Hybrid six-input operational transconductance amplifier

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Abstract **The paper presents idea and practical realizations of multiple input transconductance operational amplifier (MIOTA) of hybrid integrated circuit (HIC). There have been presented applications of HIC-MIOTA for analog signal processing systems which are digitally controlled. There are shown the samples of output voltage curves vs. time for voltage integrator with digitally adjustable gain by analogue switches based on MIOTA.**

Keywords **multiple input operational transconductance amplifier, analog signal processing**

I. Introduction

Electronic amplifiers with multi-terminal inputs enable to design the analog active systems with a small amount of elements. These systems can be easily controlled by digital signals. One of those is multiple input operational transconductance amplifier (MIOTA) depictured by symbol presented in Fig. 1., with the main equation in the form of

$$I_o = G_m\left(\sum_{k=1}^{n} V_{pk} - \sum_{k=1}^{n} V_{nk}\right). \quad (1)$$

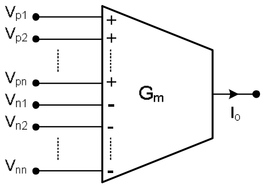

Fig. 1. Symbol of multiple input operational transconductance amplifier (MIOTA)

II. Practical realizations of MIOTA

The paper presents practical realization of six-input operational transconductance amplifier based on operational amplifiers shown in Fig. 2a. Assuming, that the gain of each amplifier is infinitely great, the voltages at the nodes (b÷g) are given by the following equations

$$V_b = V_{n1}\left(1+\frac{R}{R}\right) - V_a = 2V_{n1} - V_a, \quad (2)$$

$$V_c = V_{p1}\left(1+\frac{R}{R}\right) - V_b\frac{R}{R} = 2V_{p1} - V_b, \quad (3)$$

$$V_d = V_{n2}\left(1+\frac{R}{R}\right) - V_c\frac{R}{R} = 2V_{n2} - V_c, \quad (4)$$

$$V_e = V_{p2}\left(1+\frac{R}{R}\right) - V_d\frac{R}{R} = 2V_{p2} - V_d, \quad (5)$$

$$V_f = V_{n3}\left(1+\frac{R}{R}\right) - V_e\frac{R}{R} = 2V_{n3} - V_e, \quad (6)$$

$$V_g = V_{p3}\left(1+\frac{R}{R}\right) - V_f\frac{R}{R} = 2V_{p3} - V_f. \quad (7)$$

a)

b)

c)

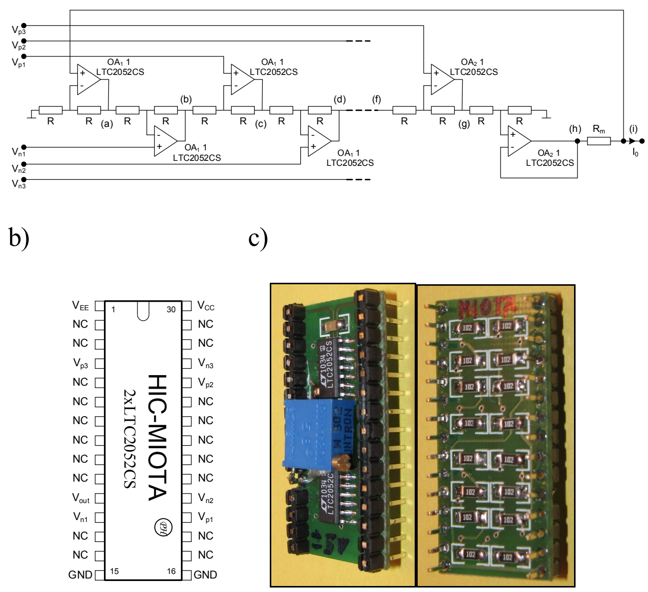

Fig. 2. Realization six-input operational transconductance amplifier of HIC: schematic diagram (a), connection diagram (b) and the view (c)

Taking into account equations (2÷6) the Eqn. (7) can be rewritten in the form

$$V_g = 2\left(V_{p3} - V_{n3} + V_{p2} - V_{n2} + V_{p1} - V_{n1} + \frac{1}{2}V_a\right). \quad (8)$$

Finally, the output current is given by the formula

$$I_o = G_m(V_h - V_i) = G_m\left(\frac{1}{2}V_g - \frac{1}{2}V_a\right) = G_m(V_{p3} - V_{n3} + V_{p2} - V_{n2} + V_{p1} - V_{n1}) = . \quad (9)$$
$$G_m\left(\sum_{k=1}^{3} V_{pk} - \sum_{k=1}^{3} V_{nk}\right)$$

The prototype constructed of six-input operational transconductance amplifier of hybrid integrated circuits (HIC-MIOTA) presented in Fig 2c. is made by surface mount technology (SMT) which package size is 1206. Printed circuits board is designed for chip carrier of type DIP-600 mil. These integrated circuits are compatible with standard sockets. There have been used the resistances R=1kΩ at tolerance of 0,1%. The amplifiers are two integrated circuits, each of them consist of four operational amplifiers of type LTC2052CS. Connection diagram is shown in Fig. 2b. Firstly, the resistance R_m has been replaced by potentiometer of 5kΩ. Finally, in the place of resistance R_m will be put non-volatile digital potentiometer of type MCP4023.

III. APPLICATIONS BASED ON HIC-MIOTA

Basing on multiple input operational transconductance amplifier and analogue switches (AS) can be easily built digitally controlled current source with adjustable gain by difference input voltage (Fig. 3).

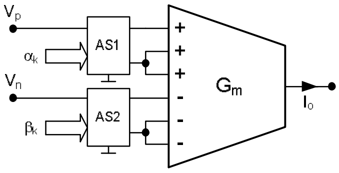

Fig. 3. Digitally controlled current source based on HIC-MIOTA. (gain is controlled by difference input voltage)

The output current is given by the relation

$$I_o = G_m(\sum_{k=1}^{3}\alpha_k V_p - \sum_{k=1}^{3}\beta_k V_n)\,. \qquad (10)$$

The voltage integrator is obtained when the capacitor C is put on the output of circuit in Fig. 3., and the input V_p and V_n are connected directly. The gain of voltage integrator is digitally tuned by analogue switches.

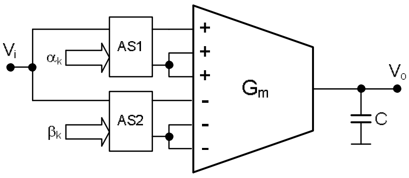

Fig. 4. Voltage integrator based on HIC-MIOTA with digitally adjustable gain by analogue switches

The output voltage of circuit in Fig. 4. is given by

$$V_0 = \frac{\sum_{k=1}^{3}\alpha_k - \sum_{k=1}^{3}\beta_k}{sR_mC}V_i\,. \qquad (11)$$

IV. EXPERIMENTAL RESULTS

In order to present features of the prototype six-input operational transconductance amplifier the laboratory measurement of constructed voltage integrator with digitally adjustable gain by analogue switches (Fig. 5). In this circuit the four analogue switches (2xDG303B) and debunced logic switch (SW_1-SW_4 and 74LS14) have been applied for digital control. The waveforms of measurements have presented in Fig. 6.

V. CONCLUSION

The hybrid model of six-input operational transconductance amplifier described in this paper can be applied for initial researches and simulations of systems with them. The presented researches enable the design and realizations of MIOTA in other technologies.

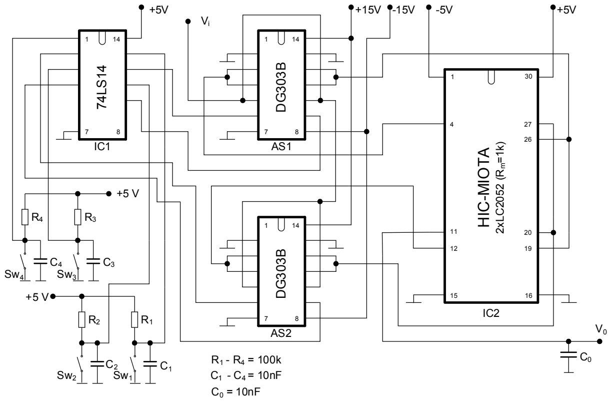

Fig. 5. Practical realization of voltage integrator with digitally adjustable gain by analogue switches

a) b)

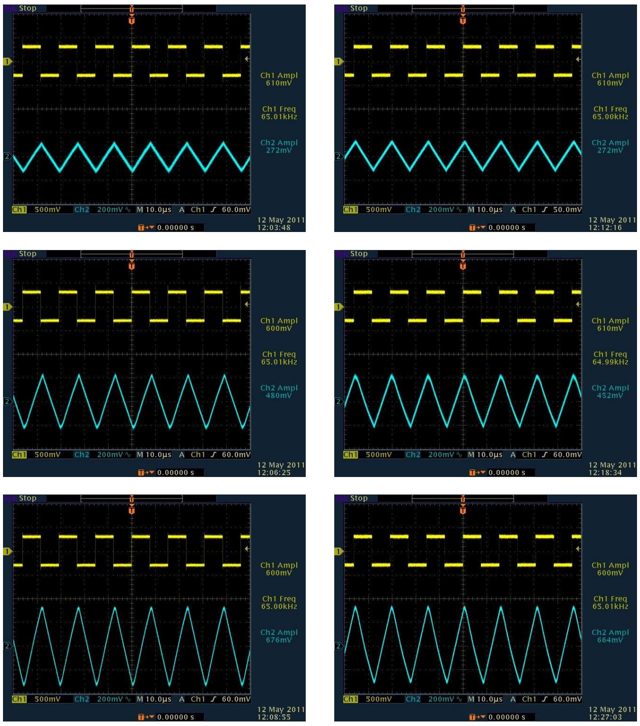

Fig. 6. Waveforms of output voltage of integrator in Fig. 5 for square signal given at input V_i for parameters: (a) α = (1, 2, 3) and β = 0, and (b) α = 0 and β = (1, 2, 3)

VI. REFERENCES

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