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A Low Voltage Tuned Colpitt's Oscillator Using CDTA

[1]NAWAZ SHAFI, [2]SHREYA GUPTA

[1,2] School of Electrical, Electronics & Communication Engineering
Galgotiya's University ,Agra, Uttar Pradesh

nawazshafi8@gmail.com, shreyagupta.aec.ec@gmail.com

Abstract-In this paper by using current differencing trans-conductance amplifier (CDTA) as an active building block COLPITT's oscillator has been proposed. The oscillator is realized by a single block of CDTA, two capacitors and an inductor. The resistor is replaced by a NMOS transistor connected to z terminal of the CDTA. The frequency of the oscillation can be controlled by the tank circuit. The oscillator can produce oscillation of frequency ranging from 10KHz to 100MHz. The operation of the proposed Colpitt's oscillator has been verified using SPICE. The CDTA was implemented on 350nm CMOS technology.

Index Terms – Colpitt's oscillator, active building block, CDTA, positive feedback, tank circuit.

1. INTRODUCTION

In past decade active building blocks have widely been investigated and used for implementation of various analog signal processing circuits such as filters, oscillators, rectifiers especially in current mode operation. Low voltage operating devices have always been a priority of analog circuit designers for making the portability of devices more feasible. The goal of low power devices can be achieved by making the devices to operate in current mode. Hence there is a strong drive for using the current mode active building blocks for signal generation and processing [1]. The circuits that operate in current mode rather than voltage mode have many advantages which include low gain errors, high dynamic range, higher bandwidth, high linearity, simple implementation and less power consumption. Various current mode circuits have been proposed so far that are much advantageous to that of their counterparts that include operational trans-conductance amplifier (OTA), current conveyors (CCI, CCII), current feedback operational amplifier (CFOA), current differencing trans-conductance amplifier (CDTA) and many more. Using these new current mode active building blocks and implementing them in CMOS technology the designers have solved the problems associated with classical operational amplifier such as slew rate, bandwidth etc. It must be noted that even if the circuits are classified into current mode and voltage mode the definition that differentiates between the two classes of circuits is still blurred as suggested by Barrie Gilbert in 2003. This work focuses on the development of Colpitt's oscillator based in CDTA with minimum usage of passive elements. The CMOS configuration of CDTA used is presented in section II. The CDTA operates at voltages of ±0.75V. Section IV presents the topology of the Colpitt's oscillator.

2. CURRENT DIFFERENCING TRANSCONDUCTANCE AMPLIFIER (CDTA)

This active building block for IC's was proposed in 2003 by D. Biolek. It is a five terminal block that can be considered to work in real current mode. Hence it can be also called as a current operational amplifier. The CDTA consists of a current differencing unit (CDU) in the input stage much like that of current differencing buffered amplifier (CDBA). This CDU is followed by a dual output operational trans-conductance amplifier (OTA). The CDU takes the current signals (Ip, In), differences them and transfers this difference current to the intermediate terminal (z) of CDTA where it is converted to voltage by

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externally connected impedance. The voltage developed over this impedance (Vz) is converted into output currents (IX+, IX-) by the trans-conductance amplifier stage with trans-conductance gm for the positive output and –gm for negative output. The symbol and equivalent circuit of CDTA can be shown as

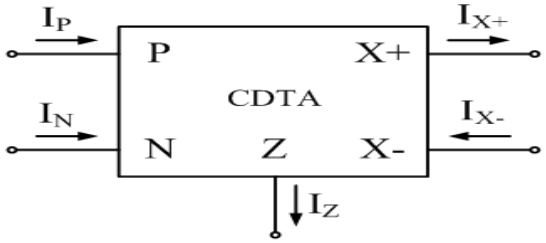


Figure 1: Circuit symbol of CDTA

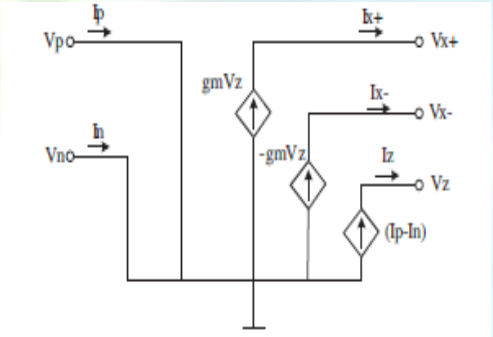


Figure 2: Equivalent circuit of the CDTA

Since the outputs and input of the CDTA are in the form of currents (Ip, In, Ix), the circuit operates as a true current mode amplifier. The gain of CDTA is given by the product of external impedance and the trans-conductance of OTA stage. In order to make the circuit to work in ideal current mode the voltage of z terminal is maintained low. The characteristic matrix of CDTA that define its behavior is given as:

$$\begin{bmatrix} V_p \\ V_n \\ I_z \\ I_x \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 1 & -1 & 0 & 0 \\ 0 & 0 & 0 & \pm g_m \end{bmatrix} \begin{bmatrix} I_p \\ I_n \\ V_x \\ V_z \end{bmatrix}$$

According to the equations from the characteristic matrix a current (Ip-In) flows through the z terminal into the external impedance. The matrix equations are verified by the equivalent circuit shown in figure 2. This difference of current is transferred into the output currents by transconductance gain of gm. The gain can be controlled by bias currents or bias voltages.

3. CMOS IMPLEMENTATION OF CDTA AND SIMULATION RESULTS

The transistor level CMOS implementation is shown in figure 4. Transistors M1 to M10 constitute the input stage of CDTA. The input stage consists of a current differencing unit formed by current mirrors and flipped voltage followers (FVF). The FVF is a sort of source follower circuit where the source current of one transistor is held constant. Unlike to that of conventional voltage follower circuit, a FVF can source a large amount of current however its current sinking capacity is limited. Due to very little impedance at output of FVF which is of the order of 20-100ohms it has large current sourcing capability. To provide very low input impedance to current mirrors FVF's are used at the input stage. Since FVF's are connected in feedback to current mirrors the output impedance of FVF'S gives the input impedance of current mirrors i.e. impedance of p and n terminals. In this CMOS configuration of CDTA transistors M2, M3, M8, and M9 form the voltage follower circuits. Transistors M11, M15, M12, M16, M13, M17, M14, and M18 all transistors form a differential amplifier at the output stage.

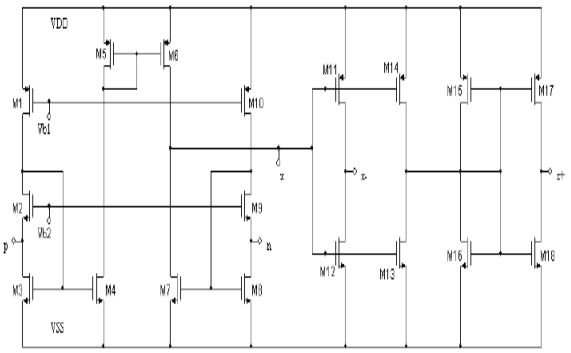


Figure 4: CMOS Implementation of CDTA

The aspect ratios for the MOS transistors used in implementation of CDTA are given in the table no. 1.

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M1W=30µ L=0.7 µ	M10 W=30µ L=0.7 µ
M2 W=30µ L=0.7µ	M11 W=50µ L=0.7 µ
M3 W=90µ L=2.1µ	M12 W=4µ L=1.4 µ
M4 W=90µ L=2.1µ	M13 W=4µ L=1.4 µ
M5 W=150µ L=3.5 µ	M14 W=50µ L=0.7 µ
M6 W=150µ L=3.5 µ	M15 W=50µ L=0.7 µ
M7 W=90µL=2.1µ	M16 W=4µ L=1.4 µ
M8 W=90µ L=2.1µ	M17 W=50µ L=0.7 µ
M9 W=30µ L=0.7µ	M18 W=4µ L=1.2 µ

Table No. 1: Aspect Ratios OF Transistors Used IN CDTA

The current mirror transistors in the implementation of a CDTA are chosen to have larger channel lengths in order to compensate the DC offset at the input stage which is caused due to the channel length modulation effect (lambda parameter of transistors). However it suffers from the limitation that the bandwidth obtained in the transfer of current from the input terminals (p and n) to z terminal gets reduced to a considerable value. Hence trade-off values are to be set the appropriate DC offset and bandwidth. The DC offset can be further reduced by selection of appropriate current mirrors but using such configuration will cause higher power dissipation due to increase in the supply voltage. The various SPICE simulation results are shown in figures:

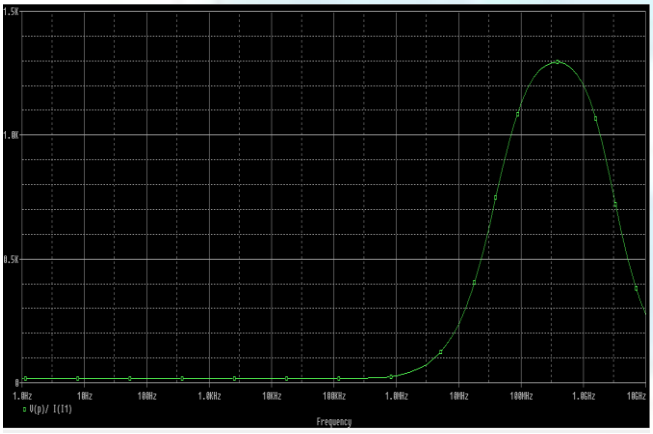


Figure 5: Variation of Input Impedance with Frequency

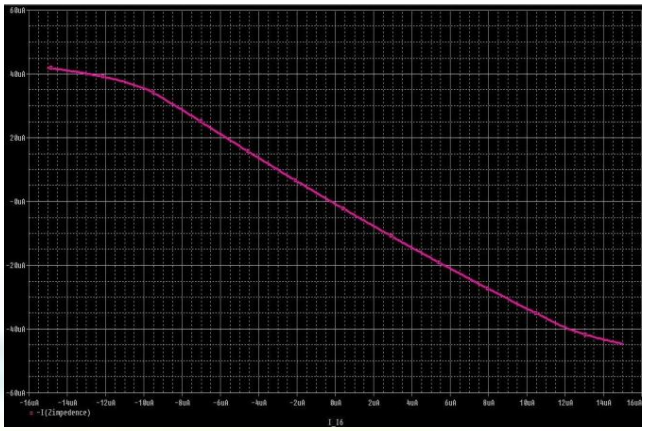


Figure 6: Variation of z terminal current with respect to n terminal current

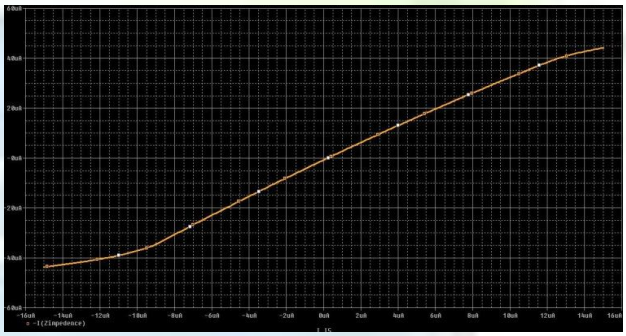


Figure 7: Variation of z terminal current with respect of p terminal current

It can be seen in figure 6 & figure 7, it is due to biasing current the offset is low and DC current remains constant. This range of current linearity can be easily extended by using higher supply currents for current mirror transistors but at the cost of higher power dissipation. The plot showing the variation of transfer of current between n and p terminals is shown in figure 8. The operating bandwidth of the CDTA can be increased by employing the use of small sized current mirror transistors while a trade-off is to be done for the current mirror accuracy as it may not replicate the current exactly due to channel length modulation factor (lambda).

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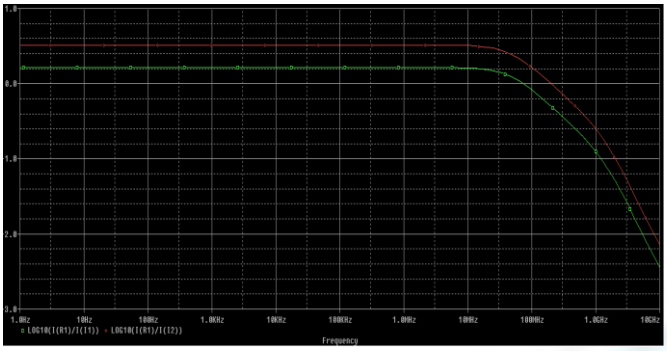


Figure 8: Variation of input terminal current with frequency

To make the dual output stage in CDTA inverters are employed. The inverted output (x+ terminal) is fetched from the output of the first inverter, the same current is replicated by using a current mirror of same corresponding aspect ratio and is fed to another inverter which in connected in unit gain configuration. The positive output current is produced by the last inverter. This configuration connected all together consists of dual output trans-conductance amplifier and the trans-conductance value (gm) is equal to the sum total of trans-conductance values of inverter transistors.

$$gm = gm11 + gm15 \quad (5)$$

The variation of trans-conductance values of both positive and negative output with frequency is shown in figure 9. Due a considerably higher value of trans-conductance than its counterparts, CDTA is more suitable for high frequency operations.

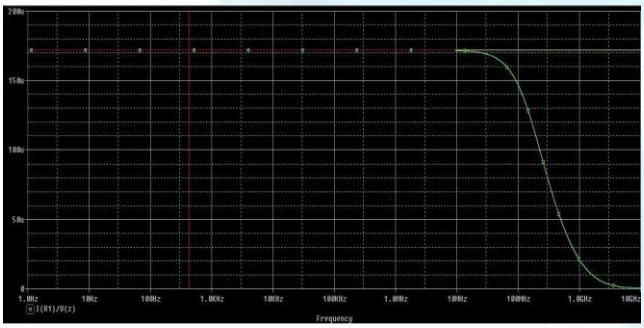


Figure 9: Trans-conductance of CDTA

IV.PROPOSED COLPITT'S OSCILLATOR CONFIGURATION

Oscillator basically can be defined as an electronic amplifier with positive feedback that generates periodic, oscillating signal of any desired shape (square, sinusoidal etc.) and frequency. An oscillator must necessarily satisfy the Barkhausen's criterion in order to produce sustained oscillations which includes that the loop gain (product of the gain of the amplifier and the gain of the feedback network) should be unity and the phase shift around the loop must be 00. The oscillating circuits that consist of inductors and capacitors, the frequency of oscillation is inversely depends on the values of L and C (higher is the frequency when smaller are the values of L and C). LC oscillators generate a very good shape of sine wave and have quite good frequency stability. That is, the frequency does not change very much for changes in D.C. supply voltage or in ambient temperature.

The Colpitt's oscillator involves the use of a tank circuit much like that of Hartley's oscillator. The used tank circuit consists of a resonant circuit which involves two capacitors connected in series and an inductor. The tapping is done on the capacitor. It is the value of L and C that determine the frequency of oscillation produced and thus is also referred as a tuned circuit. The proposed Colpitt's oscillator is designed using single CDTA which is an active building block. The configuration used in realizing the Colpitt's oscillator is shown in figure 11.

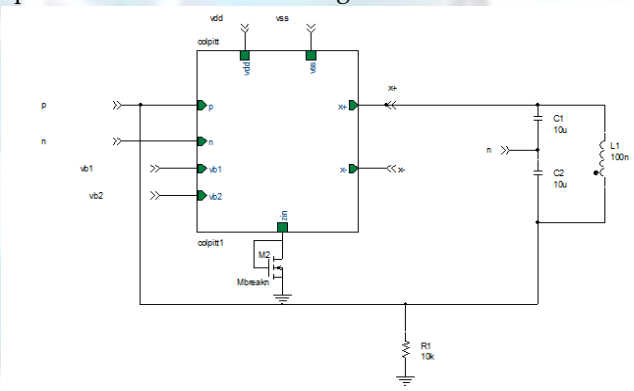


Figure 11: Proposed Colpitt's Oscillator

The approximate value of frequency of the established oscillation is given by the frequency of the tank circuit given as:

fr = 1/ (2*pi*sqrt(LCT))

where Ct is the series equivalent capacitance of C1 and C2..

Feedback fraction:

mv = vf / vout

mv = IXC1 / IXC2

mv = XC1 / XC2

mv = (1/2πfrC1) / (1/2πfrC2)

mv = C2/C1

For oscillation:

Av mv= 1

Av = C1/C2

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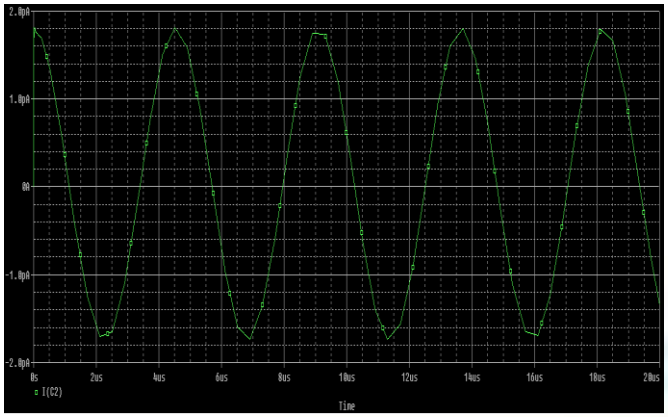


Figure 12: Simulation result of the proposed oscillator

The simulation results for the CDTA and the values of the components used in the proposed oscillator to obtain the oscillations are given in the tabular form as:

Characteristics	Simulation Results
Power consumption of CDTA	0.38mW
3dB bandwidth IZ/IN	20MHz
3dB bandwidth IZ/Ip	87MHz
Trans-conductance	215uA/V
Input p and n resistances @1MHz	Rp = 25ohms, Rn = 25ohms
Measurement Conditions	VDD = -VSS = 0.75V, Vb1 = -0.2V, Vb2 = 0.3V
Passive Component Values	C1 = C2 = 100uf, L1 = 10nhH R1 = 10K
Calculated Oscillating freq.	0.225MHz
Observed Oscillating freq.	0.223MHz
MOS Resistor W/L ratio	w = 30 μ l = 0.7 μ
Feedback Fraction	1
Gain of Oscillation	Unity
Technology	350nm AMIS

V.CONCLUSION

In this study, a low voltage compact CMOS current differencing trans-conductance amplifier is used to form an improved Colpitt's oscillator. Using flipped voltage followers enable the CDTA element to have very low input resistances (25 ohms @1MHz). The proposed Colpitt's oscillator configuration is able to give a very near to perfect sine wave. This can be advantageous feature for different active circuit design which used in analog signal processing. This research has focused on the minimum usage of passive components.

REFERENCES

[1] Dalibor Biolek. CDTA building block for current mode analog signal processing. Department of Electrical Engineering Military Academy Brno,Kounicova 65, 2003 , 61200 Brno,Czech Republic.

[2] A. Uygur and H.Kuntman.vA Low voltage current differencing transconductance amplifier in a novel all pass configuration. IEEE MELECON 2006, May 16-19, Benalmadena(Malaga), spain.

[3] Montree Siripruchyanun , Winai Jaikla.v CMOS current controlled current differencing transconductance amplifier and applications to analog signal processing. Int. J. Electron. Commun. (AEU) 62 (2008) 277-287.

[4] A.S.ELWAKIL and M.P.KENNEDY. Chaotic Oscillator configuration using a frequency dependent negative resistor. journal of circuits, systems, and computers, Vol NO.9 , Nos. 3 & 4 (1999) 229 – 242© world scientific publicshing company.

[5]A.S. Elwakil. On the two-port network classification of Colpitts oscillators. IET Circuits, Devices & Systems, vol. 3, pp. 223 - 232, 2009.

[6] AHMED M. SOLIMAN. Current Mode CCII Oscillators Using Grounded Capacitor And Resistor. INTERNATIONAL JOURNAL OF CIRCUIT THEORY AND APPLICATIONS Int. J. Circ. ¹heor. Appl., 26, 431—438 (1998).

[7] Shweta Gautam, Neeraj Jain and Anshul Kumar Sharma. Implementation of Monostable Multivibrator

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using Low Voltage Current Differencing Transconductance Amplifier". International Journal of Innovations in Engineering and Technology, ISSN: 2319-1058, Volume 2 Issue 3- June 2013

[8] SRINIVASULU AVIRENI , CHANDRA SHAKER PITTALA. Grounded resistance/capacitance-controlled sinusoidal oscillators using operational transresistance amplifier. WSEAS TRANSACTIONS on CIRCUITS and SYSTEMS, Volume 13, 2014, E-ISSN: 2224-266X.

[9] Firat KACAR and Hulusi Hakan KUNTMAN. Improved CMOS Realization of CDTA and its Application. Turk J Elect Eng & Comp Sci, Vol.19,No.4,2011.

[10] D.S. Jayalalitha and D. Susan. Grounded Simulated Inductor - A Review. Middle-East Journal of Scientific Research 15 (2): 278-286, 2013 ISSN 1990-9233 © IDOSI Publications, 2013 DOI: 10.5829/idosi.mejsr.2013.15.2.3706.

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