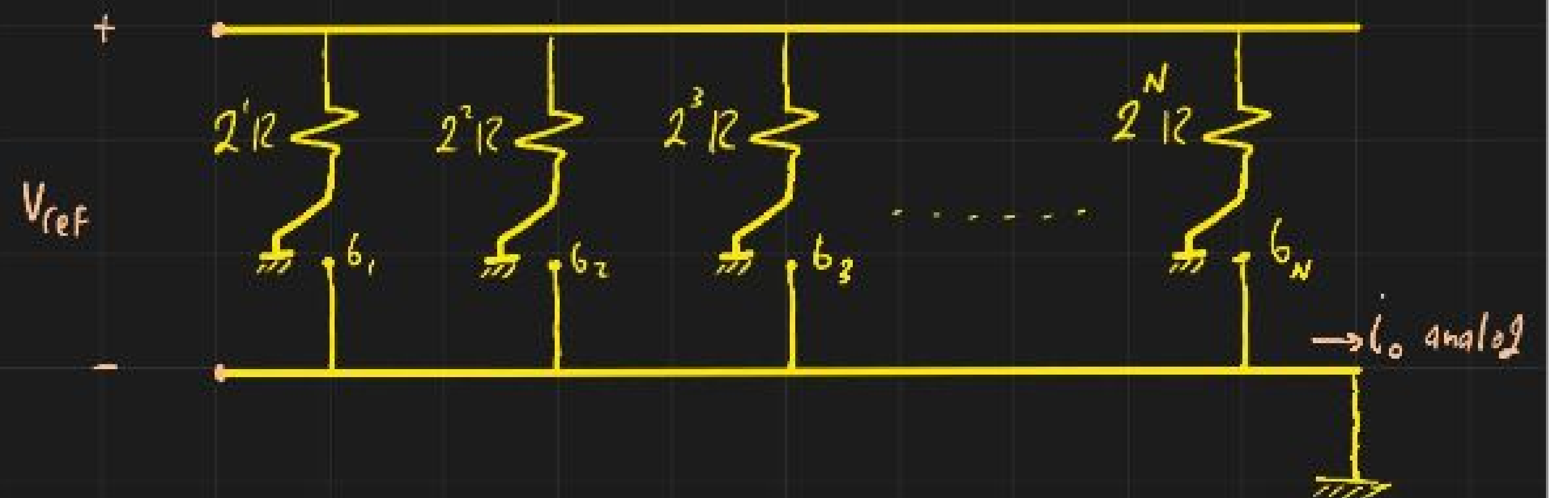
⋆ Digital to Analog Converter (DAC):

→ total current i_o:



resultant current in each branch if it's switch isn't grounded.

$$i_o = \frac{V_{ref}}{2R} b_1 + \frac{V_{ref}}{4R} b_2 + \dots + \frac{V_{ref}}{2^N R} b_N$$

$$\therefore i_o = \frac{V_{ref}}{R}\left[\frac{b_1}{2^1} + \frac{b^2}{2^2} + \dots + \frac{b^N}{2^N}\right] = \boxed{\frac{V_{ref}}{R}\sum_{n=1}^{N}\frac{b_n}{2^n}}$$

MSB (b_1), LSB (b^N)

c) for Vref = 10 V , R = 10 KΩ and N = 8 find the maximum value of I_o obtained. $I_{o_{max}}$ → all bits are on → b = 1

$$\therefore i_{o_{max}} = \frac{V_{ref}}{R}\sum_{n=1}^{8}\frac{1}{2^n} = \frac{10}{10}(0{,}996) \rightsquigarrow \therefore \boxed{i_{o_{max}} = 0{,}996 \text{ mA}}$$

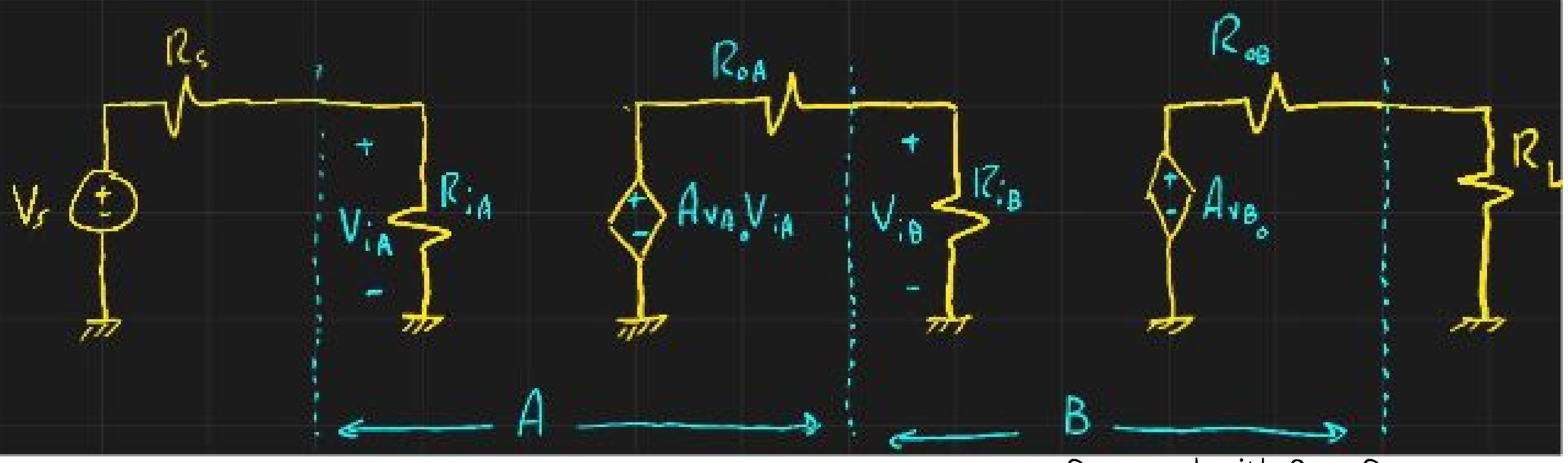
→ what is the change in i_o resulting from the LSB change from 0 to 1.

→ LSB is $b_N = b_8$ → $i_{o_8} = \frac{V_{ref}}{R}\left[\frac{\cancel{b_8}^{1}}{2^8}\right] = 3.9\ \mu A$

∴ the o/p will change by $\boxed{3.9\ \mu A}$

⋆ A,B Amplifer:

→ it's an amplifer of 2 cascaded amplifers to increase the gain.



1.53) A, B amplifiers

$V_s = 10\ mV$

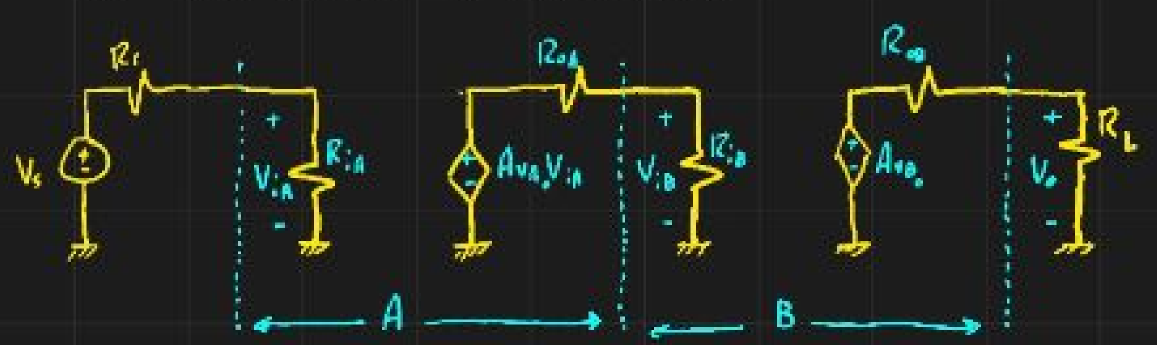
$R_s = 100\ k\Omega$ $\quad R_L = 100\ \Omega$

هل التوصيلة الأفضل SABL ولا SBAL ؟

Source ↙ ↘ Load

	A	B
A_{vo}	100	10
R_i	100 kΩ	10 kΩ
R_o	10 kΩ	1 kΩ

• we'll get overall gain in both cases and the bigger is the better.



$$\cdot A_v = A_{vA} \cdot A_{vB} = \frac{V_o}{V_s} = \frac{V_{iA}}{V_s} \cdot \frac{V_{iB}}{V_{iA}} \cdot \frac{V_o}{V_{iB}}$$

$$\rightarrow \frac{V_{iA}}{V_s} = \frac{R_{iA}}{R_{iA}+R_s} = \frac{100}{100+100} = 0,5$$

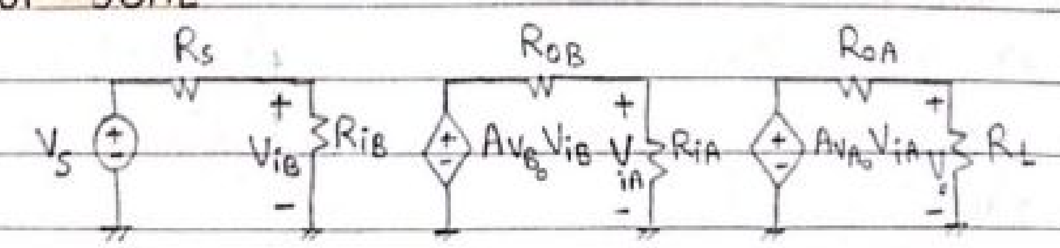
$$\rightarrow \frac{V_{iB}}{V_{iA}} = \frac{R_{iB}}{R_{iB}+R_{oA}} (A_{vA_o}) = \frac{(10)(100)}{10+10} = 50$$

$$\rightarrow \frac{V_o}{V_{iB}} = \frac{R_L}{R_L+R_{oB}} (A_{vB_o}) = \frac{(100)(10)}{100+1000} = 0,909$$

$\therefore A_v = (0,5)(50)(0,909) \rightsquigarrow \therefore A_v = 22.73$

$\therefore A_v = 20\log(22.7) \rightsquigarrow \therefore A_{v_{SABL}} = 27.1\ dB$

② for SBAL



$$\frac{V_{iB}}{V_s} = \frac{R_{iB}}{R_s + R_{iB}} = \frac{10}{100+10} = \frac{1}{11}$$

$$\frac{V_{iA}}{V_{iB}} = \frac{A_{vB_o} R_{iA}}{R_{oB} + R_{iA}} = \frac{10 * 100}{1 + 100} = \frac{1000}{101}$$

$$\frac{V_o}{V_{iA}} = \frac{A_{vA_o} R_L}{R_o + R_{oA}} = \frac{100 * 100}{100 + 10.000} = \frac{100}{101}$$

$$\frac{V_o}{V_s} = \frac{1}{11} * \frac{1000}{101} * \frac{100}{101} = 0.891$$

$$A_{v_{SBAL}} = 20\ \text{Log}(0.891) = -1\ dB$$

$\therefore A_{v_{SABL}} > A_{v_{SBAL}}$

$\therefore$ SABL is better

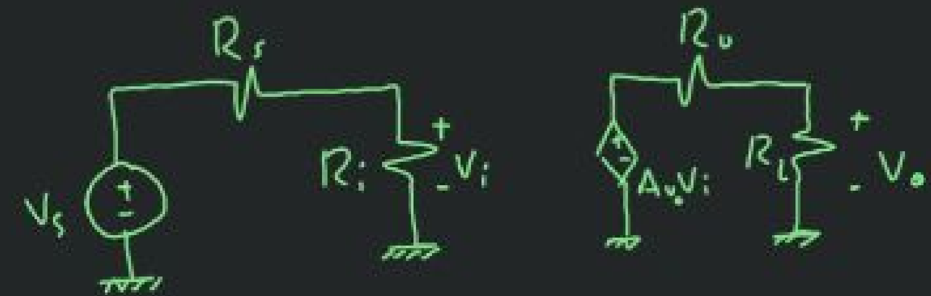
• note that we can know without calculating anything, we know that the higher the R_{in} ↑↑ the better and also the lower the R_{out} ↓↓ the better

. A has a higher R_{in}, and B has the lower R_{out} $\rightsquigarrow \therefore$ A at i/p and B at o/p $\rightsquigarrow \therefore$ SABL

Scanned with CamScanner

Amplifier Model:

- it's Prefered to make $R_i >>$ to neglect the dropout Voltage on R_s
- ideal $\rightarrow V_i = V_s$ " $R_i = \infty$ "
- $R_o \downarrow\downarrow$



MOSFET Circuit at DC:

EX (5.3)

$I_D = 0.2mA$

$V_D = 0.2\ V$

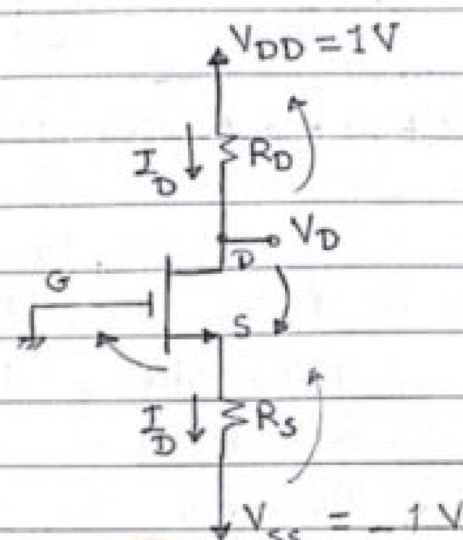
$V_t = 0.5\ V$

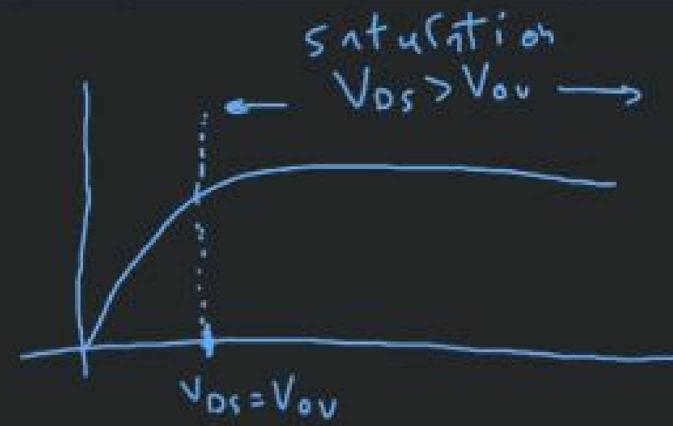
$\mu_n C_{ox} = 400\ \mu A/V^2$

$L = 0.5\ \mu m$, $W = 15\ \mu m$

$\lambda = 0$

find: R_D, R_S





→ Assume Saturation " $V_{DS} > V_{ov}$ "

$\therefore V_{DS} - V_{GS} = V_D - \cancel{V_s} - V_G + \cancel{V_s}$

$= 0.2 - 0$

$\therefore V_{DS} - V_{GS} = 0.2 \rightarrow ①$

$\because V_{GS} = V_{ov} + V_t$

$\therefore V_{DS} - 0.2 = V_{ov} + 0.5$

$\therefore V_{DS} - V_{ov} = 0.7$ $\quad \therefore V_{DS} > V_{ov}$ $\quad \therefore$ Saturation

$R_D = \frac{V_{DD} - V_D}{I_D} = \frac{1 - 0.2}{0.2} = 4\ k\Omega$

$\because I_D = \frac{1}{2} \mu C_{ox} \frac{W}{L} V_{ov}^2$

$\therefore 0.2 \times 10^{-3} = \frac{1}{2}(400 \times 10^{-6})(\frac{15}{0.5}) V_{ov}^2$

$\therefore V_{ov}^2 = \frac{1}{30} \rightsquigarrow \therefore V_{ov} = 0.18\ v$

$\therefore V_{ov} = V_{GS} - V_t$

$\therefore V_{GS} = 0.18 + 0.5$

$\therefore V_{GS} = 0.68\ v$

$\therefore V_G - V_s = 0.68 \rightsquigarrow \therefore V_s = -0.68\ v$

$R_s = \frac{V_s - V_{ss}}{I_D} = \frac{-0.68 + 1}{0.2} = 1.6\ k\Omega$

~~$R_s = \frac{V_s - V_{ss}}{I_D} = \frac{-0.68 + (-1)}{0.2mA}$~~

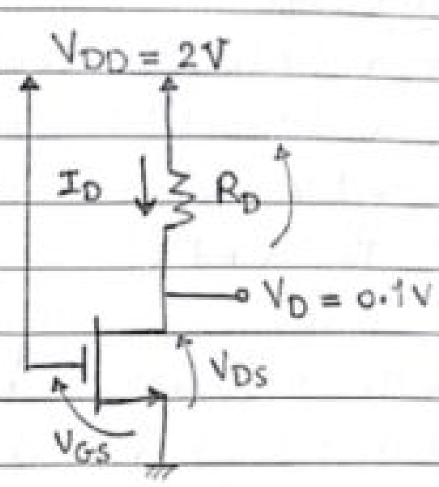
~~$\boxed{R_s = 1.6\ k\Omega}$~~

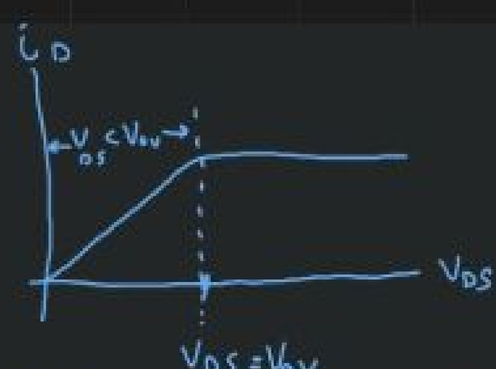
EX (5.5)

$V_D = 0.1\ V$

$V_t = 0.5\ v$ $\quad k_n'(\frac{W}{L}) = 2\ mA/V^2$

find: effective resistance between drain and source. $R_{DS} = \frac{V_{DS}}{I_D}$





Linear approx.

$r_{os} = \frac{1}{slope} = \frac{1}{k_n V_{ov}} = \frac{1}{(2 \times 10^{-3})(1.5)} = 333.3\ \Omega$

1) determine operation mode

$V_G = 2v$, $V_s = 0$ $\quad \therefore V_{GS} = 2v$

$V_D = 0.1$, $V_s = 0$ $\quad \therefore V_{DS} = 0.1v$

$V_{ov} = V_{GS} - V_t = 2 - 0.5 \rightsquigarrow \therefore V_{ov} = 1.5v$, $\quad \therefore V_{DS} < V_{ov} \rightsquigarrow \therefore$ triode mode

$I_D = k_n' \frac{W}{L} [V_{ov} V_{DS} - \frac{1}{2} V_{DS}^2]$

$\therefore I_D = 2 \times 10^{-3} [(1.5)(0.1) - \frac{1}{2}(0.1)^2]$

$\therefore I_D = 0.29\ mA$

$R_{eff} = \frac{V_{DS}}{I_D} = \frac{0.1}{0.29} = r_{os}$

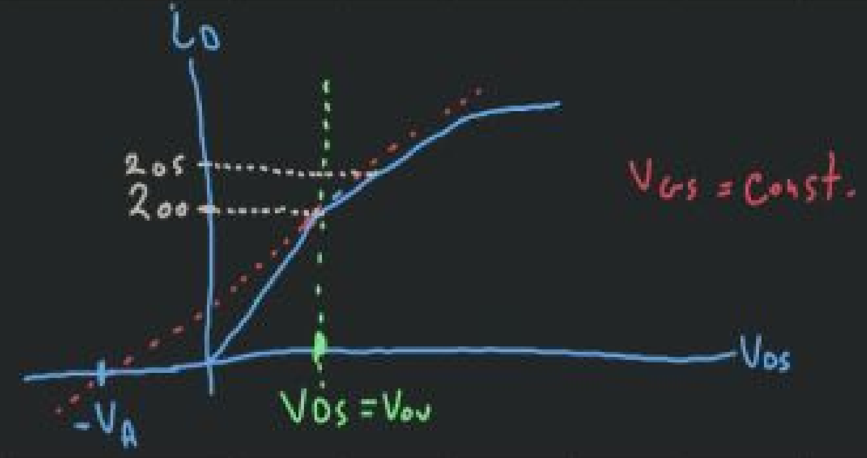
$\therefore R_{eff} = 345\ \Omega = r_{os}$

$R_D = \frac{2 - 0.1}{0.29}$

$\therefore R_D = 6.5\ k\Omega$

Prob (5.29)

for a particular MOSFET operating in the saturation region at a constand V_{GS}, i_D is found to be 200 μA for $V_{DS} = 1$ V and 205 μA for $V_{DS} = 1.5$ V find the values of r_o, V_A and λ



i_D	200	205	μA
V_{DS}	1	1.5	V

- in saturation, i_D is constant with changing V_{DS}, but here i_D increases.
- So there's λ in this example.

$$- r_o = \frac{1}{\text{slope}} = \frac{1}{K_n V_{ov}} = \frac{\Delta V_{DS}}{\Delta i_D} = \frac{1.5-1}{205-200} \rightsquigarrow \therefore \boxed{r_o = 100\ k\Omega}$$

• $V_{DS} = V_A$ when $i_D = 0$

$$\therefore i_D = \frac{1}{2} K_n (V_{GS} - V_t)^2 (1 + \lambda V_{DS}) = 0$$

$$\therefore 1 + \lambda V_{DS} = 0 \rightsquigarrow \therefore V_{DS} = \frac{-1}{\lambda} = -V_A$$

$$\therefore r_o = \frac{V_{DS}}{i_D}, \quad \therefore r_o = \frac{1}{\lambda i_D} = \frac{V_A}{i_D}$$

$$\therefore 100k = \frac{V_A}{200\mu}, \quad \therefore \boxed{V_A = 20\text{ V}}, \quad \therefore \boxed{\lambda = \frac{1}{20}}$$

or

• From line eq we get the intersection with x-axis "V_{DS}" and this point will be V_A

$$\therefore \frac{i_D - 200}{V_{DS} - 1} = \frac{205 - 200}{1 - 1.5}$$

$$\therefore V_{DS} - 1 = (\cancel{i_D}^{\,0} - 200)\,\frac{1 - 1.5}{205 - 200}$$

$$\therefore \boxed{V_{DS} = -V_A = 19\text{ V}}$$

$$\therefore \boxed{\lambda = \frac{1}{19}}$$