LOW VOLTAGE DOCCII-BASED BIQUAD FILTER

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ABSTRACT

In this paper a novel Dual Output Current Conveyor (DOCCII) based on second generation current conveyors (CCIIs) is proposed. The DOCCII having the particular feature that output signals show a very little phase shifting between the two high impedance current outputs. The circuit has been implemented in a standard CMOS technology (AMIS 0.7 μm), using a supply voltage of ±1 V.

A current-mode biquad filter using as active elements unity gain current conveyors is presented. The structure shows one input and three different outputs, performing simultaneously low-pass, band-pass and high-pass filtering operation. Circuit simulations are shown attractive characteristics.

1. INTRODUCTION

Current-mode circuits are receiving significant attention for their potential advantages of inherent wider bandwidth, simpler circuitry, lower power consumption, and wider dynamic range [l],[2]. In these circuits the main active element is classically the second generation current conveyor (CCII).

In this paper a current-mode filter with one input and three outputs, using three CCIIs with two outputs and only two grounded capacitors, is presented.The proposed filter presents low passive and active sensitivities and the attractive characteristic of independent control of the current transfer function parameters. Furthermore, the fact that all the passive elements are grounded makes it suitable for integrated realizations; the circuit has been simulated with orcad 9.2 using 0.7 um process model from AMIS.

2. DUAL OUTPUT CURRENT CONVEYOR

Dual output current conveyor is four terminal devices representing a simple modification of the CCII topology, obtained implementing another output terminal, and named Z−, on CCII architecture [3]. The latter terminal has to show a current flowing in the opposite direction with respect to the conventional output Z+. DOCCII basic block and characteristics matrix are shown in figure 1.

$$\begin{bmatrix} i_Y \\ v_X \\ I_{Z+} \\ I_{Z-} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ A & 0 & 0 \\ 0 & +B & 0 \\ 0 & -B & 0 \end{bmatrix} \cdot \begin{bmatrix} v_Y \\ i_X \\ v_Z \end{bmatrix}$$

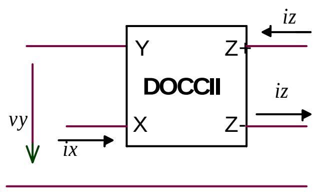

Figure 1: Characteristic matrix and basic block of DOCCII.

Where A and B must be close to 1. For what concerns terminal impedances, as in basic CCII, Y, Z+ and Z− are high impedance nodes, while X terminal shows a low impedance value.

2.1. DUAL OUTPUT CURRENT CONVEYOR IMPLEMENTATION

A proposed dual output version of a given CCII is easily obtained simply adding some current mirrors at the output node**Error! Reference source not found.**. the corresponding dual output version is presented in figure 2, so obtaining a different current conveyor, having two output terminals (named Z+ and Z-).

One of these terminals (Z+) gives the same current flowing at X node, while the other (Z-) gives it with the opposite sign. In this way an "improved" second generation current conveyor, named dual output current conveyor (DOCCII), has been built-up. DOCCII allows an easy implementation of a biquad filter but causes an increase in power consumption.

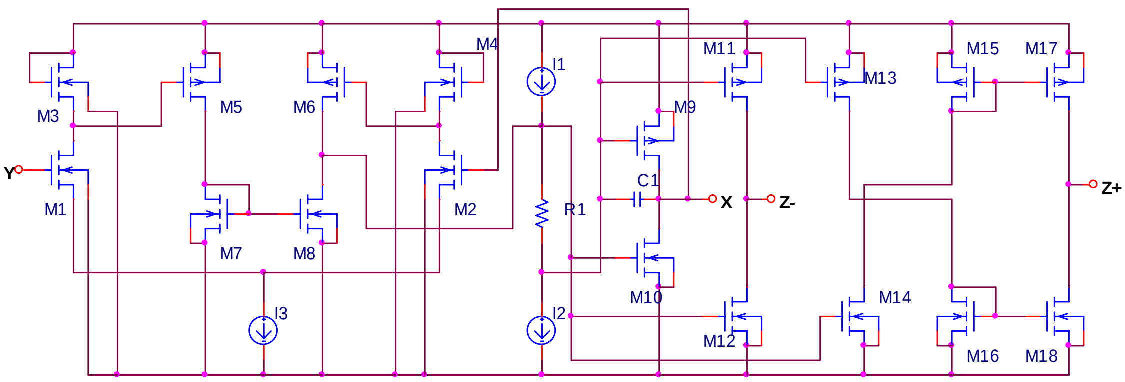

Figure 2: LV OTA based DOCCII scheme.

The proposed CCII has been designed in a standard CMOS technology (AMIS 0.7µm). It has been characterized from the electric point of view at the input and output nodes once the MOS aspect ratios have been optimized for the total supply voltage of 2 V (±1V). In order to verify the effective behavior of the filter topology, the parasitic impedances of the proposed CCII have been evaluated too.

In figure 3, the simulated results concerning input impedance at X node, output impedance at Z± node, dynamic range and current transfer ratio giving satisfied values in low voltage supply. The main simulated results of the DOCCII, have been summarized in table1.

$$r_X \cong \frac{2}{g_{m2}(g_{m9} + g_{m10})} \tag{1}$$

$$r_Z = \frac{r_{O11} r_{O12}}{r_{O11} + r_{O12}} \tag{2}$$

Characteristics	Value
R_x	26 ohm
R_{z+}	280 Kohm
R_{z-}	260 Kohm
Dynamic range	360mV to -500mV
-3dB Bandwidth	35MHz
V_{DD}, V_{SS}	±1v

Table 1: DOCCII characteristics.

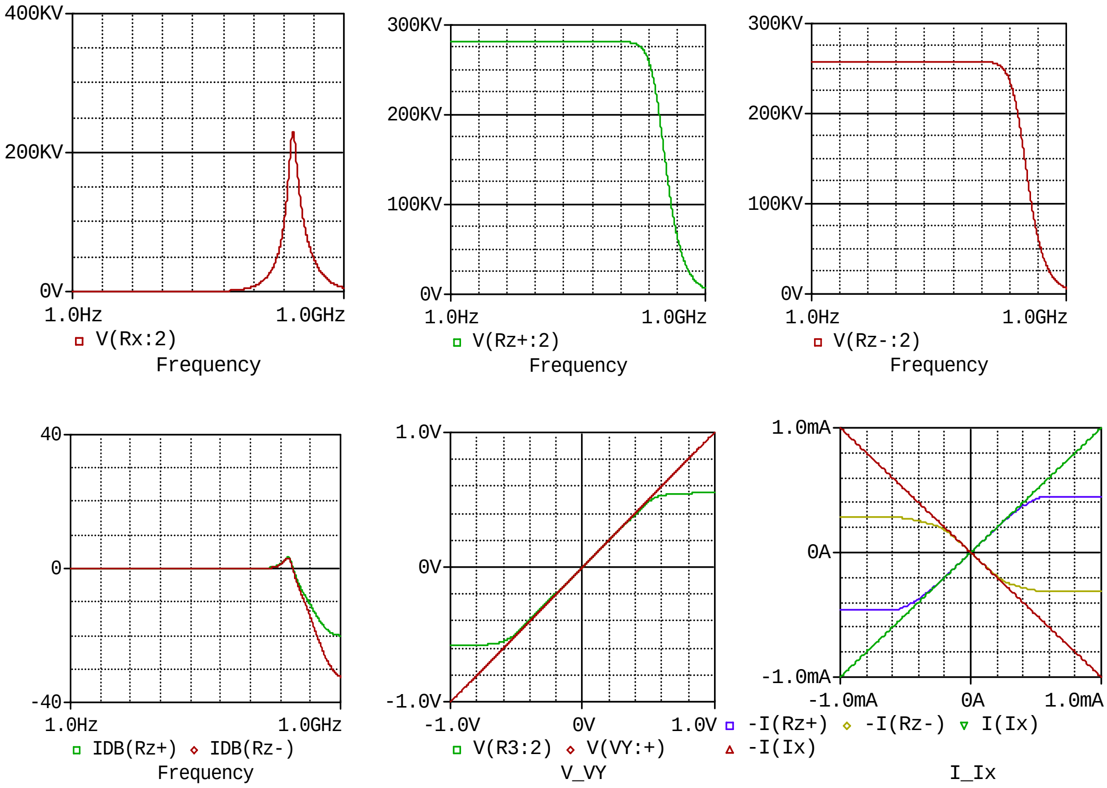

Figure 3: DOCCII simulations.

3. DOCCII-BASED FILTERS

Current-mode filter with one input and three outputs is presented in figure 4, using three DOCCIIs depicted in figure 1 only two grounded capacitors,. It can simultaneously realize low-pass, band-pass and high-pass responses. This circuit is derived from the Kenvin-Huelsman-Newcomb (KHN) structure[4]. Filter with one input and three outputs is reported, but the number of active and passive elements is higher with respect to this kind of circuit. The proposed filter presents low passive and active sensitivities and the attractive characteristic of independent control of the current transfer function parameters. Furthermore, the fact that all the passive elements are grounded makes it suitable for integrated realizations, because the resistors can be replaced with OTAs configured as positive resistors. The circuit has been determined by means of the following considerations. One of the most popular biquad structures for classical op amp-based RC filters is the KHN circuit, in which a summer and two integrators are present.

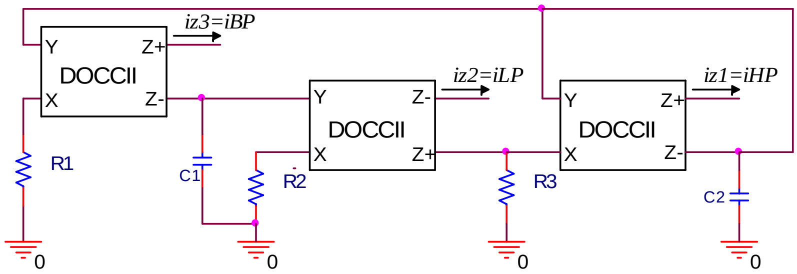

Figure 4: CCII-based biquad universal filter.

In the circuit in figure 4 the output voltage-input current ratio for the first and third CCII is of integrator kind. The first CCII transforms the output voltage of the third CCII in a current through the resistor R1. Then the relation between IZ1 and IZ3 is of integrator kind. On the other hand the second CCII transforms the output voltage of the first CCII in a current through the resistor R2. Then the relation between IZ2 and IZ1 is of integrator kind. The third CCII performs the adding function, because IZ3 is equal to the sum of: a) the input current Iin b) the current IZ2 and c) the integration of the current IZ3 performed through the feedback of the third CCII and the resistor R3.

Routine analysis allows deriving the following low-pass eq. (3), band-pass eq. (4) and high-pass eq. (5) transfer functions:

$$\frac{i_{LP}}{i_{IN}} = \frac{\frac{1}{R_1 R_2 C_1 C_2}}{S^2 + \frac{S}{R_3 C_2} + \frac{1}{R_1 R_2 C_1 C_2}} \tag{3}$$

$$\frac{i_{LP}}{i_{IN}} = \frac{\frac{1}{R_1 C_2}}{S^2 + \frac{S}{R_3 C_2} + \frac{1}{R_1 R_2 C_1 C_2}} \tag{4}$$

$$\frac{i_{LP}}{i_{IN}} = \frac{S^2}{S^2 + \frac{S}{R_3 C_2} + \frac{1}{R_1 R_2 C_1 C_2}} \tag{5}$$

From the previous analysis it is clear that the filter behavior is ensured by three current conveyors. The dual output version is needed only if the three different filter outputs are separately needed.

Figure 5 shows the three output currents of the circuit in figure 4. Simulation results are in a good agreement with the theoretical calculations. The behavior has been optimized, for a central frequency of 15 KHz, for the three outputs, but a wide tuning range has been obtained.

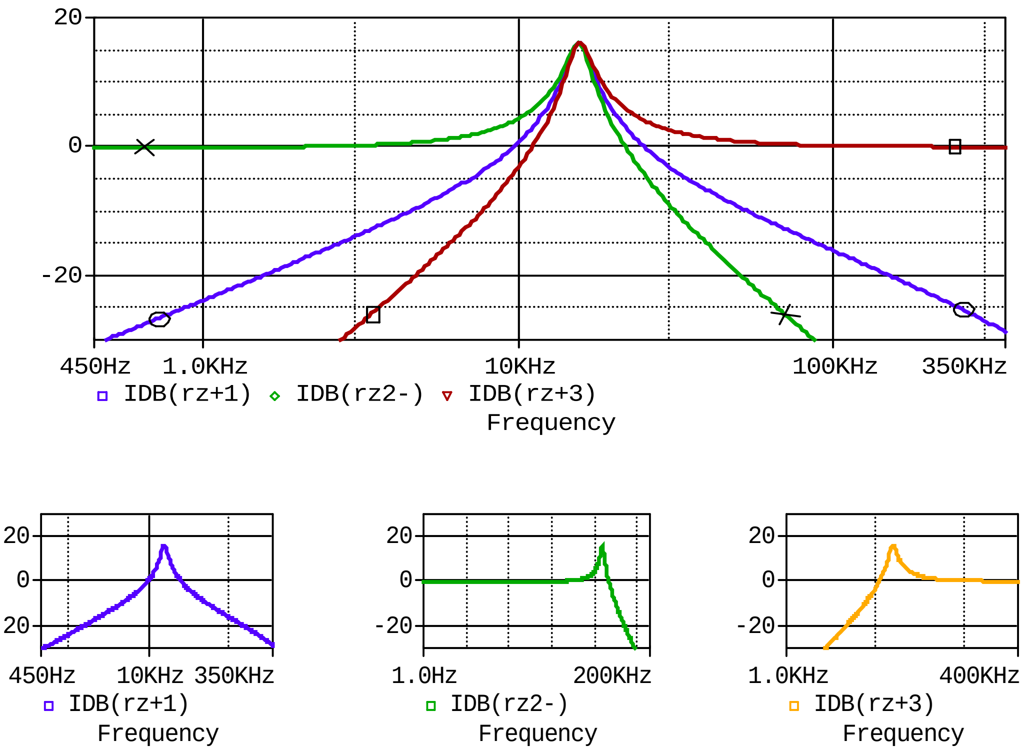

Figure 5 : DOCCII based-biquad filter response.

4. CONCLUSION

In this paper a new architecture of unity gain low voltage (±1v) DOCCII as active element is used to construct tunable current mode biquad filter with one input and three outputs, with interest results and attractive features.

To conclude, we summarize the contributions of the present work to say; new architecture of DOCCII are presented. The DOCCIIs designed using model 0.7um from AMIS to operate at low supply voltage and showing good performance are verified. Simulations using Pspice orcad 9.2 confirm good performance of such conveyor and validity of using it in analog functions.

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