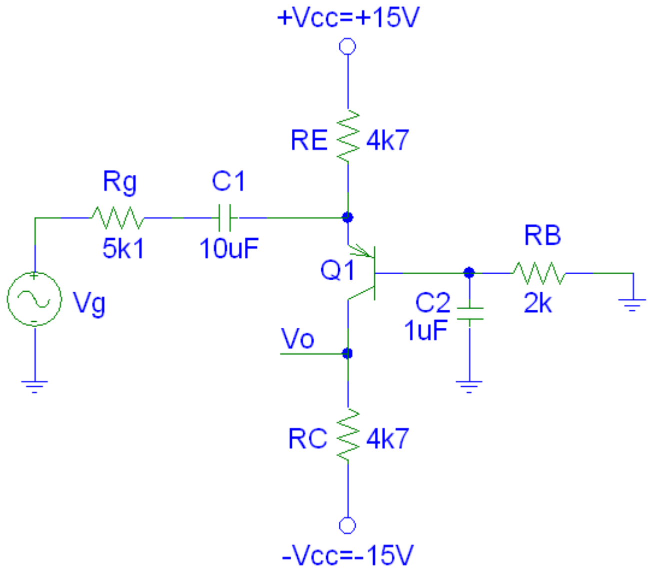
Jose A. Garcia-Souto

Time: 1 hour and 30 minutes

EXERCISE 1



DATA:

$|V_{BE}| = 0.7$ V
$|V_{CE\text{-}sat}| = 0.2$ V
$\beta_F = \beta_0 = 300$
$r_0 \rightarrow \infty$
$V_T = 25$ mV

$R_B = 2K\Omega$
$R_E = R_C = 4.7K\Omega$
$R_g = 5.1\ K\Omega$
$C_1 = 10\ \mu F$
$C_2 = 1\ \mu F$

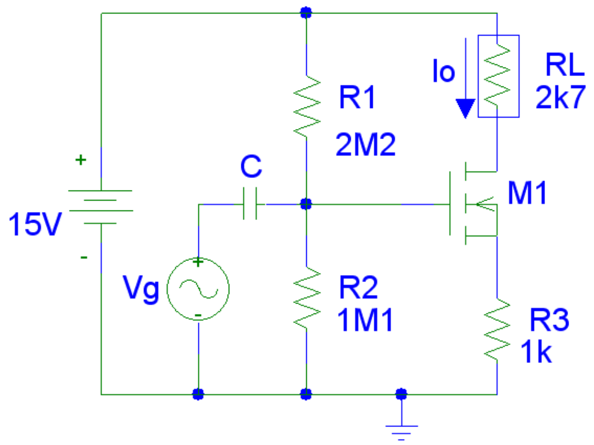
a) $V_B \approx 0$ V $\quad V_E = 0.7$ V $\quad I_E = 3$ mA $\quad I_B = 10.1\ \mu A \Rightarrow V_B = 20.2$ mV

b) $I_{CQ} = 3$ mA $\quad V_{ECQ} = 1.6\text{ V} > V_{EC\text{-}SAT} \Rightarrow$ Active

c) C1 and C2 are short-circuits ⇨ Base to ground
$g_m = 120$ mA/V $\quad r_\pi = 2.5\ K\Omega$

d) Include C1 and C2.

EXERCISE 2



DATA:

MOSFET Transistor

$V_t = 1$ V

$K = 0.5$ mA/V^2

NOTA: $I_D = K\cdot(V_{GS}-V_t)^2$

$V_A = 100$ V

$C \rightarrow \infty$

a) $V_{GS} = 3$ V　　$I_0 = I_D = 2$ mA

b) $V_{DSQ} = 7.6$ V $> V_{DS\text{-}SAT}$　　Saturation
$I_{DQ} = 2$ mA　　$V_{DS\text{-}SAT} = 2$V

c) $r_{ds} = 50$ KΩ　　$g_m = 2$ mA/V
$i_o/v_g = g_m r_{ds} / [R3(1+g_m r_{ds}) + RL + r_{ds}] \approx 1/R3 = 1$ mA/V

d) Z1 = R3 = 3 KΩ　　Z2 = R4 //R5//r_π = 7.7 KΩ　　Zi = R1 = 1MΩ
Vo/Vg = $[-g_{m2}R7]\cdot[-g_{m1}(R3//R4//R5// r_{\pi})] = 1742.4$ V/V　　64.8dB

e) C short-circuit　　Include C_{gs} and C_{gd}

EXERCISE 3

The circuit of Figure 3 is an AC coupled amplifier based on a JFET transistor.

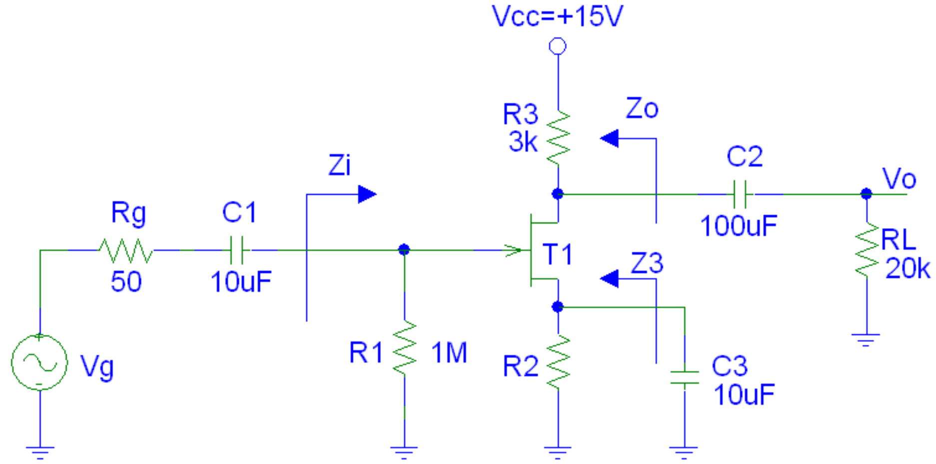


Figure 3

DATA:

I_{DQ} = 2.5 mA	Rg = 50 Ω	R1 = 1 MΩ	R3 = 3 KΩ	RL = 20 KΩ
I_{DSS} = 10 mA	V_p = -3 V	$r_{ds} \to \infty$	$I_D = I_{DSS} \cdot (1-V_{GS}/V_p)^2$	
C1 = 10 μF	C2 = 100 μF	C3 = 10 μF	Cgs = 2 pF	Cgd = 1 pF

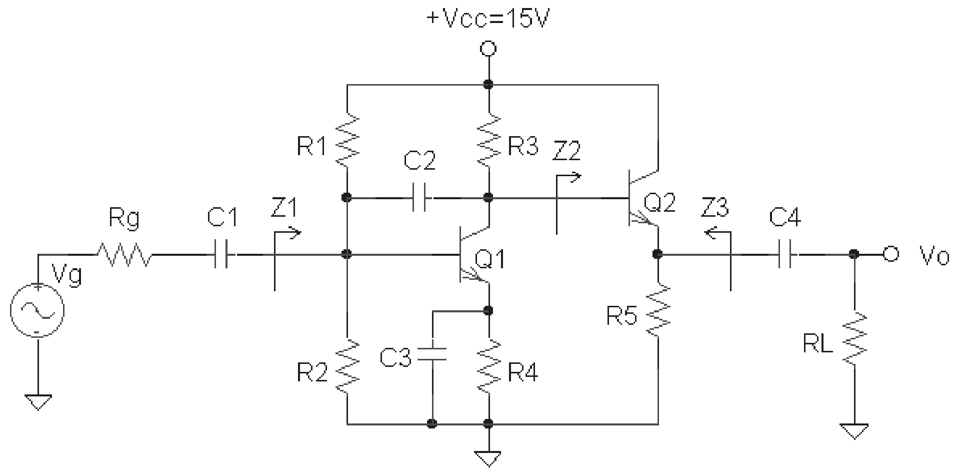
a) V_{GS} = -1.5 V R2 = $-V_{GS} / I_D$ = 600 Ω g_m = 3.33 mA/V

b) C1 and C2 are short-circuits ⇨ coupling AC

c) $Vo/Vg = -g_m(R3//RL) \cdot [R1/(R1 + Rg)] = -8.7$ V/V
Zi = R1 = 1 MΩ Zo = R3 = 3 KΩ

d) $Z3 = R2//(1/g_m) = 200\ \Omega$

EXERCISE 4



a) $I_{C1} = 0.5$ mA $V_{CE1} = 5.6$ V $I_{C2} = 2$ mA $V_{CE2} = 5.6$ V $Vo = 0$ V

b) $r_{\pi1} = 10$ KΩ $r_{\pi2} = 2.5$ KΩ $g_{m1} = 20$ mA/V $g_{m2} = 80$ mA/V
$Z1 = R1//R2//r_{\pi1} = 5$ KΩ
$Z2 = r_{\pi2} + (1+\beta_o)[R5//RL] = 474.85$ KΩ
$Z3 = [(R3 + r_{\pi2})/(1+\beta_o)]//R5 \approx 62\ \Omega$

c) $R_{C4}{}^{o} = Z3 + RL = 4.7$ KΩ $\tau_{C4} = 94$ ms $f_L = 1.7$ Hz

d) Miller $C_M = 603$ pF $C'_M = 3$ pF
$R_M{}^{\infty} = Rg//R1//R2//\ r_{\pi1} = 2.5$ KΩ $\tau_M = 1.51\ \mu s$
$R_{M'}{}^{\infty} = R3//Z2 = 10$ KΩ $\tau_{M'} = 30$ ns
Dominant pole approximation $f_H = 103$ KHz

e) Bode plot