Sub V_T

$$g_m = \frac{\kappa I_{bias}}{V_T}$$

$$r_o = \frac{V_A}{I_{bias}}$$

$$a_v = -g_m r_o = -\frac{\kappa V_A}{V_T}$$

Above V_T

$$g_m = \sqrt{2K I_{bias}}$$

$$r_o = \frac{V_A}{I_{bias}}$$

$$a_v = -g_m r_o = \frac{V_A \sqrt{2K}}{\sqrt{I_{bias}}}$$

for $W = 7\mu m$, $L = 2\mu M$ | $I_d = 100nA$, $V_A = 9.89V$ | $I_d = 100\mu$, $V_A = 69.1V$

Now for $I_d = 100nA$, $V_A = 9.89V$

Sub $r_o = \frac{9.89V}{100nA} = 98.9 M\Omega$

above $r_o = \frac{69.1V}{100\mu A} = 69.1\mu\Omega$

$$I_d = \frac{1}{2} K (V_{gs} - V_T)^2 \left(1 + \frac{V_{ds}}{V_A}\right)$$

To determine V_T lets do a Test simulation of nfet with $W = 7um$, $L = 2um$

Sweep the Vg and then Plot sqrt(Id)

Next get the slope of the Linear Region

which is 0.0127

$$V_{Th} = V_{GS} - \frac{I_d}{\text{Slope}}$$

Say $V_{Th} = (1.003) - \frac{0.00768}{0.0127} = 0.398V$

Now on Test sim when $V_g = 0.398$

then we get $I_{th} \approx 44.59\ nA$

Therefore the above sub and above bias currents are wrong.

So we pick $W = 7um$ and $L = 2\mu$

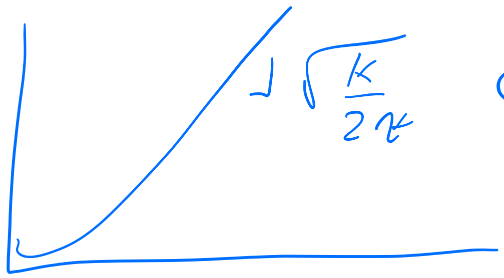
now we need to find I_{bias}

So $a_v = -50, -300$

$$I_d = \frac{1}{2} k (V_{gs} - V_T)^2 \left(1 + \frac{V_{ds}}{V_A}\right)$$

$$I_d = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{gs} - V_T)^2 \left(1 + \frac{V_{ds}}{V_A}\right)$$

From square Law Plot



estimate γ as ≈ 1 in above V_T

new $\sqrt{\frac{1}{2}k}$ = slope

$$= \sqrt{\frac{1}{2}\mu_n C_{ox}\frac{W}{L}} = S$$

$$S^2 = \frac{1}{2}\mu_n C_{ox}\frac{7}{2}$$

$$\mu_n C_{ox} = \frac{2S^2}{7}$$

slope $\approx 0.0125 \frac{\sqrt{A}}{V}$

$$\mu_n C_{ox} = \frac{2(0.0125)^2}{7}\frac{A}{V^2}$$

$$\mu_n C_{ox} = 4.464 \times 10^{-5}$$

List of parameters

$k' = 44.6 \frac{\mu A}{V^2}$

$V_{th} = 0.398$ V

$I_{th} = 44.59$ nA

$W = 7 \mu m$

$L = 2 \mu m$

$a_v = -50, -300$

above V_T => $g_m = \sqrt{2kI}$

Lets use the graph of

$\frac{\partial(I_d)}{\partial(V_{GS})}$ to determine g_m at

the amplification region $(0 \to 1V)$ ~ from graphs

$0 - 0.9$ avg $g_m = 185.9 \mu S$

now use that to find ro for gain of -300|

$$-a_v = -g_m r_o$$

$$r_o = \frac{300}{185.9\,\mu S} = 1613770$$

$$= 1.6\,M\Omega$$

Now we have

List of parameters

$k' = 44.6\,\frac{\mu A}{V^2}$

$V_{th} = 0.398\,V$

$I_{th} = 44.59\,nA$

$W = 7\,\mu m$

$L = 2\,\mu m$

$a_v = -50, -300$

$g_m \approx 185.9\,\mu S$

$r_o \approx 1.6\,M\Omega$

find I_{bias} |

$g_m = \sqrt{2k' \frac{W}{L} I_d}$

$I_d = \frac{(g_m)^2}{2k' \frac{W}{L}} = \frac{(188.9\ \mu)^2}{2(44.6 \frac{\mu A}{V^2})(\frac{?}{2})}$

$I_d = 110\ \mu A$

for above V_T gain ≈ -50

New for $a_v = -300$

List of Parameters

$k' = 44.6\ \frac{\mu A}{V^2}$

$V_{th} = 0.398\ V$

$I_{th} = 44.59\ nA$

$W = 7\mu m$

$L = 2\mu m$

$a_v = -50, -300$

$$g_m = \sqrt{2kI_{bias}}$$

$$r_o = \frac{V_A}{I_{bias}}$$

$$a_v = -g_m r_o$$

$$-a_v = \frac{V_A \sqrt{2 \cdot \frac{1}{2} k' \frac{W}{L} I_d}}{I_d}$$

avg V_A for above V_T for length 2

$= 27.55V$

So

$$-50 = \frac{(27.55)\left(\sqrt{44.9\mu \cdot \frac{7}{2} \cdot I_d}\right)}{I_d}$$

$$-50\, I_d = 27.55 \sqrt{1.5715\times10^{-4}\, I_d}$$

$$-1.8148\, I_d = \sqrt{1.5715\times10^{-4}\, I_d}$$

$$3.294\, I_d^2 = 1.5715\times10^{-4}\, I_d$$

$$I_d \approx 48\,\mu A$$

a ballpark number

guess and check around there

New Gain of -300 Lets use subthreshold for a higher gain

$$g_m = \frac{\kappa I_{bias}}{V_T}$$

$$r_o = \frac{V_A}{I_{bias}}$$

$$-300 = \frac{(9.89)\sqrt{1.5715\times10^{-4}\, I_d}}{I_d}$$

$$(30.334\, I_d)^2 = 1.5715\times10^{-4}\, I_d$$

$a_v = -g_m r_o = -\frac{2 V_A}{V_T}$

$92 \cdot 0.1 \ I_d = 1.5715 \times 10^{-4}$

$I_d = 164 \ nA$

---

doing drain sweeps show that

$\frac{W}{L} = \frac{7}{5}$ never reaches -300 for gain

Switching $\frac{W}{L} = \frac{7}{4}$ sweeps show reaches

$a_v = 300$ around $0.1 \rightarrow 10 \ nA$ range

So fine tune with one sweep

for $\approx 1 nA$
