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Positive current output DVCC-based first-order APSs

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Abstract: *This paper introduces voltage-mode and current-mode first-order all pass sections (APSs) employing positive current output differential voltage current conveyors (DVCCs) and grounded capacitor. The circuits enable all pass characteristics by choosing the current output of the DVCC. Additionally, the circuit parameters ω_0 and H can be set independently through adjusting the circuit components. The APSs enjoy very low sensitivity to circuit passive components.*

Keywords: *active circuit, all pass characteristic, DVCC, CMOS technology*

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I. Introduction

High performance active circuits have received much attention. The circuit designs employing active devices such as second generation current conveyors (CCIIs), operational trans-conductance amplifiers (OTAs) and DVCCs have been reported in the literature [1]-[10].

A DVCC is a very useful active device, and DVCC-based circuit is suitable for high frequency operation. The circuit designs with the DVCC performances have been discussed in the past [3]. There are two kinds of the DVCC. One is positive current output DVCC, another is negative current output one. The positive current output DVCC is composed of a simpler circuit configuration than the negative current output one. Hence it has a wide band operation and low power performance compared with the negative current output DVCC.

An APS is a very useful function block for realizing phase shifter, phase equalizer, oscillator and so on. The APS designs using the CCII, DVCC and differential difference current conveyor (DDCC) etc. have been discussed [4]-[10]. However the APS based on the positive current output DVCCs hasn't been studied sufficiently. In addition, the independent tuning capability for the circuit parameters ω_0 and H is needed.

This paper introduces voltage-mode and current-mode first-order APSs using positive current output DVCCs and grounded passive components. The circuits enable the all pass characteristics by choosing the current output of the DVCC. Additionally, the circuit parameters ω_0 and H can be set independently by adjusting the circuit components. It is made clear that the APSs have very low sensitivities with respect to the circuit components.

The circuit configurations are very suitable for implementation in CMOS technology.

II. DVCC

Figure 1 shows the symbol for the positive current output DVCC. This shows dual current output DVCC.

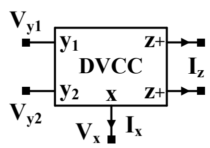

Figure 1: Symbol for DVCC

The DVCC is characterized by the following terminal equations:

$$V_x = V_{y1} - V_{y2}, \quad I_z = I_x \qquad (1)$$

Moreover the DVCC [3] with MOS transistors is shown in Fig.2.

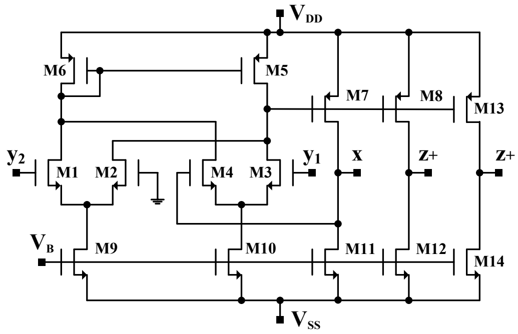

Figure 2: Positive current output DVCC with MOS transistors

III. Circuit configuration and analysis

Figure 3 shows basic current-mode APS configuration. The circuit is constructed with one positive current output DVCC and grounded passive components.

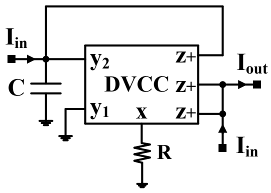

Figure 3: Basic current-mode APS configuration

The circuit transfer function $T(s)(=I_{out}(s)/I_{in}(s))$ is given by:

$$T(s) = \frac{-1 + sCR}{1 + sCR} \qquad (2)$$

The voltage-mode APS configuration is consisted of the basic current-mode APS shown in Fig.4.

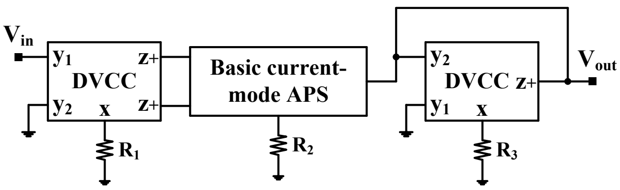

Figure 4: Voltage-mode APS configuration

The circuit transfer function $T(s)(=V_{out}(s)/V_{in}(s))$ is given by:

$$T(s) = \frac{R_3(-1 + sCR_2)}{R_1(1 + sCR_2)} \qquad (3)$$

The circuit parameters ω_0 and H can be expressed as:

$$\omega_0 = \frac{1}{CR_2}, \quad H = \frac{R_3}{R_1} \qquad (4)$$

The parameter ω_0 can be set by R_2 and C. The parameter H are able to be set by R_1 and R_3 without disturbing ω_0. Therefore, this circuit has independent tuning capability for the circuit parameters.

The phase response is given by:

$$\theta = \pi - 2\tan^{-1}(\omega CR_2) \qquad (5)$$

In (5), θ shows the phase response of the current output in the first stage DVCC. The phase θ takes the value of from π to 0 with the angular frequency ω.

Figure 5 shows current-mode APS configuration.

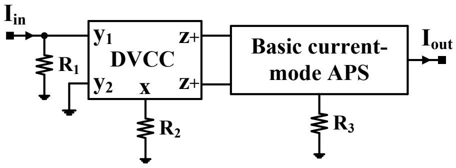

Figure 5: Current-mode APS configuration

The circuit transfer function $T(s)(=I_{out}(s)/I_{in}(s))$ is given by:

$$T(s) = \frac{R_1(-1 + sCR_3)}{R_2(1 + sCR_3)} \qquad (6)$$

The circuit parameters ω_0 and H become:

$$\omega_0 = \frac{1}{CR_3}, \quad H = \frac{R_1}{R_2} \qquad (7)$$

It is found from equation above that the circuit parameters ω_0 and H can be tuned independently like as the voltage-mode one.

The phase response θ is given by:

$$\theta = \pi - 2\tan^{-1}(\omega CR_3) \qquad (8)$$

In addition, the APSs with other operation modes (i.e. trans-admittance-mode and trans-impedance-mode) can be realized using the basic current-mode APS.

We consider below the deviations of the circuit components on the circuit characteristic. Table 1 shows the sensitivities with respect to the circuit components (R_1, R_2, R_3 and C). We can find from these values that the APSs enjoy very low sensitivities to the circuit components. It is also noted that the sensitivities do not depend upon the circuit component values.

Table 1 Sensitivity to circuit components.

(a) voltage-mode APS

x	ω_0	H
R_1	0.0	-1.0
R_2	-1.0	0.0
R_3	0.0	1.0
C	-1.0	0.0

(b) current-mode APS

x	ω_0	H
R_1	0.0	1.0
R_2	0.0	-1.0
R_3	-1.0	0.0
C	-1.0	0.0

IV. Conclusion

The voltage-mode and current-mode first-order APSs using positive current output DVCCs and grounded passive components have been presented. The circuits enable all pass characteristics, and the circuit parameters can be tuned independently by the circuit components. It has been made clear from sensitivity

analysis that the APSs enjoy good sensitivity performance to the circuit passive components. The circuit configurations have some advantages (i.e. wide band operation, low power performance, independent tuning for circuit parameters).
The non-idealities of the DVCC affect the circuit characteristic. A solution on this must be discussed further.

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