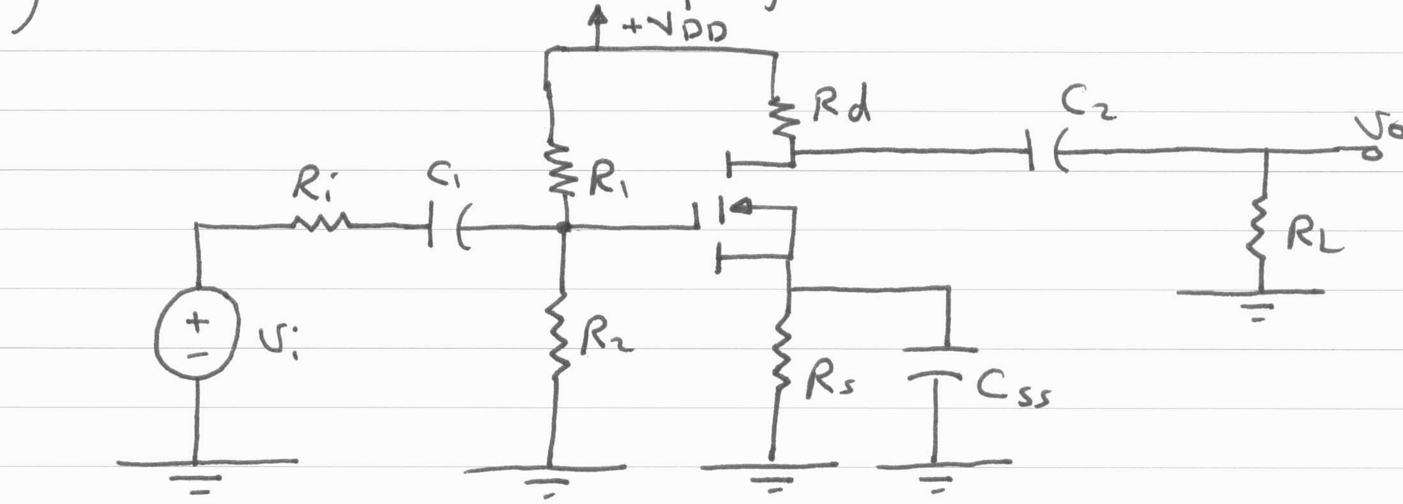
FET High-Frequency Analysis

1) Common Source Amplifier



$R_i = 0.3K$, $R_1 \| R_2 = 100K$, $R_d = R_L = 5K$

$R_s = 1K$, $g_m = 10m℧$

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

Estimate ω_H

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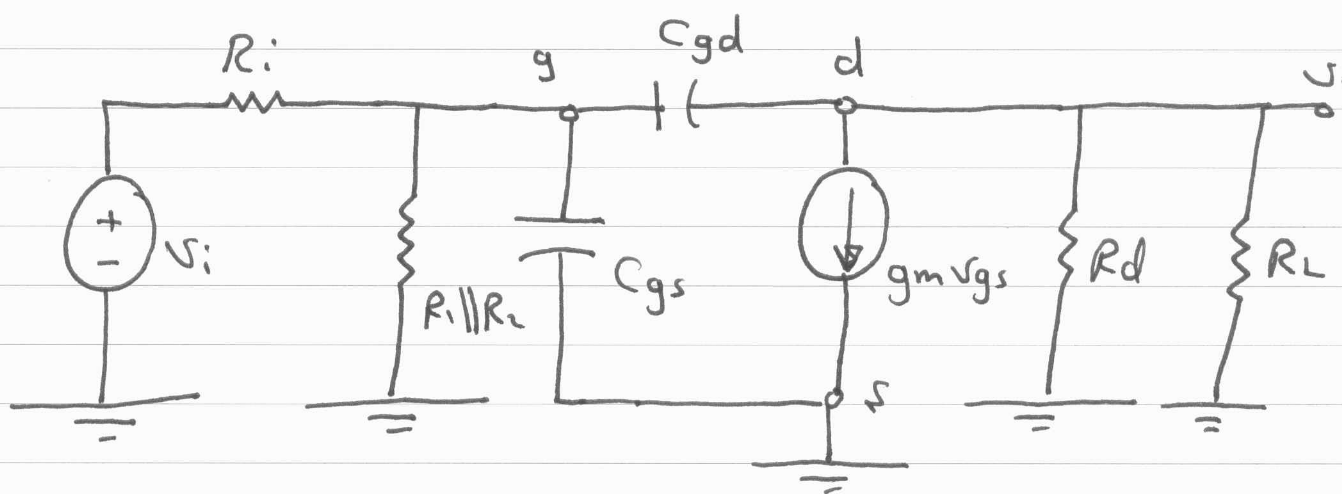
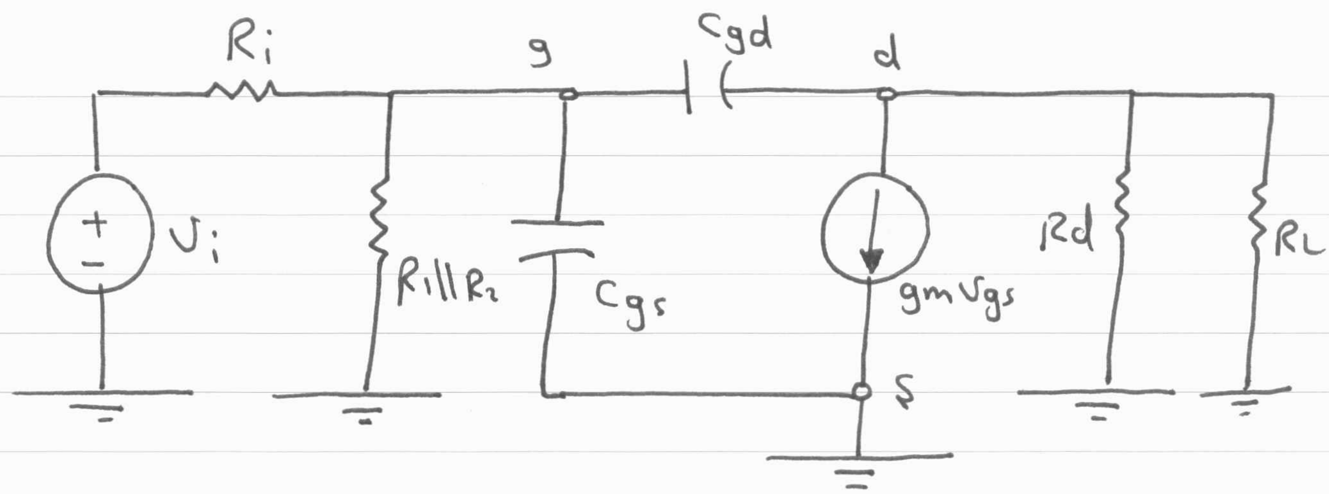
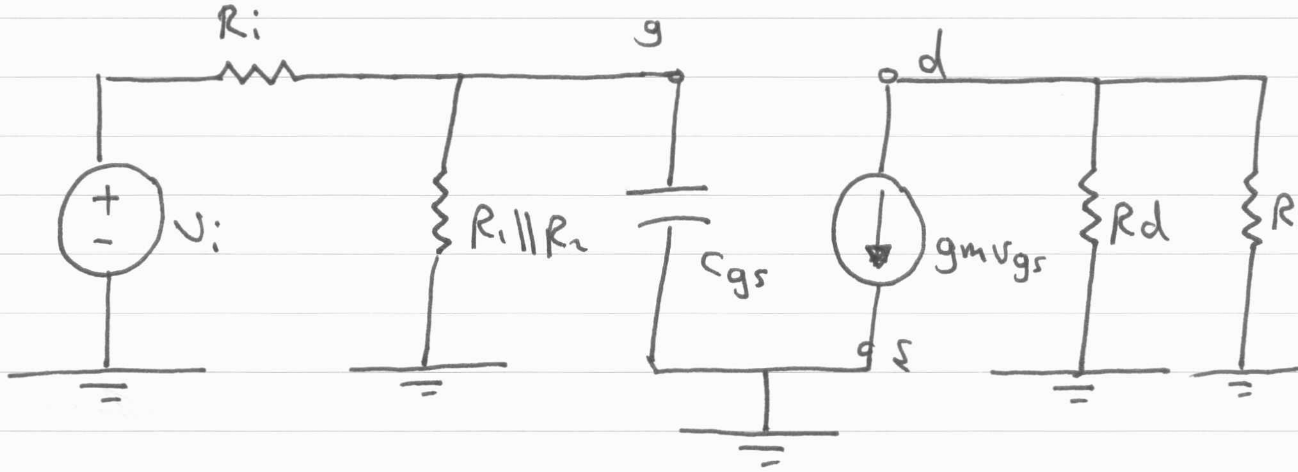
ac small signal high-frequency equivalent CKT:





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



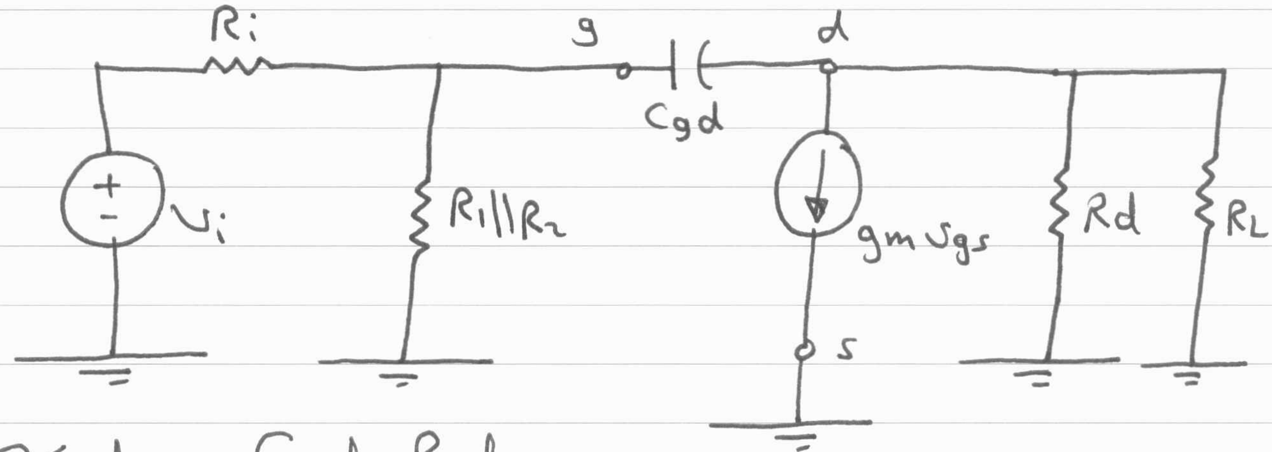
$$\tau_{gs} = C_{gs} R_{gs}$$

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

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

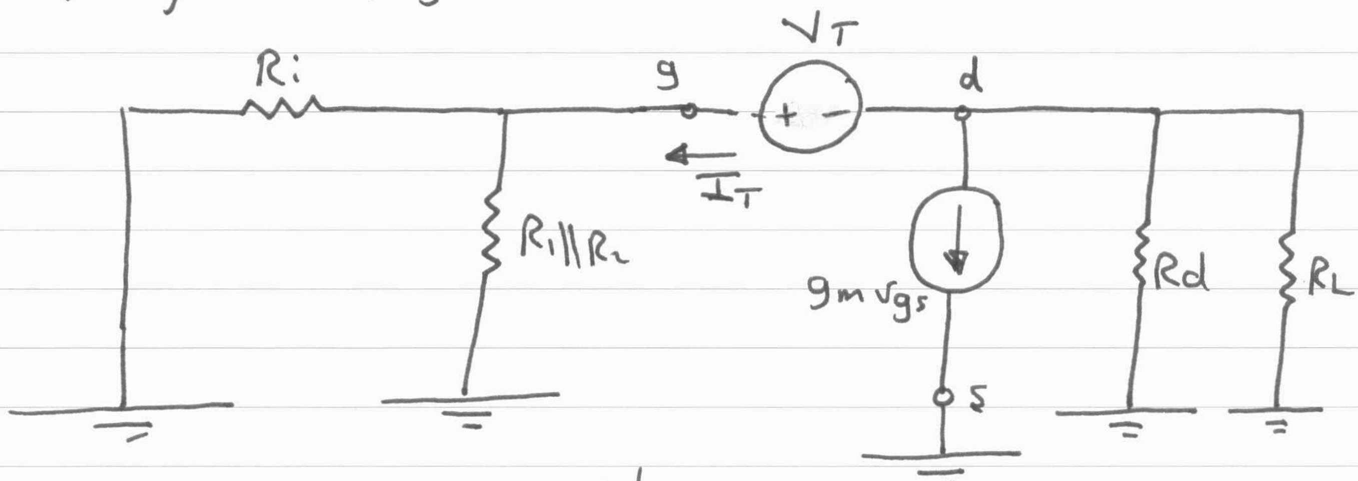
$$\therefore \omega_{gs} = \frac{1}{\tau_{gs}} = 668.45 \text{ M r/s}$$

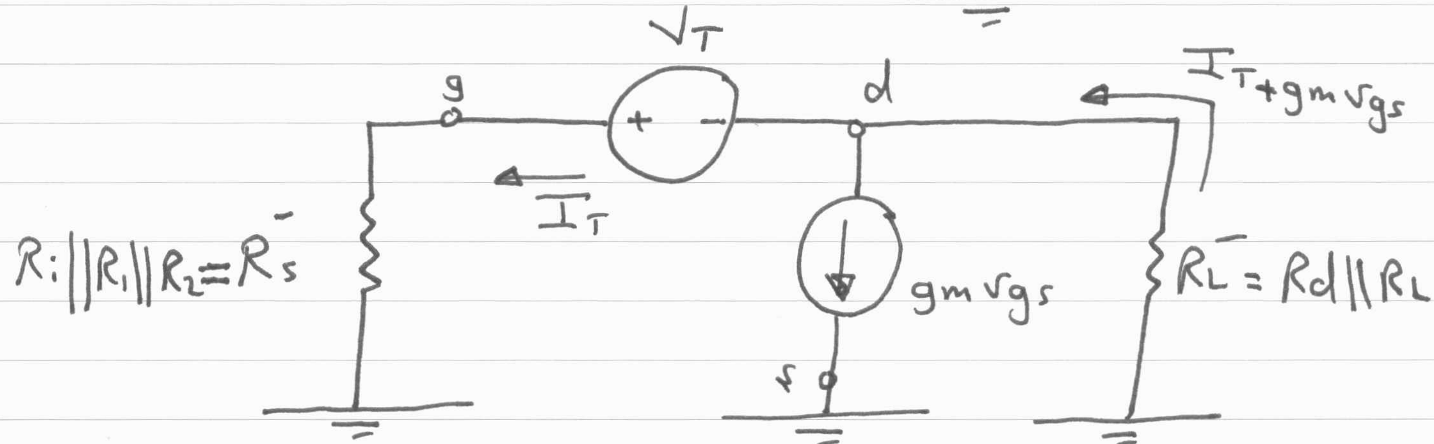
2) To find τ_{gd} ; set C_{gs} open circuit



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

To find R_{gd}





$$\bar{R_L}\left(I_T + g_m v_{gs}\right) + \bar{R_s} I_T = V_T$$

$$v_{gs} = v_g - v_s = v_g = \bar{R_s} I_T$$

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

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

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

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

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

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

$$\omega_H \cong 48.4 \text{ Mr/s}$$

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

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

$\tau_{gd} = C_{gd} \bar{R_L} + C_{gd} \bar{R_s} + C_{gd}\, g_m \bar{R_L} \bar{R_s}$

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

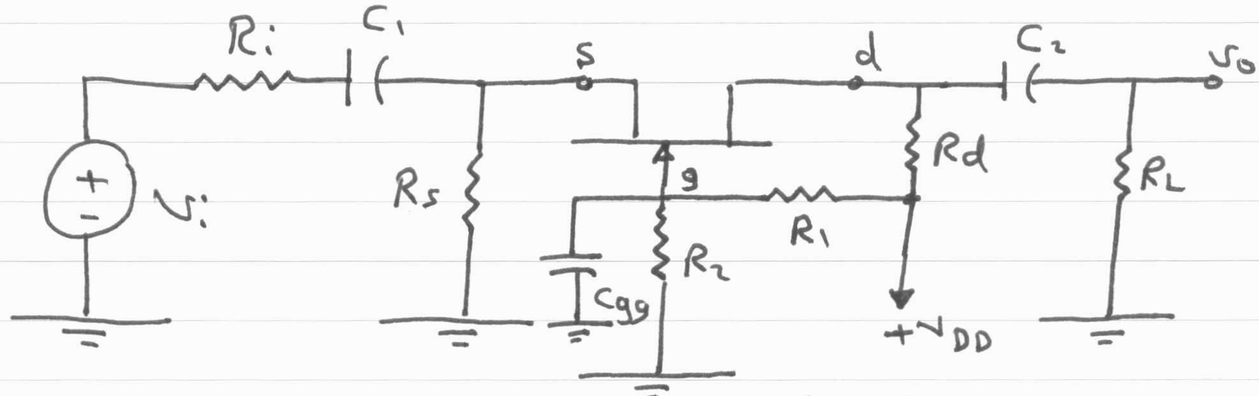
and to decrease τ_{gd} ; we need to decrease

$g_m \bar{R_L} \cong A_v(\text{mid})$

∴ Thus increasing bandwidth is usually achieved by reducing the midband gain.

∴ The product of gain and bandwidth tends to be Constant.

2) Common gate amplifier



$R_i = 0.3K$, $R_1 \| R_2 = 100K$, $R_d = R_L = 5K$
$R_s = 1K$, $g_m = 10 m℧$

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

Estimate ω_H

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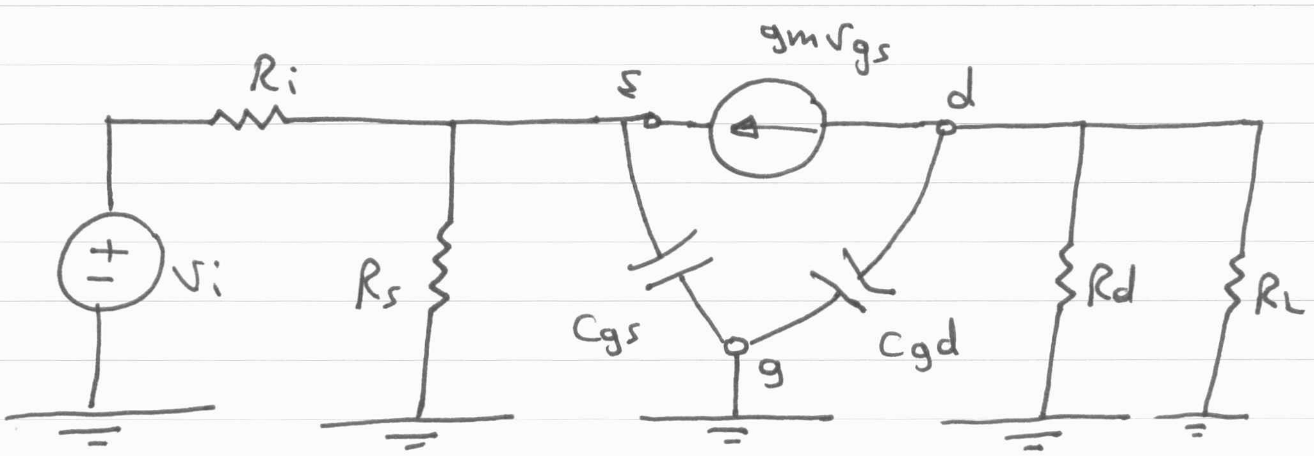
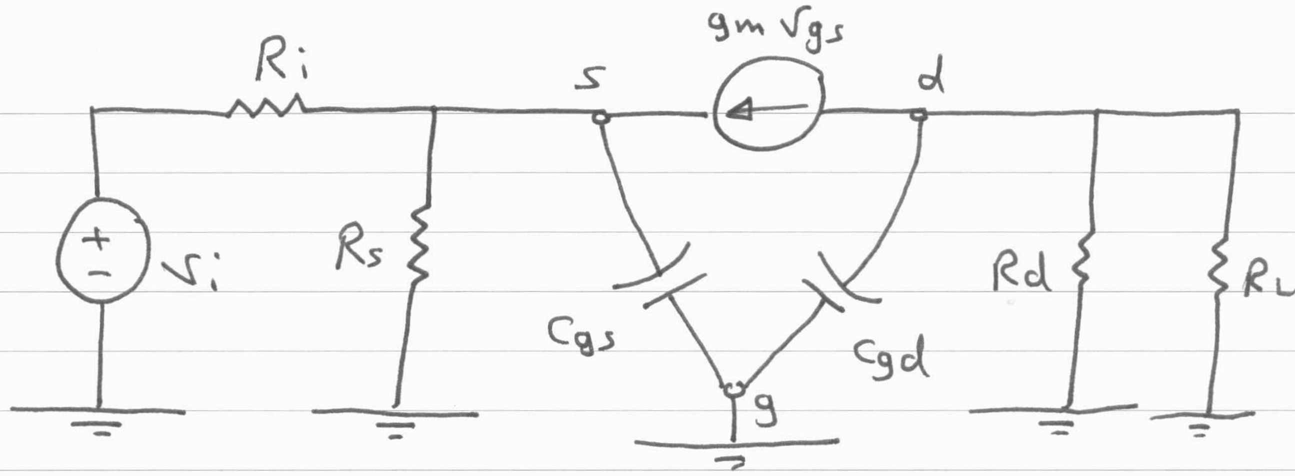
ac small-signal high-frequency equivalent CKT:





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

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

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

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

$\therefore W_{gs} = 2865\ M\ r/s$

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

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

$R_{gd} = R_L \| R_L$

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

$\therefore W_{gd} = 200\ M\ r/s$

$$\frac{1}{\tau_{gd} + \tau_{gs}} < W_H < 200\ M\ r/s$$

$$187\ M\ r/s < W_H < 200\ M\ r/s$$