Implementation of KHN Biquad Filter using Differential Voltage Current Controlled Conveyor

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ABSTRACT

This research study shows KHN biquad filter realization using Differential Voltage Current Controlled Conveyor (DVCCC). The Proposed Filters presents Low Pass (LP), High Pass (HP) Band Pass (BP), Notch and All Pass (AP). The circuit uses four DVCCC as an active building block (ABB) in each circuit together with grounded passive elements. The circuit is beneficial for IC implementation because it consists only grounded components. The proposed circuit is verified through PSPICE simulation using 0.25µm TSMC CMOS technology parameters.

Keywords - Analog Filter, CMOS, DVCCC, Integrator, KHN Filter

I. INTRODUCTION

In IC technology during the last few years, technocrats use the current mode technique for the several circuit design problem. The current mode technique for signal processing has proved many advantages such as high frequency, lower power consumption, high slew rate, better linearity and better accuracy. The variety of current mode active elements is Current Conveyor (CC) [1], Differential Voltage Current Conveyor (DVCC) [2], Differential Voltage Current Controlled Conveyor (DVCCC) [3-4] etc.

Active Filters are widely used in electronics and communications. In this KHN biquad filter are realized using DVCCC. KHN biquad filter provides low sensitivity and good stability. KHN biquad filter [5-8] consists of summing amplifier and two integrators. KHN biquad filter provides three filters namely Low Pass (LP), High Pass (HP) and Band pass (BP).

II. DVCCC

The DVCCC [3-4] is the extension of DVCC [2]. DVCCC consists of DVCC and translinear loop. It’s parasitic resistance (R_x) can be controlled by bias current (I_B). The symbol of the DVCCC is shown in Figure (1).

The DVCCC has two high input impedance terminals Y_1 and Y_2. The terminal X is current input terminal and Z is high impedance current output terminal.

The input output port relationship of DVCCC can be characterized by equation (1),

\[
\begin{bmatrix}
    I_{Y1} \\
    I_{Y2} \\
    V_X \\
    I_Z
\end{bmatrix} =
\begin{bmatrix}
    0 & 0 & 0 & 0 \\
    0 & 0 & 0 & 0 \\
    1 & -1 & R_X & 0 \\
    0 & 0 & 1 & 0
\end{bmatrix}
\begin{bmatrix}
    V_{Y1} \\
    V_{Y2} \\
    I_X \\
    V_Z
\end{bmatrix}
\]

(1)

Where, \( R_X = \frac{1}{\sqrt{B \cdot L}} \),

\[ k = \mu_p C_0 \left( \frac{W}{L} \right)^{15.16} = \mu_n C_0 \left( \frac{W}{L} \right)^{17.18} \]
The CMOS diagram of DVCCC is shown in Figure (2). In this diagram, transistor \( M_2 - M_3 \) and \( M_5 - M_6 \) realizes differential pair and transistor \( M_7 - M_8 \) realizes current mirror. \( M_1 - M_{10} \) realizes DVCC and transistor \( M_{11} - M_{23} \) realizes translinear loop.

III. KHN-BIQUAD FILTER

1. The Proposed Circuit

The Proposed Circuit is consists of four DVCCC as an active block and two capacitor and one resistor as passive elements is shown in Figure (3) which provides frequency response of low pass, high pass and band pass.

The voltage transfer function of proposed circuit in Figure (3) is as

\[
\frac{V_{HI}}{V_{IN}} = \frac{\frac{1}{R_X}}{\frac{R_X}{R_1} + \frac{R_1}{R_X} + \frac{1}{C_1 R_1} + \frac{1}{C_2 R_1}}
\]

(2)

\[
\frac{V_{BF}}{V_{IN}} = \frac{\frac{1}{R_X}}{\frac{R_X}{R_1} + \frac{R_1}{R_X} + \frac{1}{C_1 R_1} + \frac{1}{C_2 R_1}}
\]

(3)

Figure (4) shows the circuit diagram for other two frequency response of notch and all pass filter. By adding the output voltage of high pass and low pass the notch filter can be designed and by adding of output voltages of high pass, low pass and band pass the all pass filter can be designed.

The voltage transfer function of Figure (4) is as

\[
V_G = \frac{\frac{2}{R_X} + \frac{1}{R_1} + \frac{1}{C_1} + \frac{1}{C_2}}{\frac{2}{R_X} + \frac{1}{R_1} + \frac{1}{C_1} + \frac{1}{C_2}}
\]

(5)

The angular frequency \( (\omega_0) \) and quality factor \( (Q) \) are as follows:

\[
\omega_0 = \frac{1}{R_X \sqrt{C_1 C_2}} \quad \text{and} \quad Q = \sqrt{\frac{C_1 R_1}{R_2 C_2}}
\]

(6)

(7)

2. Sensitivity

The sensitivity of proposed circuit is calculated from equation (6) and equation (7) is follows as:

\[
S_{R} = \frac{1}{2} S_{R} \quad \text{and} \quad S_{C} = \frac{1}{2} S_{C}
\]

\[
S_{R} = \frac{1}{2} S_{R} \quad \text{and} \quad S_{C} = \frac{1}{2} S_{C}
\]

TABLE2. ASPECT RATIO OF VARIOUS TRANSISTORS

<table>
<thead>
<tr>
<th>Transistors</th>
<th>Aspect ratio (W(µm)/L(µm))</th>
</tr>
</thead>
<tbody>
<tr>
<td>( M_1, M_4, M_9, M_{11-14}, M_{23} )</td>
<td>3.0/0.25</td>
</tr>
<tr>
<td>( M_{23,3,5,6} )</td>
<td>1.0/0.25</td>
</tr>
<tr>
<td>( M_{5,8,17,19,22} )</td>
<td>5.0/0.25</td>
</tr>
<tr>
<td>( M_{10} )</td>
<td>12.5/0.25</td>
</tr>
<tr>
<td>( M_{15} )</td>
<td>8.0/0.25</td>
</tr>
<tr>
<td>( M_{16} )</td>
<td>8.5/0.25</td>
</tr>
<tr>
<td>( M_{18} )</td>
<td>4.35/0.25</td>
</tr>
</tbody>
</table>
IV. SIMULATION AND RESULTS

The Proposed KHN biquad filter has been simulated using PSpice 0.25µm TSMC CMOS technology parameters. The aspect ratios of NMOS and PMOS of DVCCC are shown in TABLE 1. For the verification of the low pass, high pass, band pass, notch and all pass filter cut-off frequency is taken 100kHz. The supply voltage \( V_{DD} = V_{SS} = 1.25V \), \( V_{BB} = -0.8V \) and bias current \( (I_B) = 25\mu A \). The value of passive elements used in proposed filter is, 
\[ C_1 = C_2 = 1.098nF, \quad R = R_X = 1.536k\Omega \]
The frequency responses of low pass, high pass, band pass, notch and all pass are shown in Figure (5), Figure (6), Figure (7), Figure (8) and Figure (9) respectively.

V. CONCLUSION

In this research study, the KHN biquad filter has been simulated through PSpice 0.25µm TSMC CMOS technology parameter. The filter consists of DVCCC block, capacitors and resistors and all passive elements are grounded which is suitable for IC implementation. It provides five filters namely as low pass, high pass, band pass, notch and all pass responses.

VI. REFERENCES

Proceedings Papers:

Journal Paper:

Proceedings Paper:

Journal Papers: