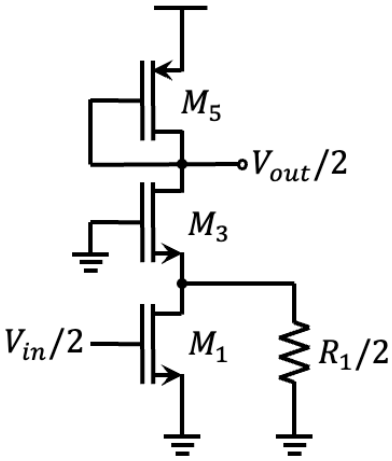
EE-523 – In-Class Quiz Solutions

1. Let's calculate the small-signal differential voltage gain of the circuit given in question1.

We will start by drawing the small-signal half-circuit model, and we will write the voltage gain in terms of transconductance of the transistors.



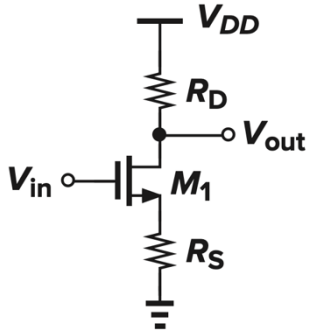
$$A_V = \frac{\frac{V_{out}}{2}}{\frac{V_{in}}{2}} = -g_{m1} \times (\frac{R_1}{2} \parallel \frac{1}{g_{m3}}) \times (g_{m3} \times \frac{1}{g_{m5}})$$

$$A_V = -\frac{g_{m1}}{g_{m5} \times (1 + \frac{2}{R_1 g_{m3}})}$$

2. We will calculate the input-referred thermal noise voltage of the circuit by assuming that λ = γ = 0.

$$\overline{V_{n,in}^2} = \frac{\overline{V_{n,out}^2}}{|A_v^2|}$$

$$|A_v| = \frac{R_D}{R_S + 1/g_m} = \frac{g_m R_D}{g_m R_S + 1}$$



$$\overline{V_{n,out}^2} = 4kTR_D + 4\text{kT}\gamma \times \frac{1}{g_m} \times \left(\frac{g_m R_D}{g_m R_S + 1}\right)^2 + \frac{4kT}{R_S} \times \left(\frac{R_S}{R_S + \frac{1}{g_m}}\right)^2 \times R_D^2$$

$$\text{where coefficient } \gamma \approx \frac{2}{3}$$

(please do not confuse it with the body effect coefficient)

$$\overline{V_{n,in}^2} = \frac{\overline{V_{n,out}^2}}{|A_v^2|} = 4kT \times \frac{2}{3} \times \frac{1}{g_m} + 4kTR_S + 4kTR_D \times \left(\frac{1 + g_m R_S}{g_m R_D}\right)^2$$