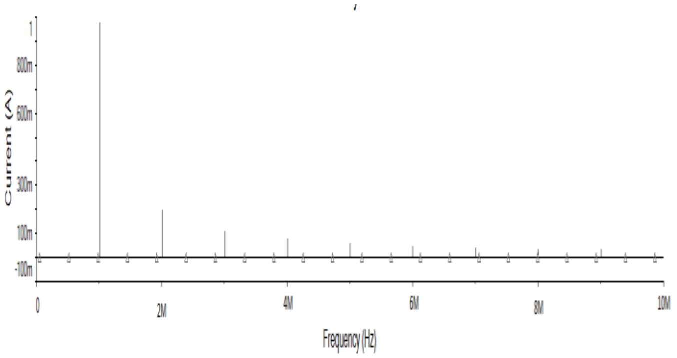

Fig12: output spectrum of Io1 for the design value of 1 MHz

when IB is tuned from 40.8 to 81.6 micro amps and IB4=18µA, whereas others stay unchanged, the designed value for fo is Changed from 500kHz to 1MHz which is shown in fig10, indicates that the simulated value for fo by adjusting IB.

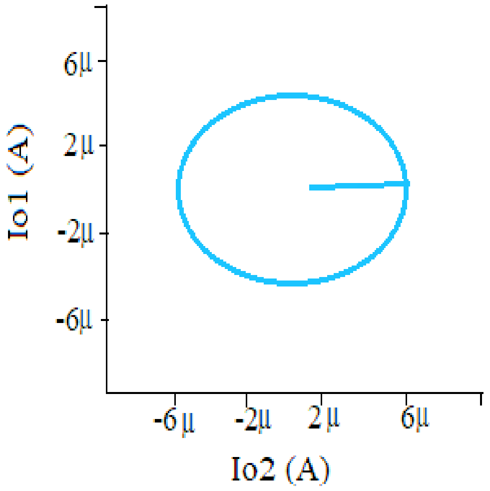

Fig13: Lissagous figure formed by Io1 and Io2.

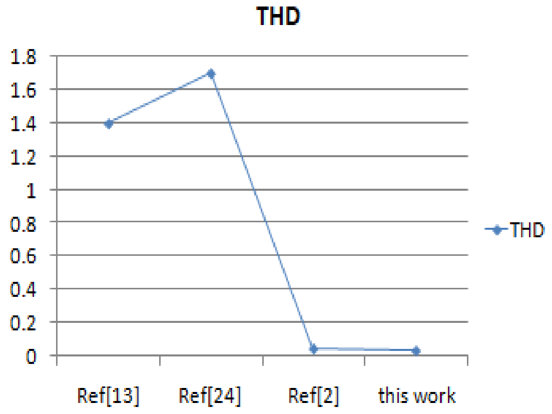

Fig 14: Comparison of Total Harmonic Distortion for different oscillators.

Since the propound circuit relies on the Bipolar Junction Transistor (BJT), a transient analysis for various various IB values.

For the planning worth values of 1MHz, the frequency response of the feedback loop indicates that the 3db bandwidth.

the simulated lissagous figure shown in fig 13 indicates that oscillator will offer two phase current outputs with equal amplitude . the entire harmonic distortion for simulated output spectrum for Io1 , Io1 and Io2 are 0.021% . figure 12 that is very below the reported oscillators [40-48], as shown in TABLE ONE . consequently the osc generator will sustain 2 outputs with little distortion.It goes will not saying that the output of circuit simulations are in agreement with practical analysis.

Table1: comparison of characteristics different Quadrature oscillators.

Ref	Basic block	No of blocks Used	Passive components Used	ALC Circuit used	Capacitor grounded
[13]	CCCII	4	0+2	no	yes
[24]	CCCII	1	1+2	no	yes
[2]	CCCII	4	1+2	no	yes
present work	CCCII	4	0+2	no	yes

VII. CONCLUSION

As much as we all know, ther are alternative measurements strategies of getting RC oscillators. However, this study Emphasizes the utilization of high-Q frequency-selecting network and therefore the ALC circuit to get the Quadrature Oscillator with tiny distortion. In contrast to the generator proposed by Bhaskar et al. p[13]. The parasitic electrical phenomenon of the CCCII in our oscillator is a smaller amount susceptible to the result of alternative parasitic admittances since the terminal X of every CCCII is on the ground.

Therefore, the accuracy of the oscillation frequency is comparatively high electrical phenomenon characteristics of the CCCII. Finally, the final given circuit may be a Quadrature type oscillator with ALC unit, giving rise to terribly tiny distortion outputs.

Additionally, the derived oscillator conjointly enjoys the subsequent features:

(a) Linear, freelance, and electronic management of the oscillation frequency,

the oscillation condition, and therefore the 3 dB information measure.

(b) use of grounded capacitors.

(c) High output impedances.

The computer simulation results agree with the implemented method.

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