Class-AB Op-Amp with High Slew Rate using Common Gate Technique

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Abstract: In miller compensated class-A op-amp, the symmetrical slew rate is not achieved due to fact that the output nmns transistor acts as a dc current source with $2I_{th}$. Slew rate can only be increased by increasing $I_{th}$ and consequently the static power dissipation. The class-AB two stage op-amp with large resistive element $R_{large}$ and small capacitor $C_{bat}$ is designed to achieve large positive and negative output currents and less power dissipation, but operates only for dynamic changes with frequencies greater than $1/(2\pi R_{large} C_{bat})$. Class-AB op-amp with current replicating branch is designed which can be operated even for the static input signals. Even though the maximum positive output current and slew rate is achieved, the maximum negative current is limited. In order to achieve maximum negative output current and large negative slew rate adaptive loads are used. Class-AB two stage op-amp with approximately symmetrical slew rate using current replicating branch in combination with adaptive loads is designed. In this brief a class-AB two stage op-amp using common gate technique is proposed in order to increase the slew rate. Simulation and measurement results are presented and slew rate is verified.

Keywords: Symmetrical Slew Rate, Operational Amplifiers, Class AB Operation, Gain, CMOS Analog Integrated Circuits.

I. INTRODUCTION

In single-stage op-amps achieves highly symmetrical slew rate by using different efficient schemes\textsuperscript{[2]}-[\textsuperscript{3}]. A drawback of a single stage op-amp is that relatively low open-loop gain(AOL) since the output cascading transistors is to increase the output resistances(Rout) would seriously limit the maximum output current and the slew rate enhancement factor. In the conventional class-A two-stage Miller-compensated op-amp is characterized by a highly asymmetrical slew rate with large positive slew rate and much lower negative slew rate. This lower negative-slew rate is due to the output transistor (MoN) acts as a dc current source with value $2IB$ and increase the static power dissipation. To avoid this limitation many class AB two-stage op-amps have been reported\textsuperscript{[4]},\textsuperscript{[14]}-[\textsuperscript{16}]. Most of them feature is relatively modest effective slew rate improvement and require additional complex circuitry, and non negligible additional static power dissipation or increased supply requirements. This decreases their current efficiency. In Free-class AB op-amp achieves class AB operation with additional small hardware. It consists of a large resistive $R$ large and small capacitor $C_{bat}$ This combination operates as a open battery that transfers ac variations taking place at the gate of Mop to the gate of Mon transistors. The output stage operates as a push-pull amplifier and provides dynamic class-AB operation with large positive and negative output currents. This does not increase power dissipation or supply requirements but operates only for dynamic changes with frequencies. In this brief, two-stage op-amps with increased slew rate are presented. In section II the different topologies of an op-amp are described. Section III deals with the simulation results and finally concluded with the achieved slewrare which shows the better performance of an op-amp.

II. CLASSAB TWO-STAGE OP-AMPS

A. Op-Amp with Current Replication Branch

To achieve class AB operation, the output transistor MoN can be transformed into an active amplifying device by simply adding a current replicating branch [\textsuperscript{3}],[\textsuperscript{7}],[\textsuperscript{12}] formed by M2R and MoNR. This transfers current variations $I_{n}$ in M1-M2 to the output transistor MoN and increases and increases the maximum positive output current by $2IB$. The maximum negative current is still limited to a value of $2IB$. The current replicating branch does not require additional compensation circuit. Since the node $V_{x}$ with gain in the current replicating branch is gate to the drain of MoN and at the higher frequencies miller compensation causes MoP to behave as low impedance load. This reduces the gain between the gate of MoN and the op-amps output terminal to closely a unity value. The current replicating branch has small dimensions reducing area and static power dissipation. In order to achieve large negative output currents, a non-linear adoptive load can be used. This modification is seen in another circuit.

B. Class AB Two-Stage Op-Amp Using Adaptive Loads

By using an adaptive load at the input side in the circuit we can achieve class AB operation efficiently [\textsuperscript{1}]. Two different alternatives are shown in fig 3(a). In both cases, the adaptive loads manoeuvre the large variation of output resistance of transistors between triode and saturation regions in quiescent conditions. In both schemes a current increase in
Ia causes transistors to go in triode region and to develop large drain-source voltages. These changes cause large currents flow in the output transistors Mop and thanks to the current replicating branch, MoN. A bias voltage with value $V_{b\text{triode}} = V_{TH} + 2V_{DS\text{sat}}$ is required at the gate of MoNR. Where $V_{DS\text{sat}} = V_{gs} - V_{th}$ is the minimum Vds voltage to operate in saturation region. This $V_{b\text{triode}}$ leaves a quiescent drain-source voltage for MoNtriode with value $V_{DS\text{sat}}$, which causes MoNtriode to operate at the boundary between the triode and saturation regions. The circuit of fig 4(a) is denoted as operational amplifier with current replicating branch and adaptive loads. These topologies are not harmful in terms of stability of the ac responses. The current replicating branch helps compensating the current through the miller capacitor just as in other multipath miller zero-cancellation scheme.

C. Proposed Class AB Two-Stage Op-Amp using Common Gate

The design procedure of the two-stage CMOS operational amplifiers employing Miller capacitor in conjunction with the common-gate current buffer is presented. Avoid closed-loop instability, frequency compensation is necessary in opamp design. The zero which is occurred due to feed-forward path can be nullified if the compensation capacitor is connected in conjunction with either a nullifying resistor or a common-gate current buffer which is shown in fig 5.

III. SIMULATION RESULTS

Simulation results of this paper is as shown in bellow Figs. 1 to 5.
IV. CONCLUSION

The different schemes of power-efficient class AB two-stage op-amps are discussed and introduced an op-amp by using a common gate technique which have been achieved the high slew rate. Simulation results confirm that compared to the slewrate (7.9761Meg) of an op-amp with adaptive loads, proposed design procedure can be used to design the opamp that has high slewrate (9.2948Meg). They achieve approximately symmetrical and high slew rate with very small additional static power dissipation and small additional circuitry.

V. REFERENCES


