A Current Mode Schmitt Trigger Based On CCCDTA Without Any Passive Components

Rupam Das, Hemanshu Kumar, Anup Kr Giri and Anish Prasad

Abstract

In this paper a new current mode Schmitt trigger circuit is presented using current controlled current differencing transconductance amplifier (CCCDTA). The proposed circuit is designed using a single CCCDTA without any passive components, which is suitable for IC implementation. The Schmitt trigger is designed at a supply voltage of ±1V using PSPICE and model parameter of 0.35μm TSMC CMOS technology is used for simulation. The circuit presented in this paper operates at a low voltage and low frequency.

Keywords

Current Mode, Schmitt Trigger, CCCDTA, Low voltage, PSPICE

I. INTRODUCTION

The Schmitt Trigger circuit was first introduced by O.H. Schmitt in 1938 [1]. The circuit has the property of converting varying voltage into a stable logical signal which can be used in analog and digital domain. Schmitt Trigger circuit has many applications such as function generator [2], monostable multivibrator [3], [4] pulse width modulator, [5] [6] [7] and square waveform generator [8], [9], [10].

Barrie Gilbert first introduced the term current mode signal processing. In current mode circuits currents are the main operating parameter i.e. instead of voltage individual circuit elements should interact by means of current. Information in current mode circuits is represented by the branch currents in the circuit. Recently there are various current mode building blocks which have wide bandwidth and large dynamic range as compare to operational amplifier based circuits. The building blocks which support this current mode signal processing are current conveyor (CC) [11], Differential difference current conveyor (DDCC) [12], Differential voltage current conveyor (DVCC) [13], current controlled differential difference current conveyor transconductance amplifier (CCCDCTA) [14]. Recently a new building block is introduced named Current Controlled Current Differencing Transconductance Amplifier (CCCDTA) [15]. In CCCDTA building block the parasitic resistances at two input port can be controlled by input bias current so it does not need a resistance in practical application.

Using different voltage and current mode devices various Schmitt trigger circuits are present in the literature. Op-amp based Schmitt trigger is designed with one active block and three passive components [11], current conveyor based Schmitt trigger circuit using two active building block and four passive components [16], another current conveyor based circuit has large number of passive components [17], Schmitt trigger based on OTRA uses a switch and a floating resistor [18], DVCC based Schmitt trigger uses a single active building block and two passive components [13]. In [19] Schmitt trigger circuit is proposed by building block CDTA, in [20] OTA based Schmitt trigger uses maximum number of active and passive components, MO-CTTA based Schmitt trigger is designed without using any passive components [21].

The paper is organised as follows in section 2 the basic concepts of CCCDTA is given, in section 3 the proposed circuit operation is discussed, section 4 refers the simulation results and comparison of the previous work and conclusion is given in section 5.

II. CCCDTA FUNDAMENTS

The building block, its equivalent circuit diagram and CMOS based circuit diagram of a CCCDTA is shown in Fig. 1, Fig. 2 and Fig. 3 respectively.

![Fig. 1. Block diagram of CCCDTA](image1)

![Fig. 2. Equivalent circuit diagram of CCCDTA](image2)

![Fig. 3. CMOS circuit diagram of CCCDTA](image3)

All the properties of CCCDTA and CDTA are similar except that input voltages of CCCDTA are not zero and CCCDTA has input resistances $R_p$ and $R_n$ at p and n terminals respectively. These resistances can be controlled by bias current $i_{b1}$, the port relationship can be represented by the following matrix:
\[
\begin{bmatrix}
 V_p \\
 V_n \\
 I_x \\
 I_z \\
 I_n \\
 I_p
\end{bmatrix} = \begin{bmatrix}
 R_p & 0 & 0 & 0 & I_p \\
 0 & R_n & 0 & 0 & I_n \\
 1 & -1 & 0 & 0 & V_x \\
 0 & 0 & 0 & \pm g_m \end{bmatrix} \begin{bmatrix}
 V_p \\
 V_n \\
 V_x \\
 V_z
\end{bmatrix}
\]

The ideal conditions are given as:

\[
V_p = I_p R_p, V_n = I_n R_n, I_x = I_p - I_n, I_z = \pm g_m V_z
\]

From Fig 4 the p and n are input terminal z is an auxiliary terminal and x is the output terminal and \( g_m \) is the transconductance of the CCCDTA. Here the outgoing current is the difference between the two input current but different direction. The product of transconductance (\( g_m \)) and the z terminals voltage gives their magnitude.

**III. PROPOSED CIRCUIT**

The proposed Schmitt trigger circuit is designed by using a single CCCDTA without using any passive components is shown in Fig.3. The proposed circuit is operated as follows: when a triangular or sign waveform is applied to terminal n then input will change from + lin to −lin then the output will change from \(-I_{B2}\) to \(I_{B2}\). The output current remains at the state \(-I_{B2}\) until input lin is greater than or equal to \(I_{B2}\), this is called upper threshold point (UTP).

When input current will change from −lin to lin then output will be changing from \(+I_{B2}\) to \(-I_{B2}\) until the input is less than or equal to \(I_{B2}\) and this point is called lower threshold point (LTP).

**Table 1. W/L ratio of various transistors**

<table>
<thead>
<tr>
<th>Transistors</th>
<th>Aspect Ratio W((\mu m))/L((\mu m))</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1-M3, M21</td>
<td>4/0.5</td>
</tr>
<tr>
<td>M4-M6, M20</td>
<td>2/0.5</td>
</tr>
<tr>
<td>M7-M13</td>
<td>5/0.5</td>
</tr>
<tr>
<td>M14-M19</td>
<td>15/0.5</td>
</tr>
<tr>
<td>M22-M23</td>
<td>30/1.5</td>
</tr>
<tr>
<td>M24-M25</td>
<td>15/1.5</td>
</tr>
</tbody>
</table>

**IV. SIMULATION RESULTS**

The proposed circuit is simulated using 0.35\(\mu m\) TSMC technology process parameter. The W/L ratio of CMOS transistor in CCCDTA is given in Table 1. Here the supply voltage is ±1V and bias current \(I_{B1}=50uA\) and \(I_{B2}=60uA\) are taken. The proposed circuit is suitable for low voltage and low power applications. A triangular waveform of ±50uA amplitude and 10 KHz waveform is applied to the circuit and the corresponding input and output waveform is shown in Fig.6. A sine waveform of ±50uA amplitude and 1kHz waveform is applied to the circuit and the corresponding input and output waveform is shown in Fig.7. The hysteresis curve of the circuit is also shown in Fig.8. Comparison of the previously published papers with the proposed work is given in Table 2.
V. CONCLUSION

By using a single CCCDTA building block Schmitt trigger is presented here. In this circuit diagram no passive component is used which is easy implementation of monolithic integration. To design the circuit ±1v supply voltage and .35μm TSMC process parameter is used. Hysteresis curve and transient response of the proposed circuit are presented in this paper. The proposed circuit has various applications like analog signal processing, instrumentation and measurements.

REFERENCES

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*Rupam Das*
Asansol Engineering College, Asansol, India
e-mail: das_rupam@rediffmail.com

*Hemanshu Kumar*
Asansol Engineering College, Asansol, India
e-mail: hemanshusasani@gmail.com

*Anup Kr Giri*
Asansol Engineering College, Asansol, India
e-mail: amuogirl94@gmail.com

*Anish Prasad*
Asansol Engineering College, Asansol, India
e-mail: anish8129@gmail.com