Finding $R_{out}$ by Inspection

Looking into the Source of a MOSFET, with drain degeneration, we can find $R_{out,source}$ by drawing the equivalent small-signal model:

By inspection we find that: (1) $V_{gs} = V_{bs} = -V_T$ and (2) $V_x = i_TR_D$.

Using KCL at S gives (3):

$$i_T + g_mV_{gs} + g_mbV_{bs} = \frac{V_T - V_x}{r_o}$$

Plugging in (1) and (2) into (3) yields:

$$i_T - g_mV_T - g_mbV_T = \frac{V_T - i_TR_D}{r_o}$$

Rearranging:

$$i_T \left(1 + \frac{R_D}{r_o}\right) = V_T \left(g_m + g_mb + \frac{1}{r_o}\right)$$

Dividing $V_T$ by $i_T$ results in $R_{out,source}$:

$$\frac{V_T}{i_T} = R_{out,source} = \frac{r_o + R_D}{1 + (g_m + g_mb)r_o}$$
Looking into the Drain of a MOSFET, with source degeneration, we can find $R_{\text{out,\,drain}}$ by drawing the equivalent small-signal model:

![Diagram](image)

By inspection we find that: (1) $V_{gs} = V_{bs} = -V_x$ and (2) $V_x = i_T R_S$

Using KCL at S gives (3):

$$i_T = g_m V_{gs} + g_{mb} V_{bs} + \frac{V_T - V_x}{r_o}$$

Plugging in (1) and (2) into (3) yields:

$$i_T = -g_m V_T - g_{mb} V_T + \frac{V_T - i_T R_S}{r_o}$$

Rearranging:

$$V_T \left( \frac{1}{r_o} \right) = V_T \left( 1 + \frac{R_S}{r_o} + (g_m + g_{mb}) R_s \right)$$

Dividing $V_T$ by $i_T$ results in $R_{\text{out,\,drain}}$:

$$\frac{V_T}{i_T} = R_{\text{out,\,drain}} = r_o + R_S + (g_m + g_{mb}) r_o R_S$$