Implementation of Non-Sinusoidal Oscillator using Current Conveyor

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Abstract—*A non-Sinusoidal oscillator based on integrating the diode-switched currents and Regenerative Comparator is presented. The Implementation is derived from a known circuit with operational amplifiers where these are replaced by current conveyors. The circuit contains grounded resistances and capacitance and is suitable for high frequency square and triangular signal generation and frequency can be accurately controlled by voltage that is applied to a high-impedance input. The Circuit functionality has been verified by Computer simulation with a PSpice model of manufactured sample of Universal current conveyor.*

Keywords—*Current conveyor, non-Sinusoidal oscillator, Regenerative Comparator, Voltage-controlled oscillator.*

INTRODUCTION

Non-Sinusoidal waveform generator with controllable frequency is widely used circuit in radio and TV transmitters and receivers, and in the laboratory test equipment. They serve as interfaces for signal processing from sensors [1] as they offer better electromagnetic interference immunity, lower sensitivity, and simpler structures compared to harmonic oscillators based on a linear positive feedback structure. Due to these advantages, many non-Sinusoidal or relaxation oscillators have been published recently [2]. The Square/Triangular wave Generator is usually consists of a Schmitt trigger and a low pass filter in a closed loop. Designers employed various active elements like transistor, operational amplifier in these blocks. Initially mostly operational amplifiers were used, later operational Voltage to Current amplifiers, current conveyors, current feedback operational amplifiers etc.

This paper presents a novel square/triangular wave generator with current conveyors, only grounded resistances and integration capacitance. High-impedance voltage input is used to accurate, linear, and wideband control of oscillation frequency. The generator is a modification of an opamp-based circuit where the active elements were appropriately replaced by current conveyors. Current Conveyors have been chosen due to their wider bandwidth, high slew rate, better accuracy and higher dynamic range.

Non-Sinusoidal WAVE GENERATOR Circuit

2.1 Original Circuit with Opamps and Transistors

The Non-Sinusoidal wave generator designed in this paper is based on the circuit shown in Fig. 1.

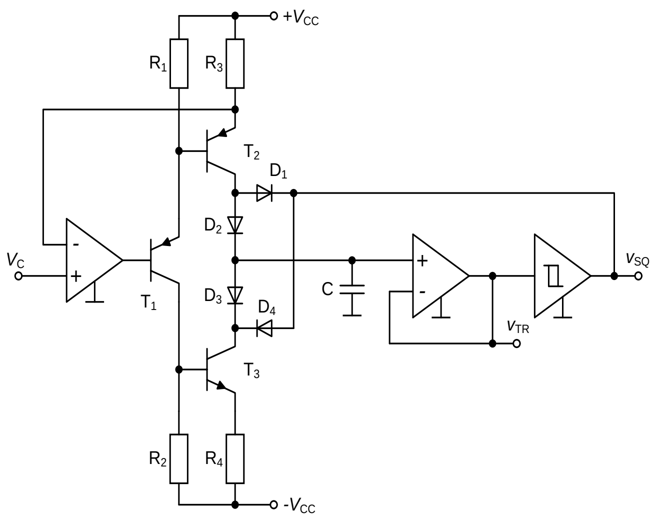


Fig- 1: Non-Sinusoidal Wave Generator with operational amplifiers and transistors

In this structure of relaxation oscillator the capacitor C is periodically charged and discharged by a constant current whose magnitude is directly proportional to the control voltage V_C. The control voltage regulates the speed of charging the capacitor and also the frequency of the generated output signal. For the same value of R_3 & R_4, the collector currents of the transistors T_2 and T_3 are equal and are flowing down in the schematic if the control voltage is positive. The diodes D_1 to D_4 ensure switching the T_2 and T_3 collector currents in the following way: when the hysteresis comparator output is low, D_1 is open and provides the entire T_2 collector current into the comparator output. Thus no current flows through D_2. In this period C is being discharged by the T_3 collector current via D_3. If the capacitor voltage reaches negative threshold of the comparator, the output of comparator changes to high. In this case D_2 leads the entire T_2 collector current into the capacitor which is being charged until its voltage reaches the positive threshold of the comparator. D_4 is open and no current flows through D_3. The voltage at v_{TR}

output has a triangular waveform and voltage at v_{SQ} output a square waveform.

2.2 Symbols and terminal specifications of UCC and CCII+/-

The current conveyors CCII+/- and UCC [12] are employed in the circuit solution. Their symbols and terminal specification are shown in Fig. 2. The following relations are valid for the voltages and currents in Fig. 1:

UCC :

$$\begin{pmatrix} V_X \\ I_{Y1+} \\ I_{Y2-} \\ I_{Y3+} \\ I_{Z1+,2+} \\ I_{Z1-,2-} \end{pmatrix} = \begin{pmatrix} 1 & -1 & 1 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & -1 \end{pmatrix} \begin{pmatrix} V_{Y1+} \\ V_{Y2-} \\ V_{Y3+} \\ I_X \end{pmatrix}$$

CCII+/–:

$$\begin{pmatrix} V_X \\ I_Y \\ I_{Z+} \\ I_{Z-} \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 0 \\ 0 & 1 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} V_Y \\ I_X \end{pmatrix}$$

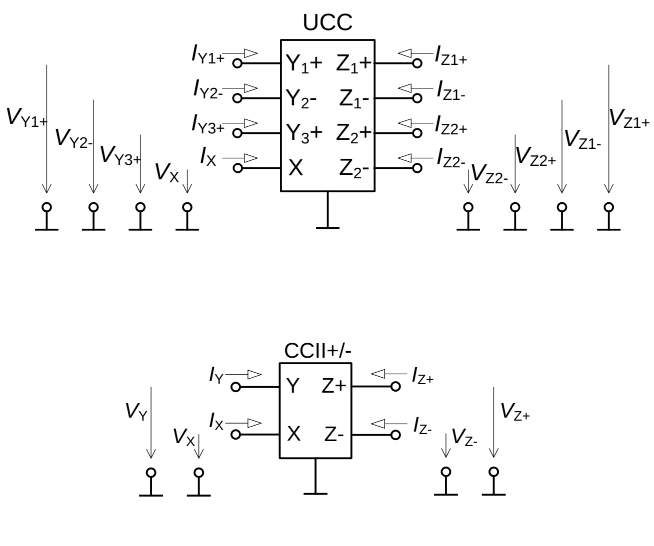


Fig -2: *UCC and CCII+/- symbols and their terminal specification*

2.3 Oscillator with Current Conveyors

The proposed square/triangular wave oscillator is shown in Fig. 3.

Here the transistor current source is replaced by CCII+/- which converts the input control voltage V_C to currents with opposite directions at Z+ and Z- outputs. The diodes D_1 to D_4 ensure switching the currents in the same fashion.

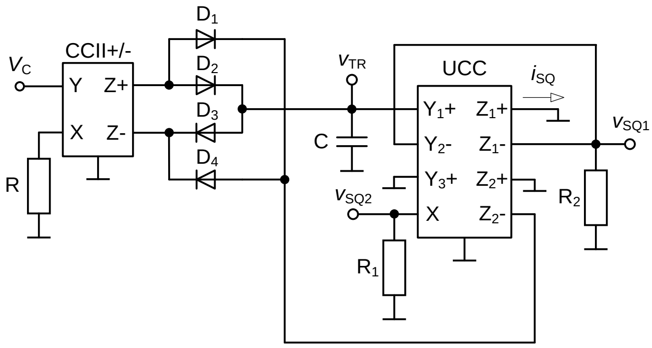


Fig- 3: *Square/triangular wave generator based on UCC & CCII+/-*

The hysteresis comparator (Schmitt trigger) [11] consists of UCC, R_1, and R_2. The connection of terminals Z_1- & Y_2- provides a positive feedback in the comparator. It is necessary to select $R_2 > R_1$ to ensure the positive feedback with a loop-gain higher than unity. The input threshold level is given as

$$V_{TH} = -V_{TL} = I_{XZ_{\max}} (R_2 - R_1) \qquad (1)$$

where I_{XZmax} is the lower value of the two currents I_{Xmax} and I_{Zmax} which are the maximum currents that can be supplied by UCC at pins X and Z_1- respectively. The Schmitt trigger can be also designed using simple CCIIs [14], however, two active elements have to be used.

The triangular output voltage (v_{TR}) is taken directly from the capacitor C. Two voltage outputs (v_{SQ1} and v_{SQ2}) offer mutually inverted square waveforms. These outputs can be loaded only with very high impedance, otherwise a voltage buffer must be connected.

The frequency of the generated signal is

$$f_G = \frac{V_C}{2RC(V_{TH} - V_{TL})} = \frac{V_C}{4RCI_{XZ_{\max}}(R_2 - R_1)} \qquad (2)$$

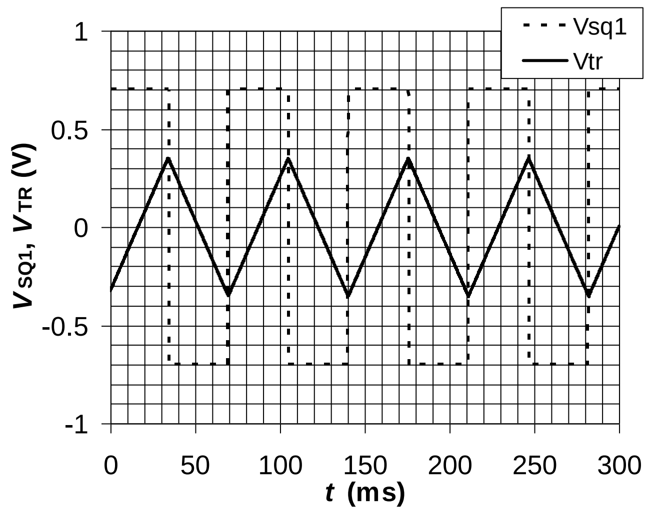
Computer Simulation

While computing numerical parameters of the circuit and performing its simulations some considerations are : The maximum X and Z terminal currents of the conveyor are the same, namely $I_{Xmax} = I_{Zmax} = I_{XZmax} = 0.7$ mA. The resistance R_2 will be chosen 1 kΩ which results in the amplitude of the output voltage v_{SQ1} of 0.7 V. If the resistance $R_1 = 500$ Ω, the Schmitt trigger threshold voltage is according to (1) $V_{TH} = -V_{TL} = 0.35$ V. The resistance R was chosen 1 kΩ and diodes BAT68 Schottky.

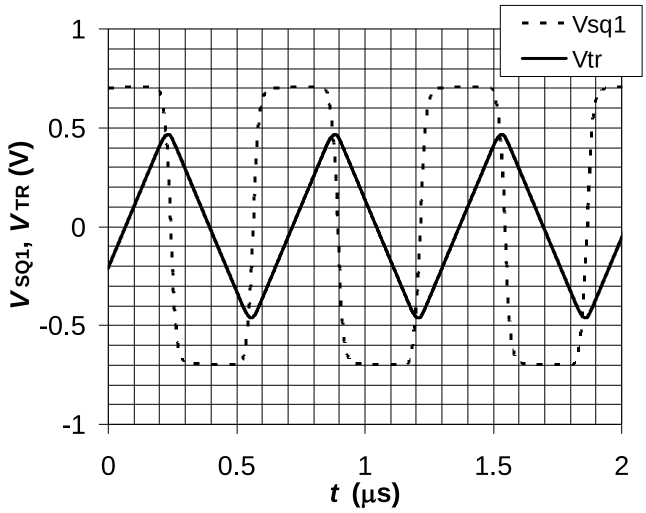
Figs. 4 a) and b) show the waveforms of the generator with V_C = 0.1 V, C = 5 nF, (theoretical frequency f_G = 14.3 kHz), and V_C = 0.7 V, C = 200 pF, (theoretical frequency f_G = 2.5 MHz), respectively. But for the generated signal frequency of 14.3 KHz the Traditioal Wave Generator Circuit requires C = 34 nF.

Fig. 4 a) shows the behaviour of the circuit at low frequency. Here the influence of conveyor non-idealities is very small and the waveforms are almost ideal.

STRUCTURE	GENERATED SIGNAL FREQUENCY (KHz)	CAPACITOR VALUE (nF)
Traditional Wave Generator Circuit	14.3 KHz	33 nF
Proposed Model		5 nF



(a)



(b)

Fig- 4: *Simulated waveforms of the generator; a) V_C = 0.1 V, C = 5 nF; b) V_C = 0.7 V, C = 200 pF*

4. ConclusionS

Relaxation oscillator with two current conveyors according to a classic circuit with operational amplifiers has been designed. It employs only grounded passive elements, which is advantageous for integrated implementation. The circuit features with voltage triangular-wave output and both voltage and current square-wave output.

The generated frequency is directly proportional to the control voltage and the relation for evaluating the generated frequency depending on the control voltage and element values has been given. The circuit functionality has been verified by computer simulations with a PSpice model of manufactured sample of universal current conveyor. The generated frequency agrees with theoretical assumptions up to about 100 kHz and linearity of the frequency setting is maintained up to units of megahertz. The future work in this area will continue with practical implementation of the proposed circuit and modifications improving the accuracy of the generated frequency according to control voltage.

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