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CMOS Realization of OTRA Based Electronically Controllable Square Wave Generator Enhancing Linearity with Minimum Total Harmonic Distortion and Power Consumption

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Abstract: *In this work, we investigate Operational Transresistance Amplifier (OTRA) based square wave generator application. The proposed configuration presents single Operational Transresistance Amplifier (OTRA) with two resistors and one capacitor. The duty cycle of the proposed configuration can be adjusted with the help of varying input voltage and with the help of resistor and capacitor. OTRA as an active building block. The advantage of the proposed configuration electronically tunable and improves its duty cycle with the help of resistor and capacitor. The proposed work describes the circuit operation in SPICE Simulation using 0.18µm CMOS technology. A total harmonic distortion (THD) of 2.10 % with low power consumption is 0.79 – 0.82mW for the frequency ranges 7.92 Hz - 7.95Hz oscillation and total harmonic distortion (THD) of 0.4 - 0.58 % at the frequency ranges 7.90KHz - 795 KHz is achieved for excellent linearity.*

Keywords: *Operational Transresistance Amplifier (OTRA), Total Harmonic Distortion (THD), CMOS Technology.*

1. INTRODUCTION

The proposed square wave generator has vital role in the field of field of communication, Instrumentation and control system, and sound system and also used in radar system. The past few decades the researchers have been presented various active building blocks in the design of electronic circuit in the new areas of analog signal processing and communication.

The most of the active building blocks which have presented less electronically tunable and having more harmonic distortion. These active building blocks namely operational Amplifier (Op-Amp), Operational active building block [11]. The differencing voltage current conveyor (DVCC) [6], VDVTA based sinusoidal oscillator[3],VDTA based sinusoidal oscillator[5], voltage controlled oscillator[7], LC oscillator[8][20],single resistance controlled oscillator[9],OTRA based sinusoidal oscillator[1][2][12] is a recently reported versatile active building block used in the realization of analog signal processing circuits. OTRA is also attractive due to its capability of electronic controllability. The analog circuits using FDCCII based sinusoidal oscillator[10]CDBA based, quadrature oscillator[13][4] ,CFOA based sinusoidal oscillator[14] as active element have been found in the literature, for realization of CMOS Inductor and universal filter [15][16]17][18][19][21]., The DVCC-based sinusoidal oscillators have been proposed in [6] Operational Transresistance Amplifier (OTRA)[1][2][12] is more suitable active building block for electronically tunable in the design of square wave and sinusoidal generators in the area of analog signal and mixed analog signal processing due to these advantages the device gain is independent of stray and junction capacitances which improves the bandwidth.

The proposed square wave generators are very commonly used for music and speech synthesis and it also find applications in other specified fields such as testing of various servo mechanisms, geophysical systems; biological and biomedical fields. An extensive literature review presented its wide application is available on square wave generator in the limited literature.

In this paper a new CMOS realization of square wave generator employing single OTRA which uses two resistors and one capacitor. [1] [2][12].

2. Proposed Square Wave Generator Configuration

The symbolical notation of Operational Transresistance Amplifier (OTRA) is shown in Fig. 1. OTRA is a three terminal device. It comprises of two current inputs (I_p, I_n) and one voltage output (V_0) and it is characterized by (1). The transresistance gain (R_m) is quite high.

$$\begin{bmatrix} V_p \\ V_n \\ V_z \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ R_m & -R_m & 0 \end{bmatrix} \begin{bmatrix} I_p \\ I_n \\ I_z \end{bmatrix} \tag{1}$$

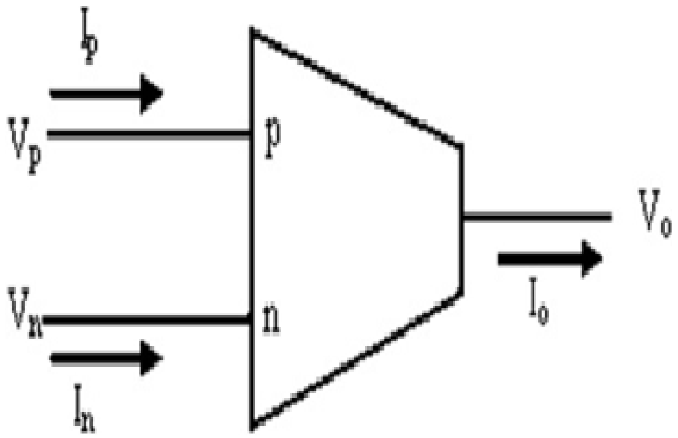

Fig1. *Symbolical Notation of OTRA*

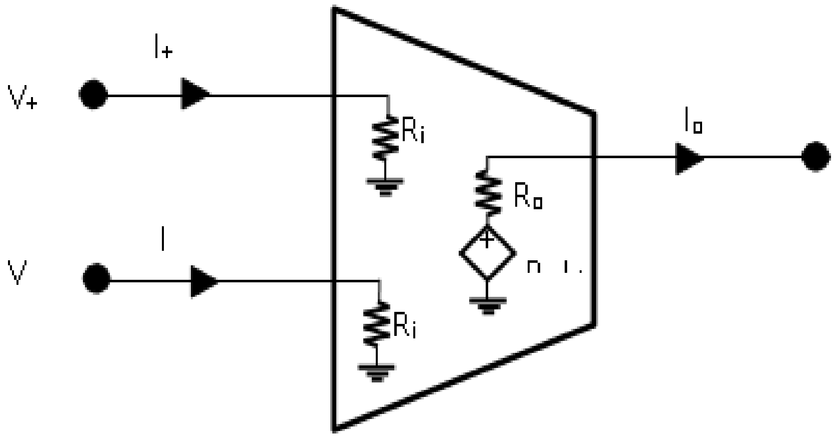

Fig2. *Non .Ideal Equivalent of OTRA*

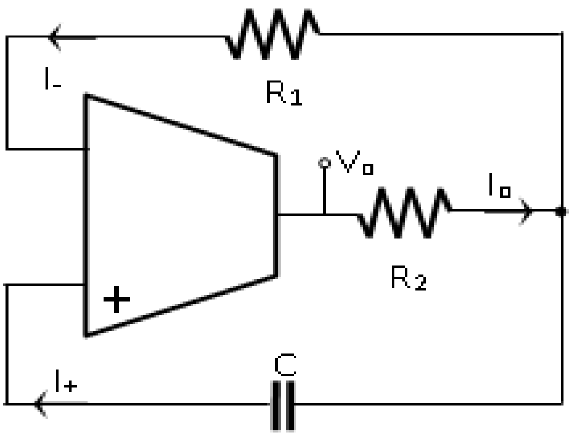

Fig3. (A). *Proposed Single OTRA Based Square Wave Generator.*

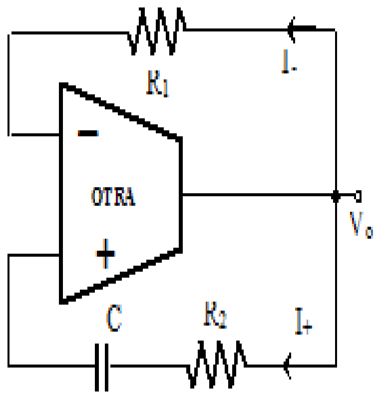

Fig3. (B). *Propos Single OTRA Based Square Wave Generator.*

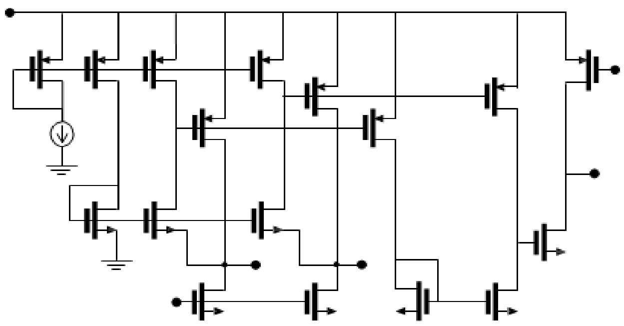

Fig4. *CMOS Realization of Single OTRA Based Square Wave Generator*

The proposed Operational Transresistance Amplifier (OTRA) based square generator configuration is shown in the fig.3a and fig.3b OTRA as the main active building block with two resistors and one capacitor. The square wave generator has been presented. The proposed configuration has been compared with Current Mode and Voltage Mode.

3. Sensitivity Analysis

The sensitivity of the proposed Operational Transresistance Amplifier (OTRA) based square generator configuration can be defined as the variation in the characteristics due to small changes in the parameters of the proposed Operational Transresistance Amplifier (OTRA) based square generator configuration is shown in the fig.3a and fig.3b OTRA as the main active building block with two resistors and one capacitor.

The sensitivities of the proposed Operational Transresistance Amplifier (OTRA) based square generator configuration is observed with the help of frequency with .respect to C, R2, R1, are less than unity.

Therefore the sensitivities of the proposed Operational Transresistance Amplifier (OTRA) based square generator configurations are very small.

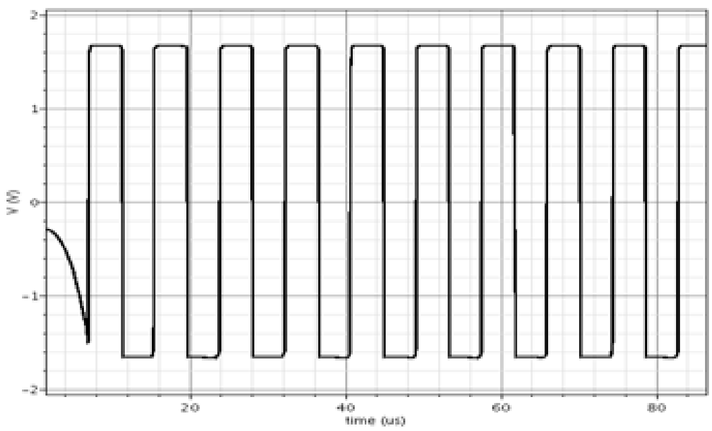

Fig5. *Output Wave Form of the Proposed OTRA Based Square Wave Generator*

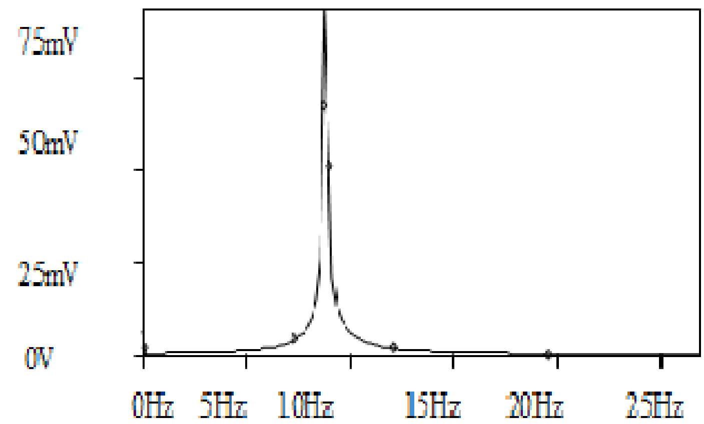

Fig6. *Frequency Spectrum of the Proposed OTRA Based Square Wave Generator F=7.92Hz – 8.03Hz*

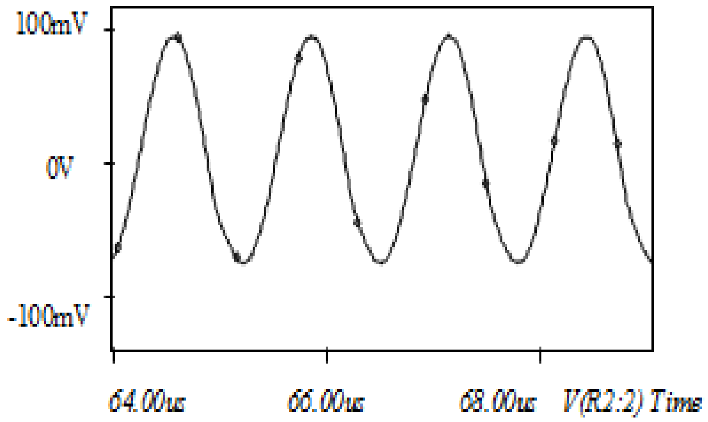

Fig7. *Transient Waveform of Proposed OTRA Based Square Wave Generator F=7.92Hz - 8.3Hz*

The linearity of the proposed Operational Transresistance Amplifier (OTRA) based square generator configuration can be improved with the proper selection of C, R2, R1, at low voltage.

4. CMOS SIMULATION RESULTS

The proposed Operational Transresistance Amplifier (OTRA) based square wave configuration is simulated with .18µm CMOS technology.

The simulation result shows linearity as well as the workability and the functionality of the proposed OTRA based square wave configuration is verified using SPICE simulation. The VSS and VDD used are below ±1.5V. SPICE simulations are performed for the frequency range f = 7.90 Hz to f = 8.03 Hz by the proper selection R = 1 KΩ to 20 KΩ, C=100 nF to 400 nF and the frequency ranges 790KHz - 803 KHz by the proper selection of $R1=R_2=$ 1 KΩ - 3KΩ, C = 100nF, Time period of CMOS simulated output wave form for the proposed square wave 80µs- 82µs is shown in fig 5. The AC analysis and frequency response of the proposed OTRA based square wave configuration is shown in fig 6.The transient response and frequency spectrum of the proposed OTRA based square wave generator are shown in Fig.8 and fig.7 respectively.

The experimental results are verified using SPICE simulation with .18µm CMOS technology at 790 KHz - 803 KHz by the proper selection of $R1=R_2=$ 1 KΩ - 3KΩ, C = 100nF,

The total harmonic distortion of the proposed OTRA based square wave configuration is 2.09 - 2.10 % with low power consumption is 0.79- .82 mW at the frequency range between 7.90– 8.03Hz and total harmonic distortion is 0.4 % - 0.58 % at the frequency ranges 790 - 803 KHz.

5. CONCLUSION

In this paper, single Operational Transresistance Amplifier (OTRA) based square wave has been presented. It employs four passive elements namely two resistors and two capacitors. The proposed structure is suitable for medium frequency range. The circuit analyzed for non-ideal effects and sensitivity analysis is carried out which shows the sensivities are less than unity. The proposed Operational Transresistance Amplifier (OTRA) based square wave oscillator is verified through SPICE simulations using 0.18µm CMOS process parameters. A total harmonic distortion (THD) of 2.09 % - 2.10 % for the frequency range 7.92Hz - 8.03Hz oscillation and A total harmonic distortion (THD) 0.4% - 0.58 % at the frequency range 790 KHz – 8.03 KHz achieved by the proper selection of $R_1=R_2= 1$ KΩ to 3KΩ, C = 100nF.

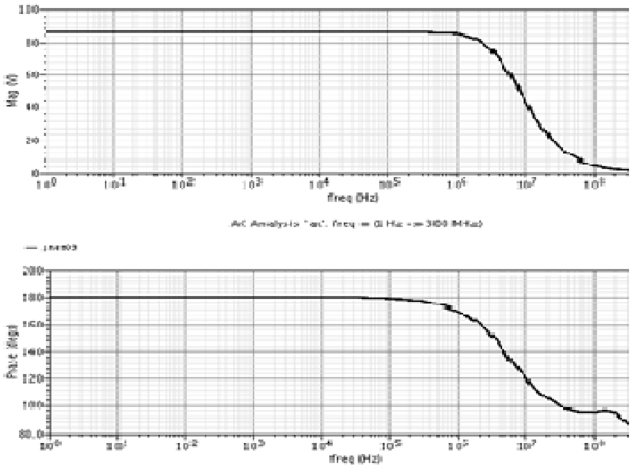

Fig8. *AC Analysis and Frequency Response of the Proposed OTRA Based Square Wave Generator*

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