

NOVEL ICCII - BASED OSCILLATOR TOPOLOGIES

Ali Toker¹ Mehmet Dişçigil¹ Oğuzhan Çiçekoğlu² Hakan Kuntman¹

¹Istanbul Technical University, Electrical and Electronics Faculty, Department of Electronics and Communication Engineering, 80626 Maslak, İstanbul, TURKEY,
alitoker@ehb.itu.edu.tr kuntman@ehb.itu.edu.tr

²Boğaziçi University, M.Y.O. Electronics Program, 80815 Bebek, İstanbul, TURKEY,
cicekoglu@boun.edu.tr

ABSTRACT

In this work, new inverting second-generation current conveyor (ICCII)-based sinusoidal oscillators are proposed. Corresponding oscillation frequencies and oscillation conditions both for the ideal and for the non-ideal cases are given in tabular form. All the passive elements of the proposed oscillators are grounded and they can easily be realized with CMOS technology and employ similar advantages compared to CCII-based counterparts. All the presented oscillators exhibit independent control between oscillator frequency and condition.

1. INTRODUCTION

Current-mode circuits are used instead of voltage mode circuits for a wide variety of applications. The reason is that in voltage-mode circuits parasitic capacitances create dominant poles at relative low frequencies, which limits the bandwidth. In general the node impedances in current-mode circuits are low and the voltage swings are small. Thus the time constant effect is minimal. Hence the slew rate for current mode circuits will be sufficiently high [1-2]. They are well suited to work at higher frequencies. Furthermore current-mode circuits are also suitable for integration with CMOS technology and thus become more and more attractive in electronic circuit design. In recent years new current-mode active building blocks like second-generation current conveyors (CCII+ and CCII-), current-feedback op-amps (CFOA) [3,4] received considerable attention due to their larger dynamic range and wider bandwidth. In addition, different additional types current-mode active elements like differential voltage current conveyor (DVCC), differential difference current conveyor (DDCC), a third-generation current-conveyor (CCIII), four terminal floating nullor (FTFN) are presented in the literature [5-9]. Finally Awad and Soliman introduce inverting second-generation current conveyor (ICCII) in 1999 [10].

The aim of this work is to contribute oscillator circuits using this new element, ICCII, which employ only grounded passive elements [11].

2. INVERTING SECOND GENERATION CURRENT CONVEYOR

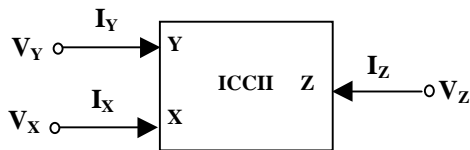


Figure 1 Circuit symbol of inverting second-generation current conveyor

The circuit symbol of ICCII is shown in Fig.1. The relation between terminal voltages and currents for this active element is given by,

$$\begin{bmatrix} I_y \\ V_x \\ I_z \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ -1 & 0 & 0 \\ 0 & b & 0 \end{bmatrix} \begin{bmatrix} V_y \\ I_x \\ V_z \end{bmatrix} \quad (1)$$

For the above matrix representation, if b is equal to 1, positive inverting second-generation current conveyor (ICCII+); and if b is equal to -1 then negative positive inverting second-generation current conveyor (ICCII-) is obtained. The matrix equation, Eq. (1) for the ICCII active element is only valid for the ideal case. In practice however for the CMOS implementation of the conveyor there will be voltage and current tracking errors ε_v and ε_i , since the transistors are not exactly identical. The non-ideal case is described by

$$\begin{aligned} v_y(t) &= -\beta v_x(t) \\ i_y(t) &= 0 \\ i_z(t) &= \pm \alpha i_x(t) \end{aligned} \quad (2)$$

where α and β are current and voltage gains, which can be represented by

$$\alpha = (1 - \varepsilon_v), \quad \beta = (1 - \varepsilon_i) \quad (3)$$

where ε_v and ε_i are much smaller than unity.

3. CMOS REALIZATION

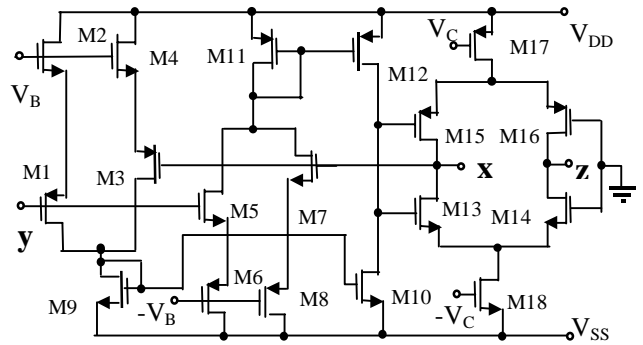


Figure 2 CMOS implementations of ICCII- [10].

The rapid development of the CMOS technology, which enables realization of complex systems on a small chip area permits wide integration of CMOS circuits for analog functions that include also current conveyors. Fig. 2 illustrates a CMOS realization circuit of (ICCI- [10]. This circuit uses single and dual output transconductance circuits. In the CMOS circuit illustrated in Fig. 2 the floating output stage introduced by Arbel and Goldminz (1992) is used to obtain accurate current following between X and Z terminals [12].

4. PROPOSED ICCII-BASED OSCILLATORS

The new ICCII-based oscillator topologies are shown in Fig. 3. The characteristic equations of these circuits in terms of admittances and the oscillators are obtained with different combination of passive elements. They are given in Table 1.

Table 1 Characteristic equations of the presented oscillators

| CIRCUIT NO | CHARACTERISTIC EQUATION |
|------------|--------------------------------|
| Circuit-1 | $y_1y_5 + y_2y_3 - y_4y_5 = 0$ |
| Circuit-2 | $y_3y_5 + y_2y_4 - y_1y_4 = 0$ |
| Circuit-3 | $y_1y_4 + y_2y_5 - y_3y_5 = 0$ |
| Circuit-4 | $y_1y_4 + y_3y_5 - y_2y_5 = 0$ |

The oscillation conditions and the oscillation frequencies of the oscillators proposed were easily derived from these equations and are given in Table 2. As it is easily seen from Table 2 two different oscillators are derived from Circuit 2, 3 and 4 by using different passive elements.

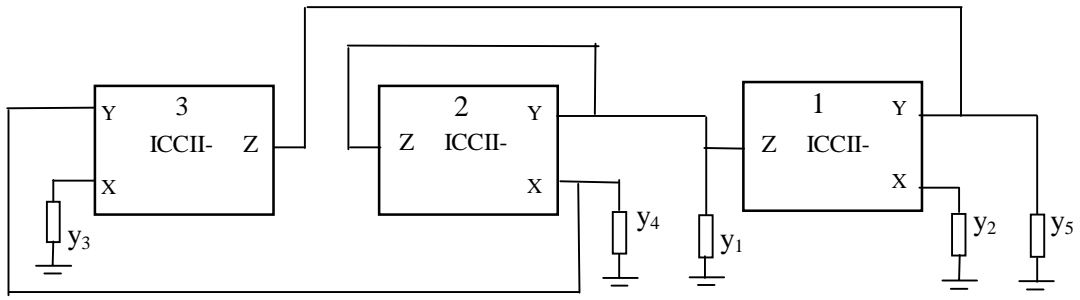
Table 2 Oscillation frequencies and the oscillation conditions of ICCII-based oscillators

| CIRCUIT NO | ADMITTANCES | | | | | OSCILLATION FREQUENCY (ω_0^2) | OSCILLATION CONDITION |
|--------------|-------------|------------|------------|--------|--------|--|-----------------------|
| | y_1 | y_2 | y_3 | y_4 | y_5 | | |
| Circuit 1 | G_1+sC_1 | G_2 | G_3 | G_4 | sC_5 | $\frac{G_2G_3}{C_1C_5}$ | $G_1 = G_4$ |
| Circuit 2 -a | sC_1 | G_2+sC_2 | SC_3 | G_4 | sC_5 | $\frac{G_2G_4}{C_3C_5}$ | $C_1 = C_2$ |
| Circuit 2-b | G_1 | G_2+sC_2 | G_3 | sC_4 | G_5 | $\frac{G_3G_5}{C_2C_4}$ | $G_1 = G_2$ |
| Circuit 3-a | G_1 | G_2+sC_2 | G_3 | G_4 | sC_5 | $\frac{G_1G_4}{C_2C_5}$ | $G_2 = G_3$ |
| Circuit 3-b | sC_1 | G_2+sC_2 | SC_3 | sC_4 | G_5 | $\frac{G_2G_5}{C_1C_4}$ | $C_2 = C_3$ |
| Circuit 4-a | sC_1 | sC_2 | G_3+sC_3 | sC_4 | G_5 | $\frac{G_3G_5}{C_1C_4}$ | $C_2 = C_3$ |
| Circuit 4-b | G_1 | G_2 | G_3+sC_3 | G_4 | sC_5 | $\frac{G_1G_4}{C_3C_5}$ | $G_2 = G_3$ |

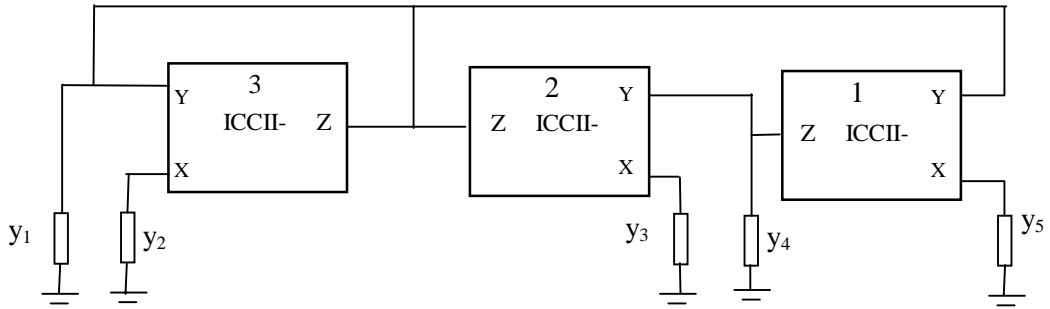
It is obvious from Table 2 that all oscillators offer independent control features between oscillation frequency and oscillation condition. Therefore they can be used as variable frequency oscillators (VFO). Furthermore a single grounded resistance can adjust their oscillation frequencies, and they are called as single resistance controlled oscillators (SRCOs). Oscillation frequencies and oscillation conditions given for the ideal case in the previous section are modified if non-idealities are included. These values for non-ideal case are given in Table 3.

5. CONCLUSIONS

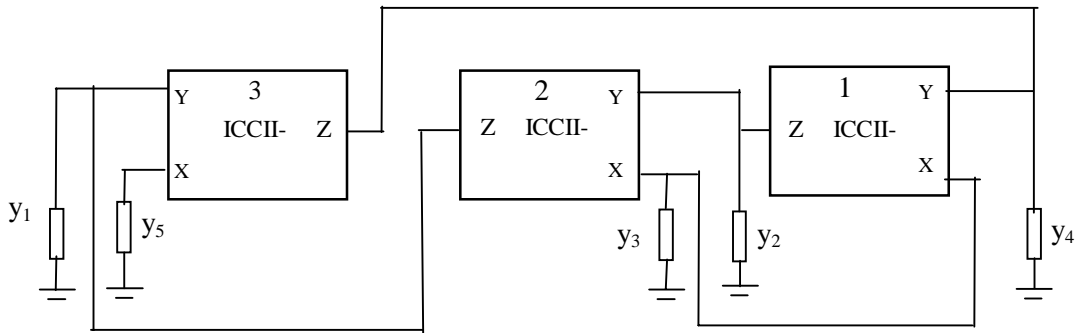
In this study novel ICCII-based R-C sinusoidal oscillators are proposed. Corresponding oscillation frequencies and oscillation conditions both for the ideal and for the non-ideal cases are given in tabular form. The proposed oscillators employ all grounded passive elements and ICCII's can be realized with CMOS technology, which can be considered as a further advantage for integration. Furthermore the oscillation frequencies and conditions of the proposed oscillators can be controlled independently from each other, thus they are all variable frequency oscillators.



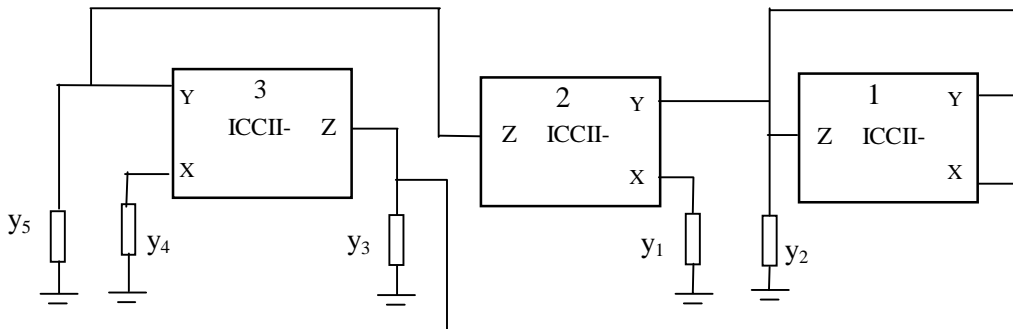
Circuit 1



Circuit 2



Circuit 3



Circuit 4

Figure 3 Proposed ICCII-based oscillator topologies

Table 3 Oscillation frequencies and the oscillation conditions of ICCII-based oscillators for the non-ideal case

| CIRCUIT NO | OSCILLATION FREQUENCY (ω_0^2) | OSCILLATION CONDITION |
|--------------|--|--|
| Circuit 1 | $\frac{\beta_1\beta_2\beta_3G_2G_3}{\alpha_1\alpha_3C_1C_5}$ | $G_1 = G_4 \frac{\beta_2}{\alpha_2}$ |
| Circuit 2 -a | $\frac{\alpha_3\beta_2\beta_3G_2G_4}{\alpha_1\alpha_2\beta_1C_3C_5}$ | $C_1 = C_2 \frac{\alpha_3\beta_3}{\alpha_2}$ |
| Circuit 2-b | $\frac{\alpha_1\alpha_2\beta_1G_3G_5}{\alpha_3\beta_2\beta_3C_2C_4}$ | $G_1 = G_2 \frac{\alpha_3\beta_3}{\alpha_2}$ |
| Circuit 3-a | $\frac{\alpha_1\beta_2G_1G_4}{\alpha_2\alpha_3\beta_1\beta_3C_2C_5}$ | $G_2 = G_3 \frac{1}{\alpha_1\beta_2}$ |
| Circuit 3-b | $\frac{\alpha_2\alpha_3\beta_1\beta_3G_2G_5}{\alpha_1\beta_2C_1C_4}$ | $C_2 = C_3 \frac{1}{\alpha_1\beta_2}$ |
| Circuit 4-a | $\frac{\beta_1G_3G_5}{\alpha_2\alpha_3\beta_2\beta_3C_1C_4}$ | $C_2 = C_3\alpha_1\beta_1$ |
| Circuit 4-b | $\frac{\alpha_2\alpha_3\beta_2\beta_3G_1G_4}{\beta_1C_3C_5}$ | $G_2 = G_3\alpha_1\beta_1$ |

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