Single-resistance-controlled/voltage-controlled oscillator using current conveyors and grounded capacitors

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Indexing terms: Current conveyors, Voltage controlled oscillators

A new single-resistance-controlled/voltage-controlled sinusoidal oscillator using two current conveyors (CCs), two grounded capacitors and three grounded resistors is presented. This oscillator provides the following advantages: (i) independently controllable oscillation frequency and condition by grounded resistors, (ii) easy conversion into a voltage-controlled oscillator, (iii) all the passive components which are suitable for IC implementation are grounded, (iv) very good frequency stability. Experimental results that confirm the theoretical analysis are obtained.

Introduction: Many sinusoidal oscillators using current conveyors (CCs) [1, 2] have been developed in the literature [3 – 6]. It is highly desirable for the oscillators whose oscillation frequency can be independently tuned by a single grounded resistor. When this grounded resistor is replaced by a JFET, a voltage-controlled oscillator can be realised. Moreover, it is attractive for monolithic integration to use grounded capacitors [7]. Most of the previous works either require at least one floating resistor and/or a floating capacitor [3 – 5] or more than two active elements [6]. In this Letter a new sinusoidal oscillator which consists of three grounded resistors, two grounded capacitors and two CCs [7] is presented. Its oscillation frequency can be controlled by a grounded resistor. Experimental results which confirm the theoretical analysis are presented.

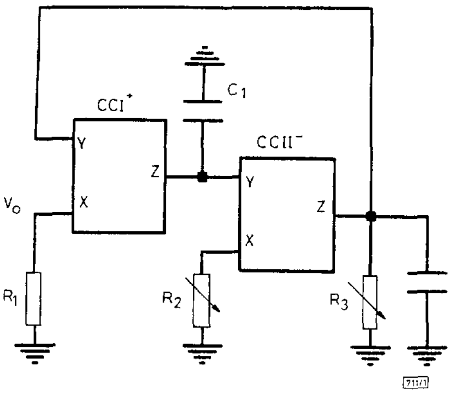

Fig. 1 *Sinusoidal oscillator using current conveyors*

Circuit description: The proposed oscillator using the plus/minus-type first-/second-generation current conveyors [7, 8] (CCI±/CCII±) is shown in Fig. 1. The port relations of a CCI± and a CCII± can be expressed by $V_X = V_Y$, $I_Z = \pm I_X$ and $I_Y = I_X$ for a CCI and $I_Y = 0$ for a CCII, respectively. The characteristic equation for the proposed oscillator in Fig. 1 can be given as

$$s^2C_1C_2 + sC_1(1/R_3 - 1/R_1) + 1/(R_1R_2) = 0 \qquad (1)$$

The oscillation condition and oscillation frequency can be obtained as

$$R_1 = R_3 \qquad (2)$$

and

$$\omega_0 = \frac{1}{\sqrt{C_1C_2R_1R_2}} \qquad (3)$$

The oscillation condition of Fig. 1 can be adjusted by a grounded resistor R_3. The oscillation frequency can be independently adjusted by a grounded resistor R_2. It is attractive for monolithic integration to use grounded capacitors [7]. This oscillator requires two grounded capacitors; by using a JFET to replace R_2, a voltage-controlled oscillator can be obtained. By using the capacitance array with analogue switches, a programmable oscillator can also be obtained. The passive sensitivities of this sinusoidal oscillator are all low and obtained as

$$S^{\omega_0}_{C_1} = S^{\omega_0}_{C_2} = S^{\omega_0}_{R_1} = S^{\omega_0}_{R_2} = -1/2$$

The classical frequency stability factor S_F is defined as [4]

$$S_F = \left.\frac{d\Phi(u)}{du}\right|_{u=1} \qquad (4)$$

where $u = \omega/\omega_0$ and $\Phi(u)$ represents the phase function of the open loop transfer function of Fig. 1. S_F can be found to be

$$S_F = \frac{2n\sqrt{n}}{1+n} \simeq 2\sqrt{n} \quad \text{if } n \gg 1 \qquad (5)$$

where $C_1 = C_2 = C$, $R_1 = R_3 = R$ and $R_2 = R/n$ for this oscillator. This oscillator has good frequency stability similar to the oscillators in [5, 6]. The required number of components in this oscillator is small. A comparison of component counts used in this proposed oscillator and previous work is listed in Table 1. In fact, a similar sinusoidal oscillator can be obtained if the CCI+ and CCII− in Fig. 1 were replaced by a CCI− and a CCII+, respectively. Moreover, by using the *RC:CR* transformation, two new sinusoidal oscillators can also be obtained [8].

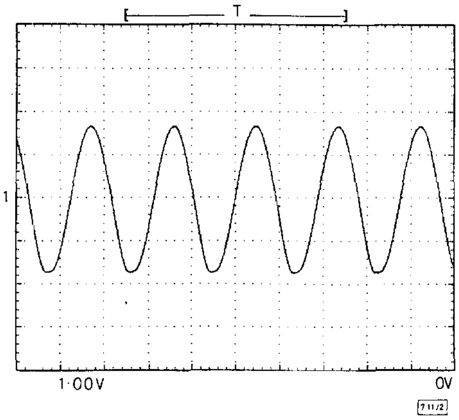

Fig. 2 *Typical output waveform of Fig. 1 with $C_1 = C_2 = 1.2$nF and $R_1 = R_2 = R_3 = 10$kΩ*

Horizontal scale is 40µs/div
Vertical scale is 1 V/div

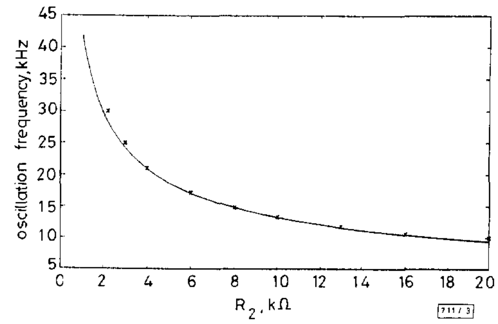

Fig. 3 *Experimental results of oscillation frequency of Fig. 1 by changing value of resistor R_2 (if $C_1 = C_2 = 1.2$nF and $R_1 = R_3 = 10$kΩ)*

× experiment
—— ideal curve

Experimental results: To verify the theoretical analysis, we implemented the proposed oscillator in Fig. 1. The CCII− and CCI+ were realised by a commercial operational amplifier (LF356) and bipolar transistor array (CA3096) [9, 10]. Fig. 2 shows a typical output waveform of Fig. 1 with $C_1 = C_2 = 1.2$nF and $R_1 = R_2 = R_3 = 10$kΩ and the ±5V power supply. Fig. 3 shows the experimental results of the oscillation frequency of Fig. 1 by varying the value of the resistor R_2 with $C_1 = C_2 = 1.2$nF and $R_1 = R_3 = 10$kΩ. Experimental results which confirm the theoretical analysis are obtained.

Table 1: Comparison between several single-element-controlled oscillators

	Active components	Grounded capacitors	Grounded resistors	Floating capacitors	Floating resistors
Senani *et al.* [4]	3	1	3	2	2
Bhaskar *et al.* [5]	2	2	1	0	2
Chang [6]	3	2	3	0	0
Proposed	2	2	3	0	0

Conclusions: A single-resistance-controlled sinusoidal oscillator using a CCI+ and a CCII– is presented. It only uses two grounded capacitors and three grounded resistors. Its oscillation frequency can be independently controlled by a grounded resistor. Its passive ω_0-sensitivities are all low. This oscillator provides the following advantages: (i) independently controllable oscillation frequency and condition by grounded resistors, (ii) easy conversion into a voltage-controlled oscillator, (iii) all the passive components which are suitable for IC implementation are grounded, (iv) very good frequency stability. The experimental results confirm the theoretical analyses.

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Third-generation current conveyor: a new helpful active element

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Indexing terms: Current conveyors, Analogue circuits

A new conveyor, which has been called the third generation current conveyor (CCIII), is introduced. It is defined from the general equations that describe the first and second generation current conveyors. As an example of its possibilities, the use of the circuit as a floating current sensing device is investigated. Its class AB implementation, obtained from two second generation current conveyors, is given. Some simulation results are also reported, the circuits being implemented from complementary bipolar arrays.

Introduction: The first and second generation current conveyors (respectively designated as CCI and CCII) were introduced in 1968 and 1970 [1 – 3]. They are now widely used, principally in the analogue domain, to implement a significant number of high-performance signal-processing functions. The general symbol associated with them is shown in Fig. 1. X, Y and Z are their input-output ports and ground is the reference. These conveyors can both be described using the following matrix-relation:

$$\begin{pmatrix} i_y \\ v_x \\ i_z \end{pmatrix} = \begin{pmatrix} 0 & a & 0 \\ 1 & 0 & 0 \\ 0 & b & 0 \end{pmatrix} \begin{pmatrix} v_y \\ i_x \\ v_z \end{pmatrix} \qquad (1)$$

b characterises their current transfer from X to Z. For b positive, the circuit is a positive transfer conveyor. This becomes a conveyor with negative transfer when b is negative. a is related to the nature of the conveyor. Thus, only two general classes of current conveyors, with either $a = 1$ or $a = 0$, have been described up to now. For $a = 1$, the circuit is a first generation current conveyor (CCI). It is called a second generation conveyor (CCII) for $a = 0$, [1 – 5]. A new conveyor, which corresponds to $a = -1$, is introduced in this Letter. Owing to its analogy with the preceding conveyors, we propose to designate this as the third generation current conveyor (CCIII). This new conveyor will be very useful to take out the current flowing through a floating branch of a circuit. It may also be advantageously used as the input cell of probes and current measuring devices. Its usefulness in current-mode circuits will be illustrated first. Then, its implementation from two CCIIs will be given. Some simulation results obtained from bipolar transistors of complementary arrays will also be indicated.

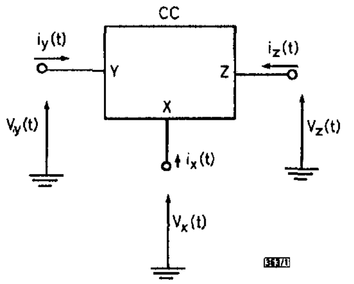

Fig. 1 *General current conveyor symbol*

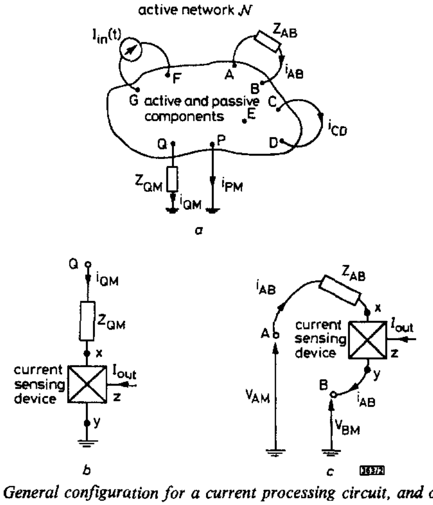

Fig. 2 *General configuration for a current processing circuit, and output currents*

a General configuration for a current processing circuit
b Output current flowing to ground
c Floating output current