EE539: Analog Integrated Circuit Design;

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1 Single stage opamp

Single stage opamp is nothing but differential amplifier, and is shown in figure(1).

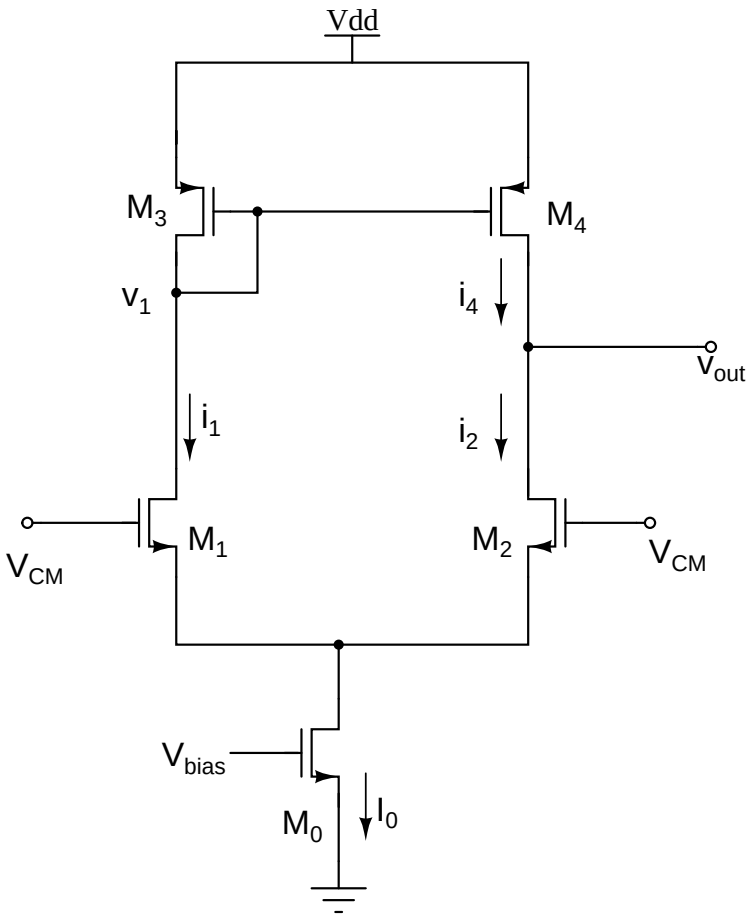

Figure 1: Single stage opamp

In figure(1),DC gain,

$$A_{dc} = g_{m1}.Rout = \frac{g_{m1}}{g_{ds1} + g_{ds3}}$$

To increase DC gain, increase r_{ds1}, r_{ds3}.To achieve large $Rout$,we can choose cascode configuration.

2 Telescopic cascode opamp

Let the upper part of differential pair,and convert it into cascode.

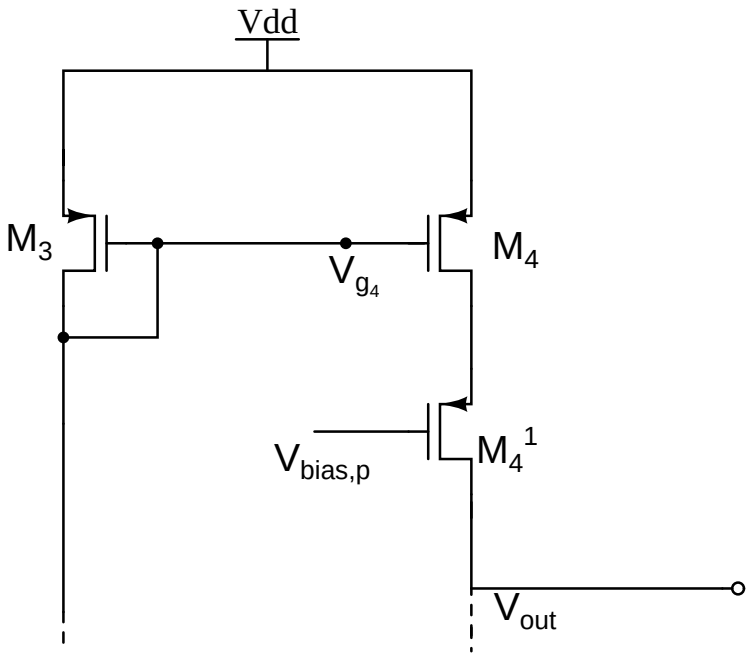

Figure 2: CASCODE CURRENT MIRROR

In the above figure,

$$V_{bias,p} < V_{dd} - V_T - 2V_{dsat}$$

$$V_{out,max} = V_{bias,p} + V_T$$

We can also use the configuration shown below,

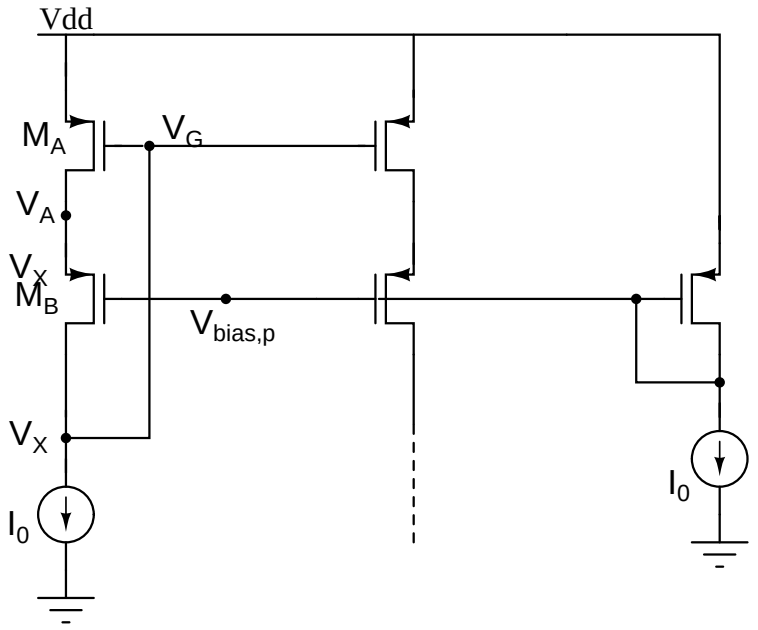

Figure 3: CASCODE CURRENT MIRROR

Similarly, bottom part of differential pair,can be convert it into cascode.

Now by putting all together,

For the Telescopic cascode opamp,

$$G_{out} = \frac{g_{ds1}^2}{g_{m1}} + \frac{g_{ds3}^2}{g_{m3}}$$

$$A_{dc} = g_{m1}.R_{out} = \frac{g_{m1}}{\frac{g_{ds1}^2}{g_{m1}} + \frac{g_{ds3}^2}{g_{m3}}}$$

$$A_{dc} \approx \frac{g_m^2}{2.g_{ds}^2}$$

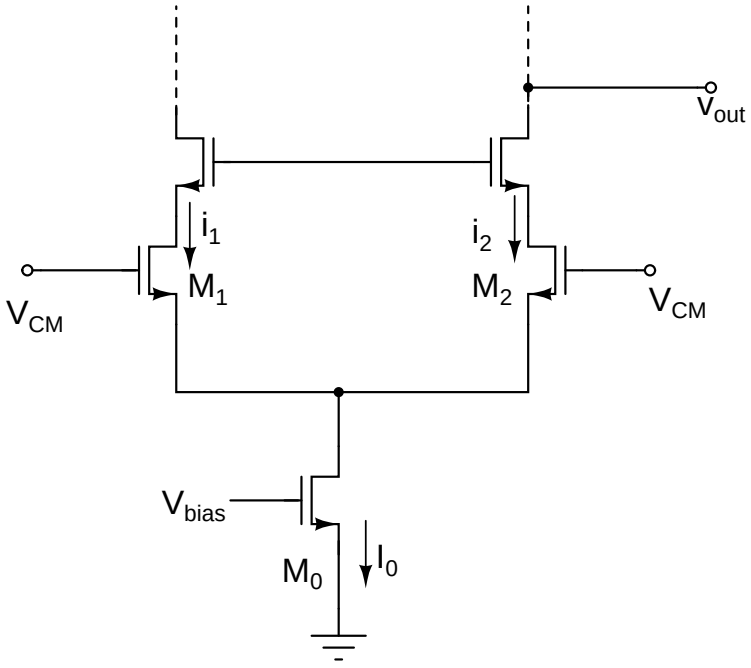

Figure 4:

2.1 Frequency response of telescopic cascode opamp

For the Telescopic cascode opamp,

If C_1 is zero,

$$A = \frac{v_{out}(s)}{v_{in}(s)} = \frac{g_{m1}}{\frac{g_{ds1}^2}{g_{m1}} + \frac{g_{ds3}^2}{g_{m3}} + sC_L}$$

If C_1 is present then,

$$P_1 = \frac{\frac{g_{ds1}^2}{g_{m1}} + \frac{g_{ds3}^2}{g_{m3}}}{C_L}$$

$$P_2 = \frac{g_{m3}}{C_1}$$

$$Z_1 = \frac{2g_{m3}}{C_1}$$

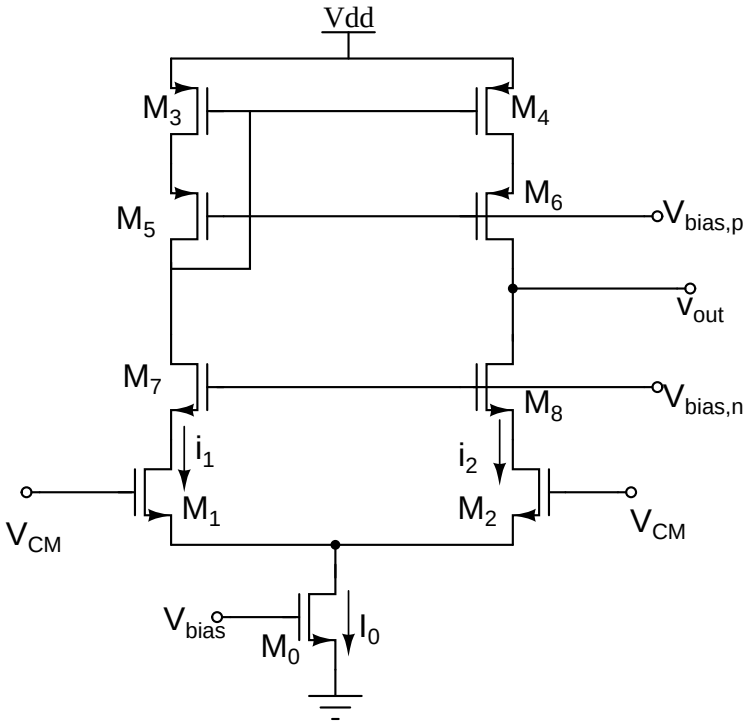

Figure 5: Telescopic cascode opamp

$$w_u = \frac{g_{m1}}{C_L}$$

Frequency response of telescopic cascode opamp is shown in the below figure.

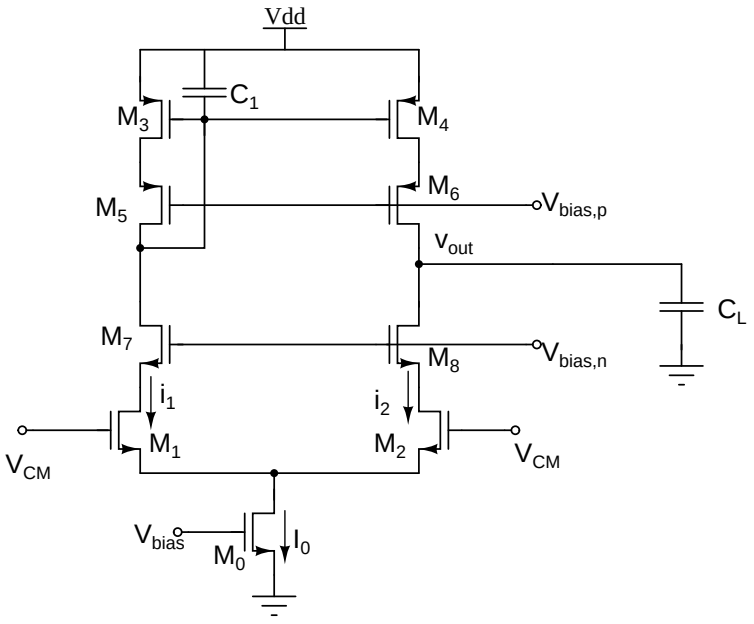

Figure 6: Telescopic cascode opamp

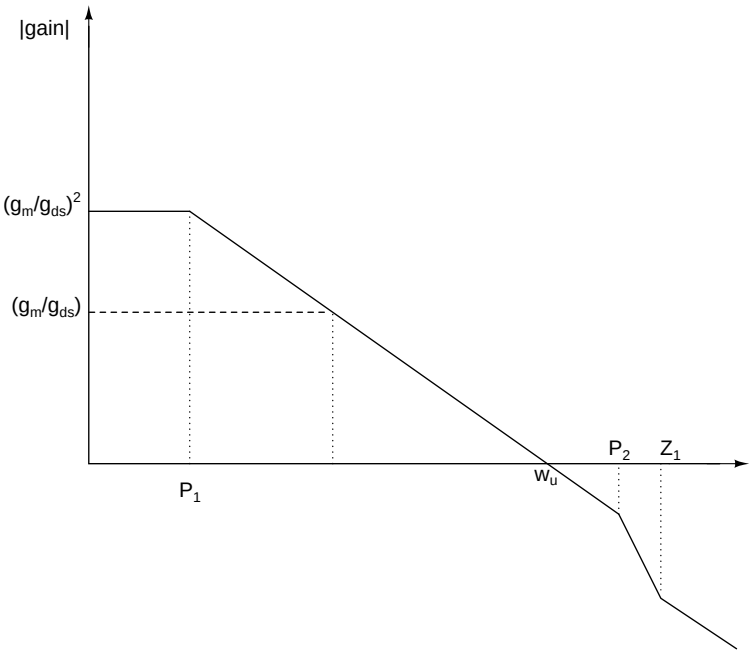

Figure 7: Frequency response Telescopic cascode opamp