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DDCCTA-Based Universal filter and Quadrature Oscillator

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Abstract : The study presents a universal filter and Oscillator obtain by applying only single input. All the passive component used are grounded which is suitable for integrated circuit implementation. In the circuit by applying single input simultaneously low pass, High Pass ,Band Pass ,All Pass and Notch filter is obtained by using two block of Differential Difference current conveyor transconductance amplifier

Keywords: Differential Difference Current Conveyor Transconductance Amplifier; Universal Filter; SymicaDE Tool; Quadrature Oscillator; Voltage Mode.

I. INTRODUCTION

The work presented here deals with building block, which operates in active mode, known as Differential Difference Current Conveyor Transconductance Amplifier and it has applications in analog circuit design such as in signal processing. By cascading the differential difference current conveyor and transconductance amplifiers the Differential Difference Current Conveyor Transconductance is formed. Using differential difference current conveyor transconductance amplifiers (DDCCTAs) several Active Filter transfer function can be realized. Hence for different analogue functionality of circuit, it is implemented on monolithic chip. DDCCTAs has the capability to generate various circuits and it provide electronic tunability. In the present microelectronics technology, the electronic circuits require low power consumption, low power supply and long term durable device. All of these demand strive to fulfill simultaneously but this is problematic and comes with several challenges.

II. DDCCTA BLOCK DESIGN AND ITS APPLICATION

A. Implementation using DDCCTA Block using MOS

Differential Difference current conveyor transconductance amplifier block is the combination of Differential Difference Current Conveyor and Transconductance amplifier. Using it as an active block, Low Pass, High Pass, Band Pass, All Pass ,Band stop filter have been simulated, which operates in voltage mode.Transconductance of the DDCCTA block can be change by changing the bias current therefore it is electronically tunable .The Differential Difference Current conveyor transconductance Amplifier symbol and its Complementary MOS implementation is shown in figure1 and figure2.

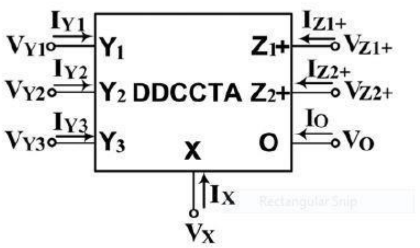

Fig. 1.Block representation of DDCCTA

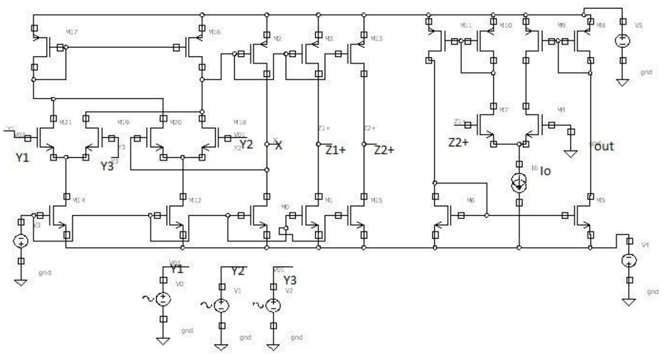

Fig.2. DDCCA implementation using MOS

Relationship between ports can be characterized by the following way-

$I_{y1}=0, I_{y2}=0, I_{y3}=0$

$V_x=V_{y1}- V_{y2}+ V_{y3}$

$I_{z1}= I_{z2}= I_x$

$I_o=g_m V_{z1+}$

It can be written in Matrix form as-

$$\begin{bmatrix} I_{Y1} \\ I_{Y2} \\ I_{Y3} \\ V_X \\ I_{Z1+} \\ I_{Z2+} \\ I_O \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & -1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & g_m & 0 & 0 \end{bmatrix} \begin{bmatrix} V_{Y1} \\ V_{Y2} \\ V_{Y3} \\ I_X \\ V_{Z1+} \\ V_{Z2+} \\ V_O \end{bmatrix}$$

Here current through the terminal Y1, Y2 and Y3 is zero therefore it offers high impedance terminal and current at X terminal is finite , hence it offers low impedance terminal. Port X follows the voltage difference of port Y1 and Y2 and then add voltage of port Y3. The current at Z1+ duplicates the current of port X in positive magnitude. The Z2+ port has a current which is duplicated of current at Z1+ port. Current at Z2+ is an extended output. Here gm is transconductance which acts as a transfer function and convert voltage at Z1+ port to the current at Io port. Since gm is controlled by external bias current I_B, therefore it is electronically tunable which is very useful in variety of circuit implementation while designing a circuit.

B. Filter Configuration

Nowadays massive electronics tools use the filter. It is almost impossible to design an electronics system without use of filter. They use in all the area of electronics system ranging from mobile phone , broadband network to demodulation and tuning , loudspeaker. The main characteristic of filter is, it allows passing specific range of frequency and blocking the frequency other than desired frequency. The circuit in the filter uses two Differential Difference Current Conveyor Transconductance Amplifier block and two capacitor and resistor respectively. The capacitor and resistor which used here is grounded. Since the grounded capacitor compensates for stray capacitance at their port therefore it is attractive for monolithic integrated circuit prospective .Grounded resistor can be replaced by electronic resistor using MOS device. It uses SIMD i.e single input multiple output.

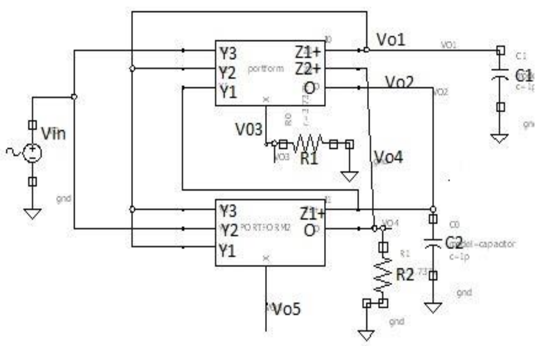

Fig.3 Block diagram of Universal Filter

The figure shown above is the schematic of universal filter where band pass filter is obtained at port V01 and Low pass filter is obtained at port V02 and High pass filter is obtained at port V03 and Notch Filter is obtained at port V04 and All Pass Filter is obtained at port V05. It used 180 nm technology PTM file for the circuit components dimension. It uses two grounded capacitor and two grounded resistor. Due to grounded component in the circuit parasitic effect is minimized in the circuit. Gain plot and phase plot is plotted using symica DE tools. Value of resistor and capacitor are adjusted to provide band pass filter for different resonance frequency and different quality factor. It uses two blocks of Difference Difference Current Conveyor Transconductance Amplifier. Connection between two active blocks is provided to obtain Universal Filter. Frequency and quality factor can be change orthogonally. Biasing current is adjusted to provide tunability in the circuit. Formula for natural frequency, quality factor and band width can be given as

$$W0 = \sqrt{\frac{gm1}{RI\,CI\,C2}}, \quad Q=\sqrt{\frac{gm1R1C1}{C2}}, \quad BW=\frac{1}{R1C1} \qquad (1)$$

Where transconductance of upper block is taken as g_{m1}

C. Simulation Result of Filter

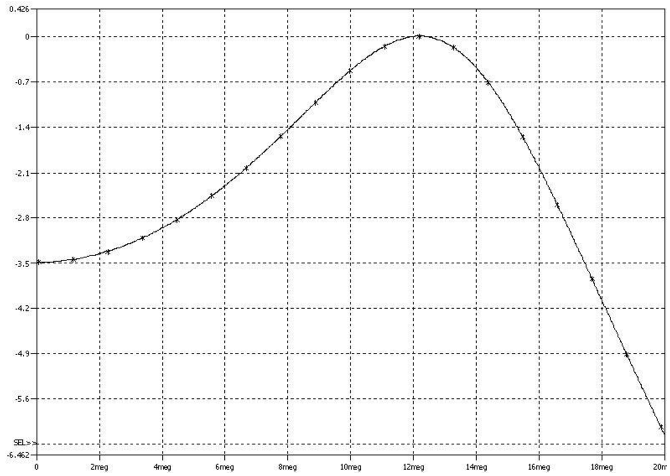

Fig .4 .Gain Response of Band Pass Filter

The band pass filter response obtained at port Vo_1 where Centre frequency is coming as 12.4031MHz.This graph is drawn by taking transconductance of both Differential Difference Current Conveyor Transconductance block as 267.53559uA/V. This value is calculated by applying 0.3V at the X terminal and calculate the value of V_{Z1+} and Io and the value of V_{Z1+}/Io is transconductance of the transconductance block by taking bias current as 68.65uA,where R_1=6.5Kohm C_1=1pF ,C_2=1pF.

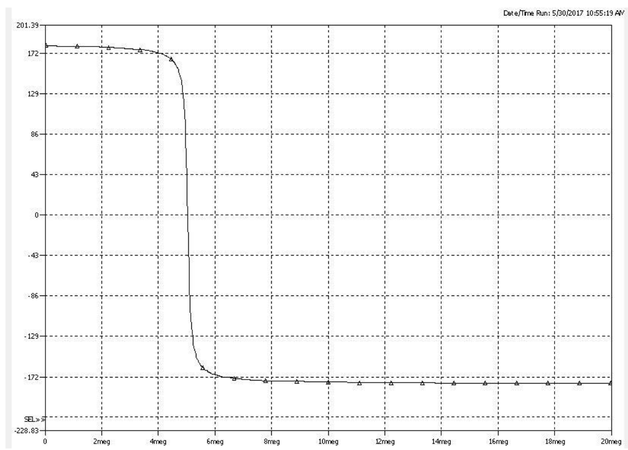

Fig.5 Phase Response of Band Pass Filter

From the above graph of phase response of band pass filter it can be seen that at very low frequency phase of the response is 180 degree and very high frequency value of the phase response is -180 degree. At the value around 5 mega Hz frequency there is transition of frequency from 180 degree to -180 degree.

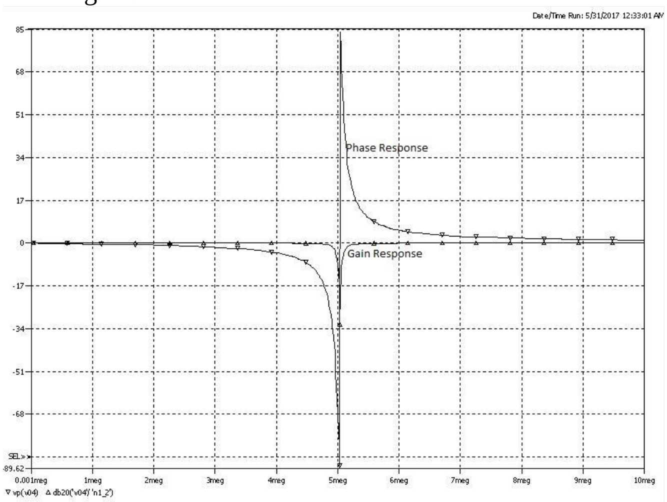

Fig.6 Gain and Phase Response

Notch Filter response obtained at port V04 of filter which allows passing all low and high frequencies contents and block the band of frequency around 5 mega Hz. Phase of the notch filter shows almost zero degree phase at all the frequency except at 5MHz where transition of phase occurs from -90 to +90 degree, 180 degree phase shift occurs at transition frequency.

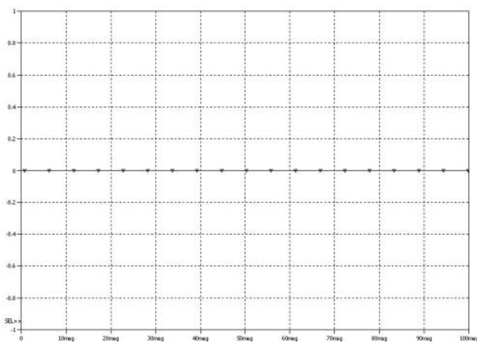

Fig.7 Gain plot of All Pass Filter

Above graph shows the gain response of all pass filters at the terminal V05 of the filter. It allows passing the entire frequency component.

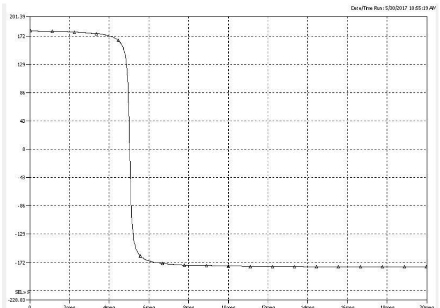

Fig.8 Phase Plot of All Pass Filter

Phase of the All Pass Filter shown in the figure varies from 180 degree to -180 degree.

III. OSCILLATOR DESIGN

Through Symica DE Tool oscillator circuit tested on PTM 180nm Technology. Power supply in the circuit is set to be Vdd=-VSS=.9V.Oscillator is designed using one block of Differential Difference Current Conveyor Transconductance Amplifier and two capacitor of value 8pF and 4pF and Bias current is adjusted to 65micor Amp. During the simulating I obtain sinusoidal waveform at V01 and V02 of amplitude 202mV and 110mV respectively with the frequency of 2.5MHz .V01 and V02 are in the quadrature phase shifts with respect to each other. Bias current in the active block is set to 65uamp. Oscillation condition and frequency of oscillation can given by following formula

$$\frac{1}{gm} + \frac{C1R1}{C2} < 2R1 \qquad (2)$$

$$W_{O} = \sqrt{\frac{gm}{C1\ C2\ R1}} \qquad (3)$$

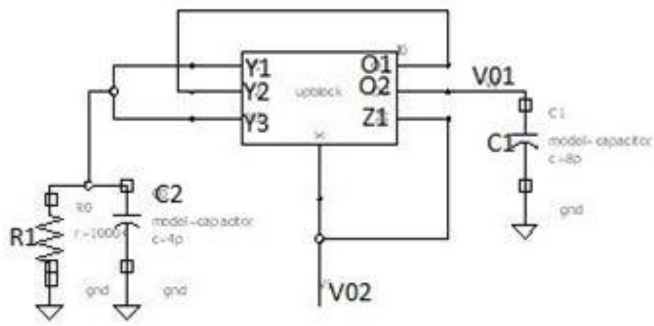

Fig.9 Block diagram of oscillator

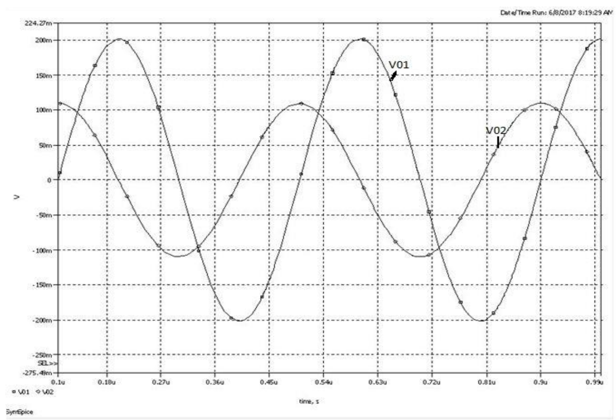

Fig.10 Waveform

A. Waveform obtain at Vo_1 and Vo_2

From the above waveform it can be seen that sinusoidal Voltage of value of 202mV is obtain at port V01 and sinusoidal voltage of value 110mV is obtain at port V02.Both the voltages are of time period 0.4u second ,or in other words frequency of 2.5MHz ,Both the voltage are in quadrature phase shift with respect to each other.

IV. CONCLUSIONS

The Study presents universal biquadratic filter which has very high input impedance and designed using two block of differential difference current conveyor transconductance amplifier ,two grounded capacitor and resistor. By applying single input in universal filter simultaneously low pass ,high pass ,band pass ,all pass ,notch filter is obtained. Filter configuration does not required critical component matching condition to realise all pass filter. Using one block of differential difference current conveyor transconductance amplifier ,two capacitor and a resistor oscillator is presented. Two voltage source in oscillator circuit is obtained which are in quadrature phase shift with respect to each other.

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