Realization of Voltage mode Universal Filter by Using Single Differential Voltage Current Conveyor Transconductance Amplifier

Kavita Verma¹, Shweta Gautam²
¹,²Dept. of Electronics & Communication Engineering, IMS Engineering College, Ghaziabad, India
23kavitaverma@gmail.com, gautam.shweta74@gmail.com

ABSTRACT

The paper presents a new voltage-mode universal filter using a differential voltage current conveyor transconductance amplifier (DVCCTA). It has three inputs and single output. The proposed circuit can simultaneously realize low-pass, band-pass, and high pass, band reject and all pass filter functions without changing the circuit topology and passive elements. The circuit exhibits a good frequency performance. SPICE simulation using 0.25µm TSMC CMOS technology parameters are included to show the workability of the proposed circuits.

Keywords- Differential voltage current conveyor, Transconductance amplifier and Universal voltage mode filter.

I. INTRODUCTION

Current-mode circuits have been receiving considerable attention owing to their potential advantages such as wider bandwidth, greater linearity, higher slew rate, wider dynamic range, simple circuitry, and low power consumption [1]-[2] compared to voltage-mode circuits. Active filters are so widely used in electronic systems, such as telecommunications, radar, consumer electronics, instrumentation systems, and military ordnance [3]-[4]. Many voltage-mode universal filters with multi-inputs were proposed. From different combinations of injection of input voltage signals, voltage-mode low pass, band pass, high pass, notch, and all pass filters can be obtained without changing the circuit topology. Recently there are reports of some new analog building blocks, such as current-conveyor transconductance amplifier (CCTA) [5], current controlled current conveyor transconductance amplifier (CCCTA) [6], current difference transconductance amplifier (CDTA) [7], differential voltage current conveyor transconductance amplifier (DVCCTA) [8] and differential voltage current controlled conveyor transconductance amplifier DVCCCTA. These can be obtained by cascading of current mode building blocks with TA analog building blocks in monolithic chip for compact implementation of signal processing circuits and systems. The differential voltage current conveyor (DVCC) is an analog building block which reduces the drawbacks of current conveyor. For the applications which require two high input impedance terminals (differential or floating inputs) like impedance converters and current-mode instrumentation amplifiers, a single CCII block [9]-[10] is not sufficient to provide two high input impedances. So the differential voltage current conveyor (DVCC) [11]-[12] block is used for providing two high input impedance terminals. The transconductance amplifier (TA) [13] is a differential amplifier whose differential input voltage produces an output current. The DVCCTA is made by cascade connection of DVCC & TA (Transconductance amplifier). This paper presents a universal voltage-mode filter and a universal current mode filter based on recently proposed active building block, namely, differential voltage current conveyor transconductance amplifier (DVCCTA) which has DVCC as input block followed by transconductance amplifier (TA). In this paper, a voltage-mode universal filter circuit that has three input terminals and single output terminal is presented. The proposed circuit has been implemented through spce simulation using 0.25µm TSMC CMOS technology parameters.

II. DESIGNING OF UNIVERSAL VOLTAGE MODE FILTER USING DVCCTA

The DVCCTA is made by cascade connection of DVCC and TA. The DVCCTA [14]-[15] has two inputs and two outputs. The port relationship is shown in form of matrix.
The $g_m$ is called transconductance from Z terminal to O terminal of the DVCCTA. The $g_{m}$ is depend on the bias current $I_B$. The schematic of DVCCTA is shown in fig.1 and the CMOS implementation of DVCCTA is shown in fig.2.

Universal Voltage-Mode Filter is [16] made by single DVCCTA, two capacitors and two resistors. Universal Voltage-Mode Filter is shown in fig.3. The universal filter can performed all the filter operation like low pass, high pass, band pass, band reject (notch) and all pass filters.

\[
\begin{bmatrix}
I_{V1} \\
I_{V2} \\
V_X \\
I_Z \\
I_O
\end{bmatrix} =
\begin{bmatrix}
0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 \\
1 & -1 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & -g_m & 0
\end{bmatrix}
\begin{bmatrix}
V_{V1} \\
V_{V2} \\
I_X \\
V_Z \\
V_O
\end{bmatrix}
\]

\[V_X = V_{V1} - V_{V2}, \quad I_Z = I_X, \quad I_C = -g_m V_O \quad (1)\]

Fig.3: Universal voltage mode filter.

The output voltage of proposed universal voltage mode filter is shown in eq. (2).

\[V_o = \frac{V_2 S^2 C_1 C_2 + V_3 S C_4 C_2 + V_1 S C_1 + g_m C_X + g_m C_X}{S^2 C_1 C_2 + S C_4 C_2 + g_m C_X} \quad (2)\]

The values of $V_1$, $V_2$, and $V_3$ for each filter function response are shown in table 1.

Table 1

<table>
<thead>
<tr>
<th>Frequency Response</th>
<th>Inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_o$</td>
<td>$V_1$ $V_2$ $V_3$</td>
</tr>
<tr>
<td>Low pass Filter</td>
<td>0 0 1</td>
</tr>
<tr>
<td>High pass Filter</td>
<td>1 0 0</td>
</tr>
<tr>
<td>Band pass Filter</td>
<td>0 1 0</td>
</tr>
<tr>
<td>Band reject Filter</td>
<td>1 0 1</td>
</tr>
<tr>
<td>All pass Filter</td>
<td>1 -1 1</td>
</tr>
</tbody>
</table>

From Eq. (2), $V_1$, $V_2$ and $V_3$ can be chosen as in Table 1 to obtain a standard function of the 2nd order network.

Table 2. Aspect Ratio of Various Transistors

<table>
<thead>
<tr>
<th>Transistors name</th>
<th>Aspect ratio $[W(\mu m)/L(\mu m)]$</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1, M2, M3, M4</td>
<td>1/0.25</td>
</tr>
<tr>
<td>M5, M6</td>
<td>4.5/0.25</td>
</tr>
<tr>
<td>M7, M8</td>
<td>12.5/0.25</td>
</tr>
<tr>
<td>M9, M10, M11, M12</td>
<td>3/0.25</td>
</tr>
<tr>
<td>M13, M14, M15, M16</td>
<td>5/0.25</td>
</tr>
</tbody>
</table>
III. RESULTS AND DISCUSSIONS

The performance of the voltage mode universal filter by using single DVCCTA has been analysed. The simulation has been done by using PSPICE simulation with 0.25µm TSMC CMOS technology parameters and power supply of ± 1.25V. The aspect ratio of various transistors of DVCCTA is listed in table 2. The supply voltages used were ± 2.5 V and VBB=−0.8V. The proposed circuit of second-order current mode biquad filter (Figure 3) circuit was designed with \( f_o = 1\text{MHz}, \ C_1 = C_2 = 0.1 \text{nF}, \ R_1 = 1 \text{KΩ} \) and \( R_X = 1.454\text{K} \). The simulation results of second-order voltage-mode universal filter are shown in Figures 4-8.

| M17 | 3/0.25 |
| M18 | 4.5/0.25 |
| M19 | 2.75/0.25 |
| M20 | 4.5/0.25 |

IV. CONCLUSIONS

In this paper, a new voltage-mode universal filter has been presented. The new voltage-mode circuit with three input terminals and single output terminals
employs two capacitors, two resistors and single DVCCTA block. The simulation results verify the theory. PSPICE simulations using 0.25 μm CMOS parameters support the validity and practical utility of the proposed circuit.

V. REFERENCES