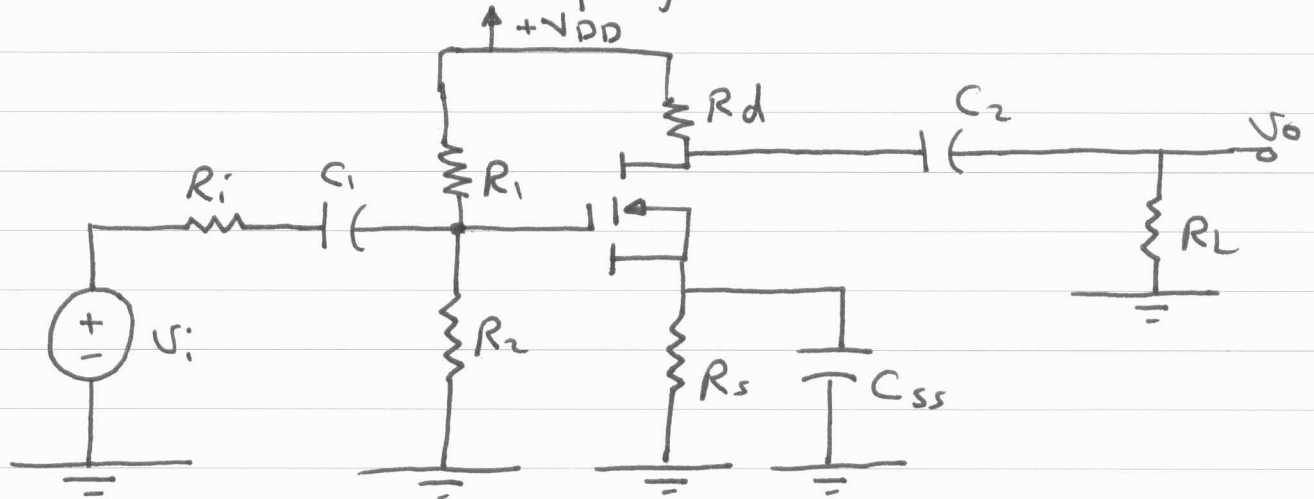


FET High-Frequency Analysis

1) Common Source Amplifier

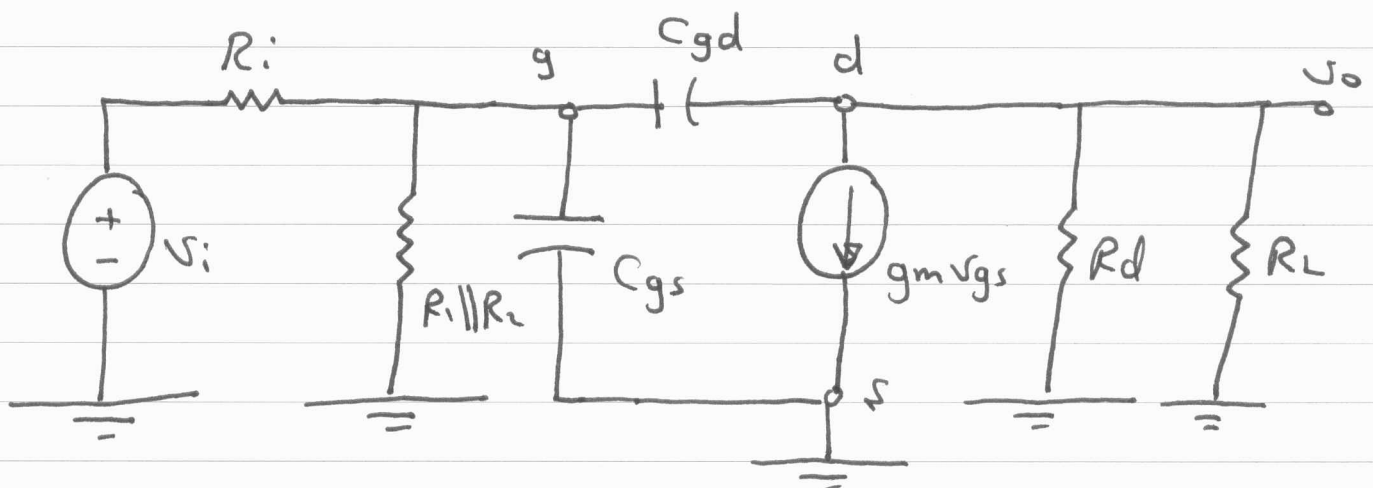


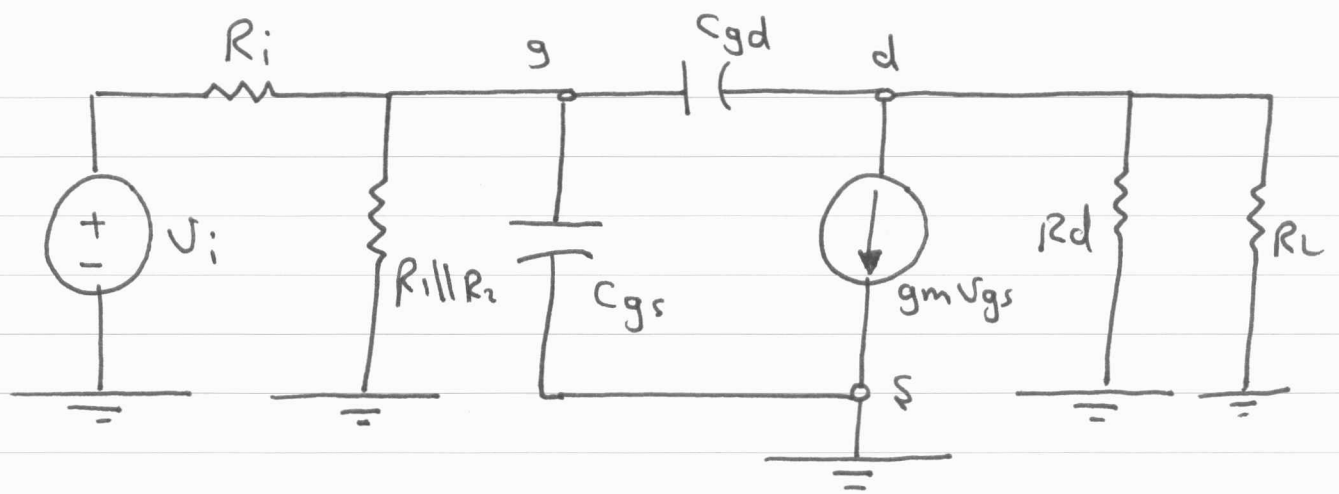
$$R_i = 0.3k, R_1 \parallel R_2 = 100k, R_d = R_L = 5k$$
$$R_s = 1k, g_m = 10mS$$

$$C_{gd} = 2pF \text{ and } C_{gs} = 5pF$$

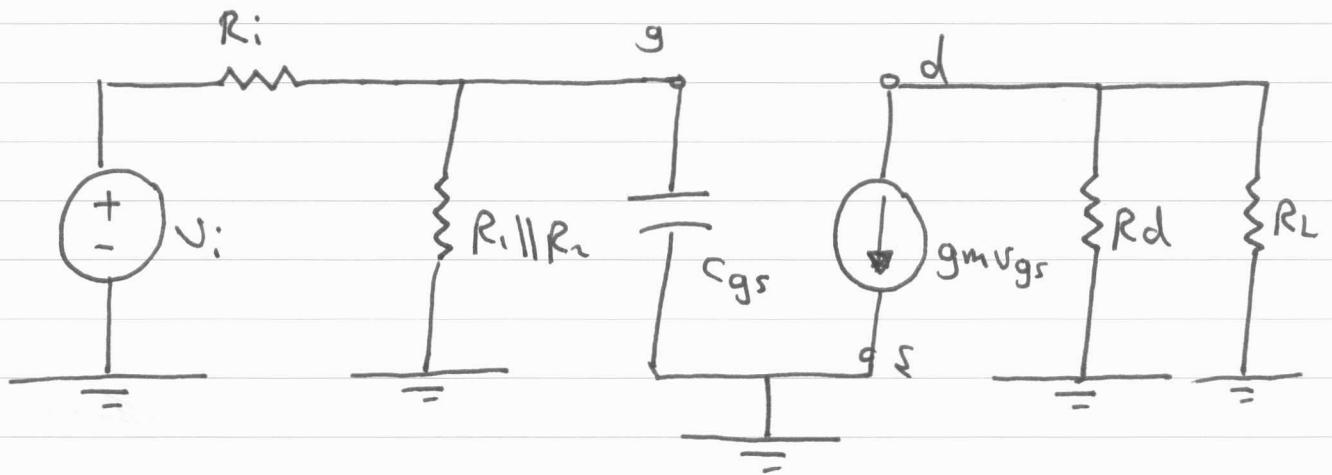
Estimate ω_H

ac small signal high-frequency equivalent ckt:





1) To find τ_{gs} ; set C_{gd} open circuit



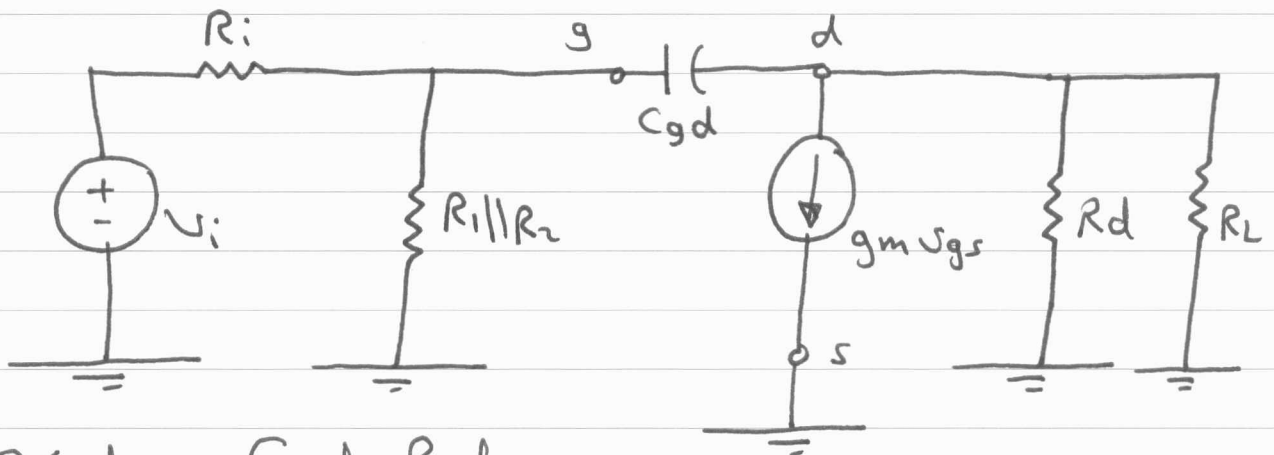
$$\tau_{gs} = C_{gs} R_{gs}$$

$$R_{gs} = R_i \parallel R_1 \parallel R_2$$

$$\therefore \tau_{gs} = 1.496 \text{ ns}$$

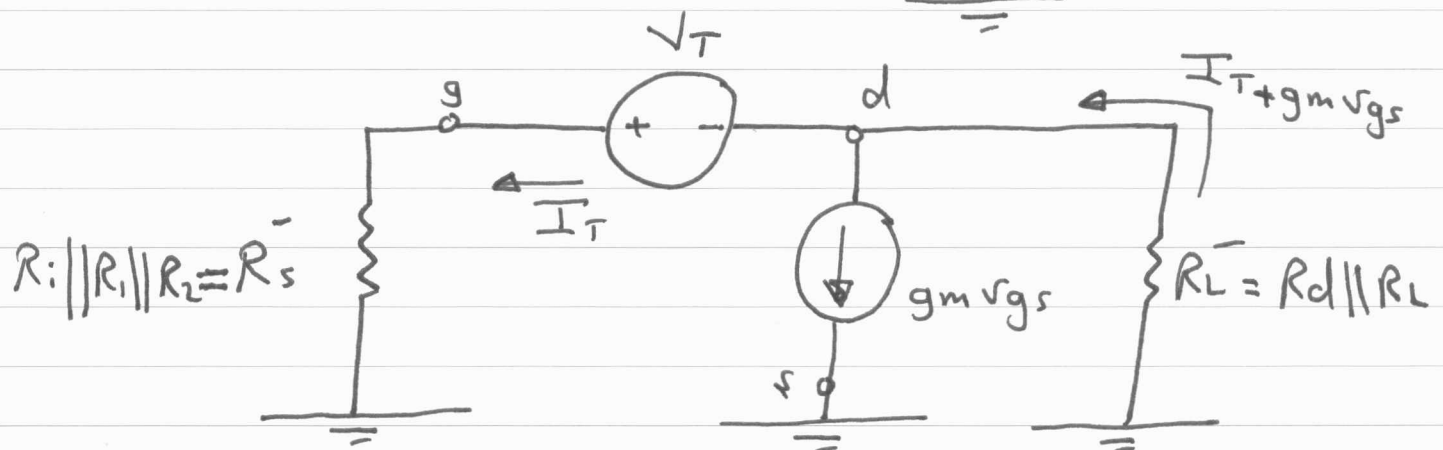
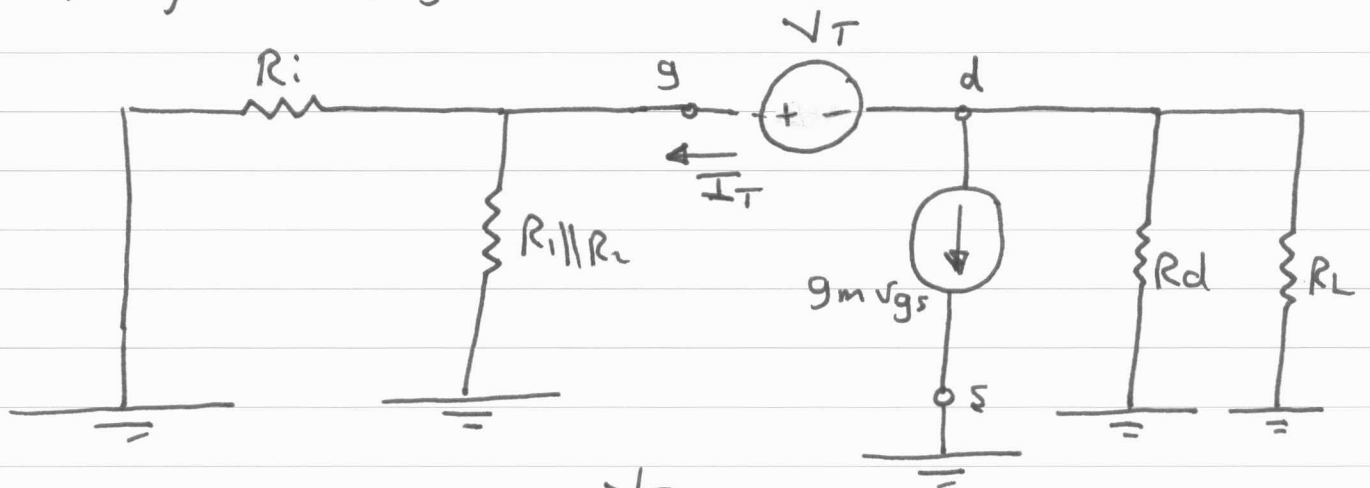
$$\therefore \omega_{gs} = \frac{1}{\tau_{gs}} = 668.45 \text{ Mrad/s}$$

2) To find T_{gd} ; set C_{gs} open circuit



$$T_{gd} = C_{gd} R_{gd}$$

To find R_{gd}



$$R_L^{-} (I_T + g_m V_{gs}) + R_s^{-} I_T = V_T$$

$$V_{gs} = V_g - V_s = V_g = R_s^{-} I_T$$

$$\therefore \frac{V_T}{I_T} = R_s^{-} + R_L^{-} + g_m R_L^{-} R_s^{-} = R_{gd}$$

$$\tau_{gd} = C_{gd} R_{gd}$$

$$\tau_{gd} = 20.6 \text{ ns}$$

$$\therefore \omega_{gd} = 48.54 \text{ Mrad/s}$$

$$\frac{1}{\tau_{gd} + \tau_{gs}} < \omega_H < 48.54 \text{ Mrad/s}$$

$$45.3 \text{ Mrad/s} < \omega_H < 48.54 \text{ Mrad/s}$$

$$\omega_H \approx 48.4 \text{ Mrad/s}$$

$$\tau_{gd} = 20.6 \text{ ns} ; \tau_{gs} = 1.496 \text{ ns}$$

$\therefore$ To increase the bandwidth, we must decrease τ_{gd}

$$\tau_{gd} = C_{gd} R_L + C_{gd} R_S + C_{gd} g_m R_L R_S$$

$$\tau_{gd} = 5 \text{ ns} + 0.6 \text{ ns} + 15 \text{ ns} = 20.6 \text{ ns}$$

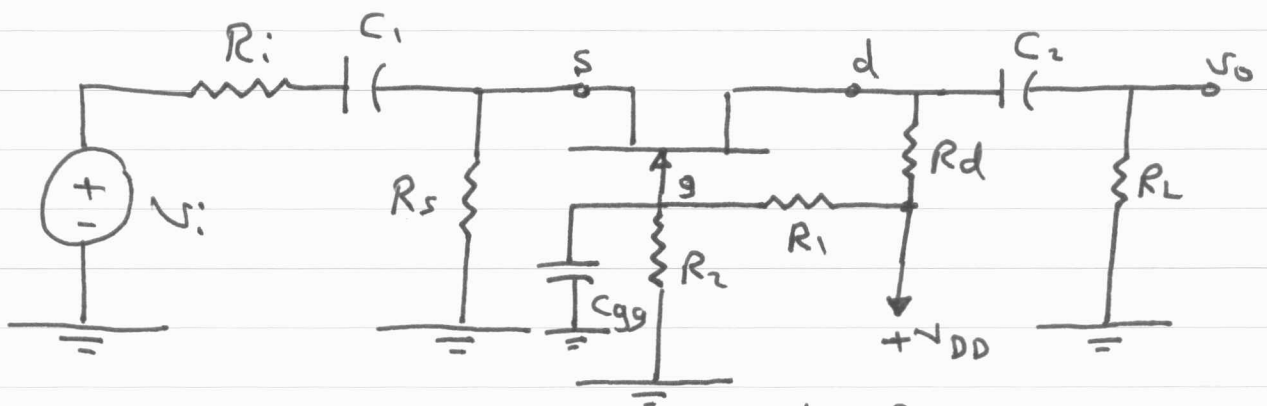
and to decrease τ_{gd} ; we need to decrease

$$g_m R_L \approx A_v(\text{mid})$$

$\therefore$ Thus increasing bandwidth is usually achieved by reducing the midband gain.

$\therefore$ The product of gain and bandwidth tends to be Constant.

2) Common gate amplifier



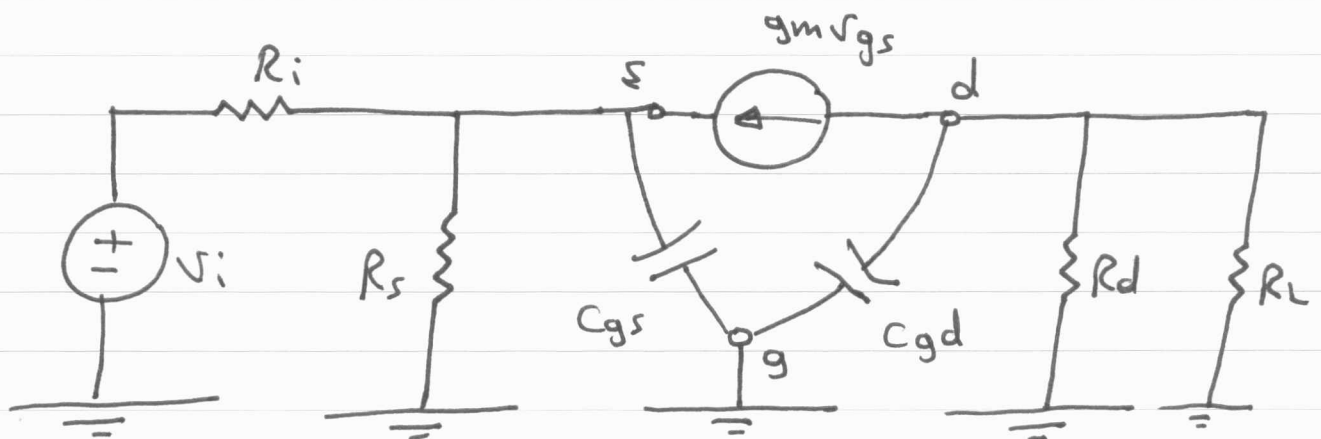
$$R_i = 0.3\text{ k}\Omega, R_1 \parallel R_2 = 100\text{ k}\Omega, R_d = R_L = 5\text{ k}\Omega$$

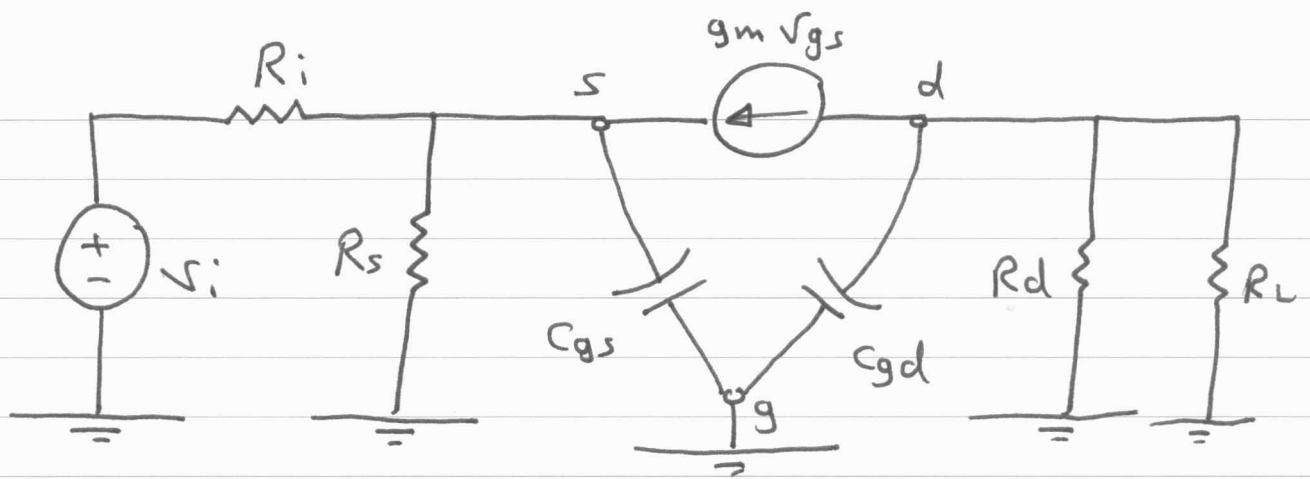
$$R_s = 1\text{ k}\Omega, g_m = 10\text{ mS}$$

$$C_{gd} = 2\text{ pF}, \text{ and } C_{gs} = 5\text{ pF}$$

Estimate WH

ac small-signal high-frequency equivalent CRT:





1) To find τ_{gs} , set C_{gd} open circuit

$$\tau_{gs} = C_{gs} R_{gs}$$

$$R_{gs} = R_s \parallel R_i \parallel \frac{1}{g_m}$$

$$\therefore \tau_{gs} = 0.349 \text{ ns}$$

$$\therefore W_{gs} = 2865 \text{ mV/s}$$

2) To find τ_{gd} , set C_{gs} open circuit

$$\tau_{gd} = C_{gd} R_{gd}$$

$$R_{gd} = R_L \parallel R_d$$

$$\therefore \tau_{gd} = 5 \text{ ns}$$

$$\therefore W_{gd} = 200 \text{ mV/s}$$

$$\frac{1}{\tau_{gd} + \tau_{gs}} < W_H < 200 \text{ mV/s}$$

$$187 \text{ mV/s} < W_H < 200 \text{ mV/s}$$