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# Active Filter Based On Differential Voltage Current Conveyor Transconductance Amplifier (DVCCTA)

**Mr. J.S.Ratale,** ***Asst.Prof.*** **Mr. S.S.Mungona**
*Dept of E.X.T.C*
*Sipna C.O.E.T.Amravati, Maharashtra, India-444604*
*Sant Gadge Baba Amravati University, India*

***Abstract— This paper present a voltage mode filter and current mode filter based on recently proposed active building block, namely differential voltage current conveyor transconductance amplifier (DVCCTA) . Filter circuit employ DVCCTA, two capacitor, and single resistor. The filter circuit enjoys low voltage (1v), low current (µA) performances and exhibit electronic tenability of filter parameter via bias current of DVCCTA .ADS simulation using 0.18 µm TSMC CMOS technology parameter are included to show the workability of proposed circuit.***

***Keywords— Analog signal processing applications, Operational amplifier, Active filter, DVCCTA.Current Conveyor***

## I. INTRODUCTION

The concept of current conveyor was first presented In 1968 Smith and Sedra [1] in the field of Analog Electronics. Subsequently in 1970, they had reformulated it as second generation CCII [2]. Later in 1995, Fabre, published Third generation current conveyor [3].The current conveyor is intended as a general building block as with the operational amplifier .However operational amplifier do not perform well in application where a current output signal is needed and consequently there is an application field for current conveyor circuits. The current mode circuits such as Current conveyors (CCs) have emerged as an important class of circuits in the field of analog electronics. It has excellent properties that enable them to rival their voltage-mode counterparts (Op-Amps) in a wide range of applications. Since the gain-bandwidth product of Op-Amp is finite; thus higher the gain it realizes, the less bandwidth it possesses. In CCs, the use of current rather than voltage as the active parameter can result in higher usable gain, accuracy and bandwidth due to reduced voltage excursion at sensitive nodes [4]. The current mode active devices are appropriate to operate with signal in current or voltage or mixed mode, and are gaining acceptance as building blocks in high performance circuit designs. A number of current mode active elements such as operational transconductance amplifier (OTA) [5], differential voltage current conveyor (DVCC) [6] are available in the literature. In 2005, a modern active block current conveyor transconductance amplifier (CCTA) [7, 8] inspired by Current Feedback Operation Amplifier (CFOA) has been proposed. The differential voltage current conveyor transconductance amplifier (DVCCTA) [9],and differential voltage current controlled conveyor transconductance amplifier (DVCCCTA) [10 ].

This paper present a universal voltage –mode filter based on recently proposed active building block , namely, differential voltage current conveyor transconductance amplifier (DVCCTA) [10 ] which has DVCC [6 ] as input block and is followed by transconductance amplifier (TA). The DVCCTA has all the good properties of current conveyor transconductance amplifier (CCTA) including the possibility of inbuilt tuning of the parameters of signal processing circuits to be implemented and also all the versatile and special properties of DVCC such as easy implementation of differential and floating input circuits [6, 11, 12].The proposed circuit have been implemented using 0.18 µm TSMC CMOS technology and validated through ADS simulations for their functionality.

## II. CIRCUIT DESCRIPTION

### *A. Differential Voltage Current Conveyor Transconductance Amplifier (DVCCTA)*

The DVCCTA is based on differential voltage current conveyor (DVCC) [6 ] and consists of differential amplifier, current mirrors, and transconductance amplifier (TA).The port relationships of the DVCCTA as shown in Figure1 can be characterized by the following matrix:

$$\begin{bmatrix} Iy1 \\ Iy2 \\ Vx \\ Iz+ \\ Iz- \\ Io- \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & -gm & 0 & 0 \end{bmatrix} \begin{bmatrix} Vy1 \\ Vy2 \\ Ix \\ Vz+ \\ Vz- \\ Vo \end{bmatrix} \quad (1)$$

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Where gm is transconductance of the DVCCTA.
The CMOS based internal circuit of Differential Voltage Current Conveyor Transconductance Amplifier in CMOS is depicted in figure3.and is based on internal circuit of Differential Voltage Current Conveyor (DVCC) which is followed by Transconductance Amplifier.

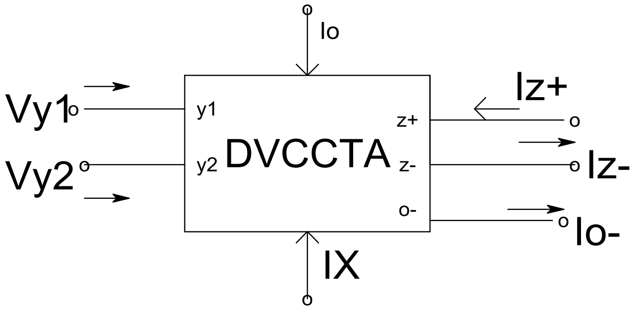


Fig 1: Circuit symbol of DVCCTA

The value of gm is given

$$\sqrt{2uC_{ox}(W/L)\,I_O}$$

As above.
Which can be adjusted by bias current $I_o$.The TSMC 0.18 µm CMOS process model parameter and supply voltage of VDD=1v and bias current 1 µA are used. The aspect ratio of various transistors is given in Table 1

| Transistor | Aspect ratio (W/L) |
|---|---|
| M1 – M4 | 23.8/0.18 |
| M5 – M7 | 20.9/0.18 |
| M8 – M9 | 4.31/0.18 |
| M10 – M12 | 8/0.18 |
| M13 – M15 | 4/0.18 |

Table:1

*B. Voltage Mode Filter*

The proposed voltage mode filter based on single DVCCTA is shown in Fig.2.It uses single DVCCTA, two capacitor and a resistor. The output voltage at various nodes for the circuit can be expressed as:

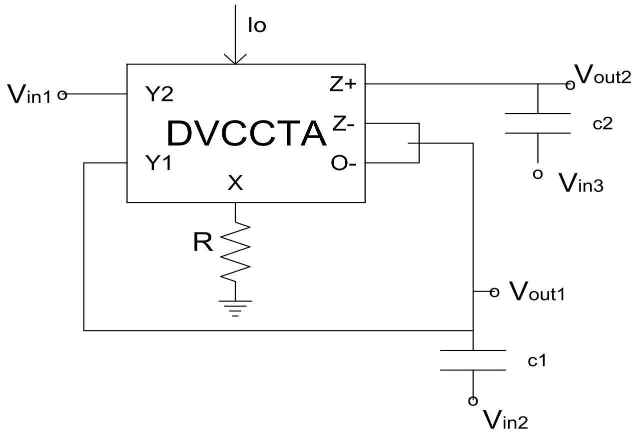


Fig2. Proposed Voltage mode filter

$$V_{out1} = \frac{-s^2 C1C2\,R\,Vin1 - sC2\,R\,gm\,Vin2}{D(s)} \quad (2)$$

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$$V_{out2} = \frac{Vin\,2\ D(s) - s\ C2\ Vin1 - gm\ Vin2}{D(S)} \quad (3)$$

$$V_{out3} = \frac{Vin\ D(s) - s^2 c1c2RVin1 - sC2\ R\ gm\ Vin2}{D(s)} \quad (4)$$

$$D(S) = s^2\ C1\ C2\ R + s\ C2 + gm \quad (5)$$

It may be observed from (2) to (4) that high pass response at Vout1 and V out2 are available simultaneously for $Vin_1$ = Vin, $Vin_2$ = 0, $Vin_3$ = Vin. The low pass (R = 1/gm) responses may be obtained at Vout1.Table 2: The $Vin_1$, $Vin_2$ and $Vin_3$ values selection for each filter function response.

| **Filter responses** | **Inputs** **Vin1** | **Vin2** | **Vin3** | **Output** |
|---|---|---|---|---|
| Low-pass | 1 | 0 | 1 | Vout1 |
| High – pass | 0 | 1 | 0 | Vout1 |
| | 1 | 0 | 1 | Vout2 |
| Band - pass | 0 | 1 | 0 | Vout2 |

Table 2

Table 2 shows the availability of each filter response and corresponding selection of input voltages Vin1, Vin2, Vin3. Thus the proposed structure is a three input and two output voltage mode filter. The responses are characterized by pole frequency (ωo), band width (ωo/ Qo), and quality factor (Qo) as follows:

$\omega o = (gm/Rc1c2)^{1/2}$, $\omega o/Qo = 1/RC1$ , $Qo = (gmRC1/C2)^{1/2}$ (6)

It may be noted that the value of gm can easily be varied by bias current Io

To verify the functionality of the proposed DVCCTA based voltage mode filter, ADS simulation have been carried out using TSMC 0.18 µm CMOS process model parameter and supply voltage $V_{DD}$ = 1v and bias current $I_{DS}$ =1mA .The aspect ratio of various transistor is given in Table 1. The filter is designed for a pole frequency of $f_o$= (100KHz), Q= (1.1), the component values are found to be C =C1 = C2 = 100Pf, R = 1kΩ, and bias current of DVCCTA equals 50µA.

Figure 4 (a) shows the simulation results for low pass (Vout1) and Figure 4(b) for high pass (Vout2) filter responses.

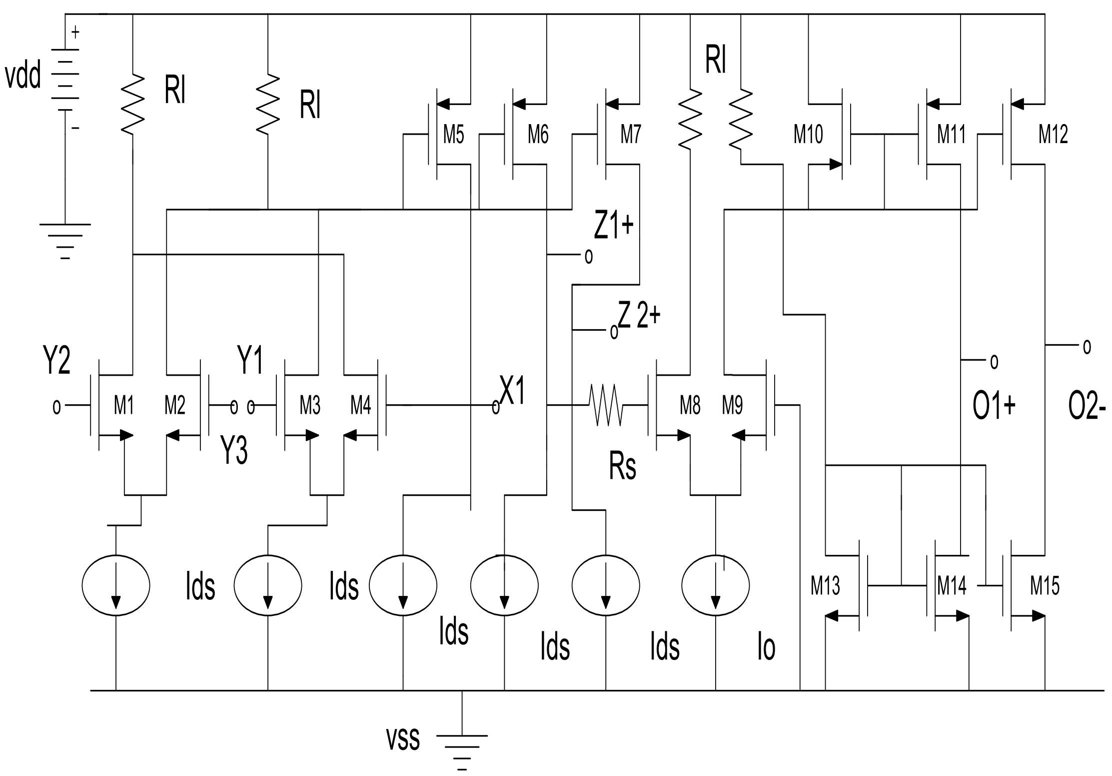


Figure 3: Internal circuit of DVCCTA

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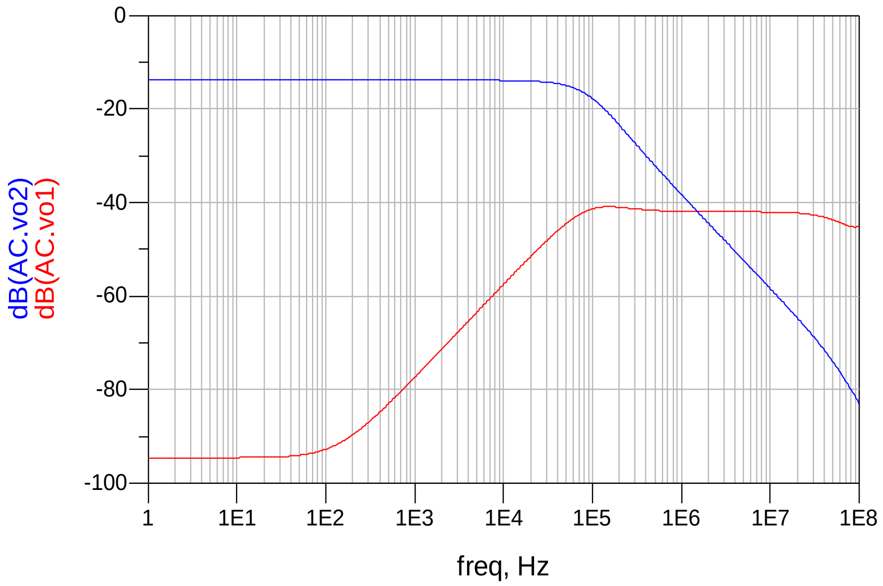


Figure 4 : shows mix simulation result for low pass (Vout1) and high pass (Vout2 )

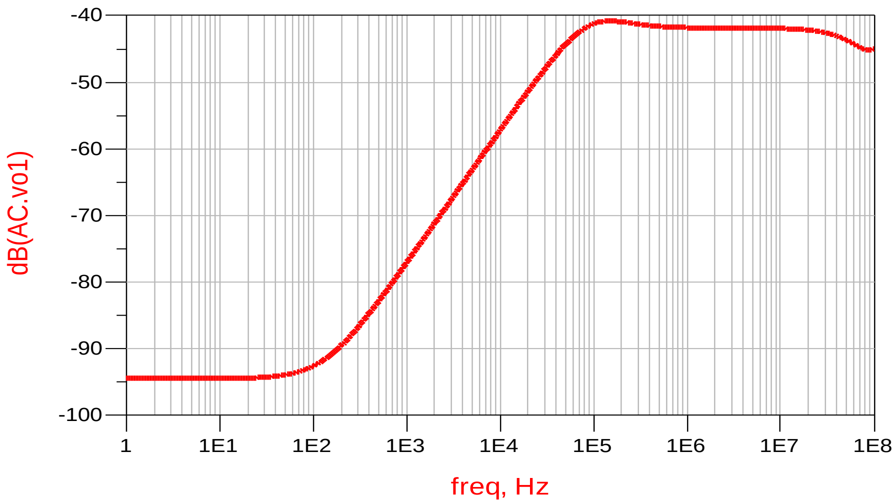


Figure 4(a) shows the simulation result for low pass

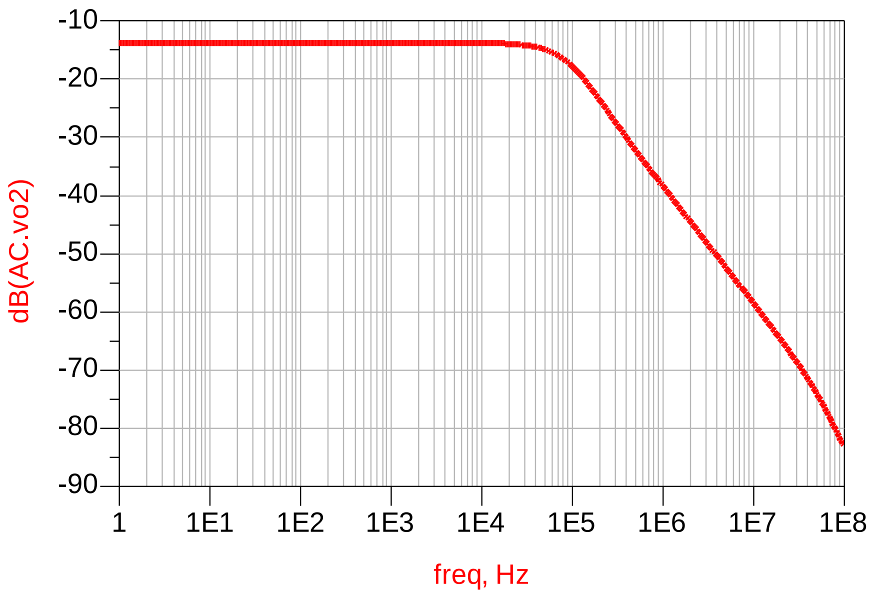


Figure 4(b) shows the simulation result for high pass

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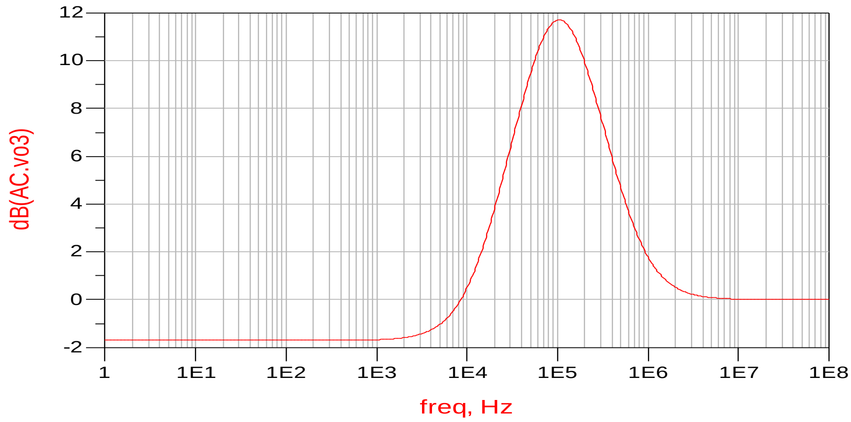


Figure 4(c) shows the simulation result for Band – pass filter

*C. Current Mode Filter*

The structure for the proposed multiple input single output current mode filter is shown in fig. 5. It employs a single DVCCTA, two grounded capacitor, and a grounded resistor.

Analysis of this circuit gives the output current as follows:

$$I_{OUT} = \frac{s^2 C_1 C_2 R I_{in1} - sC_2 I_{in3} + gm I_{in2}}{D(s)} \qquad (6)$$

$$D(s) = S^2 C_1 C_2 R + sC_2 + gm \qquad (7)$$

Table 3 shows the availability of each filter response and corresponding selection of currents $I_{in1}$ , $I_{in2}$ , and $I_{in3}$ .Thus ,the proposed structure is a three input single output current mode filter. The resistance (Rl) may easily be implemented as variable one using only two MOS transistor.

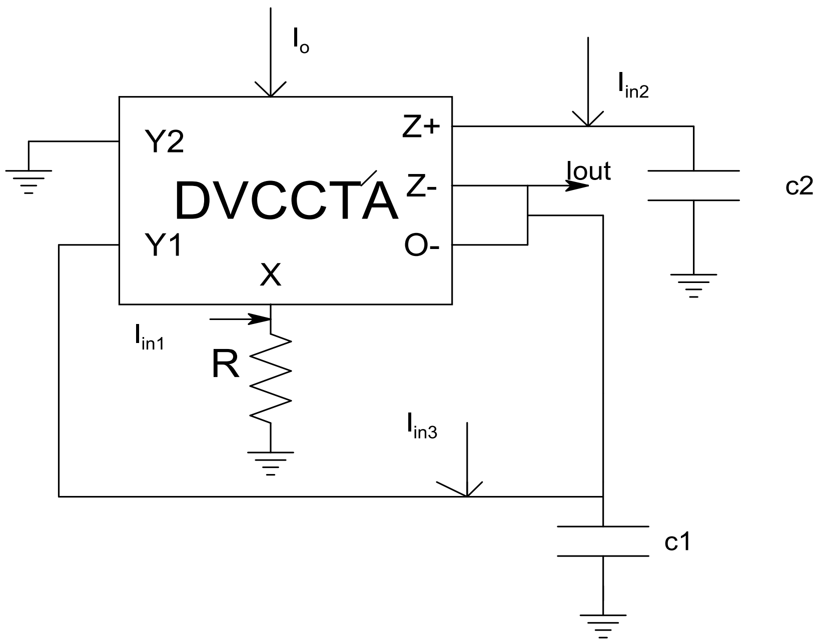


Figure 5: Current mode filter

| Filter responses $I_{out}$ | Inputs $Iin_1$ | $Iin_2$ | $Iin_3$ |
|---|---|---|---|
| Low-pass | 0 | 1 | 0 |
| High – pass | 1 | 0 | 0 |

The proposed current mode filter is validated through ADS simulations. The circuit of Figure 5 for a pole frequency of $f_o$ = (100 KHz), Q = (1.1) has been designed with the same parameter of voltage mode filter.

Figure 5: shows mix simulation result for low pass and high pass simulated response of Current mode filter

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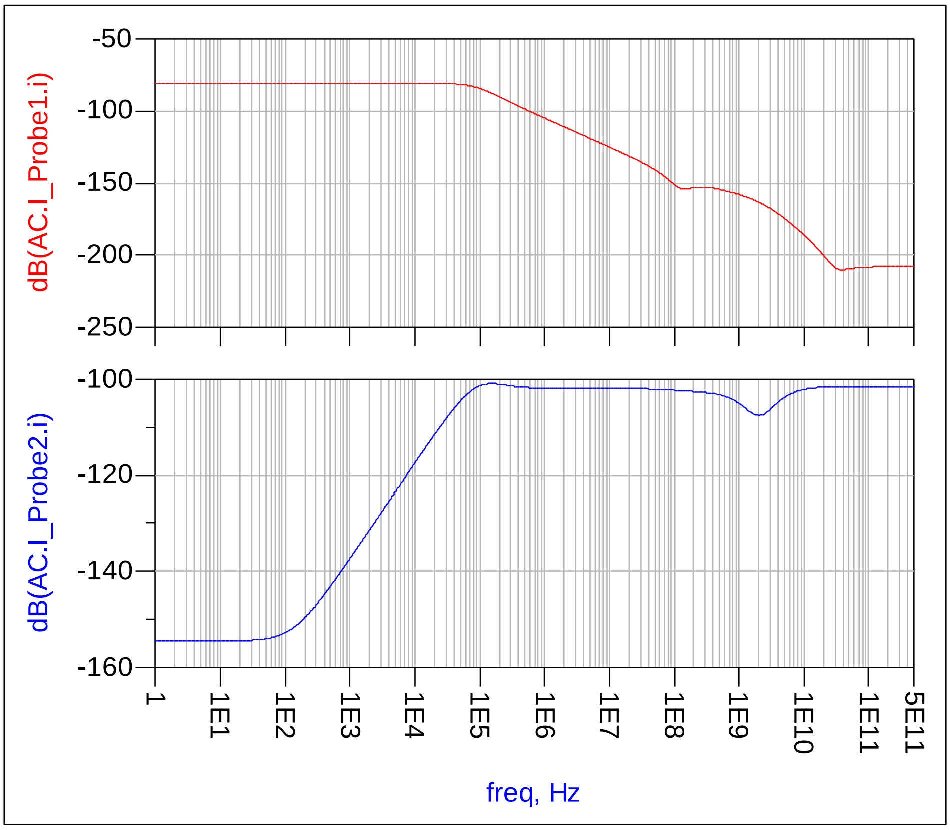


Figure 5 (a): shows the simulation result for high pass Current mode filter

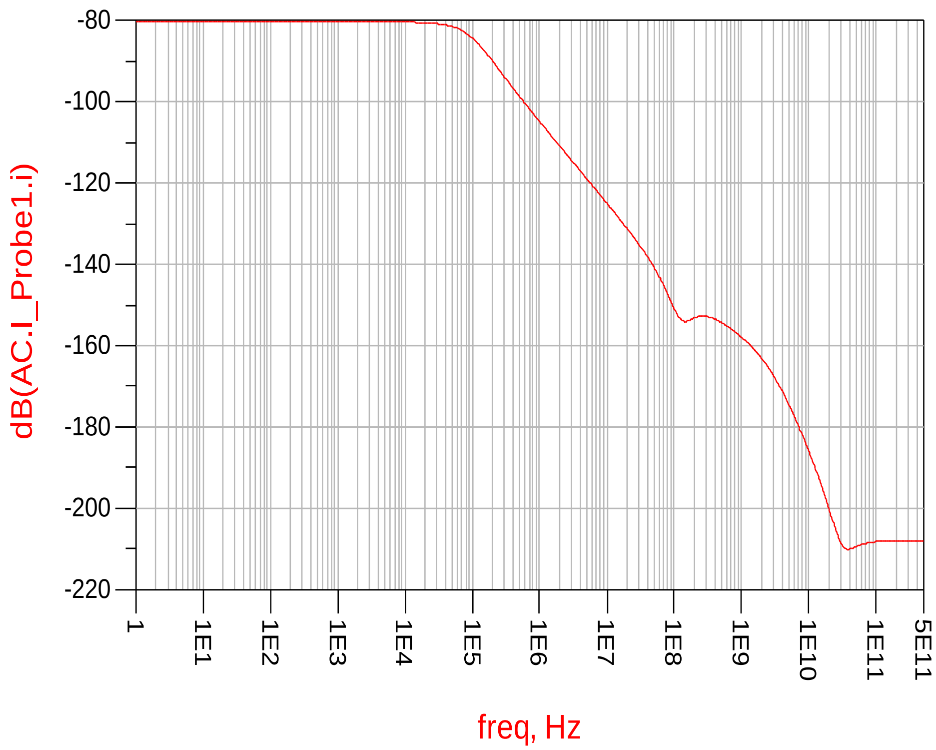


Figure 5 (a): shows the simulation result for low pass Current mode filter

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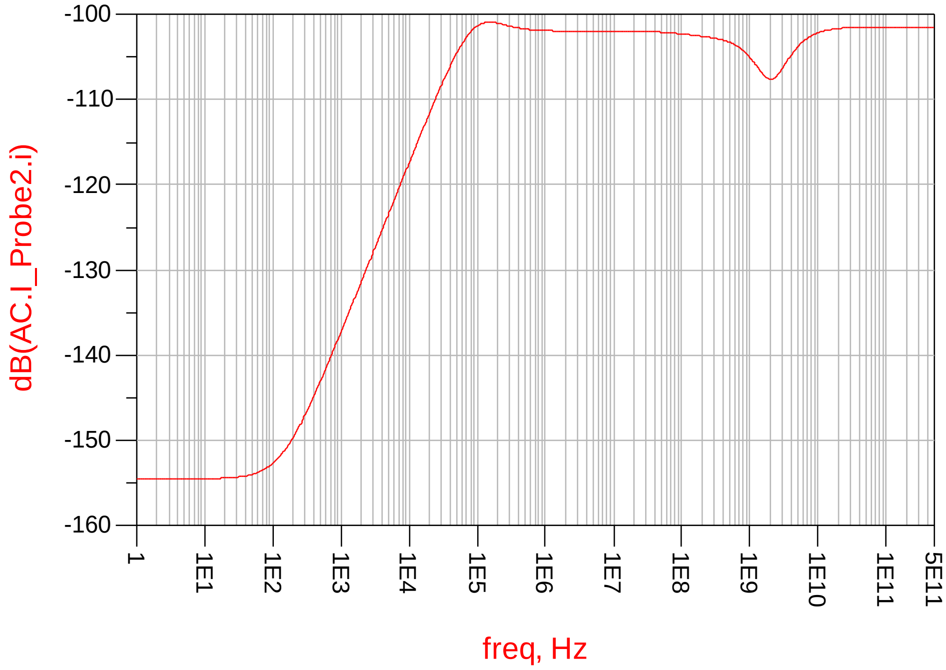


The simulation result shows high gain and very high input operating frequency up to 500GHz.

## III. CONCLUSIONS

New voltage mode and current mode filters based on 0.18µm CMOS DVCCTA has been presented .The circuit use one DVCCTA, two capacitor, and a resister for realization. The main advantages is filter circuit small in size, high speed , lower power , and high frequency problem of operational amplifier (OP-AMP) is overcome. The resistor being grounded may be implemented using two MOS. The simulation results verify the theory. The salient features of the proposed circuits are as follows: they employ a single DVCCTA, electronic tenability of ωo and $\omega_o$ /$Q_o$. Like if $C_1$=$C_2$=10pF Then cut-off frequency equal to 1MHz.

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