# NOVEL TEMPERATURE COMPENSATED OPERATIONAL TRANSCONDUCTANCE AMPLIFIER

Saurabh Pratap Singh*, Ujjwal Gupta*
*UG Research Scholar, NSIT, Delhi

***ABSTRACT***

*Conventional Operational transconductance amplifier (OTA) are widely used in circuit designing. They face a major problem due to its temperature dependencies. A unique technique, synthesizing a temperature compensated operational transconductance amplifier, using largely active elements, is presented. The designed structure does not hamper the linear input range of the OTA and its basic operation.*

***Key Words:*** Evaporative Cooling, Roof Heat Flux, Thermal Comfort

## INTRODUCTION

Operational Transconductance Amplifier is an amplifier which produces current proportional to the differential input voltage. Similar to the operational amplifier it has a very large value of the input impedance and does not create loading issues. The OTA, as a discrete element, is of great importance to analog electronics circuits. Its current mode of operation leads to an easier synthesis procedure and wide band operation. Various circuits such as precision rectifier, analog multipliers ,oscillators etc. have been proposed, which generally suffers the disadvantage of being temperature dependent , due to presence of OTA. The circuit proposes a novel method, of easily compensating the temperature factor from an OTA , as discrete element. The circuit proposed has the following advantages:

- Circuit using largely active elements.
- No matching of elements is required.
- Input linear range of OTA is not affected.
- Slew rate is of the order 50-75 V/us .Thus the circuit can be used for relatively higher frequencies as well, where the conventional op amp rectifiers may fail to work.

Output voltage is fully temperature compensated.

## OPERATIONAL TRANSCONDUCTANCE AMPLIFIERS:

Commonly known as OTA , this amplifier class has got voltage input and current output, as the name suggests. The basic equation governing this basic building block is:

$$I_{\mathrm{out}} = (V_{\mathrm{in+}} - V_{\mathrm{in-}}) \cdot g_{\mathrm{m}}$$

I_out : output current
V_in+:input voltage at the non-inverting terminal
V_out-:input voltage at the inverting terminal

$$G_{\mathrm{voltage}} = \frac{V_{\mathrm{out}}}{(V_{\mathrm{in+}} - V_{\mathrm{in-}})} = R_{\mathrm{load}} \cdot g_{\mathrm{m}}$$

gm: Transconductance of OTA.
R_load:load resistance
OTA has got a number of applications, widely used in oscillators (current mode). The word operational in its name is used because it can do a variety of mathematical operation related circuit realizations, such as task of adding up the two currents for two voltage inputs, simplified to the level of just joining the two nodes together.

## INTERNAL ARCHITECTURE OF OTA:

The internal circuit of a OTA , generally consists of a differential amplifier , biased by a current source . The currents flowing through the two differential output voltage nodes are subtracted by a simple current mirror assembly, thus giving a balanced output , w.r.t. the reference voltage. Both positive as well as negative supply voltages are required to bias the NPN and PNP transistors used in the circuit assembly. The basic equations governing the BJT has a significant temperature dependence due to the presence of the thermal voltage in the relation

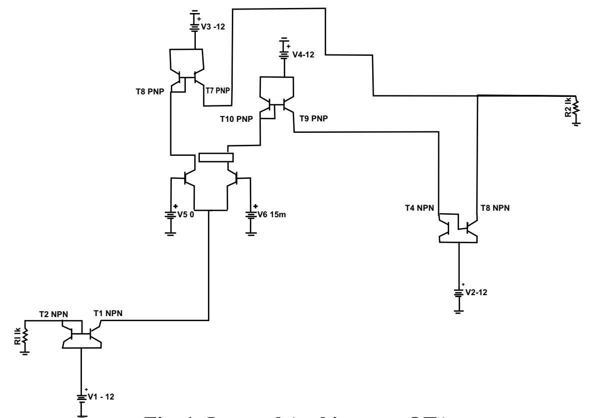


**Fig. 1: Internal Architecture OTA**

which finally leads to a temperature dependent transconductance which is not desired.

## OTA CHARACTERSTICS:

The I-V characteristics of an OTA is hyperbolic(tanh) in nature, thus its input voltage range is linear but the linearity is limited to a small proportion of the biasing voltage. For the test IC, the input voltage linear range is -50mv to +50mv. The biasing current to the circuit which determines the transconductance must be in the range 0.1uA to 100ma. OTA is generally used without any negative feedback which is almost a necessary part of op-amp circuits.

## LIMITATIONS:

The transconductance of an OTA is linearly dependent on temperature. The circuit operation and behavior is quite significantly dependent on the ambient conditions. Secondly, as mentioned above, the input linear range for them is quite low, which is a problem when using the circuit for practical purpose.

## PROPOSED CIRCUIT CONFIGURATION OF OTA

Assuming that a suitable current source is present . The mirror assembly at the starting , supplies current to output of OTA2 in the inwards direction .

By OTA analysis:

$I_c$ :output current of OTA 2

$I_b$ :biasing current of OTA 1

$R_f$ : Resistor (chosen according to the gain requirement)

Gm :transconductance of OTA 2

$V_t$ :thermal voltage

$V_t$ varies significantly with temperature. Its variations are as follows:

At room temp: 26mV

Increments by 7% for every degree rise in temperature that is doubles for every 10 degree rise.

For OTA 2: $Ic = (-Gm \cdot Vx)$ .......... (1)

$Ib = -Vx/Rf$

So,

$Ib = Ic/(Gm.Rf)$

$Io = Gm \cdot Vi$ (for OTA 1)

$Io = (Ib/(2\,Vt))Vi$...... (2)

$Io = (Ic.Vi)/(2.\,Vt\,.Gm.Rf)$

Ensuring same biasing current(Ic)

We have :

$Io = Vi/Rf$

Thus , the output of the of the OTA is

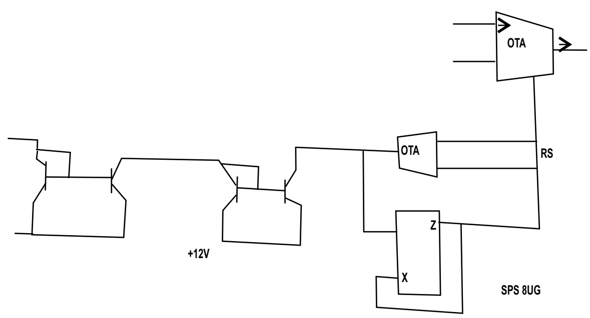


**Fig 2.Proposed Circuit**

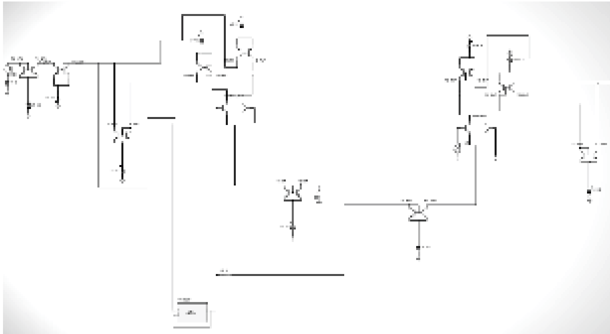

**Fig 3. Proposed Schematic**

independent of temperature.

## APPLICATIONS:

OTA is widely used as a basic building block for circuit design of circuits such as Oscillators, floating Resistors and Inductors, Rectifiers, Multipliers, etc. Removal of the temperature dependency of the circuits building block immensely improves the performance leading to a more reliable design. Current mode operation of OTA leads to a relatively easier circuit synthesis and therefore increasing the number of end applications that can be developed.

## DRAWBACKS:

The basic limitation of the OTA is compensated by removing its dependencies on the thermal voltage but this procedure introduces a Resistor which itself introduces some problems. The major problem is that the resistor is itself temperature dependent but this can be reduced to very minimum by using material with a small temperature coefficient (such as Nicrome).
Another Drawback introduced by this comes into picture if this is implemented on an IC because of the large chip space occupied by the resistor.


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