Design of Power Efficient and High Slew Rate Class AB OPAMP

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*Abstract-*The paper deals with aim to design an OPAMP of Class AB to achieve high power efficiency and slew rate. To have high slew rate the focus of the proposed work as high slew rate contributes to the fast and dynamic output response. Power efficiency is driving factor from MOORE'S law. A Push pull OPAMP with current replicating branch is used to achieve symmetrical wave with high slew rate. Adaptive biasing is another technique employed to increase the slew rate. According to the Moore's law, increase in power takes place in adaptive biasing due to increase in transistors, but the proposed circuit is best tradeoff between slew rate and power efficient factors. The existing work could only increase the slew rate by 4 to 5 times, but our proposed work increases it even further compared to the existing work, at the same time it results in decrease of power. In this work we are combining two techniques, namely adaptive biasing and current replicating branch which combine to result in better slew rate without increase in power. The proposed work is implemented with Cadence Virtuoso tool.

Keywords: *Adaptive Biasing, Class AB OPAMP, Current Replicating branch, Slew Rate.*

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I. INTRODUCTION

In conventional two stage OPAMP as shown in Fig.1, slew rate increases with moderate increase in power dissipation. Its last stage is push-pull configuration to achieve high voltage swing. Its disadvantage is one of the OPAMP transistor present below input stage acts as current sink due to this, there is no current path to output during negative cycle. Hence, current is unevenly distributed in positive and negative cycles. The applied input voltages are 1.8 V to non inverting and -0.625 V to the inverting input as shown in Fig.2. The Operating frequency of both the inputs is 100K Hz. The average power consumption is 17.34 µW and slew rate is about 149 V/s. The circuit is implemented in 180nm Technology node.

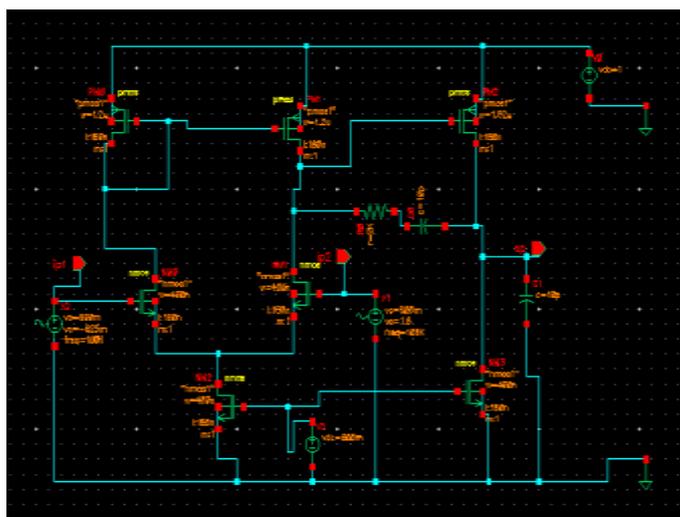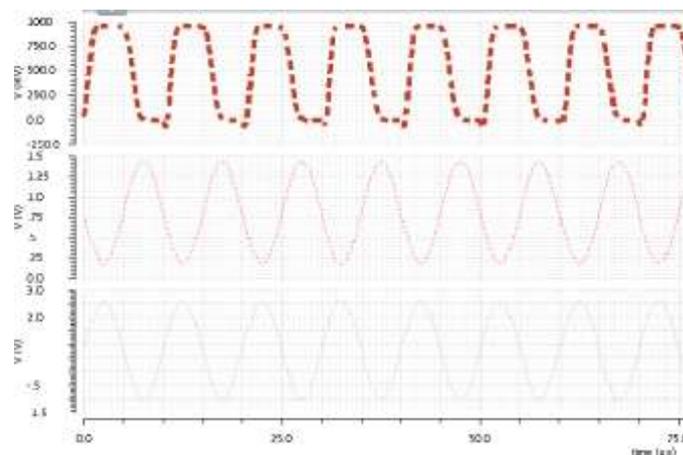Fig 2   Output of Class AB OPAMP.
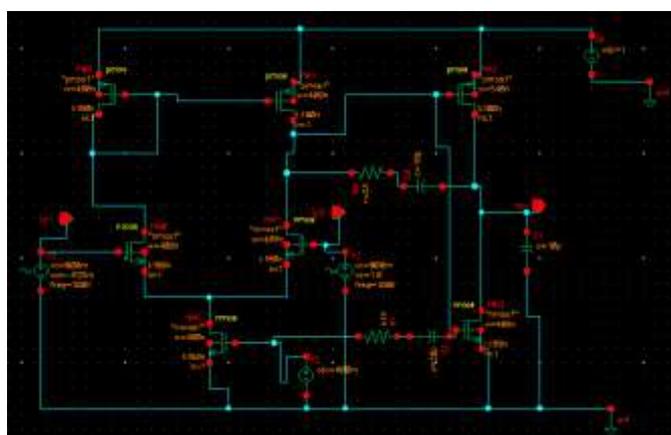
Conventional OPAMP with R-C branch

Fig3. OPAMP with R-C branch

Conventional OPAMP with R-C branch technique overcomes the drawback of previous circuit in which the output response is uneven during positive and negative cycles. This technique helps in

Fig 1 Class AB OPAMP.

improving the symmetry of output response. The slew rate and power dissipation of this circuit has better values compared to earlier circuit. But this arrangement comes with a drawback of miller effect as the frequency increases, its operation becomes ineffective. The average power consumed is 12.07 µW, where as the slew rate is about 13.96 KV/s. Power consumption and slew rate of the circuit shows big improvement over the conventional OPAMP circuit. The response shown in Fig.4, shows the output wave having symmetric positive and negative cycle. This output when compared to the output of earlier circuit has better symmetric positive and negative cycles. The applied input to inverting and non-inverting inputs are -0.625 V and 1.8 V respectively. The operating frequency of the both inputs is 100 K Hz.
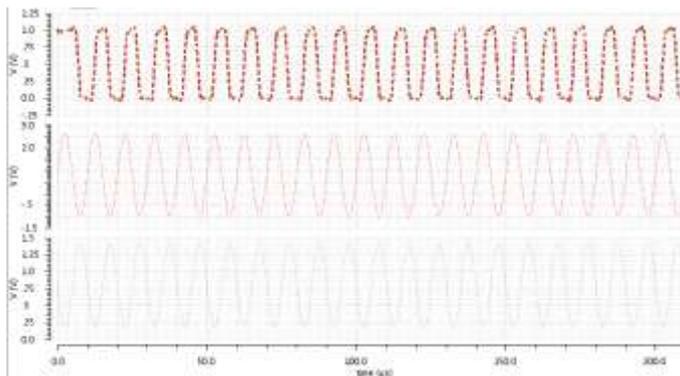

Fig.4 OPAMP with R-C branch.

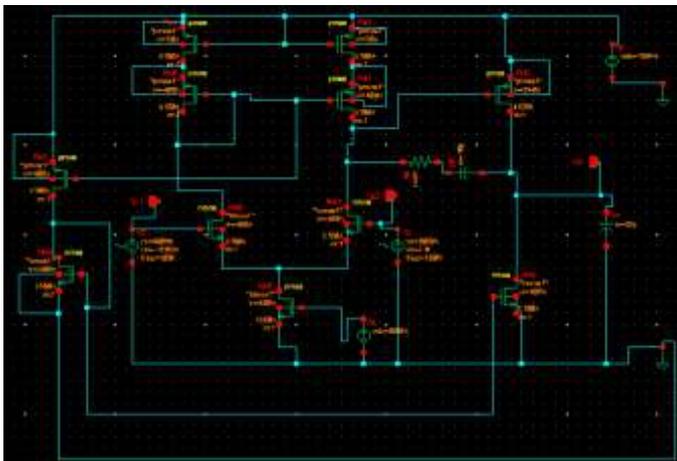## Pushpull OPAMP with Current Replicating branch:

Fig5. OPAMP with Current Replicating branch and Adaptive biasing.

The conventional opamp with r-c branch circuit has draw back of miller effect in order to reduce it we are using push pull OPAMP with current replicating branch. By using Current replicating branches we can generate required bias voltage at the gate of output transistor, other advantage is increase in slew rate. But disadvantage of this technique is increase in power consumption as shown in Fig 5. Number of transistors have increased due to which power consumption too increases in accordance with Moore's law.
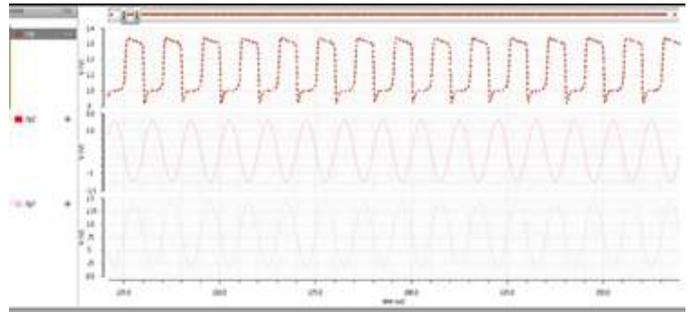

Fig6. Output of OPAMP with Current Replicating branch and Adaptive biasing.

The slew rate of OPAMP with Current Replicating branch and Adaptive biasing is 24.31 kV/s which is more 74.14% compared to conventional OPAMP with r-c branch technique. The average power is around 16.22 µW which is highest among all the circuits presented in the paper.

Proposed Paper

By using current replicating branch we have eliminated the miller effect and by using adaptive biasing we have increased the slew rate. But due to adaptive biasing power consumption has increased. Hence in order to reduce number of transistors the proposed circuit is designed in such a manner that the number of transistors are reduced.
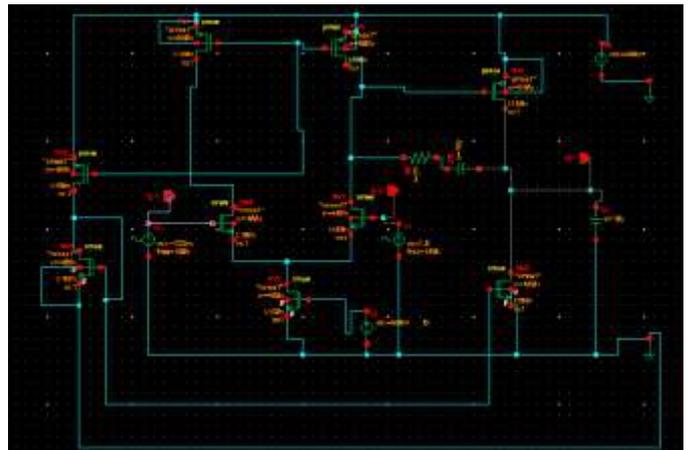

Fig 7. Proposed Circuit

The transistors in Adaptive biasing are operated in triode region due to which it provides high resistance region which results in large current due to high voltage swing. In the absence of current replicating branch the output in positive cycle was mainly contributed by PMOS, but in the proposed circuit the current replicating branch provides current path to output in negative cycle. Hence a symmetric wave is obtained in both positive and negative cycles. The biasing voltage is taken from current replicating branch which results in increased slew rate, with little increase in power. The slew rate is 110 kV/S and power consumed is 12.4 µW. The powerful combination of Current replicating branch and adaptive biasing results in high slew rate as evident in Fig 8. Where Output of Proposed circuit, has sharp rising and falling edges.
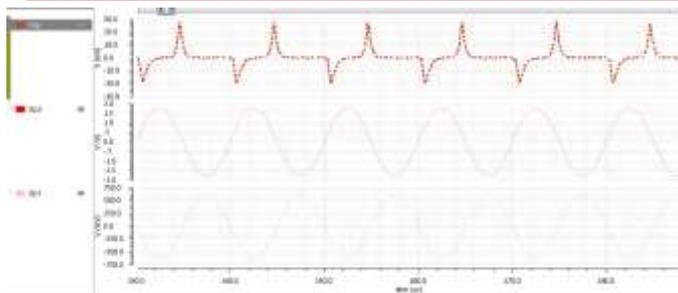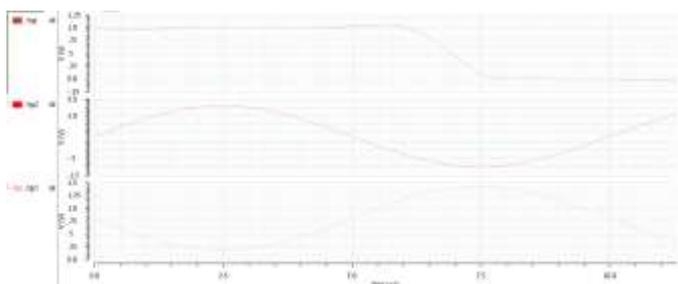
Fig 8. Ouput of Proposed Circuit.

Fig 9. Part of output illustrating the OPAMP behavior of the circuit.

As shown in Fig 9. Part of Output shows three waveforms in which the lower two waves are inputs and uppermost wave is the output, The Differential OPAMP amplifies the difference between the inputs, as shown in the above Fig 9. When inputs are moving away from each other the output increases and output decreases as the inputs move closer towards each other, this illustrates that the proposed circuit works as Differential OPAMP.

Results and Discussion.

In Conventional OPAMP slew rate is least and power consumption is highest among Conventional RC branch, Push pull with current replicating branch and proposed circuit. Conventional RC branch has second best power consumption value after proposed circuit and its slew rate is less than both circuits, Push pull with current replicating branch and Proposed circuit. Push pull with current replicating branch circuit has higher power consumption compared to Conventional RC branch and Conventional RC branch its Slew rate is lower than then proposed circuit and higher than Conventional OPAMP and Conventional RC branch. The proposed circuit slew rate is 110.7k V/S which is very high compared to all the circuits and power consumption is second best value after conventional RC branch circuit hence proposed work has optimum combination of both power and slew rate, which is best compared to other circuits.

Table 1. Comparsion of various Class AB OPAMP techniques.

Type of circuit	Conventional OPAMP	Conventional RC branch	Push pull with current replicating branch	Conventional RC branch
Slew rate (K V /S)	.149	13.96	24.31	110
Power consumed(μW)	17.34	12.07	16.22	12.40

CONCLUSION

The adaptive biasing and current replicating branch in Proposed work shows optimum values of Slew rate and power consumption, as shown in comparison Table 1. Hence it is the best circuit.

FUTURE SCOPE

To obtain better values of slew rate and Power consumption by implementing circuit in 90nm, 45nm technology node and decrease the power consumption to least possible extent.

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