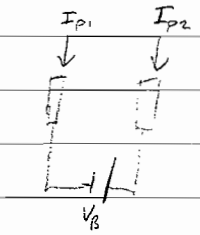
2004 Part I Q2

Exp.

a. Double probe setup:



Entire setup is floating. $V_{p2} - V_{p1} = V_B$. $V_{p2} = V_f + V_B/2$ $V_{p1} = V_f - V_B/2$

No net current: $I_{p1} = -I_{p2}$

$$I_{p1} = I_{is} - I_{es}\exp\left(\frac{e(V_f - V_B/2 - V_{sp})}{T_e}\right)$$

$$I_{p2} = I_{is} - I_{es}\exp\left(\frac{e(V_f + V_B/2 - V_{sp})}{T_e}\right)$$

Since areas are the same $I_{is1} = I_{is2}$, $I_{es1} = I_{es2}$

$$I_{is} - I_{es}\exp\left(\frac{e(V_f - V_B/2 - V_{sp})}{T_e}\right) = -I_{is} + I_{es}\exp\left(\frac{e(V_f + V_B/2 - V_{sp})}{T_e}\right)$$

$$2I_{is} = I_{es}\exp\left(\frac{e(V_f - V_{sp})}{T_e}\right) \cdot 2\cosh\frac{eV_B}{2T_e}$$

$$\Rightarrow I_{es}\exp\left(\frac{e(V_f - V_{sp})}{T_e}\right) = \frac{I_{is}}{\cosh\frac{eV_B}{2T_e}}$$

current flowing $= I_{p1} = I_{is} - \frac{I_{is}}{\cosh\frac{eV_B}{2T_e}} e^{-\frac{eV_B}{2T_e}}$

$$I = \frac{I_{is}}{\cosh\frac{eV_B}{2T_e}}\left[\cosh\frac{eV_B}{2T_e} - e^{-\frac{eV_B}{2T_e}}\right] = \frac{I_{is}}{\cosh\frac{eV_B}{2T_e}}\left[\frac{1}{2}e^{\frac{eV_B}{2T_e}} + \frac{1}{2}e^{\frac{-eV_B}{2T_e}} - e^{-\frac{eV_B}{2T_e}}\right]$$

$$I = I_{is}\tanh\frac{eV_B}{2T_e}$$

max $I = I_{is} = 0.6\, n e A\sqrt{\frac{T_e}{m_i}}$ $m_i = 16 m_p$ $T_e = 2\,eV$

$n = 10^{12}\,m^{-3}$ $A = 20\,m^2$

$I_{max} = 6.7\,mA$ voltage needed? $V_B \sim 6\,V$

b.