ISSN:2249-5789
Sunil Kr.Pandey et al, International Journal of Computer Science & Communication Networks,Vol 2(2), 236-239

A Current Mode Fifth Order Elliptic Filter Employing Current Differencing Transconductance Amplifier

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Abstract-- ***In this paper A new current mode(CM) Fifth order elliptic Filter using current differencing transconductance amplifier(CDTA) is presented. An elliptic filter also known as a Cauer Filter is a signal processing filter with equalized ripple (equiripple) behaviour in both the pass band and the stop band. The amount of ripple in each band is independently adjustable, and no other filter of equal order can have a faster transition in gain between the pass band and the stop band, for the given values of ripple (whether the ripple is equalized or not). Alternatively, one may give up the ability to independently adjust the pass band and stop band ripple.The circuit employes five CDTA and some passive components.CDTA is used especially for current mode analog signal processing. The active filters in CM have wider band width, simpler circuitery, greater linearity, wider dynamic range and lower power consumption as compared to their voltage mode counterparts.Because of these features ,the interest towards current mode has increased among many researchers.SPICE simulation results which utilizes the CMOS based CDTA model,are enclosed.***

Index Terms-- ***CDTA ,Current Mode signal processing, Elliptic Filter , SPICE.***

1. INTRODUCTION

Current differencing transconductance amplifier(CDTA) is used especially for current mode analog signal processing[1].A variety of applications of Current differencing transconductance amplifier (CDTA) can be found in various literature[2]-[5]. The active filters in CM have wider band width, simpler circuitry, greater linearity, wider dynamic range and lower power consumption as compared to their voltage mode counterparts[6]. Current mode means current is used as a signal parameter. It leads to very compact circuit structure especially when more than two output terminals are used. In current mode, current source driven low impedance nodes carry current signals,due to low input impedance time constant is low, it leads to a higher frequency poles and results in high frequency operation. Since voltages are not essentially involved in signal processing, it is possible to design circuits at low supply voltage that are capable of high frequency operation.This paper presents a new Current mode fifth order Elliptic LP filter which utilizes only five CDTA and some passive components as well.Passive structure is summarized first then it is designed using active component CDTA. Individual Inductors of passive part is replaced by one CDTA in combination with capacitor.SPICE simulation results have been incorporated to check the workability of the proposed circuit.

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2. CIRCUIT DESCRIPTION

The CDTA element[3] with its behavioural model and schematic symbol is shown in Fig.1.

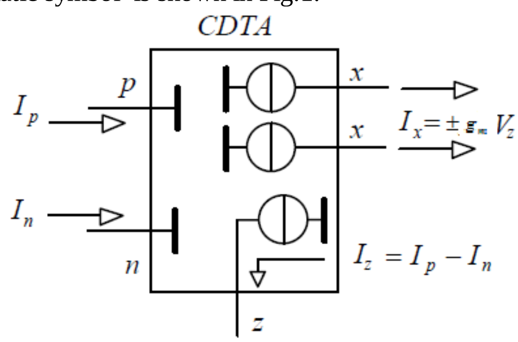
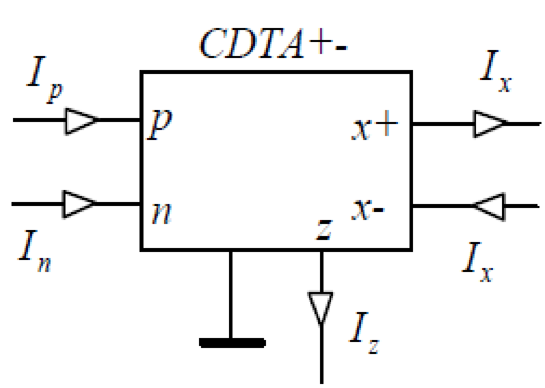


Fig.1-(a) Behavioural model



(b) symbol of CDTA element

ISSN:2249-5789
Sunil Kr.Pandey et al, International Journal of Computer Science & Communication Networks,Vol 2(2), 236-239

Here output terminal currents are equal in magnitude but flows in opposite directions, and the product of transconductance (g_m) and the voltage at the z terminal gives their magnitudes.Therefore this active element can be characterized with the following equations:

$$V_p = V_n = 0, \qquad Iz = I_p - I_n$$
$$Ix+ = g_m V_z, \qquad Ix- = -g_m V_z$$

$V_z = I_z Z_z$, and Z_z is the external impedance connected to z. CDTA can be thought as a combination of a Current differencing unit followed by a dual-output operational transconductance amplifier, DO-OTA[3].OTA is a voltage-controlled current source device and can be described by:

$$Ix = g_m (V_+ - V_-)$$

where Ix is output current, V_+ and V_- , denote non-inverting and inverting input voltage of the OTA, respectively.

The performance characteristics of the proposed filter and CDTA was simulated in SPICE for its verification.For this 0.5um MIETEC real transistor model parameters are implemented for all transistors in the circuit as indicated in Table 2, transistor aspect ratios are indicated as in Table1.

Table 1. Transistor W/L ratios used in CDTA.

Transistor	W/L(micrometer)
M1-M6	14/1
M7-M10	13/1
M11-M12	20/2
M13-M14	16/1
M15-M20	6/1
M21-M24	4/1

Table 2. CMOS model used in simulation.

.MODEL NMOS LEVEL=3 UO=460.5 TOX=1.0E-8 TPG=1 VTO=+0.62 JS=1.08E-6 XJ=0.15U RS=417 RSH=2.73 LD=0.04U VMAX=130E3 NSUB=1.71E17 PB=0.761 ETA=0.00 THETA=0.129 PHI=0.905 GAMMA=0.69 KAPPA=0.10 CJ=76.4E-5 MJ=0.357 CJSW=5.68E-10 MJSW=0.302 CGSO=1.38E-10 CGDO=1.38E-10 CGBO=3.45E-10 KF=3.07E-28 AF=1 WD=+0.11U DELTA=+0.42 NFS=1.2E11 DELL=0U LIS=2 ISTMP=10 TT=0.1E-9

.MODEL PMOS LEVEL=3 UO=100 TOX=1.0E-8 TPG=1 VTO=-0.58 JS=0.38E-6 XJ=0.10U RS=886 RSH=1.81 LD=0.03U VMAX=113E3 NSUB=2.08E17 PB=0.911 ETA=00 THETA=0.120 PHI=0.905 GAMMA=0.76 KAPPA=2 CJ=85E-5 MJ=0.429 CJSW=4.67E-10 MJSW=0.631 CGSO=1.38E-10 CGDO=1.38E-10 CGBO=3.45E-10 KF=1.08E-29 AF=1 WD=+0.14U DELTA=0.81 NFS=0.52E11 DELL=0U LIS=2 ISTMP=10 TT=0.1E-9

2.1.Simulation Results Of CMOS based CDTA Circuit

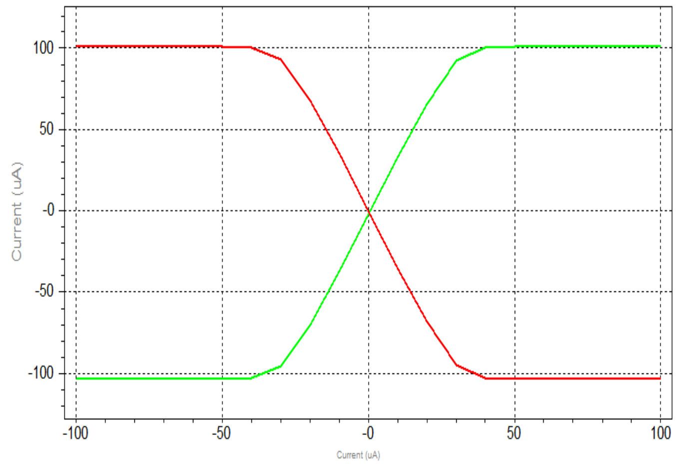


Fig.2(a) Variation of Ix+ and Ix- with respect to Ip input current(for this z terminal is loaded with 19.6Kohm impedance).

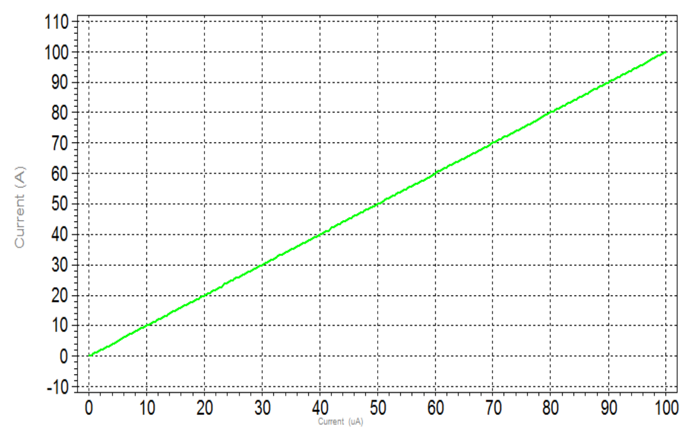


Fig.2(b) Iz/Ip Plot of CDTA

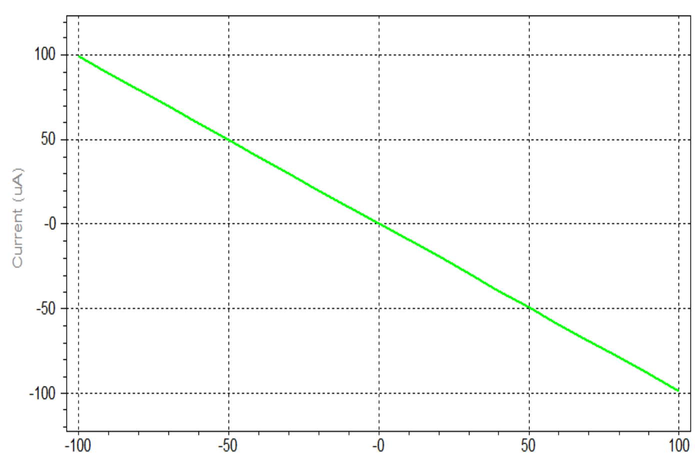


Fig.2(c) Iz/In Plot of CDTA

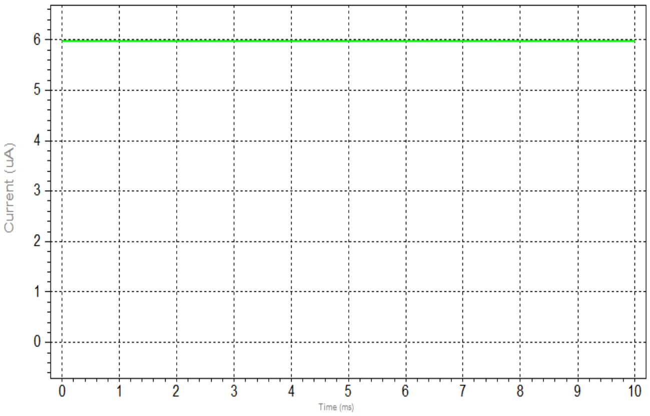


Fig.2(d) Iz Vs time Plot When I_p =10uA, I_n =4uA

2.2.Passive part of Elliptic Filter

For 5MHz cutoff frequency the values of R_1=2.5k R_2=2.5k,C_1=11.63p,C_2=1.786p,C_3=16.43p, C_4=9.03p,C_5=14.25p,L_1=86.45u,L_2=57.37u

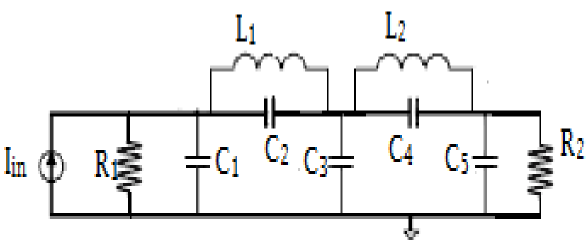


Fig.3 Fifth order passive Elliptic Filter

2.3. Simulation Results Of Passive Part

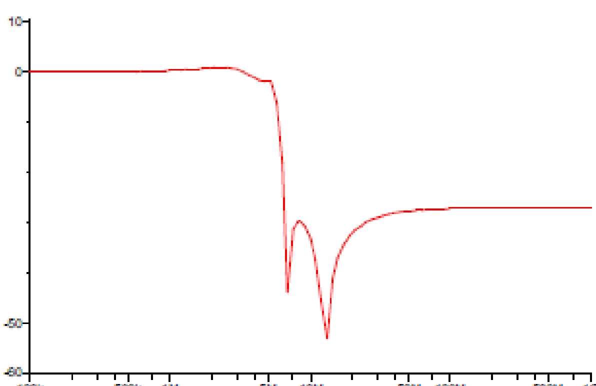


Fig.4 Fifth order passive Elliptic Filter when simulated through SNAP Tool.

3. Proposed Fifth Order Elliptic filter

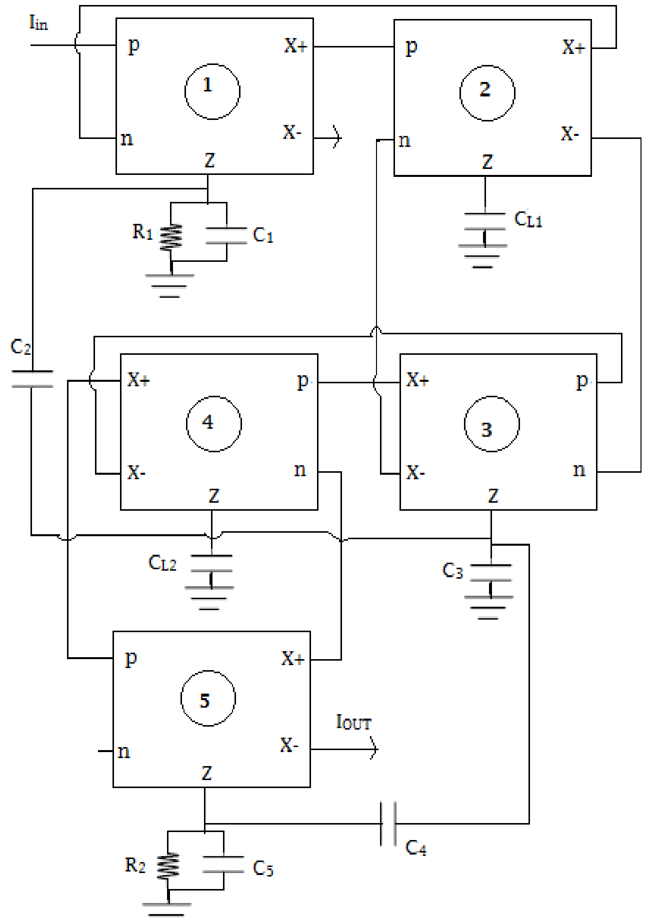


Fig.5 Fifth order Elliptic Low Pass Filter Using CDTA

Passive filter is simulated using the SNAP tool [7]-[8].To simulate the passive filter using CDTA ,transconductance of the CDTA element is used to transform the voltages of each node to currents.Active filter using CDTA is given in Fig.5. The C_{L1} and C_{L2} is used to simulate the inductors in the passive filters with the CDTA element.

The values of C_1-C_5, R_1 and R_2 are same for proposed circuit,but The C_{L1} and C_{L2} is calculated by :

$$C_{Li} = g_m \times L_i^2$$

By this Formula we get C_{L1} = 13.42p and C_{L2} = 8.9p
The Transconducatnce of CDTA circuit is 394uA/V from simulation results.Ripple amount in passband is very low,which can be adjustable.This Filter is designed as a Cauer LP filter with approximately 4MHz cutoff frequency,and with an attenuation of 25dB above 8MHz.

3.1.Simulation Results Of CDTA based Elliptic filter

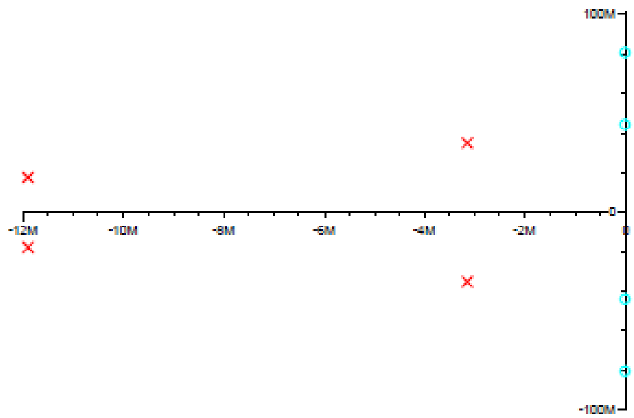


Fig.6 Pole & Zero plot of Fifth order Elliptic LP Filter using CDTA

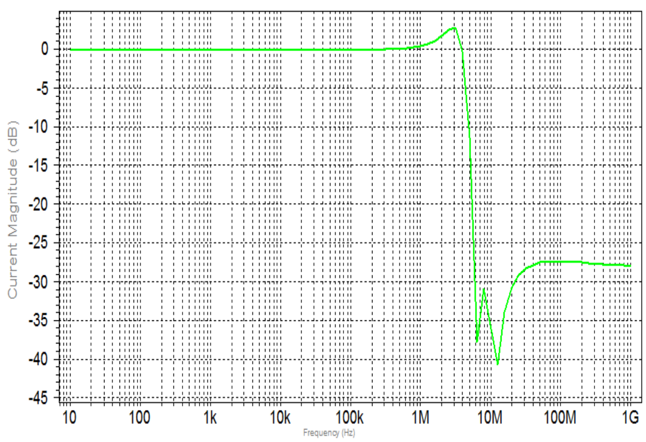


Fig.7 Fifth order Elliptic Low Pass Filter using CDTA when simulated through SPICE Programme.

4. Conclusion

A new current mode Fifth order Elliptic LP filter using CDTA is described in this paper.The circuit uses only five CDTA and some passive components.Each Inductor of passive structure is replaced by a CDTA in combination with a capacitor.This proposed circuit can be used for faster transition in gain between Passband and Stopband. It can also be used for video applications with cutoff frequency in MHz range and where less ripple is desired.Passive structure of fifth order Elliptic filter is simulated in SNAP(Symbolic numerical Analysis programme) and its CDTA part is simulated in SPICE.SPICE simulation of this circuit confirms the theoretical conclusion.

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