# Implementation of Folded OTA

**Irish Barla[#1], Mohd. Abuzer Khan[*2]**

*[#]Electronics & Communication, R.G.P.V Bhopal*
*L.K.C.T. Indore M.P. India*
[1]irish.barla27@gmail.com
[2]abuzerlkct@gmail.com

***Abstract*— In this paper we have analysis of implementation of OTA using 0.12 µm using CMOS technique. The complete implementation and verification is done on the Tanner tool, Schematic of the folded OTA is designed on the S-Edit and net list simulation done by using T-spice and waveforms are analysed through the W-edit. The circuit is characterized by using the 0.12µm technology which is having supply voltage 0f 1.2volt.***

***Keywords*—CMOS, PMOSFET, NMOSFET, OTA, S-edit, W-edit.**

## Introduction

The operational amplifier are basic building block in implementing a verity of analogue circuits such as amplifiers, filters, integrator s, summers, oscillators etc. OPAMPs work well for low frequency applications like audio and video systems. For higher frequencies but OPAMP style become tough thanks to their frequency limit. At those higher frequencies operational trans-conductance amplifiers (OTA) are deemed to be promising to replace OPAM as the building blocks for various analogue circuits and systems. The best suited element for style of contemporary OTA is CMOS devices that has less power necessities. CMOS provides highest analogue-digital on chip integration. As the feature size of CMOS process reduces, the supply voltage reduced for the reduction of power dissipation per cell. Supply voltage reduction guarantee the responsible-ness of devices because the lower electrical field within layers of a MOSFET produces less risk to diluting oxides, which ends up from device scaling. However the reduction in supply voltage leads to degrade circuit performance in terms of available bandwidth and voltage swing. Scaling down the threshold voltage of the MOSFETs reduces the performance loss to some extent but there is increase in the static power dissipation. The performance of the digital circuit is improved by scaling but the analogue cell benefit marginally because minimum size transistor cannot be used due to nose and offset requirements, with a lot of effort dedicated by analogue IC researchers and therefore the continuous reducing on business semiconductor technologies, the rumoured OTA s will work-out to many hundred MHz's. The current trends in continual scaling down of transistor gate length and reduction in supply voltage have further added to the design challenges of analogue circuits. A direct consequence of this has been performance investigation of trans-conduction circuit made using advances CMOS process technology.

**Table 1 advantages of OTA over OPAMP**

| OPAMP | OTA |
|---|---|
| Voltage source output (low impedance) | Current source output (high impedance) |
| Essential to drive resistive loads | Cannot drive resistive loads |
| Essential OTA + buffer | Use capacitive (SC) feedback |
| Buffer increases power dissipation and noise. | Transistor are trans-conductor |

## Basic of OTA

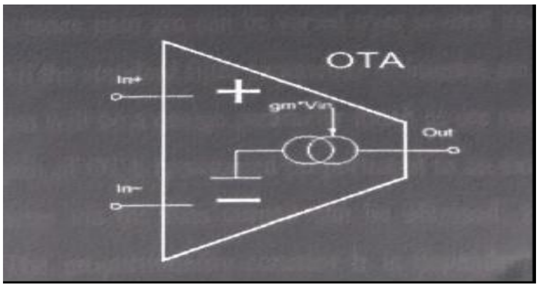
The OTA is a basic building block in analogue circuit application such as wireless communication, computer systems, biomedical circuits, instrumentation amplifier and control systems. The OTA received considerable attention as active components because the trans-conductance can be adjusted electronically. The key function of three OTA is to convert the input voltage into accuracy and linearity of output current are both maintained. The flexibility of the device to operate in both current and voltage modes allows for variety of circuit design. The ideal characteristics is therefore

$$I_o = g_m(V_+ - V_-)$$

Or by taking pre computed difference as the input

$$I_o = g_m(V_{in})$$

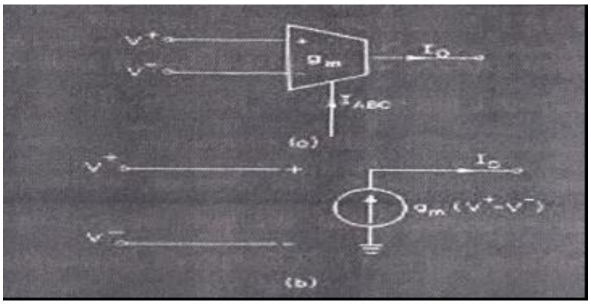
International Journal of Research
Available at https://edupediapublications.org/journals
p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 03 Issue 13
September 2016




**Block of OTA**

With the ideally constant trans-conductance as the proportionality factor between the two, in the reality the trans-conductance is also a function of input differential voltage and dependent on temperature. An OTA without buffer can only drives loads, it can be defined as an amplifier where all nodes are low impedance expect input and output nodes. The trans-conductance of an OTA is set by the trans-conductance of differential amplifier input. A feature of OTA is that its trans-conductance can adjusted by the bias current. Filters made using OTA can be tuned by the changing the bias current. OTA improve the input common range and power supply rejection of two stage op-amp.

The symbol used for the OTA is shown in figure along with the ideal small signal equivalent circuit.



**OTA symbol**

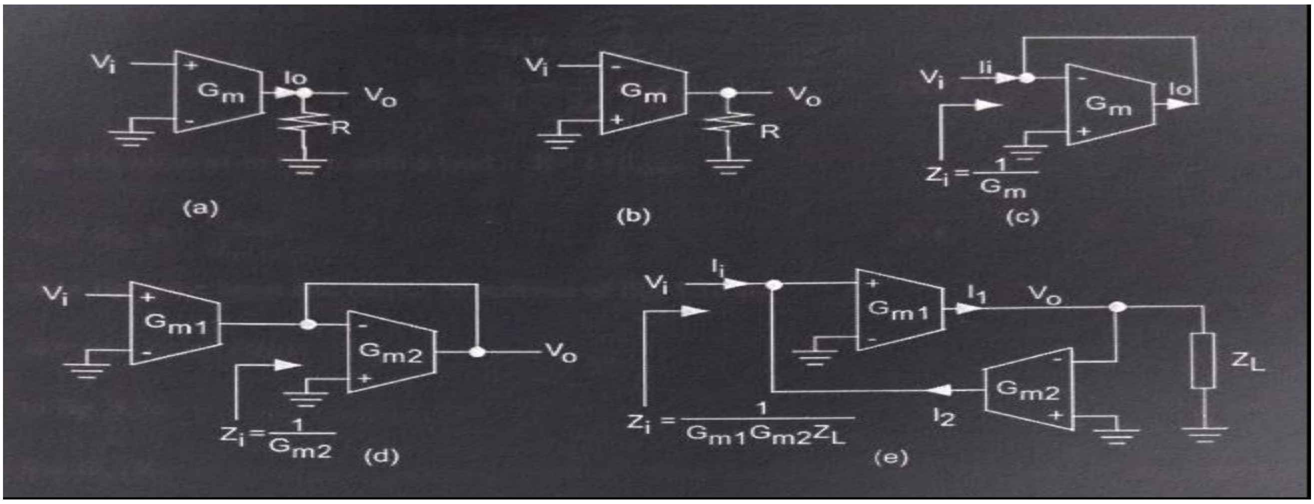
The symbol used for OTA is shown in figure along with the ideal small signal equivalent circuit. The trans-conductance gain a can be varied over several decades by adjusting external DC bias current $I_{ABC}$. All the standard filter parameter of interest are directly proportional to $g_m$ of the OTA. Thus the $g_m$ will be a design parameter much as are resistor and capacitors. Since the trans-conductance gain of OTA is assumed proportional to an external bas current, external control of filter parameter via the bias current can be obtained. Here $g_m$ is proportional to applied bias current. The proportionality constant h is dependent upon temperature, device geometry and the process.

$$G_m = hI_{ABC}$$

To summarize, an ideal OTA has two voltage input with infinite impedance (there is no input current). The common mode input range is also infinite, while the differential signal between these two inputs is used to control an ideal current source (the output current does not depend on the output voltage) that function as an output. The proportionality factor between the output current and input differentia voltage is called trans-conductance. Any real OTA will thus have circuitry to process the input voltages with low input current over a wide common mode input range, to produce an internal representation of the input differential voltage and to provide a current to the output that is relatively independent of output voltage. Since an OTA can be used without feedback, the maximum output current and with it is the trans-conductance $g_m$ often be adjusted.

The OTA is popular for implementing voltage controlled oscillator (VCO) and filter (VCF) for analogue music synthesizer, because it can act as a two quadrant multiplier. Viewed from slightly different angle an OTA can be used to implement an electrically tuneable resistor that is referenced to ground, with extra circuitry floating resistors are possible as well. The primary application for an OTA is however to drive low impedance sink such as coaial cable with low distortion at high bandwidth.

## OTA Simple Building Block Circuit



International Journal of Research
Available at https://edupediapublications.org/journals

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 03 Issue 13
September 2016

**OTA simple building block**

$$I_O = G_m V_i$$

$$V_O = RI_O = G_M RV_i$$

$$A_v = \frac{V_O}{V_i} = G_M R_i$$

$Z_i = \infty$, since the input impedance of OTA is infinite and $Z_o$=R, since the output impedance of OTA is infinite [6].

In figure (b) is same as figure (a) expect for the input inversion resulting in negative gain.

$$Z_i = \frac{V_i}{I_i} = \frac{1}{G_{m1} G_{m2} Z_L}$$

That is, the input impedance is reciprocal of the load impedance. If the load impedance is capacitive, then the input impedance in inductive. This circuit is an impedance convertor since the output impedance of OTA1 and OTA2 are both infinity, the circuit output impedance is:

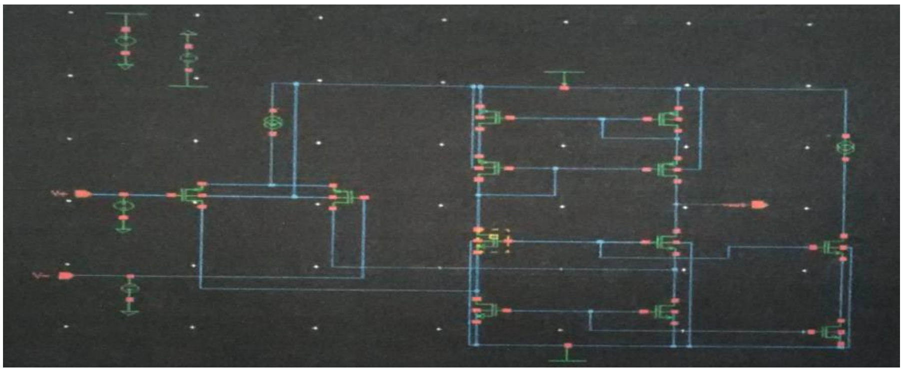
$$Z_O = Z_L$$

## PROPOSED FOLDED CASCODE OTA

The folded cascode OTA is shown in figure the name "folded cascode" comes from folding down n-channel cascode active loads of a diff-pair and changing the MOSFETs to p-channels. Folded cascode OTA has a differential stage consisting of PMOS transistors $M_9$ and $M_{10}$ intend to charge Wilson mirror. MOSFETs $M_{11}$ and $M_{12}$ provide the DC bias voltages to $M_5$ -$M_6$ -$M_7$ -$M_8$ transistors. Apply AC input voltage between $V_+$ and $V_-$ because the differential amplifier drain current to become $G_m$*$V_{in}$. This AC differential drain current is mirrored in the cascaded MOSFETs $M_1$ to $M_6$ [3].

The output of OTA is given by

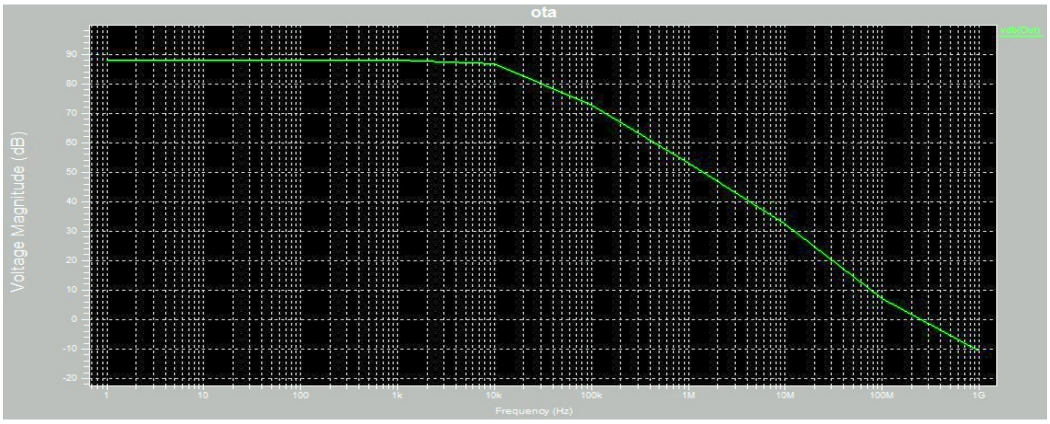
$$V_{out} = G_m V_{in} R_o$$



**Folded Cascode OTA**

## GAIN:

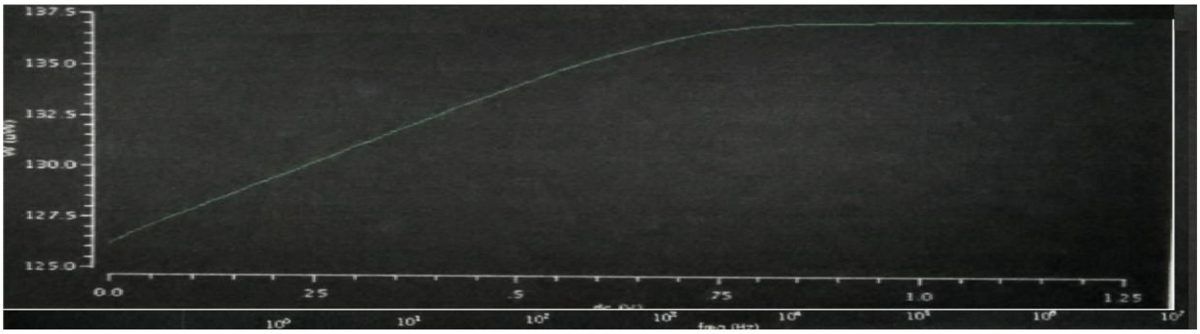
It is defined as the ratio of output to the ratio of input. Here the input voltage is 1v sine wave.



p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 03 Issue 13
September 2016

**Gain of OTA**

**DC Analysis for power calculation:**




**Total power dissipation**

## Conclusion

This contribution present an efficient methodology for OTA design, so the goal to reach high gain and large bandwidth has been fulfilled. Therefore, it has been shown that folded cascode OTA based on Wilson mirror points out a wide transition frequency escorted of output swing limitation. We mention here OTA dynamic performances abasement due to the use of parameters with different values compared to those forecasted since OTA design.

**REFERENCES**

[1] K. Smith, A. Sedra, "The current-conveyor-a new circuit building block," *IEEE Proc.*, vol. 56, pp. 1368-69, 1968.

[2] A. Sedra, K. Smith, "A second-generation current-conveyor and its applications,"*IEEE Trans. vol*. CT-17, pp. 132-134, 1970.

[9] A. Fabre: "Third-generation current conveyor: a new helpful active element". Electron. Lett., vol. 31, pp. 338-339, 1995.

[12] A. Toker, H. Kuntman, O. Cicecoglu and M.Disirgil: "New oscillator topologies using inverting second generation current conveyor". TurkjELEC. Engin., vol. 10, No. 1 2002,Tub; Tak.

[1] K. Smith, A. Sedra, "The current-conveyor-a new circuit building block," *IEEE Proc.*, vol. 56, pp. 1368-69, 1968.

[2] A. Sedra, K. Smith, "A second-generation current-conveyor and its applications,"*IEEE Trans. vol*. CT-17, pp. 132-134, 1970.

[3] C. Toumazou, F. J. Lidgey, D. G. Haigh (ed.), *Analogue IC design: the current-mode approach*, London, Peter Peregnirus Ltd, 1990, 646 p.

[4] Comlinear Corporation, A new approach to op-amp design, Application Note 300-1, March 1985.

[5] S. Daubert, D. Vallancourt, Y. Tsividis, "Current copier cells," *Electronics Letters*, vol. 24, pp. 1560-1561, Dec. 1988.

[6] A. Fabre, "Third-generation current conveyor: a new helpful active element," *Electronics Letters*, vol. 31, pp. 338-339, March 1995.

[7] R. Brennan, T. Viswanathan, J. Hanson, "The CMOS negative impedance converter," *IEEE J. Solid State Circuits*, vol. 23, pp. 1272-1275, Oct. 1988.

[8] R. L. Geiger and E. S´anchez-Sinencio, "Active filter design using operational transconductance amplifiers: A tutorial," IEEE Circuits and Devices Magazine, vol. 1, pp. 20–23, Mar. 1985

[9] Kessak Chantafong , Phamorn Silapan , Winai Jaikla and Montree Siripruchyanun," A Current-mode KHN Filter Based on OTAs", ICTE Proceedings of the 1st International Conference on Technical Education,PP.192-195 ,2010.

[10] F. J. Lidgey, K. Hayatleh, "Current-feedback operational amplifiers and applications," *Electronics & Communications Engineering Journal*, vol. 9, pp. 176-182, Aug. 1997.

[11] Soliman, A. M. (1998) A new filter configuration using current feedback op-amp. *Micoelectronics Journal*, **29**, 409-419.

[12] W. Chiu, S.-I. Liu, H.-W. Tsao, and J.-J. Chen, "CMOS differential difference current conveyors and their applications," IEE Proceeding– Circuits Devices and Systems, vol. 143, pp. 91-96, 1996.