

Sinusoidal, Pulse, Triangular Oscillator Using Second Generation Current Conveyor

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Abstract—This paper describes the sinusoidal, pulse, triangular oscillator using second generation current conveyor. To obtain the sinusoidal waveform the circuit blocks are constructed by using all pass filter and integrator. The pulse and the triangular waveforms are obtained from the output of sinusoidal oscillator. The peak-to-peak voltages of sinusoidal and triangular waveforms can be easily controlled by the dc offset voltage. Also the output frequency of the oscillator can be controlled by varying passive elements. The designed circuit is verified by HSPICE simulation.

Index Terms— sinusoidal oscillator, pulse oscillator, triangular oscillator, second generation current conveyor, operational amplifier.

I. INTRODUCTION

The second generation current conveyor(CCII) was introduced by Sedra and Smith in 1970[1]. The CCII has many advantages such as lower power consumption, better linearity and stability properties. Therefore CCII has been found useful in many applications and a number of schemes have been developed to realize the filters and oscillators[2-5]. Many application circuit blocks can be implemented by using CCIIs easier than using operational amplifier because the operation of CCII approaches its ideal behavior quite closely. CCII is available with both polarities as positive(CCII+) and negative(CCII-). CCII using integrated circuit such as LM741 was represented by S. Rana and K. Pal in 2007[6]. The circuit realized both positive and negative polarities CCIIs. In this paper the sinusoidal, pulse, triangular oscillators are introduced. The circuits are based on CCII- using operational amplifier. In the CCII+ circuit the current supplied to input node is conveyed to output node and in the CCII- circuit the output current direction is reverse compared to the output current direction in the CCII+.

In section II, the structure and the operation of CCII circuit are described. In section III, the designed sinusoidal, pulse, triangular oscillators are introduced.

Also the operation of the oscillators is analyzed using HSPICE simulation tool. In section IV, the characteristics of the oscillators are described and finally, the conclusions show in Section V.

II. CURRENT CONVEYOR CIRCUIT

Fig. 1 shows the CCII+ circuit symbol with positive polarity, and the ideal current conveyor can be described by the following equations (1), (2) and (3). When a voltage is applied at node y, that voltage is transferred to node x. This is similar to virtual short on an operational amplifier. The current supplied to node x is conveyed to node z.

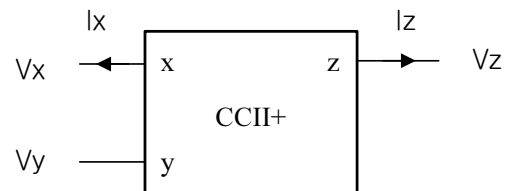


Fig. 1 Circuit symbol of the CCII+

$$i_y = 0 \quad (1)$$

$$v_x = v_y \quad (2)$$

$$i_z = i_x \quad (3)$$

Fig. 2 shows the CCII- circuit symbol with negative polarity. In CCII- the current direction at the Z node is reverse compared to the current direction in the CCII+. Therefore the current equation is expressed by equation (4).

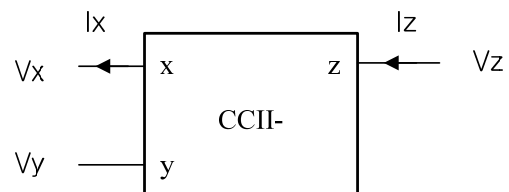


Fig. 2 Circuit symbol of the CCII-

Manuscript received August 27, 2010; revised September 11, 2010; accepted September 17, 2010.

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$$i_z = -i_x \tag{4}$$

Fig. 3 shows the CCII- circuit using operational amplifier[6]. The circuit was proposed by S. Rana and K. Pal. The input node voltages, V_x and V_y are the same. The current i_x flowing through the resistor is expressed as equation (5) because the input current is nearly zero.

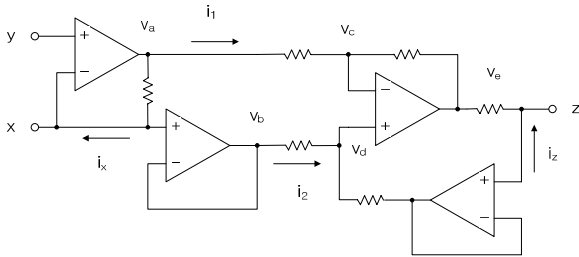


Fig. 3 Second generation current conveyor

$$i_x = \frac{Va - Vb}{R} \tag{5}$$

The current i_1 can be given by

$$i_1 = \frac{Va - Vc}{R} = \frac{Vc - Ve}{R} \tag{6}$$

From equation (6) Vc is expressed by

$$2Vc = Va + Ve \tag{7}$$

From the similar method the current i_2 can be given by

$$i_2 = \frac{Vb - Vd}{R} = \frac{Vd - Vz}{R} \tag{8}$$

From equation (8) Vd is expressed by

$$2Vd = Vb + Vz \tag{9}$$

Vd is equal to Vc because the voltages are the same in inverting node and non-inverting node of operational amplifier.

From equation (7) and equation (9) the equation is rearranged as follows:

$$\frac{Ve - Vz}{R} = \frac{Vb - Va}{R} \tag{10}$$

Solving for the currents i_x and i_z , it thus results in

$$i_z = -i_x \tag{11}$$

Fig. 4 shows the basic structure of CMOS second generation current conveyor circuit. The designed circuit is based on operational amplifier CCII.

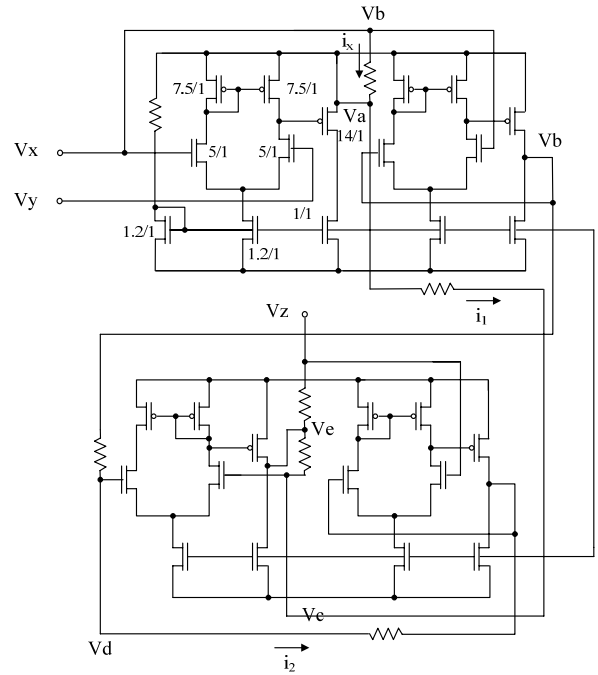


Fig. 4 CMOS Second generation current conveyor

III. SINUSOIDAL, PULSE, TRIANGULAR GENERATORS

Fig 5 shows the circuit of sinusoidal, pulse, triangular oscillators. The all pass filter circuit is realized using CCII₁-, C_1 , R_1 , C_2 and R_2 . And the integrator is realized CCII₂-, C_3 and R_3 . In Fig. 4 the all-pass filter circuit was introduced by P. Kumar and K. Pal in 2008[7]. In the CCII₁- the voltage transfer function is given by equation (12)

$$\frac{V_2}{V_1} = \frac{1 + s^2 C_1 C_2 R_1 R_2 + s(C_1 R_1 + C_2 R_2 - C_1 R_2)}{1 + s^2 C_1 C_2 R_1 R_2 + s(C_1 R_1 + C_2 R_2)} \tag{12}$$

For all-pass function the magnitude of V_2/V_1 have to equal one. The relation of C_1 , C_2 , R_1 and R_2 is expressed by equation (13) and the condition is satisfied when $R_2=4R_1$ and $C_1=4C_2$.

$$R_1 = \frac{R_2(C_1 - 2C_2)}{2C_1} \tag{13}$$

From equation (13) the parameter ω_o can be expressed as

$$\omega_o = \frac{1}{R_1 C_1} = \frac{1}{R_2 C_2} \tag{14}$$

In the CCII₂- the voltage transfer function is express by

$$\frac{V_3}{V_2} = \frac{1}{sR_3C_3} \quad (15)$$

For sinusoidal oscillations loop gain, V_3/V_1 , is one. And the parameter ω_0 can be expressed as

$$\omega_0 = \frac{1}{R_3C_3} \quad (16)$$

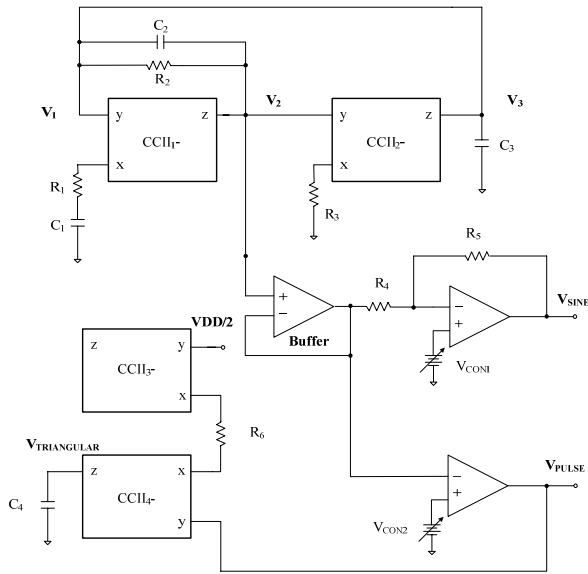


Fig. 5 Circuit diagram of sinusoidal, pulse, triangular oscillators.

In Fig. 5 the buffer is used to cancel the loading effect. To control the amplitude and offset of the sinusoidal waveform the operational amplifier is used. V_{CON1} is the offset control voltage and the output voltage swing range is controlled by controlling resistances R_4 and R_5 . To obtain the pulse waveform the buffer output is compared with V_{CON2} . Also the duty of the pulse output can be controlled by varying V_{CON2} . The triangular waveform generator is obtained from the $CCII_3^-$ and the $CCII_4^-$. The capacitor, C_4 , is discharged when V_{PULSE} is V_{DD} and the discharge current is as follows:

$$i_{discharge} = \frac{V_{DD}}{2R_6} \quad (17)$$

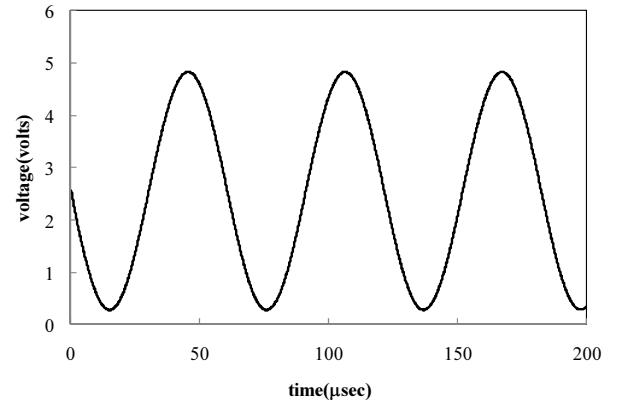
The capacitor is charged when V_{PULSE} is zero and the charge and discharge currents are the same. The peak-to-peak voltage of the triangular waveform is expressed by

$$V_{PEAK-to-PEAK} = \frac{T}{C_4} \frac{V_{DD}}{2R_6} = \frac{1}{f_o C_4} \frac{V_{DD}}{R_6} \quad (18)$$

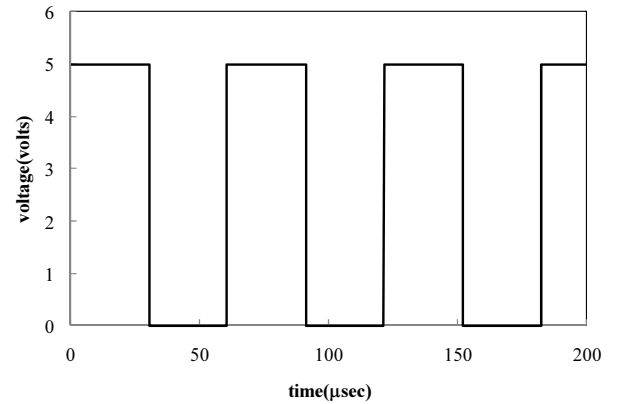
where T and f_o are the period and frequency of the sinusoidal waveform, respectively. From equation (18) the peak-to-peak voltage of the triangular waveform can be

controlled by varying C_4 or R_6 .

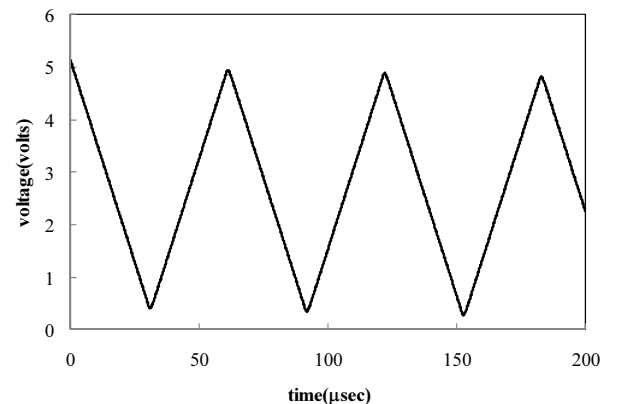
Fig. 6 shows the outputs of sinusoidal, pulse and triangular oscillators. Fig. 6(a) shows V_{SINE} waveform. Fig. 6(b) and Fig. 6(c) show V_{PULSE} and $V_{TRIANGULAR}$ waveforms.



(a)



(b)



(c)

Fig. 6 The output waveforms (a) sinusoidal generator (b) pulse generator (c) triangular generator

IV. ANALYSIS OF SINUSOIDAL, PULSE, TRIANGULAR GENERATORS

Fig. 7(a) shows the variation of frequency with R_3C_3 . Fig. 7(b) shows the error with R_3C_3 . The error is calculated as follows:

$$\text{error}(\%) = \frac{f_{\text{calculation}} - f_{\text{simulation}}}{f_{\text{calculation}}} \times 100 \quad (19)$$

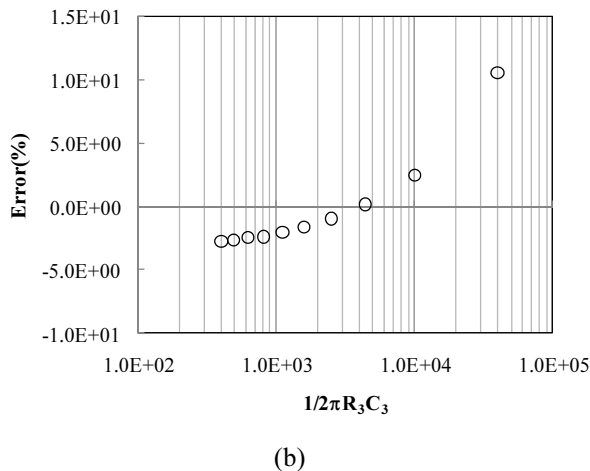
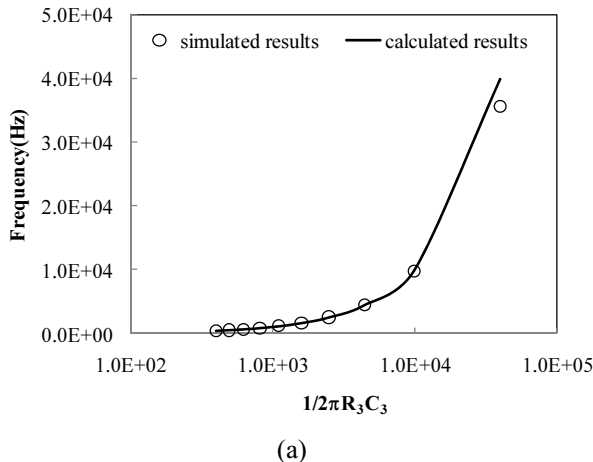


Fig. 7 Simulation results with R_3C_3 (a) frequency variation with R_3C_3 (b) error with R_3C_3

From the simulation results the error increases slightly with the frequency increases compared to calculated frequency. Therefore R_3C_3 should be controlled finely with the frequency increases.

IV. CONCLUSIONS

The various signal oscillators are designed and the circuits are designed using the CCII-. The CCII circuit is

based on operational amplifier. The output frequency can be easily controlled by varying the RC. From HSPICE simulation results the proposed circuit shows enough good characteristics in low frequency. But as increasing the frequency the value of RC has to decrease compared to the calculated RC value.

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