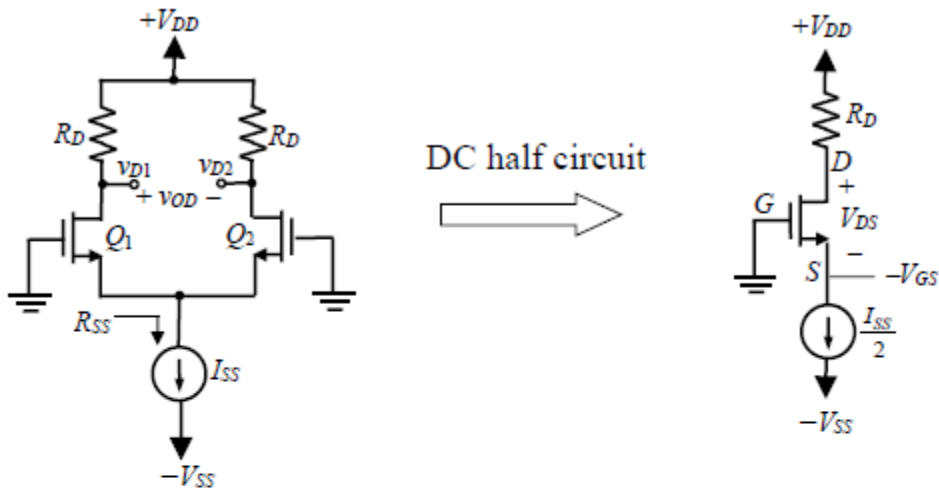


EE3122 Analogue Circuit Fundamentals Tutorial 5

1(a). DC Analysis



$$I_D = \frac{I_{SS}}{2} = 150 \mu A$$

$$V_{GS} = V_{TN} + \sqrt{\frac{2I_D}{K_n}} = 1 + \sqrt{\frac{2(1.5 \times 10^{-4})}{4 \times 10^{-4}}} = 1.866 V$$

$$V_{DS} = 15 - (75 k\Omega)I_D - (-V_{GS}) = 5.62 V$$

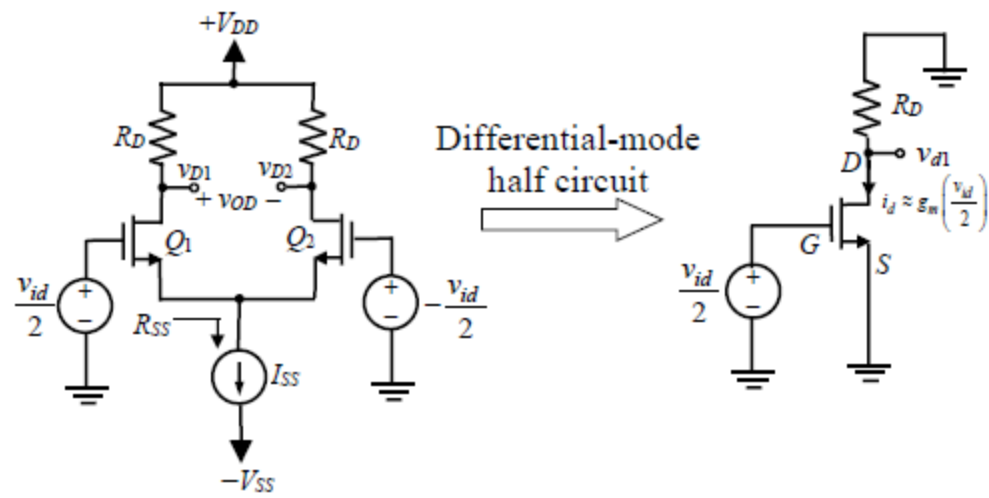
$$Q V_{DS} = 5.62 > V_{GS} - V_{TN} = 0.866 V$$

Hence, the transistors are in Saturation region

(b) AC analysis

$$g_m = \sqrt{2K_n I_D} = \sqrt{2 \times 4 \times 10^{-4} \times 150 \mu} = 0.346 mS$$

Differential mode analysis:



$$v_{d1} = -g_m \left(\frac{v_{id}}{2} \right) R_D, \quad v_{d2} = -g_m \left(-\frac{v_{id}}{2} \right) R_D$$

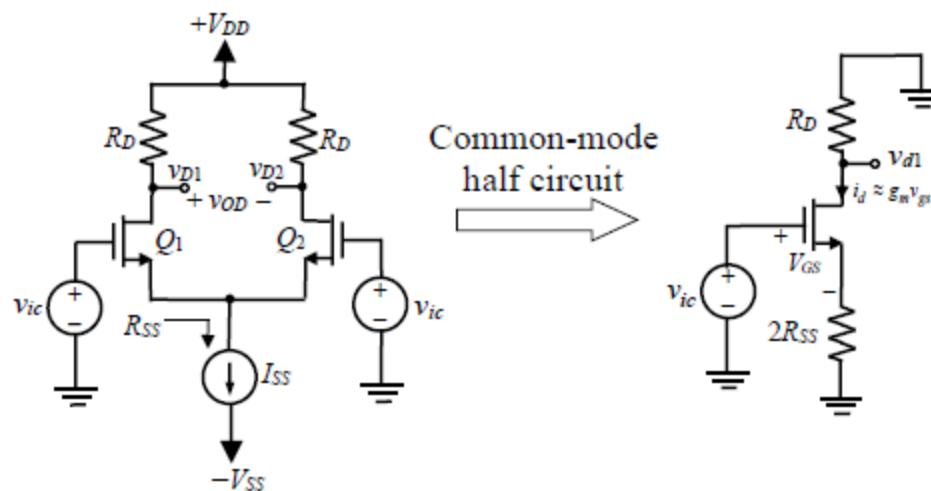
$$v_{od} = v_{d1} - v_{d2} = -g_m v_{id} R_D$$

$$A_{dm-diff} = \frac{v_{od}}{v_{id}} = -g_m R_D = -(0.346 \text{ mS})(75 \text{ k}\Omega) = -26$$

$$A_{dm-se1} = \frac{v_{d1}}{v_{id}} = \frac{-26}{2} = -13$$

$$R_{id} = \infty$$

Common mode analysis:



Since $v_{od} = v_{d1} - v_{d2} = 0$, $A_{cm-diff} = 0$.

$$A_{cm-sel} = \frac{v_{d1}}{v_{ic}} = \frac{-g_m v_{gs} R_D}{v_{gs} + g_m v_{gs} (2R_{SS})} = \frac{-g_m R_D}{1 + 2g_m R_{SS}}$$

$$= -\frac{(0.346mS)(75k\Omega)}{1 + 2(0.346mS)(160k\Omega)} = -0.232$$

$$R_{ic} = \infty$$

CMRR:

For differential output: $CMRR = \left| \frac{-26}{0} \right| = \infty$

For single-ended output: $CMRR = \left| \frac{-13}{-0.232} \right| = 56 \text{ or } 35dB$

Output resistances:

$$R_{o1} = R_{o2} = R_D \parallel r_o \approx R_D = 75 k\Omega$$

$$R_{od} = 2(R_D \parallel r_o) \approx 2R_D = 150 k\Omega$$