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A NOVEL GENERALIZED IMPEDANCE CONVERTER USING SINGLE SECOND GENERATION CURRENT CONVEYOR

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A generalized impedance converter (GIC) using single CCII(−) is presented. The circuit uses no matching constraints and provides a wide variety of ideal component simulators and multipliers. The GIC can also be made tunable by using CCCII(−) instead of CCII(−). The proposed GIC is verified using SPICE with excellent results.

Keywords: Active filters; Current conveyors; Impedance converters

1 INTRODUCTION

In recent years the second-generation current conveyor (CCII) has proved to be a functionally flexible and versatile building block. It possesses higher signal bandwidth, greater linearity and dynamic range [1]. As a result, it is gaining wide acceptance as a basic building block for designing voltage/current mode signal processing circuits [1–7].

Several circuits realizing immittance functions using CCIIs have been reported [8–11]. However, these circuits either provide non-ideal simulators and/or use component matching constraints.

In this paper a generalized impedance converter (GIC) using a CCII(−) is presented. The proposed GIC is in grounded form and provides an ideal impedance simulator without any matching constraints. The realized GIC is studied and verified using SPICE based simulations.

2 CIRCUIT REALIZATION

The proposed GIC using a CCII(−) is given in Figure 1. The routine analysis yields its driving point impedance function as:

$$Z_{\text{in}} = \frac{V}{I} = \frac{Z_1 Z_3}{Z_2}. \tag{1}$$

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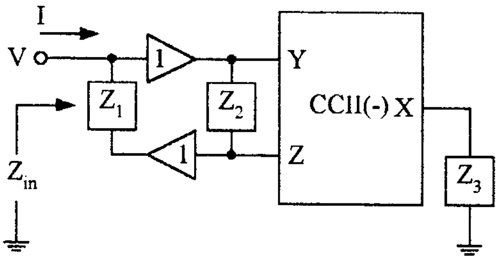

FIGURE 1 A GIC using single CCII(−).

By appropriate selection of Z_1, Z_2 and Z_3 in (1), the GIC can realize ideal grounded inductance, capacitance/resistance multipliers and frequency-dependent negative resistance (FDNR). The proposed GIC possesses the incremental sensitivity measure as:

$$|S_{Z_j}^{Z_{\text{in}}}| = 1.0, \quad \text{where } j = 1, 2 \text{ and } 3. \tag{2}$$

It is evident from (1) that the GIC also enjoys the attractive sensitivity performance. In Figure 1 if the CCII(−) along with Z_3 is replaced by a second generation current controlled conveyor CCCII(−) as shown in Figure 2, the resulting input impedance is

$$Z_{\text{in}} = \frac{V}{I} = \frac{Z_1 R_x}{Z_2} \tag{3}$$

where $R_x(= V_T/2I_0)$ is the parasitic resistance at the x-input of the CCCII(−). The V_T is thermal equivalent voltage and I_0 is the bias current [12, 13].

It is evident from (1) that the GIC of Figure 2 can realize all the immittance functions simulated from the GIC of Figure 1 except FDNR. It is to note that the CCCII(−) based GIC of Figure 2 uses only two passive components and possesses a wide range tuning facility through bias current control. It also enjoys similar sensitivity performance to that of CCII(−) based GIC of Figure 1.

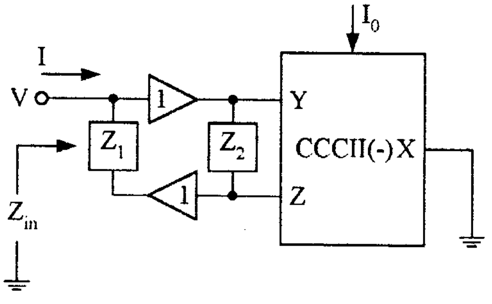

FIGURE 2 A GIC using single CCCII(−).

3 EFFECTS OF NON-IDEAL VOLTAGE BUFFER

If the voltage buffers have slight gain deviations δ_1 and δ_2 from unity, then the input impedance function of Figure 1 is:

$$Z_{\text{in}} = \frac{Z_1}{\{1 - (1 - \delta_1)(1 - \delta_2)(1 - Z_2/Z_3)\}} \tag{4}$$

and that of Figure 2 is:

$$Z_{\text{in}} = \frac{Z_1}{\{1 - (1 - \delta_1)(1 - \delta_2)(1 - Z_2/R_x)\}}. \tag{5}$$

It is evident from (4) and (5) that because of this non-ideality the actual values of the simulated components are slightly affected.

The incremental sensitivity measure of input impedance functions as given by (4) and (5) with respect to the gain deviation δ (with $\delta_1 = \delta_2 = \delta$) of the voltage buffer when used in (1) and (2) as:

$$S_{\delta}^{Z_{\text{in}}} = \frac{2\delta(1 - \delta)}{\{1 - (1 - \delta)^2(1 - Z_2/Z_3)\}}\left(1 - \frac{Z_2}{Z_3}\right). \tag{6}$$

It is evident from (6) that the incremental sensitivity of (4) and (5) with respect to gain deviation δ of the voltage buffers is found to be low in magnitude.

4 SPICE SIMULATION AND VERIFICATIONS

The working ability of the GIC is presented here and has been confirmed by SPICE simulations. The SPICE model of the current conveyor of reference [3] was used in the simulation. The voltage and the current wave shapes across an ideal inductor of 0.1 H realized from GIC of Figure 1 with $Z_1 = Z_2 = R = 10\,\text{k}\Omega$ and $Z_2 = 1/sC_2$ with $C_2 = 1.0\,\text{nF}$ are shown in Figure 3, which shows a good agreement with the theory.

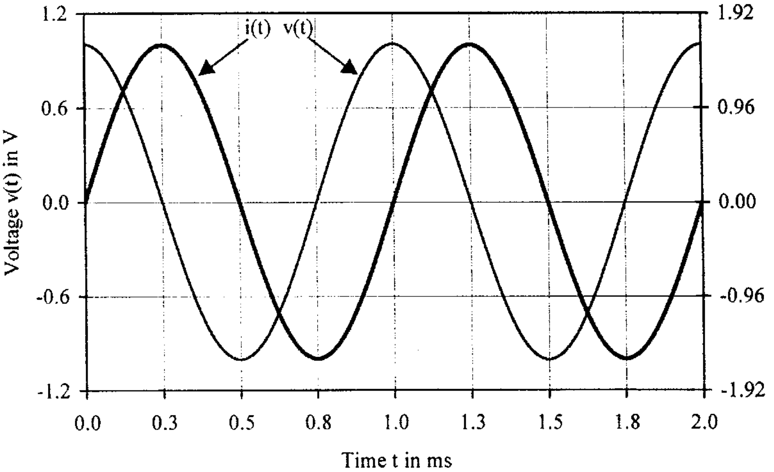

FIGURE 3 Voltage $v(t)$ and current $i(t)$ wave shapes across the simulated ideal grounded inductor from GIC of Figure 1.

5 CONCLUSIONS

A new generalized impedance converter using single CCII(−) is presented. This GIC is capable of realizing ideal grounded inductor, capacitor/resistor multipliers and frequency-dependent negative resistance. The GIC presented also enjoys the advantages of realization of ideal simulators without any matching constraints. The GIC can also be made tunable over a wide range for simulated parameters by replacing CCII(−) with CCCII(−). The SPICE simulated results of GIC verify the theory. However, by adding the tuning facility the GIC loses the capability for FDNR realization. The effects of non-ideal voltage buffers on the realized impedance functions are also examined.

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