ISSN: 2321-8169
69 - 72

Differential Difference Current Conveyor (DDCC) Based Schmitt Trigger Circuit & Its Application

Rupam Das[1], Khushi Banerjee[2], Ashmi Chakraborty[3], Lipika Mondal[4]
[1,2]Electronics & Communication Engineering
[3,4]Applied Electronics and Instrumentation Engineering
Asansol Engineering College
Asansol, India
das_rupam@rediffmail.com, khushi_banerjee@rediffmail.com

Abstract**—**A new voltage mode Schmitt trigger and its application using Differential Difference Current Conveyor (DDCC) is presented in this paper. The proposed circuit has a single DDCC block & two passive components. This circuit does not have any matching conditions. Here two passive components are used and one of them is grounded .The proposed circuit is simulated on SPICE platform.

Keywords*- DDCC, Schmitt trigger, square wave generator, triangular wave generator.*

*****

I. INTRODUCTION

To generate different waveform such as square wave, triangular wave the Schmitt trigger circuits are widely used in communication and instrumentation [1-4,7-18]. Schmitt trigger circuit can be designed by operational amplifier, current mode circuits such as current conveyor, differential difference current conveyor have advantages such as higher slew rate wider bandwidth [19-21]. By using current conveyor and 3 resistor a Schmitt trigger circuit was developed by Di-Cataldo in 1995 [7], this circuit can be used in square wave and triangular wave generator but this circuit suffers from constant high and low output state levels and use of floating resistor. Another Schmitt trigger circuit designed by current conveyor uses two CCII and 4 resistor was proposed in [18]. In this circuit one of the resistor is floating which is not suitable for IC implementation. By using two OTA and two grounded resistor another Schmitt trigger circuit was proposed by Chung [9].This circuit saturation level and threshold level can be controlled by changing the resistor and / or external biasing currents. By using two OTA in this design this circuits power consumption, cost chip area is increased.

Recently another Schmitt trigger circuit was proposed where one OTRA, one floating resistor and a switch was used [12]. This circuit can be used in square wave and triangular wave generator and switch controllable bi-stable multivibrator. depending on the position of the switch the circuit provides counter clock wise and clock wise hysteresis. By the voltage of OTRA its saturation voltage are determined.

By using CMOS a no of Schmitt trigger circuit can also be found in the literature [22]. This circuits hysteresis is set by process parameters and device dimensions. Here a simple voltage mode Schmitt trigger circuit using single DDCC and two resistors is proposed .further more a new square/triangular wave generator using Schmitt trigger is proposed .the circuit does not have any matching conditions for realization. These circuits are theoretically studied and also verified on PSPICE platform.

II. CIRCUIT DESCRIPTION

The new proposed circuit topology for realizing analogue functions, based on a DDCC (differential difference current conveyor) with only Z+ output (Figure. 1) is shown in Figure. 3.

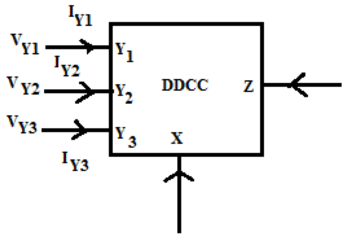

Figure 1: Symbol of DDCC

In the DDCC, Y1, Y2, and Y3 are voltage input terminals with high input impedance. Terminal X is a low impedance current input terminal. There is a high impedance current output terminal Z. It can be characterized by the following matrix relations between various voltage and current variables.

$$\begin{bmatrix} I_{Y_1} \\ I_{Y_2} \\ I_{Y_3} \\ V_X \\ I_Z \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ \beta_1 & \beta_2 & \beta_3 & 0 & 0 \\ 0 & 0 & 0 & \alpha & 0 \end{bmatrix} \begin{bmatrix} V_{Y_1} \\ V_{Y_2} \\ V_{Y_3} \\ I_X \\ I_Z \end{bmatrix}$$

The port relationship in (1) may also be represented as

$$I_{Y1}=I_{Y2}=I_{Y3}=0, V_X=\beta_1 V_{Y1}-\beta_2 V_{Y2}+\beta_3 V_{Y3,} \quad (1)$$

$$\text{And } I_Z=\alpha I_X \quad (2)$$

where α represents the current tracking error from X to Z terminal. β_1, β_2 and β_3 represent the voltage tracking errors from Y_1, Y_2, Y_3 to X terminal. Ideally $\beta_1 = \beta_2 = \beta_3 = \alpha = 1$. The source of these tracking errors are the parasitic capacitance and resistance of the DDCC. The internal structure of this device is shown in Figure. 2

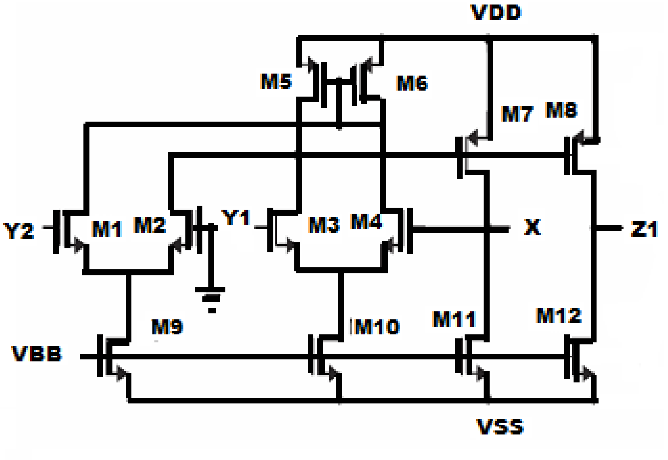

Figure. 2:Internal structure of DDCC

The proposed Schmitt trigger circuit using single DDCC and two resistor is shown in Figure. 3.

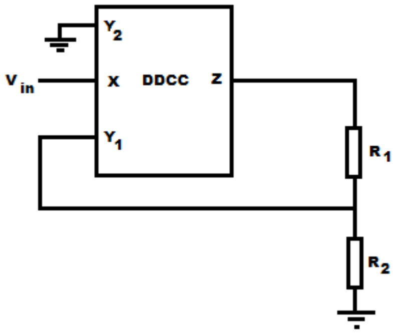

Figure. 3:Schmitt trigger using DDCC

As shown in fig 3 the threshold voltage are derived using the potential divider R1-R2 . the voltage across R1 is feedback to the non inverting terminal input of the DDCC. The voltage across R1 depends on the value and polarity of the output voltage Vout. When Vout = +Vsat the voltage across R1 is called High threshold voltage and it is given by

$$V_{th}=\frac{(+Vsat)R1}{R1+R2} \quad (3)$$

On the other hand when Vout= -Vsat, the voltage across R1 is called as lower threshold voltage Vtl & it is given by

$$Vtl=\frac{(-Vsat)R1}{R1+R2} \quad (4)$$

III. APPLICATION

Using Schmitt trigger several square and triangular wave generator circuits can be found in literature [1-4,7-18] . In literature survey all reported circuits except [9] employ one or more floating resistors/ capacitors which is not desired in IC realization .since circuit reported in [9] using passive elements are grounded it requires two OTAs. The proposed Schmitt trigger based on DDCC can be used to construct square/triangular wave oscillator as shown in figure where an integrator based on DDCC together with R3 and C is used .

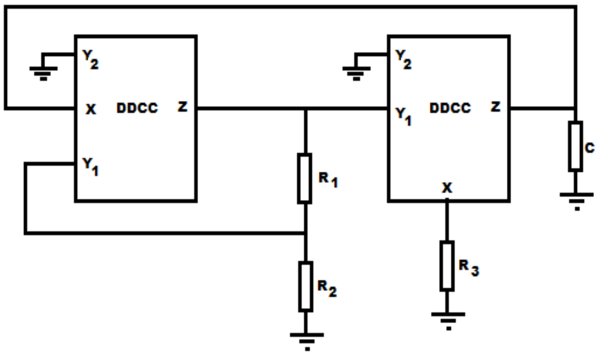

Figure. 4:waveform generator

Figure. 5 shows the waveform of Fig 4.Vsat+ is its +ve saturation level of Vsquare and the capacitor is charged with its z terminal current Iz2+. This continues until voltage of the capacitor (V triangular) reaches Vth of the Schmitt trigger circuit. After that Vsquare jumps Vsat- & the capacitor voltage discharges until it reaches Vtl.

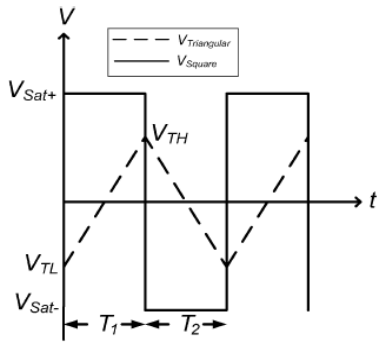

Figure .5: Graphical presentation of the outputs of the proposed square/triangular wave generator

For charging and discharging of the capacitor relationship can be written

$$\frac{Vth\text{-}Vtl}{T1}=\frac{Iz2}{C}$$

$$\frac{Vtl\text{-}Vth}{T2}=\frac{Iz2}{C}$$

Where Vth and Vtl can be found from eqn (3) and (4) .The period T=T1+T2 and from here we can easily calculate the frequency of the waveform . So the frequency of the oscillation can be obtained as

$$f=\frac{1}{T1+T2} \quad (5)$$

IV. SIMULATION RESULTS

To verify the theory for the proposed circuits, the circuits were simulated using PSPICE. The DDCC is simulated using PSPICE level-3 parameters in 0.5μm MIETEC process with supply voltage of +/- 2.5v & biasing voltage 0f -1.7v.The CMOS structure of the DDCC is shown in Figure. 2. The transistor dimensions used in this circuit is shown in TABLE I. The simulated voltage characteristics of the proposed Schmitt trigger with R1=90k and R2=10k are shown in Fig6 & Figure. 7.The high and low saturated output voltage of the circuit depends on the values of the selected resistor and are found as

ISSN: 2321-8169
69 - 72

Vsat+= 2.1v. Vsat-=-2.1v. The hysteresis curve of the Schmitt trigger is shown in Figure. 8.

The other passive elements in the circuit of Figure. 4 are selected as R3=20K & C=100n. The results are shown in Figure. 9 where the frequency of the output wave form is found approximately equal to 1KHz.The discrepancy between the results of the theoretical and practical is due to non ideality of the DDCC.

TABLE I. DIMENTIONS OF MOS TRANSISTORS

Transistor	W(μm)	L(μm)
M1-M4	0.8	0.5
M5-M6	10	0.5
M7-M8	4	0.5
M9-M10	14.4	0.5
M11-M12	45	0.5

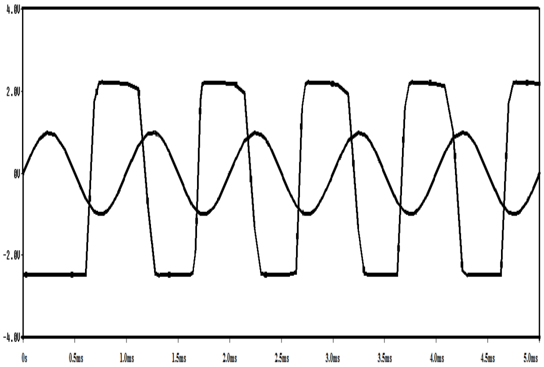

Figure. 6: sine wave as input and square wave as output

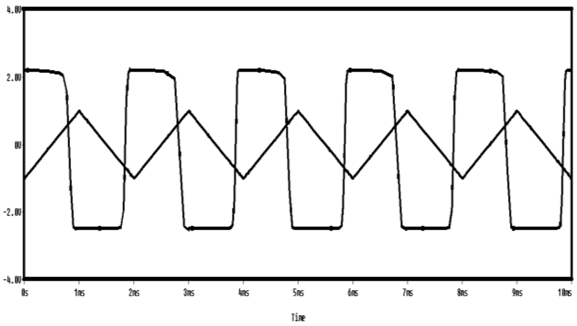

Figure. 7: Triangular wave as input and square wave as output

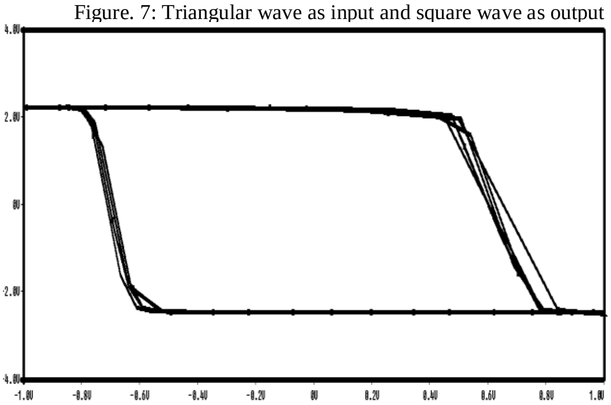

Figure. 8: sine wave as input and square wave as output

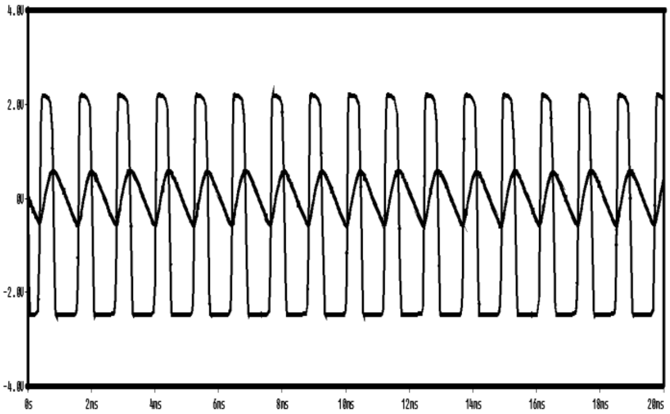

Figure. 9: sine wave as input and square wave as output

V. CONCLUSION

In this paper a new DDCC based Schmitt trigger circuit was proposed and here one of the resistor is grounded and other is floating. to construct a square / triangular wave generator a DDCC based integrator is attached in front of the Schmitt trigger circuit. The proposed circuit was simulated using 0.5 μm MIETEC process parameters. The obtained results verify the theoretical analysis.

REFERENCES

[1] B. Almashary, H. Alhokail, Current-mode triangular wave generator using CCIIs. Microelectron. J.31, 239–243 (2000)

[2] M.T. Abuelma'atti, S.M. Al-Shahrani, New CFOA-based triangular/square wave generator. Int. J.Electron. 84(6), 583–588 (1998).

[3] M.T.Abuelma'atti, M.A. Al-Absi, A current conveyor-based relaxation oscillator as a versatile electronicinterface for capacitive and resistive sensors. Int. J. Electron. 92(8), 473–477 (2005).

[4] M.T.Abuelma'atti, M.A.Al-Absi, A low-cost dual/slope triangular/square wave generator. Int. J.Electron. 91(3), 185–190 (2004)

[5] H.-C. Chien, Y.-K. Lo, Design and implementation of monostable multivibrators employing differential voltage current conveyors. Microelectron. J. 42(10), 1107–1115 (2011).

[6] E. Bruun, Feedback analysis of transimpedance operational amplifier circuits. IEEE Trans. CircuitsSyst., Part I 40(4), 275–277 (1993).

[7] G. Di Cataldo, G. Palumbo, S. Pennisi, A Schmitt trigger by means of a CCII+. Int. J. Circuit Theory Appl. 23(2), 161–165 (1995).

[8] O. Cicekoglu, H. Kuntman, On the design of CCII+ based relaxation oscillator employing single passive element for linear period control. Microelectron. J. 29, 983–989 (1998)

[9] W.S. Chung, H. Kim, H.-W. Cha, H.-J. Kim, Triangular/squarewave generator with independently controllable frequency and amplitude. IEEE Trans. Instrum. Meas. 54(1), 105–109 (2005)

[10] Y. Liu, S. Chen, K. Nakayama, K. Watanabe, Limitations of a relaxation oscillator in capacitance measurements. IEEE Trans. Instrum. Meas. 49(5), 980–983 (2000).

[11] Y.-K. Lo, H.-C. Chien, Switch-Controllable OTRA-based square/Triangular waveform generator.IEEE Trans. Circuits Syst. II, Express Briefs 54(12), 1110–1114 (2007)

[12] Y.-K. Lo, H.-C. Chien, H.-J. Chiu, Current-input OTRA Schmitt trigger with dual hystersis modes.Int. J. Circuit Theory Appl. 38, 739–746 (2010)

[13] Y.-K. Lo, H.-C. Chien, H.-J. Chiu, Switch-controllable OTRA-based bistable multivibrators. IET Circuits Devices Syst. 2(4), 373–382 (2008)

[14] S.N. Nihtianov, G.P. Shterev, B. Iliev, G.C.M.Meijer, An interface circuit for R-C impedance sensors with a relaxation oscillator. IEEE Trans. Instrum. Meas. 50(6), 1563–1567 (2001)

[15] D. Pal, A. Srinivasulu, B.B. Pal, A. Demosthenous, B.N. Das, Current conveyor-based square/ triangular wave generators with improved linearity. IEEE Trans. Instrum. Meas. 58(7), 2174–2180 (2009)
[16] A.S. Sedra, K.C. Smith, *Microelectronic Circuits*, 5th edn. (Oxford Univ. Press, London, UK, 2004), pp. 1185–1188
[17] P. Silapan, M. Siripruchyanun, Fully and electronically controllable current-mode Schmitt triggers employing only single MO-CCCDTA and their applications. Analog Integr. Circuits Signal Process. 68, 111–128 (2011)
[18] A. Srinivasulu, A novel current conveyor-based Schmitt trigger and its application as a relaxation oscillator. Int. J. Circuit Theory Appl. 39(6), 679–686 (2011)
[19] A.A. Khan, S. Bimal, K.K. Dey, S.S. Roy, Novel RC sinusoidal oscillator using second-generation current conveyor. IEEE Trans. Instrum. Meas. 54(6), 2402–2406 (2005)
[20] A.S. Sedra, G.W. Roberts, F. Gohn, The current conveyor: History, progress and new results. IEE.Proc. Part G, Circuits Devices Syst. 137, 78–87 (1990)
[21] C. Toumazou, F.J. Lidgey, D.G. Haigh, *Analog IC Design: The Current-Mode Approach* (Peter Peregrinus,London, 1990)
[22] F. Yuan, Differential CMOS Schmitt trigger with tunable hysteresis. Analog Integr. Circuits Signal Process. 62, 245–248 (2010)