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Generation of three oscillator families using CCII and ICCII

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Abstract

New minimum passive component current mode oscillators are given. Two of the new oscillators have a floating property. Two families of 16 grounded passive component oscillators each are generated from two current conveyor based oscillators. The generation method is based on the combination of both types of current conveyors and inverting current conveyors. Additional oscillators are generated using the adjoint network theorem. Some of the oscillator circuits considered in this paper have the advantage of being easily compensated for the parasitic effects of the current conveyors.

Keywords: Current conveyor; Inverting current conveyor; Oscillators; Grounded capacitors; Adjoint network theorem

1. Introduction

The single output second generation current conveyor (CCII) family consists of two members. The two members are the CCII+ and CCII– introduced in [1]. The inverting second generation current conveyor (ICCII) has also two members namely the ICCII+ and ICCII− as introduced in [2].

The second generation current conveyor (CCII) shown symbolically in Fig. 1(a) is a universal building block that was introduced in [1]. The ICCII is also a universal building block that was introduced in [2] and shown symbolically in Fig. 1(b) and they are defined by

$$\begin{pmatrix} I_y \\ V_x \\ I_z \end{pmatrix} = \begin{pmatrix} 0 & 0 & 0 \\ a & 0 & 0 \\ 0 & K & 0 \end{pmatrix} \begin{pmatrix} V_y \\ I_x \\ V_z \end{pmatrix} \tag{1}$$

The parameter a represents the conveyor type, for CCII $a=1$ and for ICCII $a=-1$.

The parameter K represents the Z polarity of the conveyor, for the Z+ polarity $K=1$ and for the $Z-$ polarity $K=-1$.

Three different oscillators [3,4] are used in this paper to generate a family of oscillators from each circuit. The adjoint network theorem [5–8] is also used to generate additional oscillator circuits.

2. Generation of current mode oscillators family-I

The minimum passive component current mode oscillator circuit shown in Fig. 2(a) employs a CCII− and a CCII+ and was introduced in [3]. This circuit is a special case from a family of eight circuits as will be demonstrated by considering the generalized configuration shown in Fig. 2(b). The circuit characteristic equation is obtained as

$$s^2C_1C_2R_1R_2+s[C_1R_1+C_2R_2+a_2K_1C_1R_2]+1=0 \tag{2}$$

From Eq. (2) a necessary condition for oscillation is that

$$a_2K_1=-1 \tag{3a}$$

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In this case the condition of oscillation is given by

$$\frac{R_1}{R_2}+\frac{C_2}{C_1}=1 \tag{3b}$$

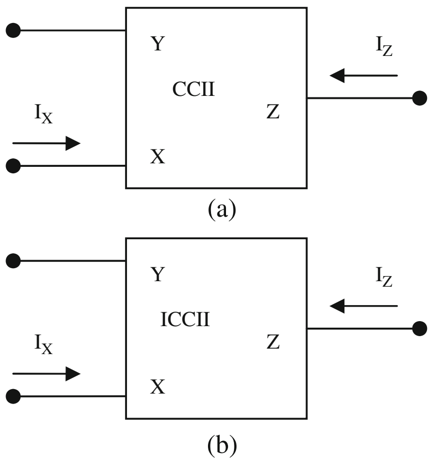

Fig. 1. (a) The symbol of CCII and (b) the symbol of ICCII.

The frequency of oscillation is given by

$$\omega_O=\frac{1}{\sqrt{C_1C_2R_1R_2}} \tag{4}$$

Although the parameters a_1 and K_2 are arbitrary, they should be considered in generating the different members of this oscillator family as given in Table 1. It is seen that the only two circuits in this family that have a floating property are circuit numbers 2 and 6 in Table 1. In determining the flotation property identified by $I_G=0$, for the current mode oscillators the output current I_O should be taken into consideration.

Fig. 2(c) represents the adjoint oscillator circuit to that of Fig. 2(a).

The circuit characteristic equation is obtained as

$$s^2C_1C_2R_1R_2+s[C_1R_1+C_2R_2+a_1K_2C_1R_2]+1=0 \tag{5}$$

From Eqs. (2) and (5) it is seen that if the conveyor numbers in the adjoint circuit of Fig. 2(d) are interchanged, the circuit will be identical to Fig. 2(b). That is the oscillator of Fig. 2(b) is self-adjoint but Figs. 2(c), (d) and Table 2 are

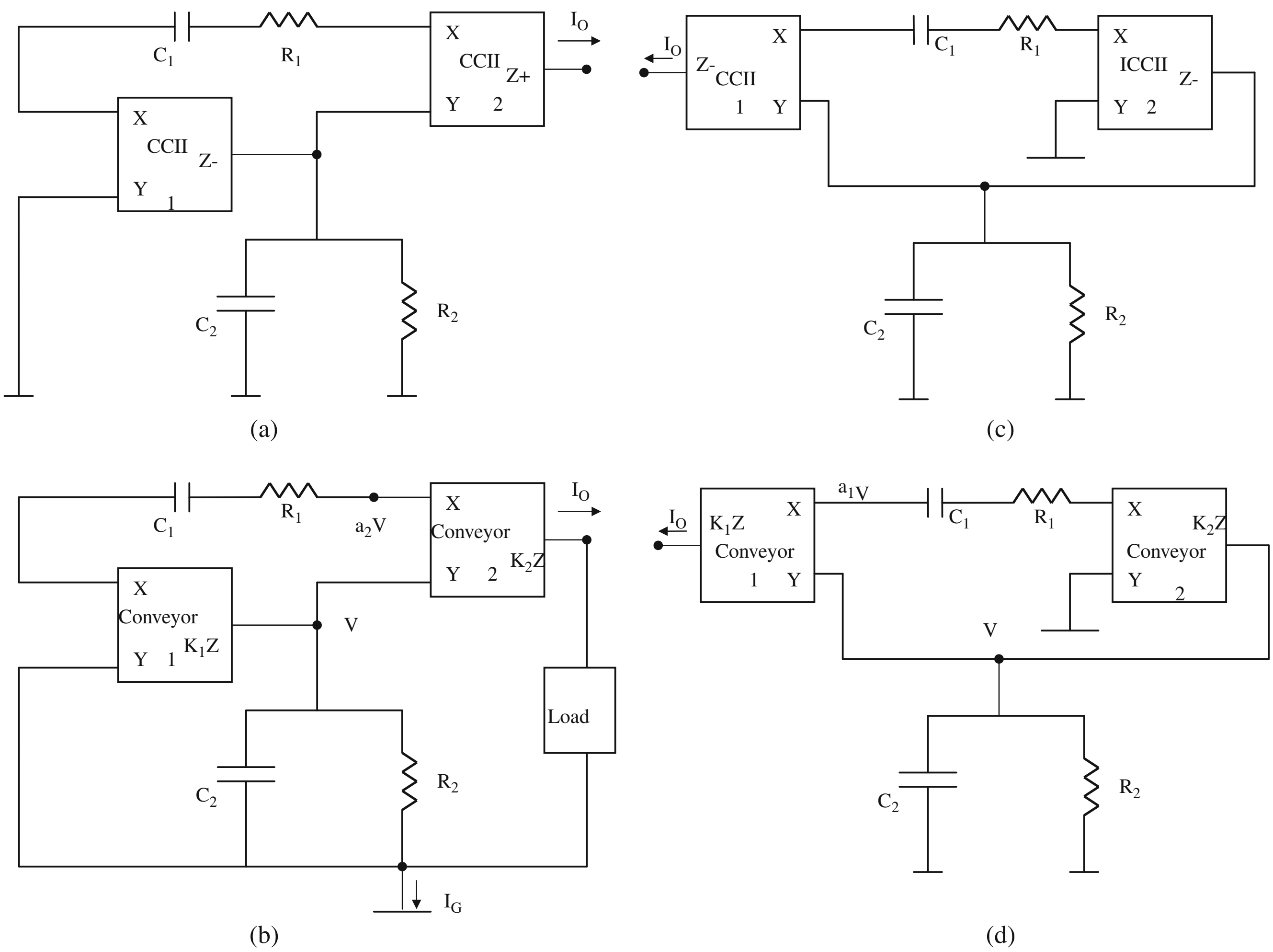

Fig. 2. (a) The minimum passive component current mode oscillator [3]; (b) generalized current mode oscillator to (a); (c) the adjoint oscillator circuit to (a); and (d) generalized current mode oscillator to (c).

Table 1. The eight oscillator circuits that are generated from Fig. 2(b).

Circuit	a_1	K_1	a_2	K_2	Conveyor 1	Conveyor 2	Adjoint to circuit	Floating
A-1	+	−	+	+	CCII−	CCII+	B-1	No
A-2	+	−	+	−	CCII−	CCII−	B-2	Yes
A-3	+	+	−	+	CCII+	ICCII+	B-3	No
A-4	+	+	−	−	CCII+	ICCII−	B-4	No
A-5	−	−	+	+	ICCII−	CCII+	B-5	No
A-6	−	−	+	−	ICCII−	CCII−	B-6	Yes
A-7	−	+	−	+	ICCII+	ICCII+	B-7	No
A-8	−	+	−	−	ICCII+	ICCII−	B-8	No

Table 2. The eight oscillator circuits that are generated from Fig. 2(d).

Circuit	a_1	K_1	a_2	K_2	Conveyor 1	Conveyor 2	Adjoint to circuit	Floating
B-1	+	−	−	−	CCII−	ICCII−	A-1	Yes
B-2	+	−	+	−	CCII−	CCII−	A-2	Yes
B-3	−	−	−	+	ICCII−	ICCII+	A-3	No
B-4	−	−	+	+	ICCII−	CCII+	A-4	No
B-5	+	+	−	−	CCII+	ICCII−	A-5	No
B-6	+	+	+	−	CCII+	CCII−	A-6	No
B-7	−	+	−	+	ICCII+	ICCII+	A-7	No
B-8	−	+	+	+	ICCII+	CCII+	A-8	No

given to provide more clear illustrations of the family of minimum passive component current mode oscillators.

This minimum component oscillator family has no independent control on the condition nor on the frequency of oscillation and it uses one floating capacitor. It has the advantage, however, that the parasitic resistances R_X can be easily compensated by taking R_1 equal to its design value minus $(R_{X1}+R_{X2})$. Similarly for Fig. 2(b) the parasitic capacitance C_{Z1} can be easily compensated by taking C_2 equal to its design value minus C_{Z1}.

3. Generation of oscillator family-II

The oscillator circuit shown in Fig. 3(a) was introduced in [4]. It has the advantages of using all grounded resistors and capacitors and it has independent control on both the condition of oscillation and on the frequency of oscillation.

This circuit is a special case from a family of 16 circuits as will be demonstrated by considering the generalized configuration shown in Fig. 3(b). The circuit characteristic equation is obtained as

$$s^2C_1C_2R_1R_2 + sC_2R_1R_2\left[\frac{1}{R} + \frac{a_3K_2K_3}{R_3}\right] - a_1a_2K_1K_2 = 0 \quad (6)$$

From Eq. (6) it is seen that necessary conditions for oscillation are given by

$$a_3K_2K_3 = -1, \quad a_1a_2K_1K_2 = -1 \quad (7)$$

In this case the condition of oscillation is $R_3 = R$ which is controlled by varying R_3 or R without affecting the radian frequency of oscillation which is given by Eq. (4). The frequency of oscillation is controlled by varying R_1 or R_2 without affecting the condition of oscillation.

There are 16 circuits that satisfy the conditions in Eq. (7) and the coefficient signs and the types of the three conveyors are given in Table 3 .

From Table 3 it is seen that oscillator circuits A-1 and A-2 have floating property.

Fig. 3(c) represents the adjoint oscillator circuit to Fig. 3(a).

This circuit is a special case from a family of 16 circuits as will be demonstrated by considering the generalized configuration shown in Fig. 3(d). The circuit characteristic equation is obtained as

$$s^2C_1C_2R_1R_2 + sC_2R_1R_2\left[\frac{1}{R} - \frac{a_2a_3K_3}{R_3}\right] - a_1a_2K_1K_2 = 0 \quad (8)$$

From the above Eq. (8) it is seen that necessary conditions for oscillation are given by

$$a_2a_3K_3 = 1, \quad a_1a_2K_1K_2 = -1 \quad (9)$$

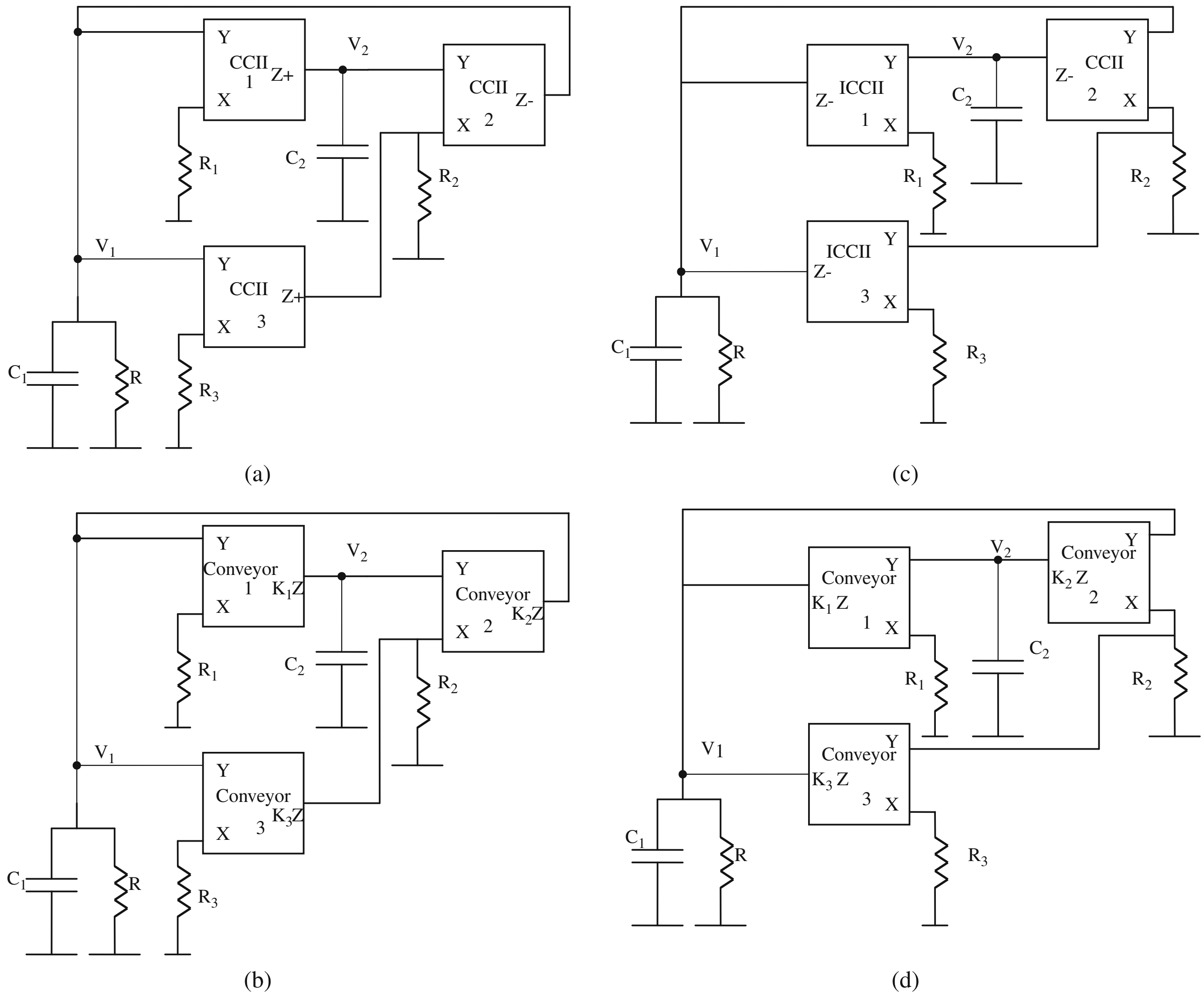

Fig. 3. (a) Grounded passive component oscillator circuit I [4]; (b) generalized oscillator I to (a); (c) the adjoint oscillator circuit to (a); and (d) generalized oscillator to (c).

From Table 4 it is seen that oscillator circuits B-5 and B-15 have floating property. This indicates that the adjoint theorem does not preserve the floating property.

4. Generation of oscillator family-III

The oscillator circuit shown in Fig. 4(a) uses three CCII+ and was introduced in [4]. It has the advantages of using all grounded resistors and capacitors and it has independent control on both the condition of oscillation and the frequency of oscillation. It has the advantage that the parasitic resistances R_X (of two of the conveyors) can be easily compensated by subtracting its value from each of the resistors connected to port *X* of the conveyor. Similarly the parasitic capacitance C_Z can be easily compensated by subtracting its value from each of the capacitors connected to port *Z* of the conveyor.

This circuit is a special case from a family of 16 circuits as will be demonstrated by considering the generalized configuration shown in Fig. 4(b). The circuit characteristic equation is obtained as

$$s^2C_1C_2R_1R_2 + sC_2R_1R_2\left[\frac{1}{R} - \frac{a_3K_3}{R_3}\right] + a_1a_2K_1K_2K_3 = 0 \quad (10)$$

From Eq. (10) it is seen that necessary conditions for oscillation are given by

$$a_3K_3 = 1, \quad a_1a_2K_1K_2K_3 = 1 \quad (11)$$

Table 3. The family of oscillator circuits generated from Fig. 3(b).

Circuit A-	a_1	K_1	a_2	K_2	a_3	K_3	Conveyor 1	Conveyor 2	Conveyor 3	Adjoint to circuit B-	Floating
A-1	−	−	+	−	−	−	ICCII−	CCII−	ICCII−	B-1	Yes
A-2	+	−	−	−	−	−	CCII−	ICCII−	ICCII−	B-2	Yes
A-3	−	−	−	+	+	−	ICCII−	ICCII+	CCII−	B-3	No
A-4	−	+	−	−	−	−	ICCII+	ICCII−	ICCII−	B-4	No
A-5	+	−	+	+	+	−	CCII−	CCII+	CCII−	B-5	No
A-6	−	+	+	+	+	−	ICCII+	CCII+	CCII−	B-6	No
A-7	+	+	+	−	−	−	CCII+	CCII−	ICCII−	B-7	No
A-8	+	+	−	+	+	−	CCII+	ICCII+	CCII−	B-8	No
A-9	−	+	−	−	+	+	ICCII+	ICCII−	CCII+	B-9	No
A-10	+	−	−	−	+	+	CCII−	ICCII−	CCII+	B-10	No
A-11	−	−	−	+	−	+	ICCII−	ICCII+	ICCII+	B-11	No
A-12	−	−	+	−	+	+	ICCII−	CCII−	CCII+	B-12	No
A-13	+	−	+	+	−	+	CCII−	CCII+	ICCII+	B-13	No
A-14	−	+	+	+	−	+	ICCII+	CCII+	ICCII+	B-14	No
A-15	+	+	+	−	+	+	CCII+	CCII−	CCII+	B-15	No
A-16	+	+	−	+	−	+	CCII+	ICCII+	ICCII+	B-16	No

Table 4. The family of oscillator circuits generated from Fig. 3(d).

Circuit B-	a_1	K_1	a_2	K_2	a_3	K_3	Conveyor 1	Conveyor 2	Conveyor 3	Adjoint to circuit A-	Floating
B-1	+	+	+	−	+	+	CCII+	CCII−	CCII+	A-1	No
B-2	+	−	+	+	+	+	CCII−	CCII+	CCII+	A-2	No
B-3	+	+	−	+	+	−	CCII+	ICCII+	CCII−	A-3	No
B-4	−	+	+	+	+	+	ICCII+	CCII+	CCII+	A-4	No
B-5	+	−	−	−	+	−	CCII−	ICCII−	CCII−	A-5	Yes
B-6	−	+	−	−	+	−	ICCII+	ICCII−	CCII−	A-6	No
B-7	−	−	+	−	+	+	ICCII−	CCII−	CCII+	A-7	No
B-8	−	−	−	+	+	−	ICCII−	ICCII+	CCII−	A-8	No
B-9	−	+	+	+	−	−	ICCII+	CCII+	ICCII−	A-9	No
B-10	+	−	+	+	−	−	CCII−	CCII+	ICCII−	A-10	No
B-11	+	+	−	+	−	+	CCII+	ICCII+	ICCII+	A-11	No
B-12	+	+	+	−	−	−	CCII+	CCII−	ICCII−	A-12	No
B-13	+	−	−	−	−	+	CCII−	ICCII−	ICCII+	A-13	No
B-14	−	+	−	−	−	+	ICCII+	ICCII−	ICCII+	A-14	No
B-15	−	−	+	−	−	−	ICCII−	CCII−	ICCII−	A-15	Yes
B-16	−	−	−	+	−	+	ICCII−	ICCII+	ICCII+	A-16	No

In this case the condition of oscillation is $R_3 = R$ which is controlled by varying R_3 or R without affecting the radian frequency of oscillation which is given by Eq. (4). The frequency of oscillation is controlled by varying R_1 or R_2 without affecting the condition of oscillation.

There are 16 circuits that satisfy the conditions in Eq. (8) and the coefficient signs and the types of the three conveyors are given in Table 5 .

From Table 5 it is seen that oscillator circuits A-15 and A-16 have floating property.

Fig. 4(c) represents the adjoint oscillator circuit to Fig. 4(a).

This circuit is a special case from a family of 16 circuits as will be demonstrated by considering the generalized configuration shown in Fig. 4(d). The circuit characteristic equation is obtained as

$$s^2C_1C_2R_1R_2 + sC_2R_1R_2\left[\frac{1}{R} - \frac{a_3K_3}{R_3}\right] - a_1a_2a_3K_1K_2 = 0 \quad (12)$$

From Eq. (12) it is seen that necessary conditions for oscillation are given by

$$a_3K_3 = 1, \quad a_1a_2a_3K_1K_2 = -1 \quad (13)$$

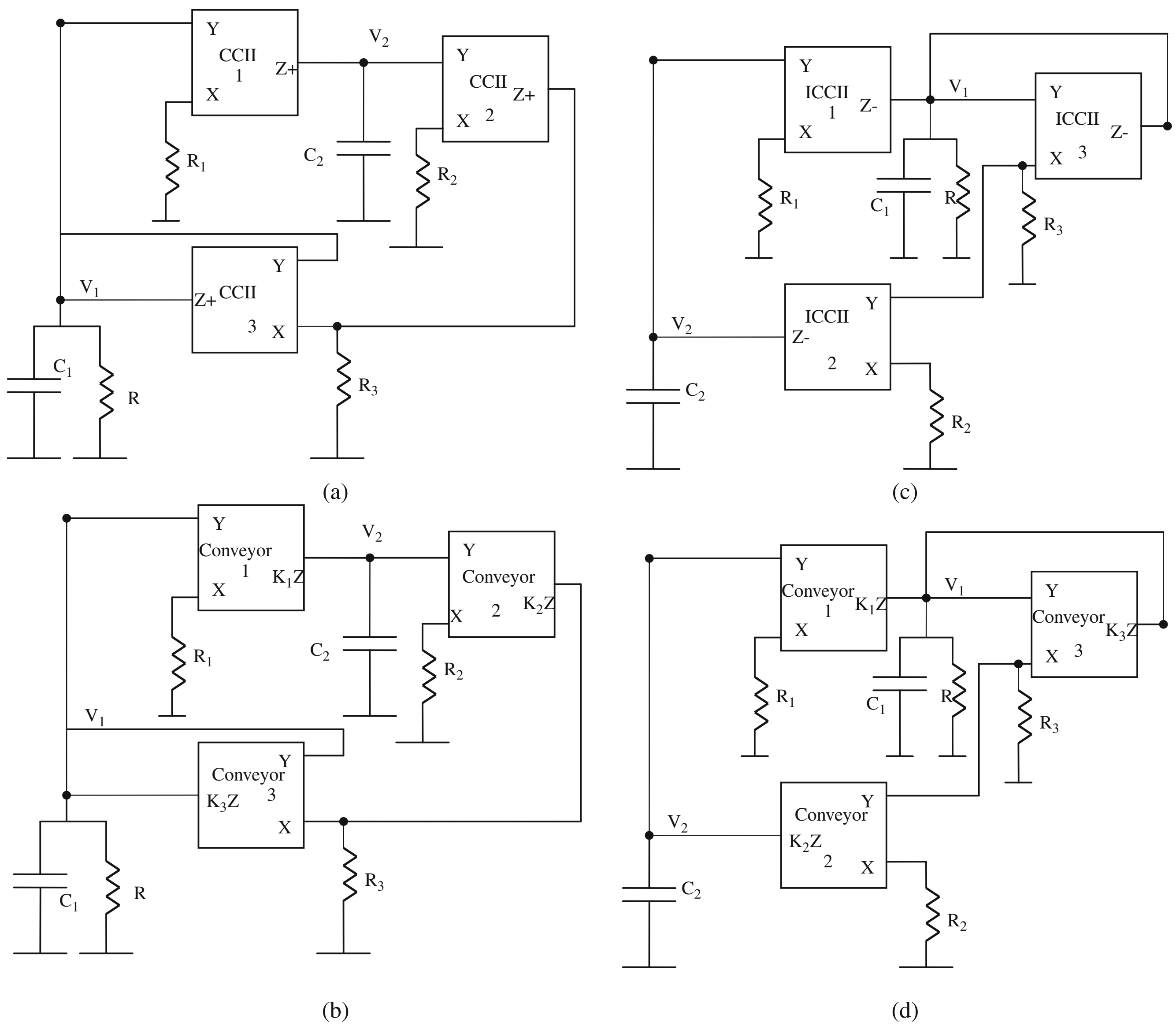

Fig. 4. (a) Grounded passive component oscillator circuit II [4]; (b) generalized oscillator II to (a); (c) the adjoint oscillator circuit to (a); and (d) generalized oscillator to (c).

From Table 6 it is seen that oscillator circuits B-9 and B-12 have floating property. Again this indicates that the adjoint theorem does not preserve the floating property.

5. Conclusions

Three different oscillator families are generated. The fist family has eight members and it belongs to the class of current mode oscillators. Families II and III employ grounded resistors and capacitors and use three conveyors and have 16 members each.

The generation method is based on the combination of both types of current conveyors and inverting current conveyors. Additional oscillators are generated using the adjoint network theorem. The oscillator circuits belonging to families I and III have the advantage of being easily compensated for the parasitic effects of the current conveyors.

It is worth noting although the three ICCII− oscillator reported recently in [9] is obtained from the oscillator circuit given in Fig. 3(a) by interchange of the branch impedances connected to ports *X* and *Y* of conveyor 3, it does not belong to the oscillator family II or its adjoint.

Table 5. The family of oscillator circuits generated from Fig. 4(b).

Circuit A-	a_1	K_1	a_2	K_2	a_3	K_3	Conveyor 1	Conveyor 2	Conveyor 3	Adjoint to circuit B-	Floating
A-1	+	+	+	+	+	+	CCII+	CCII+	CCII+	B-9	No
A-2	+	−	+	−	+	+	CCII−	CCII−	CCII+	B-12	No
A-3	−	+	−	+	+	+	ICCII+	ICCII+	CCII+	B-11	No
A-4	+	+	−	−	+	+	CCII+	ICCII−	CCII+	B-10	No
A-5	+	−	−	+	+	+	CCII−	ICCII+	CCII+	B-14	No
A-6	−	−	−	−	+	+	ICCII−	ICCII−	CCII+	B-16	No
A-7	−	−	+	+	+	+	ICCII−	CCII+	CCII+	B-13	No
A-8	−	+	+	−	+	+	ICCII+	CCII−	CCII+	B-15	No
A-9	−	+	+	+	−	−	ICCII+	CCII+	ICCII−	B-6	No
A-10	+	−	+	+	−	−	CCII−	CCII+	ICCII−	B-5	No
A-11	+	+	−	+	−	−	CCII+	ICCII+	ICCII−	B-8	No
A-12	+	+	+	−	−	−	CCII+	CCII−	ICCII−	B-7	No
A-13	−	+	−	−	−	−	ICCII+	ICCII−	ICCII−	B-1	No
A-14	−	−	−	+	−	−	ICCII−	ICCII+	ICCII−	B-3	No
A-15	+	−	−	−	−	−	CCII−	ICCII−	ICCII−	B-2	Yes
A-16	−	−	+	−	−	−	ICCII−	CCII−	ICCII−	B-4	Yes

Table 6. The family of oscillator circuits generated from Fig. 4(d).

Circut B-	a_1	K_1	a_2	K_2	a_3	K_3	Conveyor 1	Conveyor 2	Conveyor 3	Adjoint to circuit A-	Floating
B-1	−	+	+	+	+	+	ICCII+	CCII+	CCII+	A-13	No
B-2	+	−	+	+	+	+	CCII−	CCII+	CCII+	A-15	No
B-3	+	+	−	+	+	+	CCII+	ICCII+	CCII+	A-14	No
B-4	+	+	+	−	+	+	CCII+	CCII−	CCII+	A-16	No
B-5	+	−	−	−	+	+	CCII−	ICCII−	CCII+	A-10	No
B-6	−	+	−	−	+	+	ICCII+	ICCII−	CCII+	A-9	No
B-7	−	−	+	−	+	+	ICCII−	CCII−	CCII+	A-12	No
B-8	−	−	−	+	+	+	ICCII−	ICCII+	CCII+	A-11	No
B-9	−	−	−	−	−	−	ICCII−	ICCII−	ICCII−	A-1	Yes
B-10	−	−	+	+	−	−	ICCII−	CCII+	ICCII−	A-4	No
B-11	−	+	−	+	−	−	ICCII+	ICCII+	ICCII−	A-3	No
B-12	+	−	+	−	−	−	CCII−	CCII−	ICCII−	A-2	Yes
B-13	+	+	−	−	−	−	CCII+	ICCII−	ICCII−	A-7	No
B-14	+	−	−	+	−	−	CCII−	ICCII+	ICCII−	A-5	No
B-15	−	+	+	−	−	−	ICCII+	CCII−	ICCII−	A-8	No
B-16	+	+	+	+	−	−	CCII+	CCII+	ICCII−	A-6	No

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