EEE 51 Assignment 7

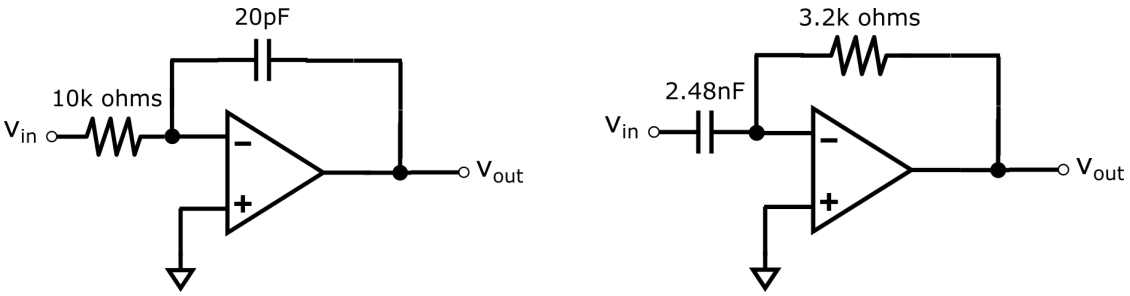
2nd Semester SY 2017-2018
Due: 5pm Tuesday, April 10, 2018 (Rm. 220)

Instructions: Write legibly. Show all solutions and state all assumptions. Write your full name, student number, and section at the upper-right corner of each page. Start each problem on a new sheet of paper. Box or encircle your final answer.

Answer sheets should be colored according to your lecture section. The color scheme is as follows:

THQ – yellow
THR – blue
THU – white
THX – green
WFX – pink

1. **Frequency response of RC circuits.** You are Special Agent Jeongyeon, a new member of the SWAT team. As part of your training, your boss, Officer Nayeon, hands you the following exercises on frequency response.



(a) (b)

Figure 1: RC circuits

(a) Determine the transfer function $H(s)$ of (a) and (b) in Figure 1. Assume the op amps are ideal. [2 pts]

(b) Draw the frequency response of both circuits. Assume that the magnitude and phase response are piecewise linear functions. Label the graph properly. Also label the slope, DC gain, phase, 3-dB point and other relevant frequencies accordingly. ($Note$: You may use Matlab for this part, but in this case, you should not assume that the response is piecewise.) [4 pts]

(c) What do circuits (a) and (b) do? (i.e. What is the functionality of each circuit?) [1 pt]

Emergency! Officer Nayeon is kidnapped by a killer who specializes in making bombs that emit a certain frequency. Your team has a measuring device, an active high pass filter which can be found in Figure 2.

(d) Your team knows that the killer's signature frequency is $4.2kHz$. From what you have gathered, you know that the signals emitted by the special bombs are small enough that they need a voltage amplification of $5dB$. Now, it's your job to configure the circuit and choose the resistor and capacitor values according to the information given and save Nayeon. Make sure that these are standard values. Good luck, Agent. [3 pts]

(e) (BONUS) What is the order of the filter? [0.5 pt]

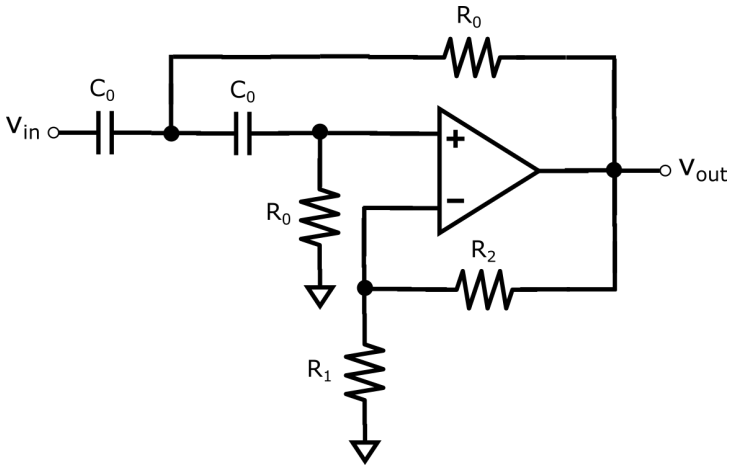


Figure 2: Active high pass filter

2. **Frequency response of a common emitter amplifier.** A common emitter amplifier is shown in Figure 3. Given that $V_{CC} = 12\,\text{V}$, $V_{IN} = 5\,\text{V}$, $V_A = 100\,\text{V}$, $I_S = 1\,\text{fA}$, $R_B = 10\,\text{k}\Omega$, $R_C = 500\,\Omega$, $C_L = 1\,\text{pF}$, $C_\pi = C_\mu = 10\,\text{fF}$, and $\beta = 50$, answer the following questions.

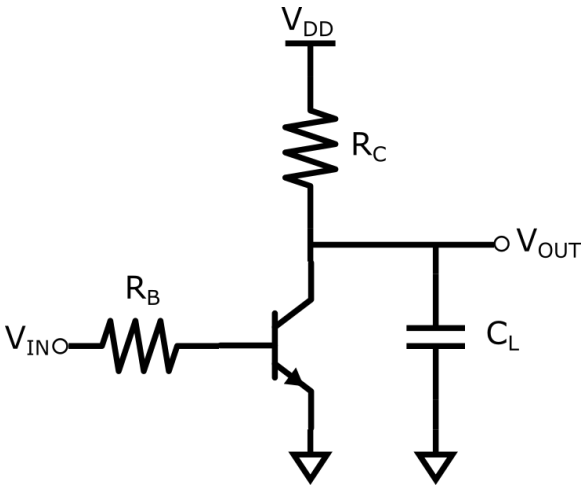


Figure 3: Common Emitter Amplifier with Capacitive Load

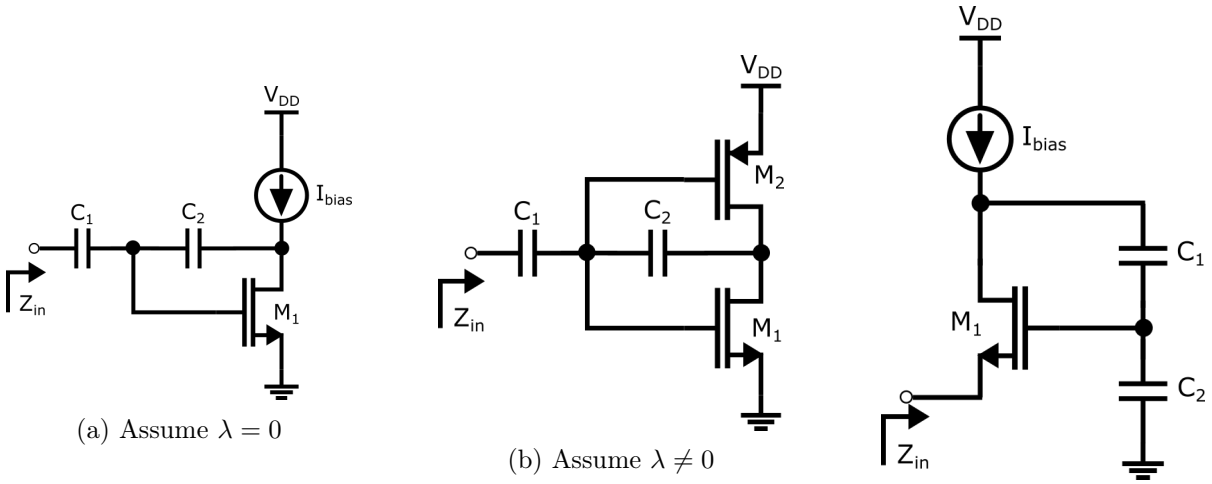
   (a) What is the quiescent collector current of the common emitter amplifier (ignoring the effects of early voltage)? [2 pts]

   (b) Draw the small signal equivalent circuit including C_π and C_μ. Calculate all small-signal parameter values. [3 pts]

   (c) Find the small-signal transfer function of the circuit. [3 pts]

   (d) Draw the magnitude and phase response of the circuit. [2 pts]

3. **Frequency analysis of basic circuits.** Capacitive and inductive elements are frequency-dependent components of our circuits whose impedances can vary and even dominate the circuit at certain operating frequencies.



(a) Assume $\lambda = 0$

(b) Assume $\lambda \neq 0$

(c) Assume $\lambda = 0$

Figure 4: Input impedance analysis for single stage circuits

For the circuits shown in Fig. 4 and neglecting all other intrinsic capacitances,

(a) Determine the input impedances, Z_{in} of each circuit. [8 pts]

(b) Find the transfer function $H(s) = \frac{v_{out}(s)}{v_{in}(s)}$ of Fig. 4a. [2 pts]

TOTAL: points.