IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Electronically tunable First Order Filter Using CCDDCC

Aaryan Garg
DEPARTMENT OF ECE
JSS ACADEMY OF TECHNICAL EDUCATION
NOIDA, INDIA
aaryangarg12@gmail.com

Aalekh Aghnihotri
DEPARTMENT OF ECE
JSS ACADEMY OF TECHNICAL EDUCATION
NOIDA, INDIA

Abhinav Yadav
DEPARTMENT OF ECE
JSS ACADEMY OF TECHNICAL EDUCATION
NOIDA, INDIA
abhi23801@gmail.com

Dr. Manoj Joshi
DEPARTMENT OF ECE
JSS ACADEMY OF TECHNICAL EDUCATION
NOIDA, INDIA
manojjoshi@jssaten.ac.in

Abstract: -

Electronic filters are circuits that selectively pass or reject specific frequencies from an input signal. They are commonly used in electronic systems to eliminate unwanted noise or extract desired signals. Analog filters use passive components such as resistors, capacitors, and inductors and can be implemented with operational amplifiers (op amps) to provide gain and filter control. However, analog filters have some drawbacks such as frequency drift, limited dynamic range, non-linear behavior, component variations, size, and complexity. While op amps are versatile, they can introduce noise, have limited

bandwidth, high cost, power consumption, and complexity. To address these limitations, active element CCDDCC (current controlled differential difference current conveyer) is used to replace op amps in filter design and implementation. These active filters offer the ability to easily adjust cutoff frequency and filter response with electronic controls. Tunable first-order filters using CCDDCC provide a flexible and effective solution for filtering applications in various electronic systems.

I. INTRODUCTION

In signal-processing circuits, first-order active filters are frequently employed and are immensely helpful. There are a lot of first-order filters that use current mode and op-amp (OA) building components in the literature. Op-amp limitations include slew rate and constant gain bandwidth product.

Active filters offer several advantages over passive filters because of the circuitry's simplicity, lower power consumption, greater slew rate, and increased dynamic range.
Wider signal bandwidth. of current mode building blocks compared to their voltage mode counterparts Various signal processing circuits are designed using multipurpose first-order filters with high-pass, low-pass filters, require extensive use of both active and passive components based on CCII/CCCII, according to references [4-6]. Only all pass filters (AP) are implemented by the references[7–10],
Using the Differential Difference Current Conveyor (DDCC), an improved version of the CCII, a new active building block has been created. The CCDDCC, is a form of current mode circuit that incorporates the traits of both the DDCC and CCII. One of the key benefits of the CCDDCC is that because the bias current affects the X-terminal's internal resistance (I_b), no external resistance needs to be put there. A new active building block has been made using the DDCC, an enhanced variant of the CCII. The CCDDCC or current mode circuit, is a form of current mode circuit that incorporates the traits of both the DDCC and CCII.

II. CIRCUIT DESCRIPTION

1.1 Basic CCDDCC Concept

The number of Y-terminals is what distinguishes DVCC from DDCC. DVCC only has two Y-terminals, whereas DDCC has three. Its properties are comparable to those of traditional DDCC or DVCC, with the exception of the finite input resistances R_x of the X-terminal in the CCDDCC. As shown in the following diagram, the bias current I_b can be used to regulate the intrinsic resistance R_x.

$$\begin{bmatrix} V_x \\ I_{y1} \\ I_{y2} \\ I_{y2} \\ I_z \end{bmatrix} = \begin{bmatrix} R_x & 1 & -1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ \pm 1 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} I_x \\ V_{y1} \\ V_{y2} \\ V_{y2} \\ V_z \end{bmatrix}$$

Figure 1(a) illustrates the symbol of the CCDDCC, while Figure 1(b) displays the CCDDCC circuit schematic.

1.2 Differential voltage buffer based on CMOS

Fig. 2 depicts the differential voltage buffer (DVB) in CMOS. This CMOS DVB's circuit topology resembles that of the DDA realization in [8].

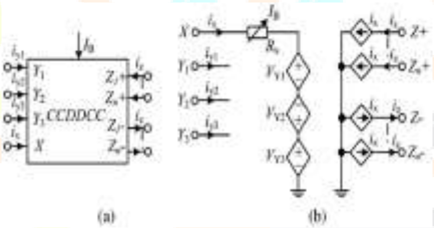


Figure 1. (a) CCDDCC (b) Circuit schematic.

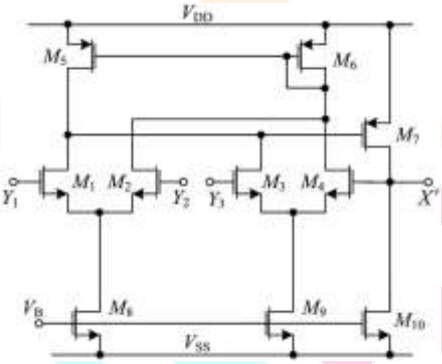


Figure. 2. Internal Structure of differential voltage buffer.

as input Two differential stages (M1 and M2; M3 and M4) are used to realise trans conductance components. A current mirror (M5 and M6) makes up the high-gain stage. The differential current is transformed into a single-ended output current (M7) by this device. The formula for this amplifier's output voltage is

$V_X = V_{Y1} - V_{Y2} + V_{Y3}$

We have assumed that transistors are completely matched and thus the present mirror has a gain of one throughout the discussion thus far. However, a number of non-idealities must be given in realistic realizations. The key considerations, in this case, will be mismatched transistors and the transistors' finite trans conductance g. Small-signal analysis can be used to determine how V_{y1}, V_{y2}, V_{y3}, and V_x are related to one another.

1.3 Current-controlled current conveyer

An active construction block having terminals X, Y, and Z is known as a CCCII. We can represent this using the equations $i_y = 0$, $v_x = v_y + i_x R_x$, and $i_z = +$ ix. The transconductance gain of the CCCII serves as the proportionality constant, and the X and Y terminals' voltage differences is proportional to the current flowing between the Z and Y terminals. The voltage difference between the Y and Z terminals multiplied by the intrinsic resistance of the CCCII and the current flowing into the Y terminal equals the current flowing into the Z terminal. The layout of a typical CMOS CCCII based on complementary source followers is shown in Figure 3. To calculate the X-terminal impedance, further analysis and calculations are required based on the specific circuit layout and components used.

$$R_x = \frac{1}{g_{m19} + g_{m20}}$$

Where $g_{mi} = \sqrt{2\beta_i I_b}$ is transistor M_i 's transconductance, and if they are matched, M_{19} and M_{20}, then $g_{m19} = g_{m20}$. Hence,

$$R_x = \frac{1}{\sqrt{8\mu C_{ox}\left(\frac{W}{L}\right) I_B}}$$

While, for MOS transistors (M19 and M20), m stands for surface mobility, Cox stands for oxide capacitance, W stands for channel width, and L stand for length, respectively. As a result, current bias IB can electronically tune RX. Small-signal analysis can be used to determine how VY and VX without a load connected at the X-terminal are related. The analogous circuits in Fig. 3 are used in place of the transistors.

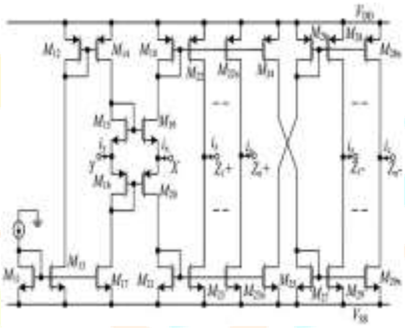
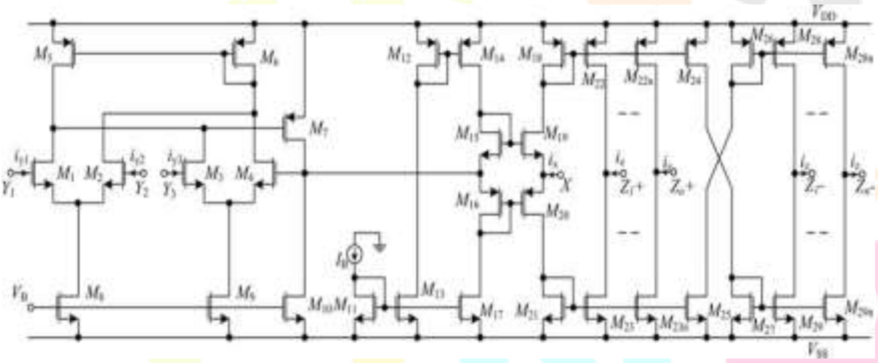


Fig. 3. Internal structure of CCCII circuit.



1.4 Current-controlled differential difference current conveyor (CCDDCC)

In order to complete the internal realization of the CCDDCC shown in The DVB can be cascaded to the CCCII due to the former's Low output impedance and high input impedance, as discussed earlier. The following matrix equations can be used to describe the combined properties of the DDCC and CCCII:

$$\begin{bmatrix} V_x \\ I_{y1} \\ I_{y2} \\ I_{y2} \\ I_z \end{bmatrix} = \begin{bmatrix} R_x & \beta 1 & -\beta 2 & \beta 3 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ \pm\alpha & 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} I_x \\ V_{y1} \\ V_{y2} \\ V_{y2} \\ V_z \end{bmatrix}$$

Fig 4. Internal Structure of CCDDCC

References	Active Element	Active Elements Used	Electronically Tunable	Resistor and Capacitor	Supply Voltage
[7]	CCII	3	No	3R + 3C	5V
[9]	DVCC	3	No	3R + 3C	2.5V
[10]	CDTA	3	Yes	3C	2.5V
[5]	CCCII	3	Yes	3C	2V
[3]	ORTA	3	No	3C + 4R	2.5V
[11]	DVCCTA	2	Yes	3C + 2R	1.25V
This Work	CCDDCC	1	Yes	3C + 2R	1.25V

Fig 5 Comparison between Different Active Elements

III. Proposed Current Tunable Filters

The generalised topology shown in Figure 6 shows how a single CCDDCC can be used to realise a multifunction first order filter transfer function.

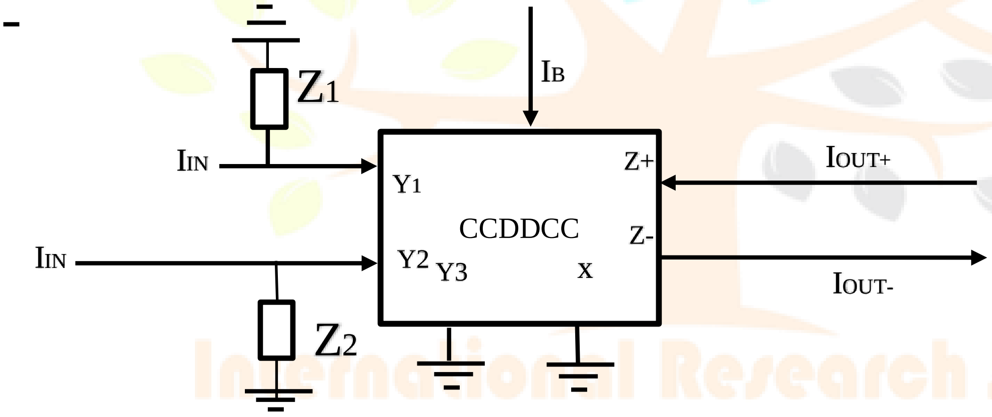


Fig 6. Generalized topology of single CCDDCC

3.1 Proposed Current Tunable Low Pass Filter

A low-pass filter is a type of filter that attenuates signals with lower frequencies and amplifies signals with frequencies higher than a selected cutoff frequency.
Z1 = 0 and Z2 = R2 ||C2 for the Low Pass Filter

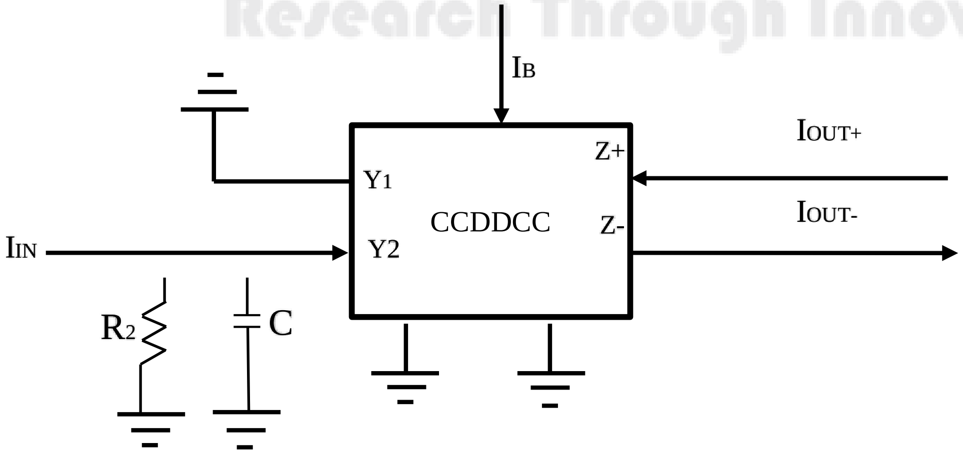


Fig. 7 Block diagram of low pass filter

3.2. Proposed Current Tunable High Pass Filter

A HPF is designed to allow the passage of all frequencies that are above its cut-off frequency. In an audio system, a HPF is used to block or filter low frequencies while letting high frequencies pass.

Z1 = R1 for the High Pass Filter, Z2 = R2||C2, and R1 = R2

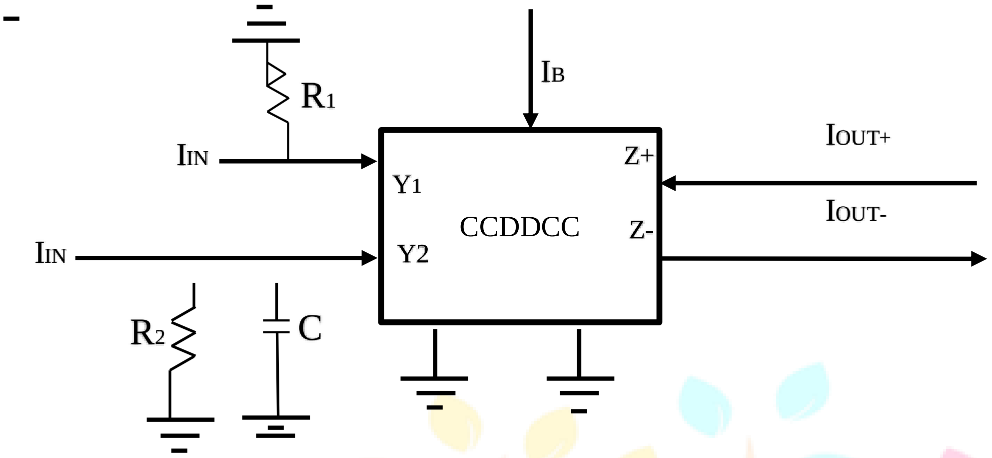


Fig. 8 Block diagram of high pass filter

IV.RESULT OF THE SIMULATION

The current mode first order filter circuit that has been proposed is simulated using the Matlab software. The code for the following is given below:-

Electronic tunable first-order filter using CCDDCC
R1 = 10e3;
Resistance value in Ohms
R2 = 20e3;
Resistance value in Ohms
C1 = 100e-9;
Capacitance value in Farads

C2 = 200e-9;
Capacitance value in Farads
k = 0.5;
Coupling coefficient
gm = 1.5e-3;
Transconductance gain of the CCII
CC = 2e-12;
The capacitance of the DDCC

s = tf('s');
Define s as a transfer function variable

Transfer Function of the filter
H = ((s*R1*C1)/(1+s*R1*C1)) *((1-s*R2*C2)/(1+s*R2*C2));

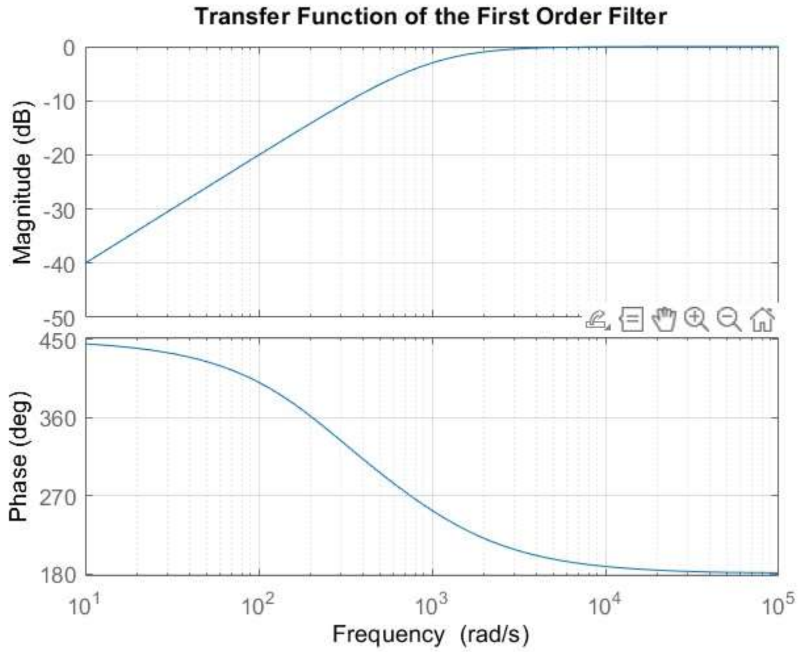


Fig. 9 Output of Low Pass and High Pass Filter

V. CONCLUSION

We came up with an appropriate transfer function for the active filter. Then we selected the values of the components. The component values were selected based on the desired frequency response. For example, for a cutoff frequency of 1 kHz, a value of 1 nF for C1 was selected. The circuit was simulated in MATLAB using the Simscape Electrical toolbox, and the frequency response was analyzed using MATLAB's plotting tools. The filter response was found to be tunable by adjusting the transconductance gains of the amplifiers. Using the signal processing capabilities in MATLAB, to evaluate the filter's performance, a sinusoidal signal with a changing frequency was supplied to the input. The outcomes demonstrated that the filter response matched the anticipated frequency response. The performance of the filter was optimized by adjusting the component values and transconductance gains using MATLAB's optimization tools. The optimal values were found to be consistent with the expected values based on the desired frequency response.

Overall, the results of the project demonstrate the successful design and simulation of the electronically tunable first-order filter using CCDDCC in MATLAB. The results highlight the tunability and simplicity of the filter and the effectiveness of MATLAB in simulating and analyzing electronic circuits.

VI. REFERENCES

[1] Sunil Kumar Yadav, Manoj Joshi and Ashish Ranjan "A Current Tunable Third-Order Oscillator Using CCDDCC"

[2] R. Schaumann, M.S Ghausi and K.R laker., "Design of Analog Filters: passive, active RC and switched capacitor", Prentice-Hall, Inc. A Division of Simon &Schuster Englewood Cliffs, New Jersey, 1990.

[3] E.S.Erdogan, R.O.Topaloglu, H.Kuntman and O.Cicekoglu, "New current mode special function continuous-time active filters employing only OTAs and OPAMPs", International Journal of Electronics, Vol.91, pp.345- 359,2004.

[4] N.A.Shah, S.Z.Iqbal and B.Praveen, "Simple first-order multifunction filter", Indian Journal of Pure and Applied Physics,Vol.42, pp.854- 856,2004.

[5] J.W.Horng, C.L.Hou, C.Y.Tseng, R.Chang and D.Y.Yang, Cascadable Current-Mode First-Order and Second-Order Multifunction Filters Employing Grounded Capacitors. Active and Passive Electronic Components, pp.1-6,2012.

[6] J.W Horng, "High –Order Current-Mode and Transimpedance-Mode Universal Filters with Multiple-Inputs and Two-Outputs Using MOCCIIs" Radioengineering, Vol.18, pp.537-543,2009.

[7] J.W.Horng, C.L.Hou., Y. S.Guo, C. H.Hsu, D.Y.Yang and M.J.Ho, "Low Input and High Output Impedances Current-Mode First-Order Allpass Filter Employing Grounded Passive Components", Circuits and Systems, Vol.3,pp.176-17,2012.

[8] S.Oztayfun, S.Kilinc, A.Celebi and U.Cam, "A new electronically tunable phase shifter employing current-controlled current conveyors", International Journal of Electronics and Communications,Vol.62,pp.228-231,2008.

[9] J.W Horng, C.L.Hou, C.M.Chang, Y.T.Lin, I.C.Shiu and W.Y Chiu, "First-order allpass filter and sinusoidal oscillators using DDCCs" International Journal of Electronic, Vol.93, pp.457-466,2006.

[10] A.U.Keskin and D.Biolek, "Current mode quadrature oscillator using current differencing transconductance amplifiers (CDTA)", IEE Proc-Circuits Devices Systems, Vol.153, pp.214-218, 2006.

[11] Chiu W, Liu SI, Tsao HW, Chen JJ (1996) CMOS differential difference current conveyor and their applications. IEE Proc Circuits Devices Syst 143:91–96

[12] Sunil Kumar Yadav, Manoj Joshi and Ashish Ranjan A Current Tunable Third-Order Oscillator Using CCDDCC