Design of Operational Transconductance Amplifierer based Multiplier

Neha Niharika
HMR Institute of Tecnology
Electrical & Electronics Department
Delhi

Swatantra Kumar
Sharda University
Electronics and Communication Department
Greater Noida, India

Abstract- **In recent years interests have been seen in wireless system and software radio using sigma-delta modulators to digitize signals near the front end of radio receivers. Such applications necessitate clocking the modulators at a high frequency (MHz or above). A continuous-time implementation using transconductors and integrators rather than discrete time implementation using switched capacitors is preferred for high frequency operation. OTA based multiplier containing two OTA's and transistor connected diode is based on 0.3µm pwell CMOS technology simulated using Pspice software**.

I. INTRODUCTION

The OTA is a programmable device and has only a single high-impedance node, in contrast to conventional op amps. This makes the OTA an excellent device candidate for high-frequency and voltage (or current) programmable analog basic building blocks.The applicability of OTA based multiplier as components in the design of linear networks has been extensively discussed. The multiplier has gigahertz frequency response is suitable to use in communication system. Excellent contributions are reported of OTA based multiplier dealing with particular important nonlinear problems. In this paper, rather than try to tackle a specific problem, we focus our attention on a general approach dealing with multiplier. Nothing special is done to optimize the circuit performance but rather to explore the potential and applicability of the OTA-based Multiplier in communication systems.

II. OTA BASED MULTIPLIER DESIGN

A two-input four-quadrant multiplier has an output current given by

$$I_0 = K_m V_1 V_2 \qquad (1)$$

where the multiplier constant K_m has units of amperes per square volt.

If V_1 and V_2 can take any positive or negative sign, the multiplier is called a four-quadrant multiplier.

This OTA based multiplier is represented in Fig.1(a). The corresponding OTA-based implementations are shown in Fig. 1(b) and 1(c).The triangular block labeled a represents a signal attenuation (with an 'attenuation factor *a); its function is to* equalize the maximum voltage swing of V_1 and V_2..

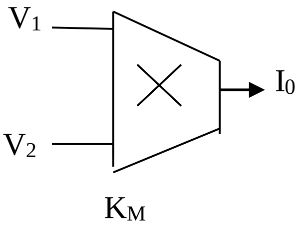
– V_{BIAS} is the usual-bias control of the OTA The two options of Fig. 1(b) and Fig. 1(c) allow us to change the sign of K_m . Thus for the circuit of Fig. 1(b) we obtain

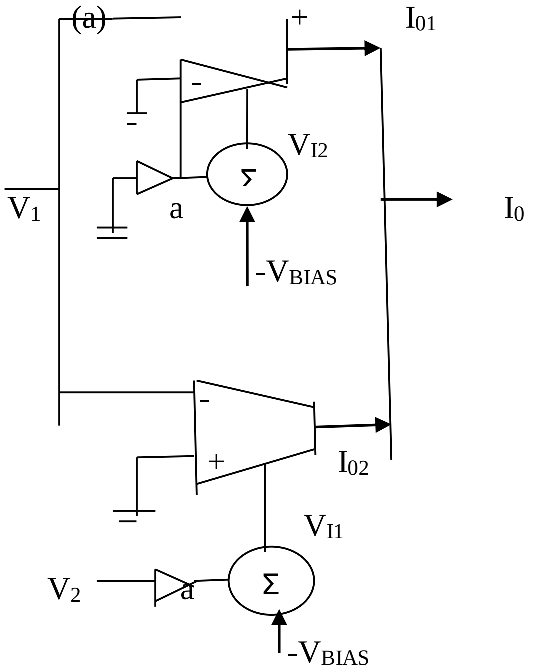
$$I_{01} = g_{m1} V_1 = K(V_{I1} + V_{SST}) V_1 \qquad (2)$$

$$I_{02} = - g_{m2} V_1 = - K(V_{I2} + V_{SST}) \qquad (3)$$

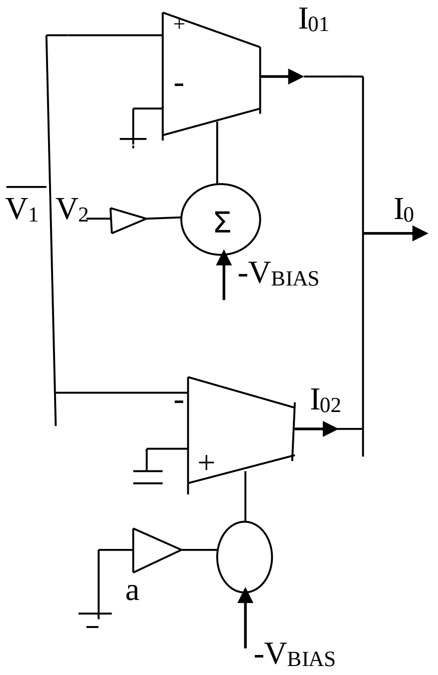
Where K is a process and geometry dependent constant,

$V_{SST} = V_{SS} – V_t$, and V_t is a transistor threshold voltage





(b)



(c)

Fig. Multiplier: (a) symbol, (b) OTA implementation 1, and (c) OTA implementation 2, 0< a <1.

$$V_{I1} = a_0 - V_{BIAS} \quad = \ - V_{BIAS} \qquad (3a)$$

$$V_{I2} = aV_2 - V_{BIAS} \qquad (3b)$$

The output current,

$$I_0 = I_{01} + I_{02}\,, \qquad (3c)$$

Put the values of I_{01} and I_{02}, in equation 3(c). Thus the output current becomes

$$I_0 = [K(-V_{BIAS} + V_{SST}) - K(a\,V_2 - V_{BIAS} + V_{SST}))]\,V_1$$

Or

$$I_0 = a\,K\,V_1\,V_2 = K_M\,V_1\,V_2\,, \qquad (4)$$

$$K_M = a\,K$$

A similar analysis of the circuit of Fig. 1(c) gives

$$I_0 = -\,a\,K\,V_1\,V_2\,, \qquad K_M = -\,a\,K$$

Therefore, we can make the sign of K_M positive or negative.

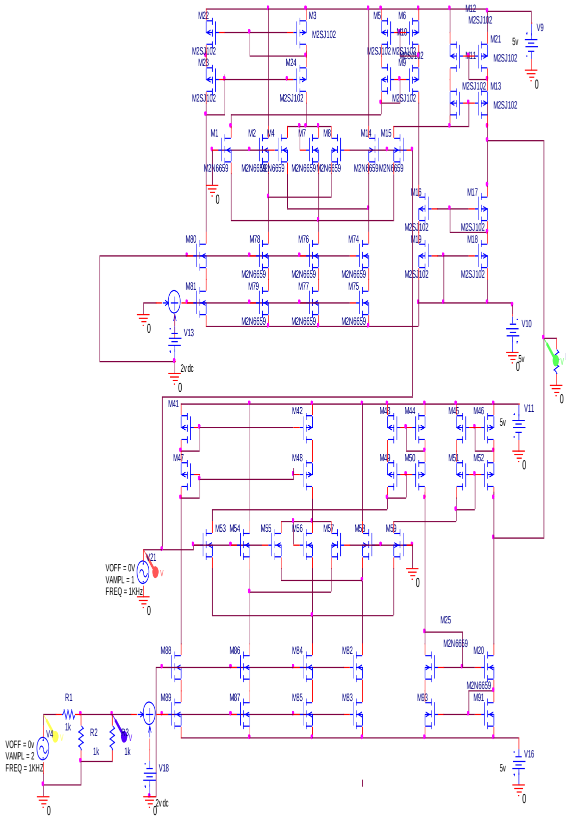


Fig.4 Internal circuit diagram of OTA Based multiplier.

III. EXPERIMENTAL RESULTS OF OTA MULTIPLIER

The structure used is as shown in Fig. 4. The measured value of K_M *is 3.3* pA/V^2. The output current was measured across a 100-kΩ load resistor.

The nonlinearity error is shown in Fig. 5 For V_2 is 2V signal is applied, while keeping V_1 equal to 1 V.

Fig. 6 shows the multiplier being used as a modulator where both input signals are sinusoidal.

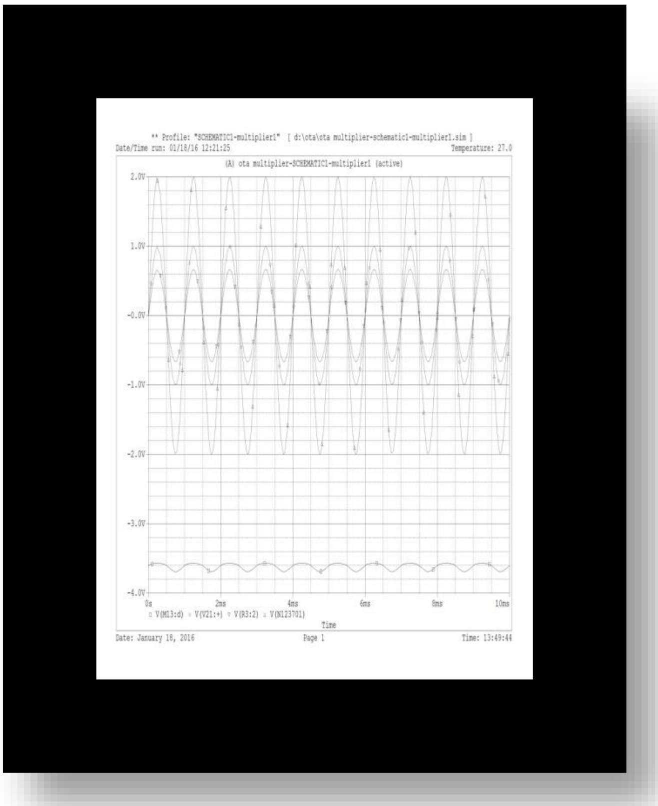


Fig.5 Nonlinearity multiplier error: fixed *V2=1* V and variable *VI.*

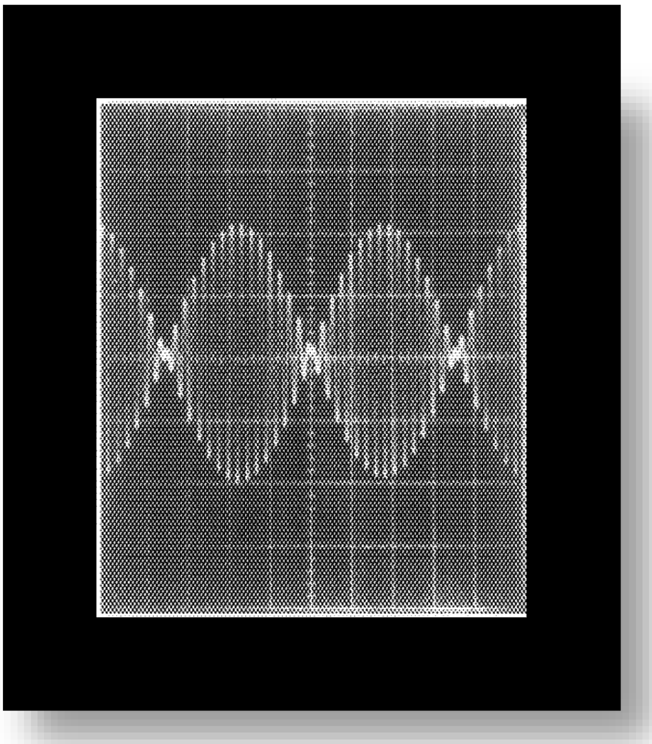


Fig. 6 Multiplier as modulator

1V. CONCLUSION

A Multiplier based on OTA is proposed. The multiplier has gigahertz frequency response is suitable to use in communication system for high frequency applications. The circuit is based on 3.0 µm pwell CMOS technology simulated using PSPICE software.

This technique provides; wide dynamic range, MHz-bandwidth response and low power consumption. The proposed circuit has been simulated with PSPICE software.

The primary application for an OTA is however to drive low-impedance sinks such as coaxial cable with low distortion at high bandwidth. Hence, “improved” OTA such as the MAX436 has optimized.

REFERENCES

1) Edgar Sanchez – Sinencio, seniormember, IEEE, Jaime, Ramirez – Angulo, member, IEEE, Bernabe linares-barranco, Andangel Rodriguez-Vazquez, member. A tutorial IEEE circuits
2) A Textbook of Operational Transconductance Amplifier and Analog Integrated Circuits Paperback – Import, 13 May 2010 by Tahira Parveen (Author)
3) http://www.itervis.com/simulation-and-layout-design-of-ota-amplifier/
4) R. L. Geiger and E. Sánchez-Sinencio, "Active Filter Design Using Operational Trans conductance Amplifiers: A Tutorial," *IEEE Circuits and Devices Magazine*, Vol. 1, pp.20-32, March 1985.
5) https://en.wikipedia.org/wiki/Operational_transconductance_amplifier.