Reduction of divider circuit errors

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Abstract **The analog divider based on transconductance multiplier is analyzed to determine its uncertainty due to voltage offsets. In the paper is shown, the divider errors can be reduced.**

Keywords **transconductance multiplier, analog divider, compensation, offset voltage**

I. Analog divider

Sometimes it is needed to use analog computation of the fact that it has wide bandwidth. The main element used in this analog processing is the multiplier which can be produced in many ways. The most popular multiplier is the transconduktance circuit.

Math operations as a division, a square, a root are realized based on multiplication function. The ratio circuit (divider) consist of a multiplier connected as a feedback element of an operational amplifier configuration. It is called "inverted multiplier" [1].

II. Transconductance divider errors

The output of the practical divider will differ from the theoretical ratio of its inputs by a generally unpredictable influences. The equation of the real divider [2] can be achieved:

$$U_{out} = \frac{1}{a}\Big(\frac{U_{in}}{X + X_o} + \frac{U_o - Z_o}{X + X_o}\Big) - (Y_o + W_o). \quad (1)$$

The block diagram of the circuit is shown in Figure 1.

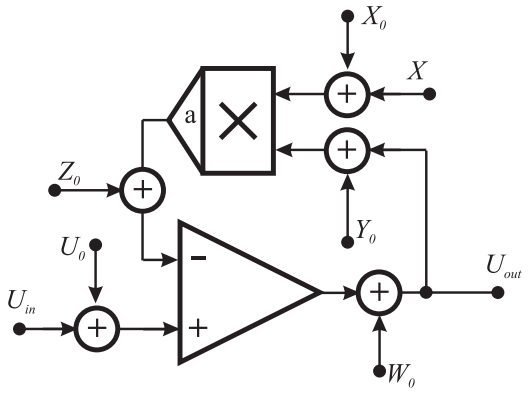

Fig. 1. Scheme of the analog divider

III. Compensation of divider errors

Sequence of operations to calibrate are:

1. Input voltage is set to zero, therefore equation (1) is reduced to form:

$$U_{out} = \frac{1}{a}\overbrace{\frac{U_o - Z_o}{X + X_o}}^{compensation} - (Y_o + W_o). \quad (2)$$

The nominator of first part equation is sum, therefore it can be compensate as the whole. The sum will be zero if $U_{\rm out}$ is constant and X is variable (ramp waveform). For practical use it is used similar circuit to calibration system for multiplier [3]. Correct scope traces of $(U_o - Z_o)$ compensation are presented on Figure 2a. If the expression is not compensated, scope traces are similar to Figure 2b. The denominator of expression (2) is working close zero therefore divider is not stable.

2. The next step is compensation the term of operation

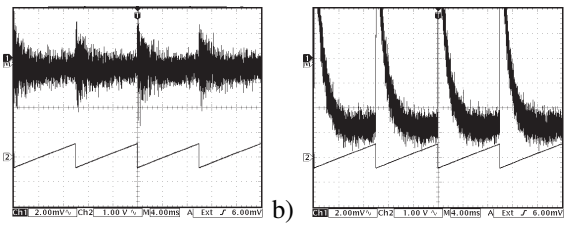

Fig. 2. Compensation scope traces of the divider

$-(Y_o + W_o)$. In that case $U_{in} = 0$. The compensation is finished if $U_{out} = 0$.

3. The last offset voltage which is needed compensation is $X_{\rm o}$. Compensation's condition for ideal "a" factor is:

$$U_{\rm wy} = \text{const} = \frac{1}{a}, \quad (3)$$

for $U_{in} = X = \text{var}$.

IV. Conclusion

Errors of analog divider based on multiplier can be reduced. Many of contemporary analog multipliers are being compensated just in time production If higher accuracy of ratio circuit is needed, external compensation had to be done. In the paper it is presented simple errors compensation method for the analog divider based on "inverted multiplier"

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