Current Mode Schmitt Trigger Circuit Design Using Only Single CCCDTA

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Abstract

Here a simple current mode Schmitt trigger circuit is designed using a single current controlled current differencing transconductance amplifier (CCCDTA). The presented circuit is proposed here by single CCCDTA without utilizing any passive components. A supply voltage of $\pm 1\text{V}$ and $0.35\mu\text{m}$ TSMC CMOS model parameter is used for the design of Schmitt trigger. The circuit presented in this paper operates at a low voltage and low frequency. The proposed circuit is tested in PSPICE platform and it meet with the theoretical prediction.

Keywords

Analog signal processing;
Current Mode Schmitt Trigger circuit;
Monostable multivibrator;
Schmitt Trigger circuit
Triangular waveform.

1. INTRODUCTION

The Schmitt Trigger circuit was first proposed or invented by O.H. Schmitt in the year of 1938 [1]. This circuit has an interesting property related to converting varying voltage into a steady logical signal basically used in analogas well as digital domain. Schmitt Trigger circuit can be used in various field such as function generator [2], monostable multivibrator [3], [4] pulse width modulator, [5] [6] [7] and square waveform generator [8], [9], [10].

The current mode signal processing techniques was first introduced by Barrie Gilbert. In current mode circuits Currents are the operating parameter of the individual circuit elements must be interact by in terms of current instead of voltage. In current mode circuits information is basically presented as branch currents in the circuit diagram. As compare to operational amplifier based circuits recently there are various signal processing is supported by the building blocks 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 (CCDDCCTA) [14]. A new building block is introduced named Current Controlled Current Differencing Transconductance Amplifier (CCCDTA) [15]. Parasitic resistances of the proposed circuit presented at two input port may be regulated by means of input bias current in CCCDTA building block so it does not require any resistances in practical applications.

Schmitt trigger circuits using different voltage and current mode devices are present in the literature. Op-amp is used as the basic block and it is designed with 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 components MO-CTTA based Schmitt trigger is designed without using any passive components [21].

Here a new circuit has been introduced using CCCDTA. The very simple it has only one CCCDTA building block without any passive components in the circuit. In this circuit the hysteresis and the amplitude electronically controlled by varying only bias current. The PSPICE simulation is also shown which satisfies the theoretical analysis. This circuit can be used in various applications such as triangular/ square wave generators, relaxation oscillator etc.

The paper is organised as follows: in section 2, CCCDTA basic concepts is given, in section 3, the operation of the proposed circuit is discussed, section 4 refers the PSPICE simulated results and the previous

work comparison with the proposed work, conclusion are given in section 5.

II. CCCDTA FUNDAMENTAL

The CCCDTA building block (Fig. 1), and its equivalent circuit diagram (Fig. 2) and CMOS based circuit diagram (Fig. 3) is shown here.

Fig. 1. Block diagram of CCCDTA

Fig. 2. Equivalent circuit diagram of CCCDTA

Fig.3. CMOS circuit diagram of CCCDTA

All the properties of CCCDTA and CDTA are similar other than input voltages of CCCDTA is not ground voltage or zero and it has input resistances R_p and R_n at the both p and n terminals. Bias current I_{B1} control these resistances. The port relationship can be represented by the following matrix:

$$\begin{bmatrix} V_p \\ V_n \\ I_z \\ I_x \end{bmatrix} = \begin{bmatrix} R_p & 0 & 0 & 0 \\ 0 & R_n & 0 & 0 \\ 1 & -1 & 0 & 0 \\ 0 & 0 & 0 & \pm g_m \end{bmatrix} \begin{bmatrix} I_p \\ I_n \\ V_x \\ V_z \end{bmatrix}$$

The ideal conditions are given as:

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

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From Fig 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

By using a single CCCDTA and without using any passive components the proposed Schmitt trigger circuit is designed and it 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 $+I_{in}$ to $-I_{in}$ then the output will change from $-I_{B2}$ to I_{B2} . The output current remains at the state $-I_{B2}$ until input I_{in} is greater than or equal to $-I_{B2}$, this is called upper threshold point (UTP).

When input current will change from $-I_{in}$ to I_{in} 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).

Fig. 4. Proposed CCCDTA based Schmitt Trigger

The transfer characteristics is shown in Fig.4. The proposed Schmitt trigger can be written as :

$$I_0 = -I_{B2} \text{ for } I_{in} \geq I_{X2} \\ I_{B2} \text{ for } I_{in} \leq I_{X2}$$

Fig. 5. Input/output waveform of the proposed Schmitt Trigger circuit

IV. SIMULATION RESULTS

proposed circuit is simulated using 0.35 μ m TSMC technology process parameter. In Table 1 the aspect ratio of CCCDTA CMOS transistors are given. Here

supply voltage of $\pm 1\text{V}$ and bias current $I_{B1}=50\mu\text{A}$ and $I_{B2}=60\mu\text{A}$ are taken for the design of the circuit. For low voltage and low power applications the proposed circuit is suitable. A triangular waveform of $\pm 50\mu\text{A}$ 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 $\pm 50\mu\text{A}$ 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.

Fig. 6. Simulated input/output waveform of the proposed Schmitt Trigger circuit

Fig. 7. Simulated input/output waveform of the proposed Schmitt Trigger circuit

Fig.8. Hysteresis curve of the proposed circuit

Table 2: Comparison of the previously published works

Ref no	ABB	Technology used	BJT/MOS based design	No of active block	No of passive components	Supply voltage
16	OPAMP	-	IC	1	3	$\pm 12\text{V}$
17	CCII	AD844	IC	2	4	$\pm 6\text{V}$
18	CCII	QN/QP-2222	BJT	1	3	$\pm 5\text{V}$

19	OTRA	AD844/AN	MOS	1	1	$\pm 10\text{V}$
20	DVCC	.25 μm	MOS	1	2	$\pm 1.25\text{V}$
21	CDTA	.25 μm	MOS	1	2	-
22	OTA	LM13600	BJT	2	2	$\pm 10\text{V}$
23	CDTA	0.25 μm MIETEC	MOS	1	2	-
Proposed CKT	CCCDTA	0.35 μm TSMC	MOS	1	0	$\pm 1\text{V}$

V. CONCLUSION

A single CCCDTA building block is used to design the Schmitt trigger. No passive component is used in the proposed circuit diagram which is easy implementation of monolithic integration. $\pm 1\text{V}$ supply voltage and .35 μm TSMC process parameter is used in the proposed circuit. 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.

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