Design of a Telescopic Cascode Operational Amplifier

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I. Abstract

This paper presents a design for a telescopic cascode operational amplifier. A telescopic opamp by its structure benefits from higher gain and lower power dissipation as compared to its two stage conventional opamp counterparts. These kind of opamps can be beneficial in applications where a large gain is required such as biomedical applications. Although a telescopic opamp structure has higher gain, it suffers from a higher number of poles and zeroes which one has to worry about, as well as it has a lower voltage swing at the output as compared to a conventional opamp due to increased number of transistors. Hence, this paper will introduce a telescopic cascode opamp that will have a high gain.

II. Circuit Details

Telescopic structure came into existence when the conventional opamp stages weren't enough to provide a certain amount of required gain. Hence these circuits have a cascoded input differential stage. This cascode structure allows for a higher output gain which when multiplied by the gm of the input transistor, presents a much higher gain than the simple opamp stage. For further gain, the current mirrors used to convert a differential strage to single ended stage is also cascoded to get an even higher output impedance which in turn provides a higher overall gain.

The overall gain of the telescopic cascode stage will be equal to:

$$A_0 = g_{m1} * ((g_{m4} r_{ds4} r_{ds2}) \mid\mid (g_{m6} r_{ds6} r_{ds}\ \ ))$$

As one can see, this is substantially larger than the simple opamp stage.

We can also see as there are more numbers of nodes in this circuit we get more number of poles due to the parasitic capacitances present at these nodes. Although the dominant pole frequency still remains at:

$$\omega_u \approx \frac{-g_{m1}}{C_L}$$

This means that there is no significant difference in the bandwidth of the opamp.

The output swing of the opamp will be:

$$V_{o,range} = \{V_{Dsat,4}, V_{Dsat,6}\}$$

This is in fact less than the output voltage swing of the one stage opamp or conventional opamp.

III. Reference Circuit Design

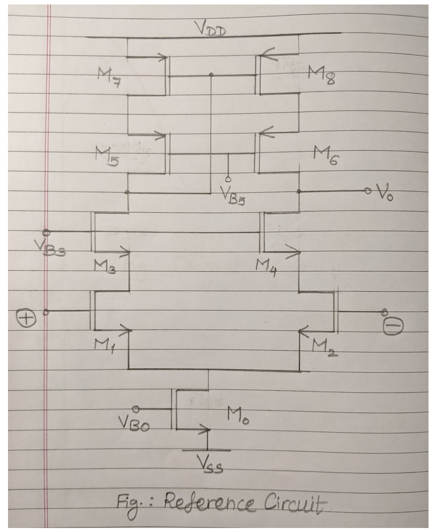

Figure 1 Reference Circuit

IV. Reference Waveforms

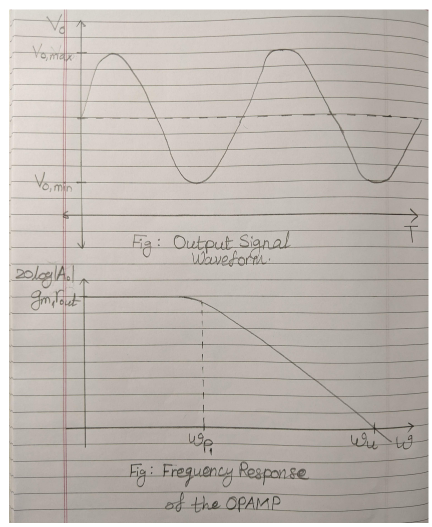

Figure 2 Reference Output waveforms and Frequency response plot

References

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[3] "*Telescopic OPAMP Design Example*" – Analog IC Design – IITM [ONLINE]