Sinusoidal Oscillator Using CCCCTA

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1 Introduction

In electronics engineering domain, sinusoidal oscillators are used widely in a number of application areas like regenerative repeaters, satellite communication, radars and other signal processing tasks, signal generation, etc. The RC sinusoidal oscillators can be easily realized with the help of active elements [1–9]. Among them, the sinusoidal oscillators which can provide independent control of the condition of oscillation (CO) and the frequency of oscillation (FO) are much useful.

On the other hand, an active element current conveyor trans-conductance amplifier (CCTA) has the advantage that it can work in both voltage and current modes and hence it gives flexibility in designing the circuits. Also CCTA provides high slew rate, high speed and wide bandwidth [10]. Further, since the CCTA in itself does not have any functionality to control the parasitic resistance at its input port, so current controlling can be provided in it to control the same, which makes this device a current controlled current conveyor trans-conductance amplifier (CCCCTA) [11, 12]. This has the additional advantage of electronic adjustability over the basic CCTA design.

This paper presents a new sinusoidal oscillator design using CCCCTA as an active element. All of the oscillators realized in [1–9] have used either more than one active element, more than three passive components, or they have not provided electronic control to either the CO or the FO. CCII-based single resistance controlled oscillator was proposed in [1] which includes a total of five passive components, and tunability is achieved with the help of one passive resistor only. OTRA-based single resistance controlled oscillator was proposed in [2] which includes again a

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total of five passive components, and no electronic tunability is possible. Sinusoidal oscillator design utilizing two CCII and four passive components is presented in [5] while [6] presented a design employing a total of three CDTA elements along with three passive components. OTRA-based design proposed in [8] utilizes four passive components while in [9] a total of five passive components are used. The proposed circuit employs only a single CCCCTA element and only three passive components, and it also gives independent control of the CO and the FO. Further, in the proposed circuit, both resistors and capacitors are grounded and not floating, and hence, it is suitable for monolithic integration.

2 Current Controlled Current Conveyor Trans-conductance Amplifier (CCCCTA)

The proposed sinusoidal oscillator is implemented based on CCCCTA which is modified form of CCTA with current controlling ability. The CCTA is basically the combination of current conveyor (CCII) and trans-conductance amplifier. So, CCCCTA is actually formed by using CCII at its input stage followed by trans-conductance amplifier with current biasing to control the current. The basic model of CCCCTA is shown in Fig. 1a with its equivalent circuit in Fig. 1b.

The CCCCTA device has two input and two output terminals as shown in Fig. 1. The input terminal '*x*' has some parasitic resistance (R_x) which varies according to the external supplied current. The input terminal '*y*', the intermediate terminal "*z*" and the output terminal '*o*' are basically high impedance terminals. Following matrix describes the property of CCCCTA:

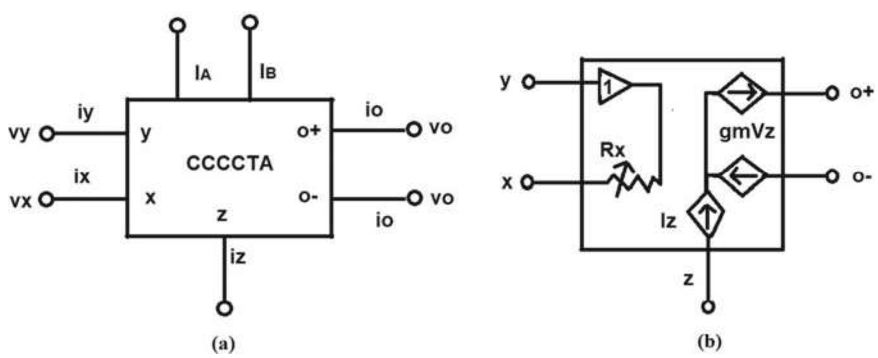

Fig. 1 CCCCTA **a** circuit representation **b** equivalent symbol [11]

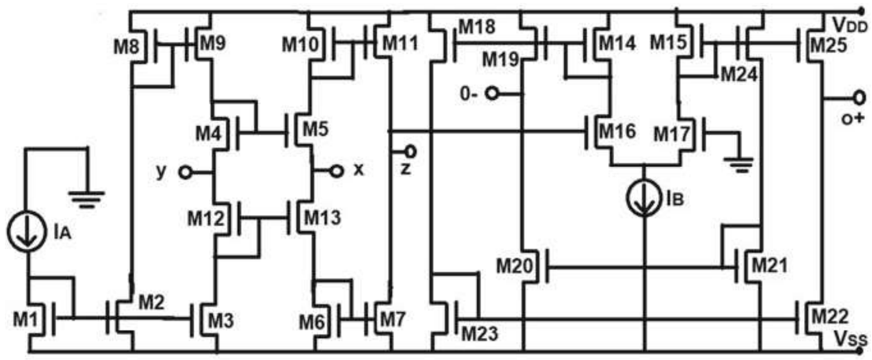

Fig. 2 Schematic CMOS realization of CCCCTA

$$\begin{bmatrix} i_y \\ v_x \\ i_z \\ i_o \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ R_x & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & g_m & 0 \end{bmatrix} \begin{bmatrix} i_x \\ v_y \\ v_z \\ v_o \end{bmatrix}$$

where g_m is the trans-conductance of CCCCTA.

Figure 2 shows the CMOS realization of CCCCTA. The CCII consists of transistors mainly M4, M5 and M12, M13. The trans-conductance amplifier action is being performed with the help of transistors M14–M17 and M18–M25. The current mirroring action is being done by current mirror circuits (M8–M9), (M10–M11) and (M6–M7), and remaining transistors are used for biasing purpose.

3 Proposed Sinusoidal Oscillator

Figure 3 shows the proposed circuit symbol, and Fig. 4 shows its MOS implementation. Only, one CCCCTA active element is used. One resistor is connected between input port y and ground while two capacitors are used; one is connected between input port y, and ground with output port z is connected directly to input y, and other capacitor is connected between second input terminal x and ground. By doing routine circuit analysis, following expression is found

$$(R_1C_1R_xC_2)s2 + (R_1C_1 + (R_x - R_1)C_2)s + 1 = 0. \tag{1}$$

From Eq. (1), it is investigated that this circuit will act as an oscillator if following condition is satisfied

$$R_1C_2 >= R_1C_1 + R_xC_2. \tag{2}$$

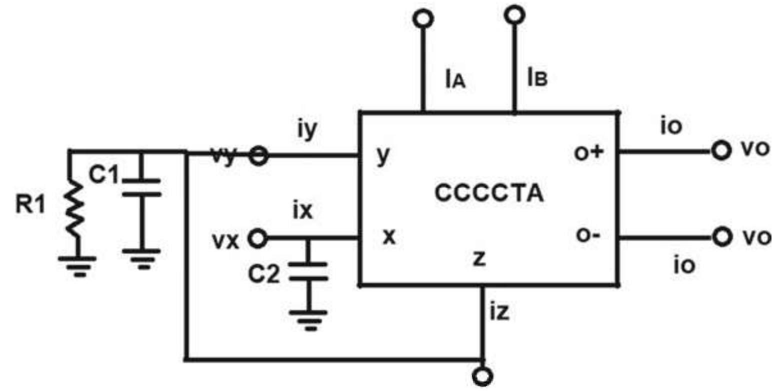

Fig. 3 Proposed sinusoidal oscillator symbolic representation

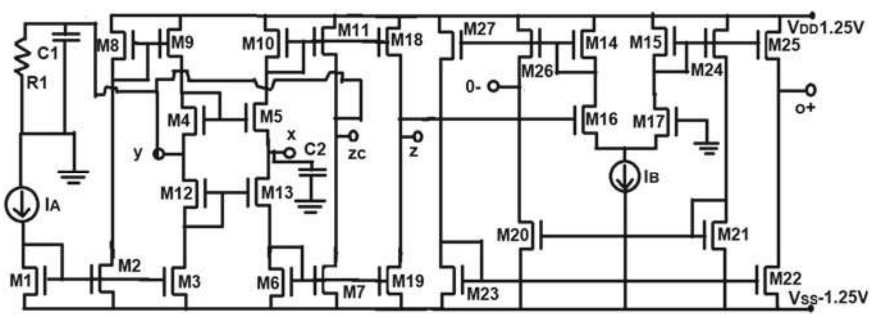

Fig. 4 Proposed sinusoidal oscillator MOS implementation

The frequency of oscillation obtained is

$$w_0 = 1/\sqrt{R_1 C_1 R_x C_2} \tag{3}$$

Since R_x can be changed with the help of biasing current I_A, CO and FO can be easily changed by suitably changing the value of current I_A only. Transistor sizes used for implementing the oscillator are mentioned in Table 1.

4 Simulation Results

ORCAD PSPICE 17.2 version was used to simulate this CCCCTA-based sinusoidal oscillator circuit with 0.18 μm CMOS technology parameters. The value of capacitor C_1 is taken as 20 pf and for capacitor C_2 is 102 pf with a biasing current I_A 60 μA and I_B 120 μA. The value of R_1 is taken as 1.88 kohm satisfying the condition of oscillation. Figure 5 shows the output waveform with the frequency obtained at

Table 1 Transistor sizes used for implementation

MOSFET's [W/L]	Size [μ]
M1–M3, M6–M7, M18	12/1
M4–M5	20/1
M8–M11, M19	20/1
M12–M13	32/1
M14–M15, M24–M27	8/1
M16–M17	5/1
M20–M23	8/1

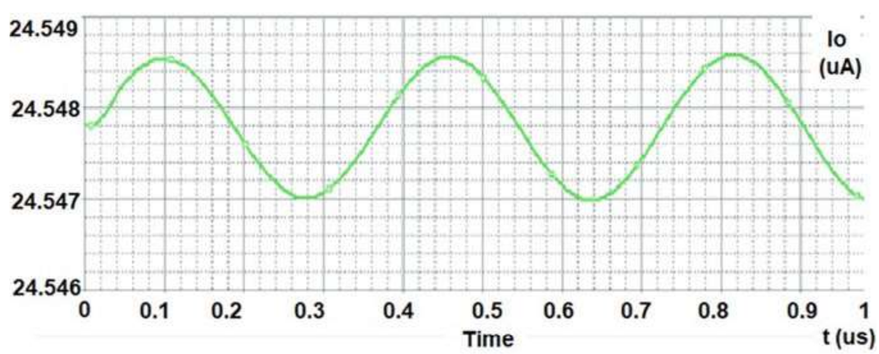

Fig. 5 Output waveform obtained for sinusoidal oscillator

Table 2 Comparison of available sinusoidal oscillator

Ref.[.]	Analog building block (ABB)	Number of ABB	Number of passive components	Electronic tunability of output current
[1]	CCII	1	5	No
[3]	OTRA	1	5	No
[5]	CCII	2	4	No
[6]	CDTA	3	3	No
[8]	OTRA	1	4	Yes
[9]	OTRA	1	6	No
Proposed work	CCCCTA	1	3	Yes

output terminal is 2.8 MHz which verifies the theoretical results. Further, it can be changed easily by varying the biasing current which proves the feasibility as well as the controllability of the designed circuit by varying the input electronically. Table 2 shows comparison of available sinusoidal oscillator with the proposed one.

5 Conclusion

This paper presents a sinusoidal oscillator which utilizes only a single CCCCTA with three passive elements. All the passive elements are grounded and not floating makes this design suitable for integration. This circuit can provide both current and voltage outputs, and its CO and FO can be tuned electronically. The simulation results show the implemented sinusoidal oscillator waveform which verifies the theoretical calculations.

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