DESIGN AND ANALYSIS OF OPERATIONAL TRANSCONDUCTANCE AMPLIFIER USING PSPICE

Alka Yadav[1], Kamlesh Kumar Singh[2]

[1]*Department of electronics & communication, Amity University, Lucknow*
[2]*Department of electronics & communication, Amity University, Lucknow*

Abstract

This paper presents the implementation of operational transconductance amplifier using pspice. Spice is a general purpose circuit program that simulates electronic circuits and can perform various analysis of electronic circuits. So with the help of pspice, the analysis of operational transconductance amplifier has been proposed. In this paper, the circuit of operational transconductance amplifier is designed using JFET. The JFET is a symmetric device, however it is useful in circuit design to designate the terminals.

Keywords: *Operational transconductance amplifier circuit using JFET, PSPICE software.*

--***--

1. INTRODUCTION

During the past, the laboratory prototype measurement was almost impossible to provide the essential information about the circuit performance. So that's why pspice has been come to provide the correct information about the complex integrated circuit. SPICE is a powerful general purpose analog circuit simulator that is used to verify circuit designs and to predict the circuit behaviour. This is of particular importance for integrated circuits. It was for this reason the SPICE was originally developed at the Electronics Research Laboratory of the University of California, Berkeley(1975), as its name implies:

Simulation Program for Integrated Circuits Emphasis .SPICE can do several types of circuit analysis. Here are the most important ones:

- Non-linear DC analysis: calculates the DC transfer curve
- Non-linear transient analysis: calculates the voltage and current as a function of time when a large signal is applied.
- Linear AC analysis: calculates the output as a function of frequency. A bode plot is generated.
- Noise analysis and many more analysis can be done by Pspice

In analog-signal processing the need often arises for a circuit that takes two analog inputs and produces an output proportional to their product. The JFET is a symmetric device (the source and drain may be interchanged), however it is useful in circuit design to designate the terminals.The operation of the JFET is based on controlling the bias on the pn junction between gate and channel.

2. IMPLEMENTATION OF OTA USING JFET

A voltage to current converter is inherently an amplifier that is capable of producing a current proportional to an applied input voltage[1]. Thus, a voltage to current converter using op-amp is an amplifier which produces an output current that is dependent on the input voltage. The proportionality constant of the circuit is called the transconductance of the amplifier circuit, and hence, such circuits are called transconductance amplifier. The constant of proportionality or the transconductance is expressed as:

$$I_o = g_m V_i = g_m (V_1 - V_2) \qquad (1)$$

In simplified circuit schematic of an OTA[8], The transistors J_1 and J_2 form a differential input pair. The current mirror formed by the transistors J_3- J_4 accept the control current $I_{C,}$ that is externally adjustable by an externally connected resistor R_{ext} with a control voltage $V_{C.}$ Due to current mirroring action of J_3- J_4 , the current $I_4 = I_{C.}$ The current I_4 is divided at the emitter terminals of J_2 and $J_{1.}$ Therefore, we have $I_1 + I_2 = I_4$. The current mirror formed by J_5 and J_6 duplicates I_2 to produce $I_9 = I_2$. The current I_2 is replicated again by the current mirror formed by J_9-J_{10} to offer $I_9 = I_2 = I_{10}$. The current mirror J_7-J_8 duplicates I_1 to gives $I_8 = I_1$ Using Kirchhoff `s current law at output node P, we get

$$I_o = I_8 - I_{10} = I_1 - I_2$$

Thus, the voltage gain A_v can be expressed as

$$A_v = V_o / V_i = I_o R_L / V_i = g_m R_L \qquad (2)$$

The transconductance g_m of the circuit can be calculated as follows:

$$I_1 = I_s \exp (V_1 / V_T) \qquad (3)$$

And

$$I_2 = I_s \exp (V_2 / V_T) \qquad (4)$$

where I_S is reverse saturation current transistors J_1 and J_2 assumed to be equal and V_T is thermal voltage of the junction .

$I_C = I_1 + I_2 = I_S [\exp (V_1 / V_T) + \exp (V_2 / V_T)]$…….(5)

Or

$$I_S = I_C / \exp (V_1 / V_T) + \exp(V_2/V_T \qquad (6)$$

$I_1 = I_S \exp(V_1/V_T) = I_C \exp(V_1/V_T)/ \exp(V_1/V_T)+\exp(V_2/V_T)$ (7)

And

$I_2 = I_S \exp (V_2 / V_T) = I_C \exp (V_2 / V_T) / \exp (V_1/ V_T) + \exp (V_2/V_T)$ (8)

$I_1 - I_2 = I_C [\exp(V_1 / V_T) - \exp(V_2 - V_T)] / \exp(V_1/V_T) + \exp(V_2/V_T)$ (9)

Multiplying both numerator and denominator by exp [- (V_1 – V_2 / 2)]

$I_0 = I_1 - I_2 = I_C[\exp (V_1 - V_2 / 2V_T) - \exp(V_1 - V_2 / 2V_T)] / \exp(V_1 - V_2 / 2V_T) + \exp(V_1 - V_2 / 2V_T)$
$= I_C \tan h (V_1 - V_2 / 2V_T)$ (10)

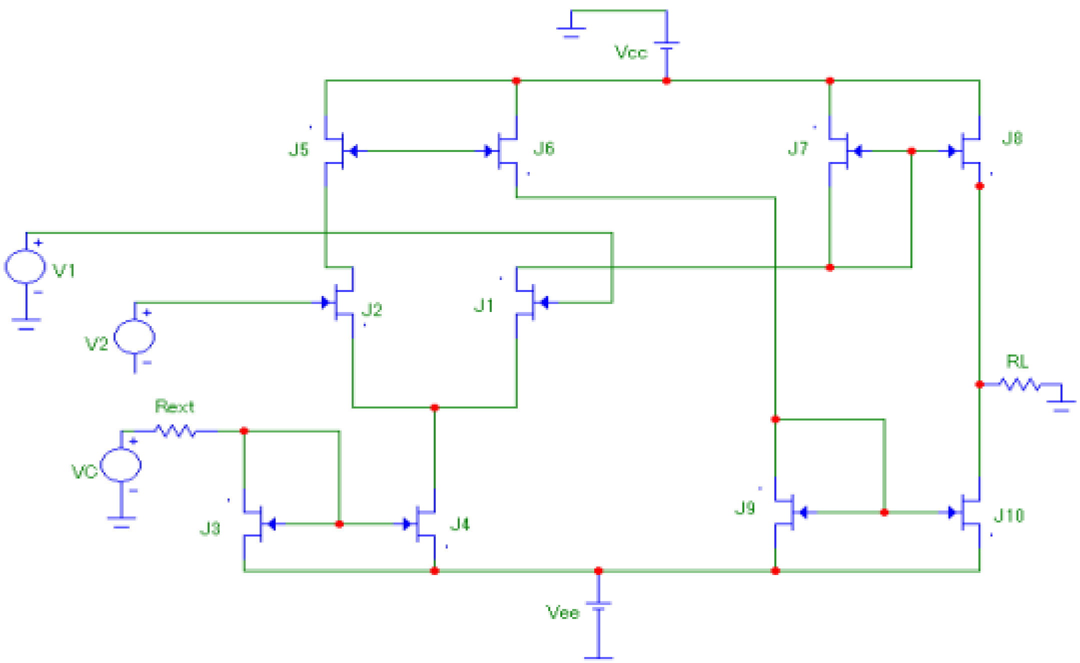

Fig 1 OTA circuit using JFET

3. SIMULATION RESULT OF OTA CIRCUIT USING JFET

3.1 Transient Analysis of OTA Circuit using JFET

PSPICE simulation is also carried out for sinusoidal inputs. These results also give a good agreement between theoretical and experimental results .Transient analysis is used for circuits with time-variant sources (e.g., ac sources and switched dc sources). It calculates all node voltages and branch currents over a time interval, and their instantaneous values are the outputs.Hence Figure 2, 3, 4 shows the Transient analysis of OTA.

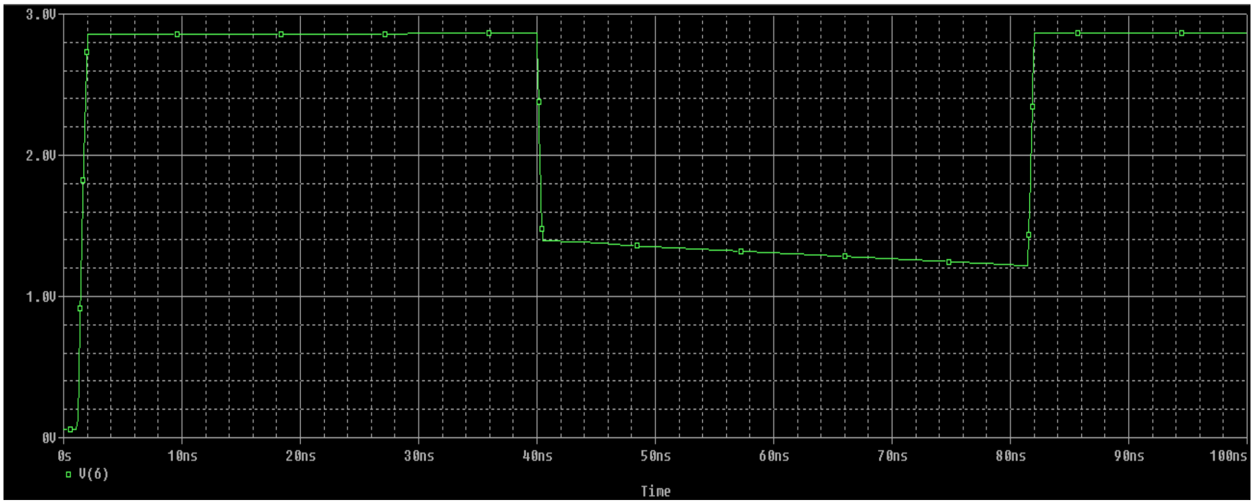

Fig 2 Output voltage waveform

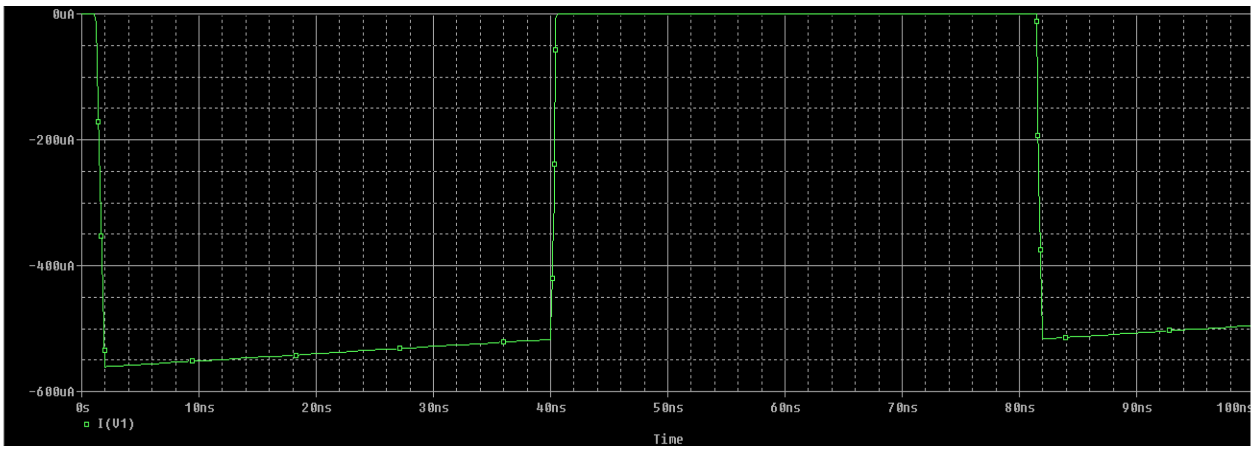

Fig 3 Input voltage waveform v (1)

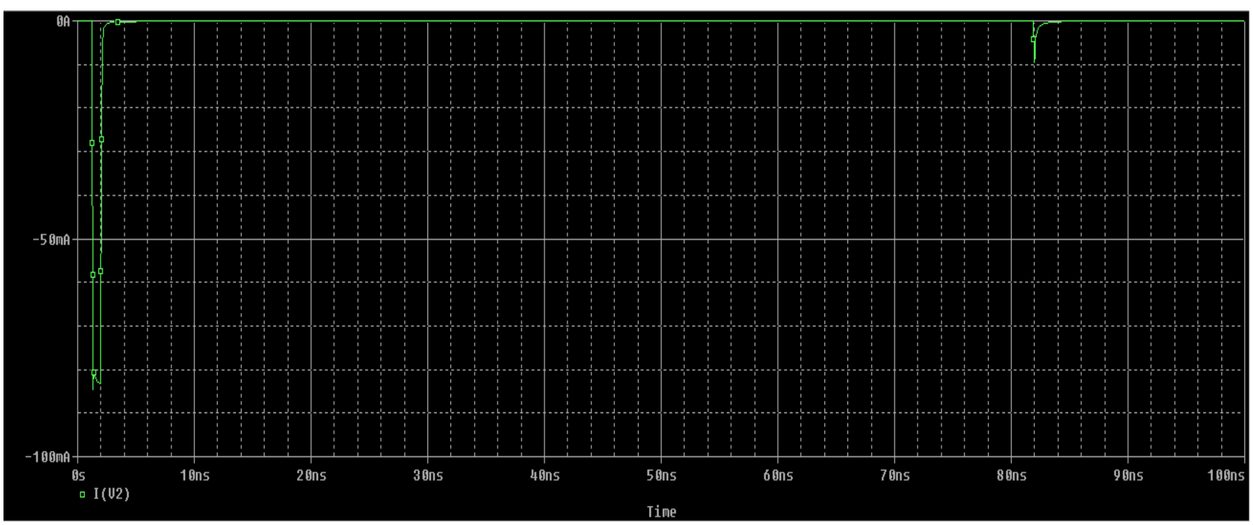

Fig 4 Input voltage waveform v (2)

4. CONCLUSIONS AND FUTURE ASPECTS

A new technique is proposed in this paper. Simulation results using PSPICE program exhibit that the presented circuit design offers practical alternative solution to be used as active filters, electronically tuned resistor, sample -and- hold circuit. This circuit is simulated by SPICE. Simulation results shows the TRANSIENT analysis of OTA. The OTA can be used for constructing active filters due to its good controllability features with voltage-variable control through the input. We can also propose the phase detection of OTA in future and also used this OTA for lowering the voltage or power which was very useful for every purposes.

REFERENCES

[1]Salivahanan,"Linear Integrated Circuits" Tata McGraw-Hill Education, 07-Oct-2008.

[2]. Intersil Americas Inc., An IC Operational Transconductance Amplifier (OTA) with PowerCapability, Oct. 2000. AN6077.3.

[3]. National Semiconductor Corporation, LM13600 Dual Operational Transconductance Amplifiers with Linearizing Diodes and Buffers, May 1998. DS007980.

[4]. E. M. Zumchak, A Short Discussion of the Operational Transconductance Amplifier (OTA), Feb. 1999. http://www.uni-bonn.de/ uzs159/ota3080.html.

[5]. 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.

[6]. Philips Semiconductors, NE5517(A)/AU5517 Dual Operational Transconductance Amplifier,Dec. 2000. Doc.No. 9397 750 10796.

[7]. Burr-Brown Corporation / Texas Instruments Incorporated, Wide Bandwidth Operational Transconductance Amplifier and Buffer, 1990. PDS-1072F / SBOS007.

[8]. Maxim Integrated Products, Wideband Transconductance Amplifiers, 1993. 19-0042.

[9]. J. Patchell, Secrets of OTAs, May 2003.

[10]. B. Gilbert, "The multi-tanh principle: A tutorial overview," IEEE Journal of Solid-State Circuits and Systems, vol. 33, pp. 2–17, Jan. 1998.

[11]. U. Tietze and C. Schenk, Halbleiter-Schaltungstechnik. Springer, 12th ed., 2002.

[12]. M. Seifart, Analoge Schaltungen. Verlag Technik Berlin, 3rd ed., 1989.