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Simulation of current mode schmitt trigger using LT-Spice

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***Abstract*—**Presently, there is a growing interest in synthesizing current controlled circuits because of their advantages. So the purpose of this article is to describe the functioning of current mode Schmitt trigger in both inverting and non-inverting mode with the help of MO-CCCDTA (multiple output current controlled current differencing transconductance amplifier). A temperature independent current mode Schmitt trigger can be constructed using MO-CCCDTA and the output of that can be controlled by the current. There is no parasitic losses because passive elements are not used.Thus impedance is low and power consumption will comparatively low.LT SPICE is used as a simulation tool.

Keywords-MO-CCCDTA, Parasitic, SPICE

I. INTRODUCTION

The Schmitt trigger comes into existence in 1934 due to great effort of Otto H Schmitt. Schmitt trigger, a regenerative comparator is a decision making circuit .Means that in Schmitt trigger original signal and feedback signals are in phase. In a basic comparator, there is no use of feedback in open loop mode. Schmitt trigger circuit has many advantages as oscillator filters and multivibrator but all of these performs on voltage mode so they have drawbacks corresponding to power consumption, switching speed, supply voltage, topological configuration etc. But all these drawbacks can be sort out using current mode circuit.

The current mode circuit was invented by British engineer Barrie Gilbert in 1975. Actually during his initial work Gilbert elaborated current mode circuit as trans-linear circuits. Because these circuits carries out its functions using trans-linear principle. There are many circuits that uses trans-linear principles such as current conveyor circuit (CCC), current mode operational amplifier. Current conveyor circuits are unity gain amplifier.

At present scenario the demand for circuit design is that it must consume low power supply , electronic controllability, circuit versatility and occupy fewer amounts of elements specially passive elements (R,L,C) that have parasitic losses. The possible solution for all these factors is Schmitt trigger using a MO-CCCDTA.MO-CCCDTA is an advanced version of CCCDTA device.

II. CIRCUIT CONFIGURATION

To understand easily the circuit configuration of MO-CCCDTA, block diagrammatic representation is given in fig.1 in which IB1, IB2 and IB3 are the bias current.MO-CCCDTA is a versatile circuit means that can be either work in inverting or non- inverting mode by just changing just a switch that is represented by Iin.

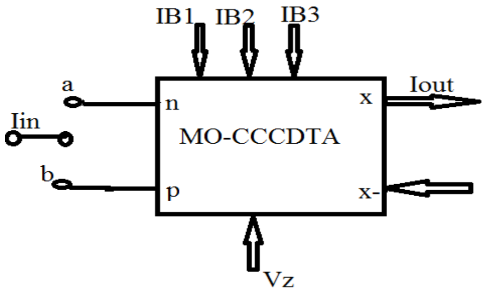

Fig.1 MO-CCCDTA block diagram

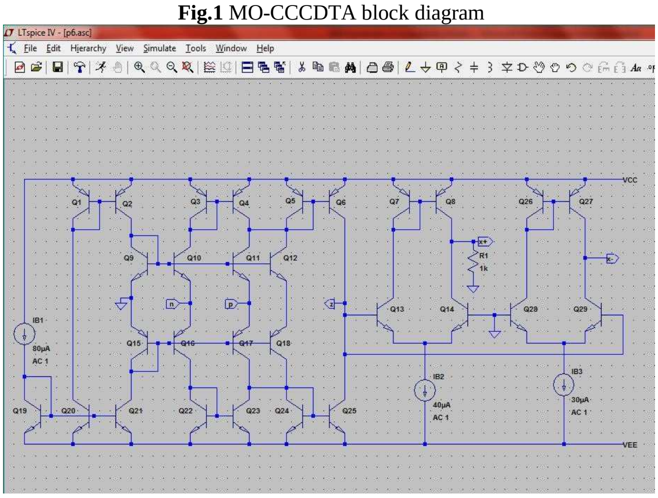

Fig.2 MO-CCCDTA circuit on LT spice

When switch is connected to **a** terminal MO-CCCDTA works in a inverting mode (CW) and when connected to **b** terminal than it works in non-inverting mode (CCW).The output has taken from the **x** terminal.

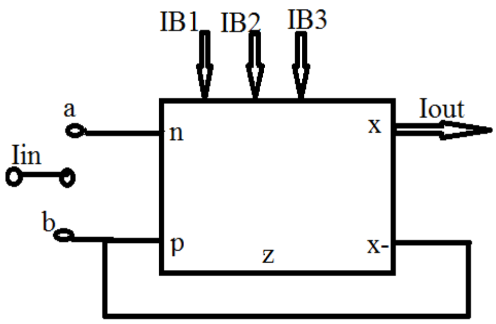

Fig.3 MO-CCCDTA based Schmitt trigger

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There are two types of feedback regenerative or positive feedback and degenerative or negative feedback and Schmitt trigger operates on a regenerative mode, to provide it non-inverting mode functioning the **x-** terminal is connected to the **p** terminal, which is shown in fig 3. From the transistor level implementation diagram of the Schmitt trigger Fig .4 the feedback that is applied from output terminal to the non-inverting terminal (node-p) can be seen. The implementation of MO-CCCDTA can also be configured using Metal Oxide Semi-conductor transistor (P and N MOS) instead of bipolar transistors.

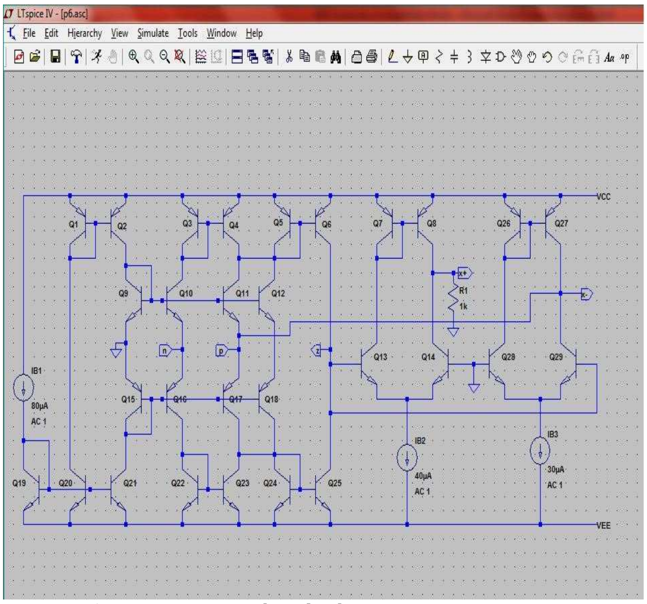

Fig.4 MO-CCCDTA based Schmitt trigger on LT spice

III. SIMULATION RESULT

To validate and analyze the various factors of the MO-CCCDTA based Schmitt trigger such like temperature independency and current controlled system, circuit is simulated on the LT-SPICE. To simulate the circuits on LT-SPICE program has the particular model for bipolar transistors and as well as MOS transistors. The model for bipolar transistor is given as below in the table-

Table 1 Model for LT spice simulation
MODEL NPN NPN(IS=5E-15 RB=200 RC=250 BF=250 +BR=2 RE=2 VA=130 TF=.35NS CJE=1PF PE=.7V ME=.33 +CJC=.3PF PC=.55V MC=.5 CCS=3PF PS=.52 MS=.5V)
*.MODEL PNP PNP(IS=2E-15 RB=300 RC=300 RE=10 +BF=50 BR=4 VA=50 TF=30NS CJE=.3PF PE=.55V ME=.5 +CJC=2PF PC=.55V MC=.5 CCS=3PF PS=.52V MS=.5V)

Here the Fig 5 represents the output of the system in non-inverting mode and Fig 6 represents the output of system in inverting mode and from these waveform it is verified that Schmitt trigger can be configured by using MO-CCCDTA. Here in the LT-Spice program IB1=80 micro-amp, IB2=40 micro-amp, and IB3=30 micro amp is applied**.** The various parameters of the MO-CCCDTA based Schmitt trigger can be controlled just by varying the bias current IB1, IB2, and IB3 .Here the bias current IB1 controls the input impedance, IB3 controls the threshold voltage (upper and lower level) , and IB2 controls the output amplitude of the waveform and that can be verified by the waveforms .

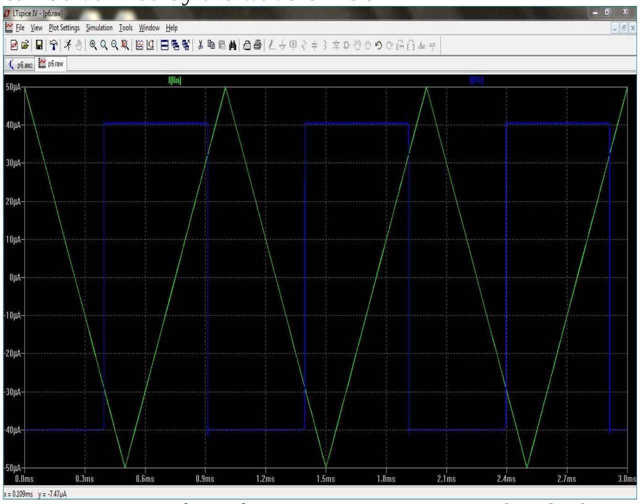

Fig.5 LT spice waveform of non-inverting MO-CCCDTA based Schmitt trigger

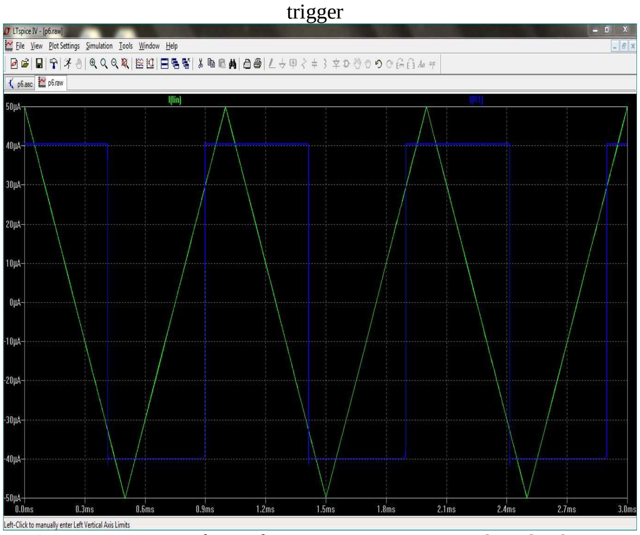

Fig.6 LT spice waveform of inverting MO-CCCDTA based Schmitt trigger

The dependency of the output amplitude on the bias current IB2 can be verified by comparing the fig 6 and fig 7 because when the applied bias current IB2 is varied from 40 micro-ampere to 50 micro-ampere then there is also change in output amplitude from 40 micro-ampere to 50 micro-ampere so it is verified that to control the output amplitude it is just needed to control the bias current IB2.

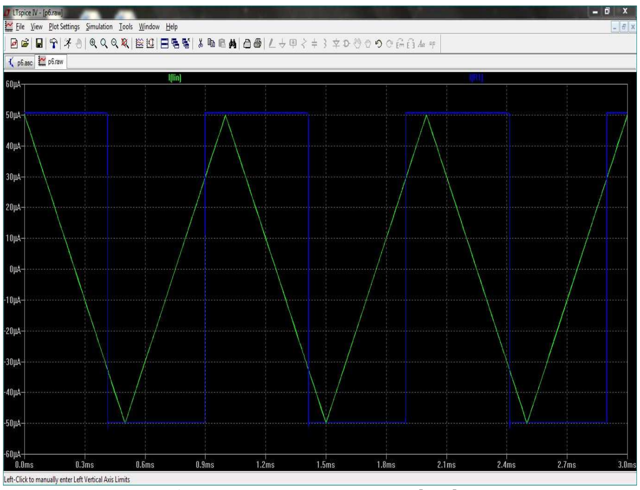

Fig.7 Variation in output amplitude

The dependency of the threshold level on the bias current IB3 can be verified by comparing the fig 6 and fig 8 because when the applied bias current IB3 is varied from 30 micro-ampere to 40 micro-ampere then there is also change in upper threshold level and lower threshold level. From 30 micro-ampere to 40 micro-ampere variation in upper threshold level and-30 micro-ampere to- 40 micro-ampere variation in lower threshold level and this result clearly justify that the threshold level is controlled by the bias current IB3.

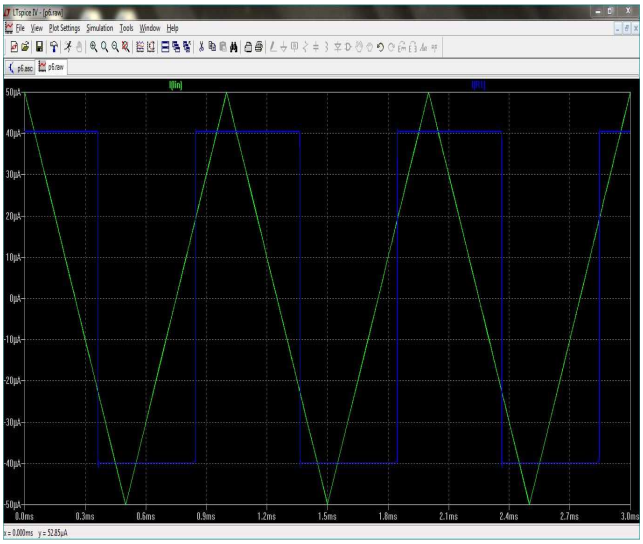

Fig.8 Variation in threshold level

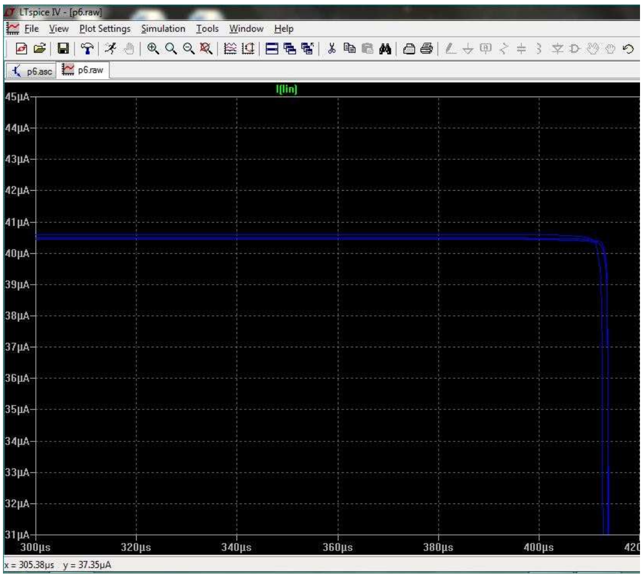

Fig.9 Variation in temperature

The temperature independency of the MO-CCCDTA can be validated from the Fig.9 and for that purpose the result is analyzed on LT-spice program at three temperatures 0, 27 and 100 and at every temperature it can analyzed that variation in the output is very minute that can be neglected and that appeals the temperature independency of the MO-CCCDTA based Schmitt trigger.

The dependency of the input impedance on the bias current IB1 can be verified by fig 10 because when the applied bias current IB1 is varied from 80 micro-ampere to 60 micro-ampere then there is also change in the input impedance and this result clearly justify that input impedance is controlled by the bias current IB1.

Fig.10 Variation in Input Impedance

IV. SPICE NETLIST

Q1 5 5 1 PNP
Q2 6 5 1 PNP
Q3 11 11 1 PNP
Q4 12 11 1 PNP
Q5 12 12 1 PNP
Q6 14 12 1 PNP
Q7 16 16 1 PNP
Q8 17 16 1 PNP
Q9 6 6 0 NPN
Q10 11 6 10 NPN
Q11 12 6 3 NPN
Q12 12 6 13 NPN
Q13 16 14 15 NPN
Q14 17 0 15 NPN
Q15 7 7 0 PNP
Q16 8 7 10 PNP
Q17 9 7 3 PNP
Q18 9 17 13 PNP


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        Q19 4 4 2 NPN
        Q20 5 4 2 NPN
        Q21 7 4 2 NPN
        Q22 8 8 2 NPN
        Q23 9 8 2 NPN
        Q24 9 9 2 NPN
        Q25 14 9 2 NPN
        Q26 19 19 1 PNP
        Q27 3 19 1 PNP
        Q28 19 0 18 NPN
        Q29 3 14 18 NPN
.MODEL NPN NPN(IS=5E-15 RB=200 RC=250 BF=250
+BR=2 RE=2 VA=130 TF=.35NS CJE=1PF PE=.7V
ME=.33
+CJC=.3PF PC=.55V MC=.5 CCS=3PF PS=.52 MS=.5V)
.MODEL PNP PNP(IS=2E-15 RB=300 RC=300 RE=10
+BF=50 BR=4 VA=50 TF=30NS CJE=.3PF PE=.55V
ME=.5
+CJC=2PF PC=.55V MC=.5 CCS=3PF PS=.52V
MS=.5V)
        VCC 1 0 2.5V
        VEE 2 0 -2.5V
        IB1 1 4 60U
        IB2 15 2 50U
        IB3 18 2 10U
IP 0 n pwl(0 50u 0.5m -50u 1m 50u 1.5m -50u 2m 50u
2.5m -50u 3m 50u)
        R 17 0 1k
        .ic v(x+) =0
        .tran 3m
        .END
```

V. CONCLUSION

In MO-CCCDTA based Schmitt trigger a single MO-CCCDTA can be used to operate in both CW and CCW direction and that makes it electronically controllable. Another advantage that is corresponding to that MO-CCCDTA based Schmitt trigger is temperature independency of output amplitude and that makes its performance stable and the dependency of the parameters (input impedance, threshold level and output amplitude) on the current reduces the power consumption because signals that are carried by the current has the low impedance value and that's why low power supply and low power consumption. Low power consumption is the basic need of the present scenario devices or circuits.MO-CCCDTA provides better linearity to this new current mode Schmitt trigger because current mode circuits (CC circuits) have unity gain. In current mode circuit the required node impedance is low so the fewer elements are used and circuit complexity is also reduced. In current mode circuits the signal is represented by current instead of voltage, the node impedances need to be lowered so that poles of the circuits go to the higher frequencies.

$$F_{Pole} = \frac{1}{2\pi\, R_{node} C_{node}}.$$

VI. FUTURE SCOPE

The development of current mode circuit over last few years such CDTA, CCCDTA, CCCTA, OTA, CC(CCI/CCII/CCIII) are very essential over voltage mode circuit. But now a days MO-CCCDTA circuit models are very important for many applications such as microwave and optical system application, neural networks. Interfacing to VLSI, sampled data filter, current mode logic, A/D and D/A converter, continuous time filter, memories etc. Our future work is to find more application on MO-CCCDTA.

VII. ACKNOWLEDGMENT

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