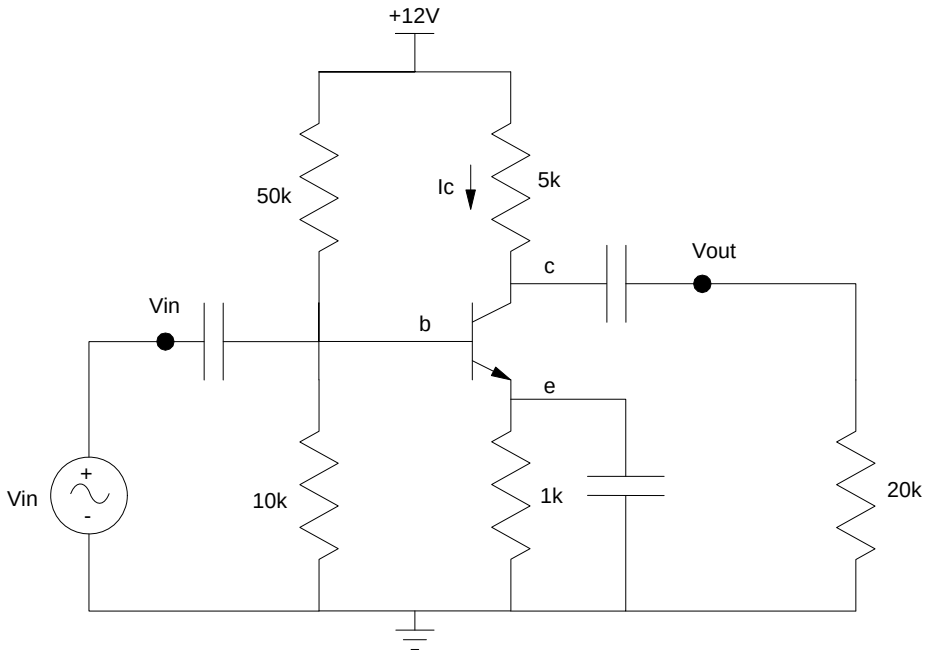
ECE 321 - Homework #5

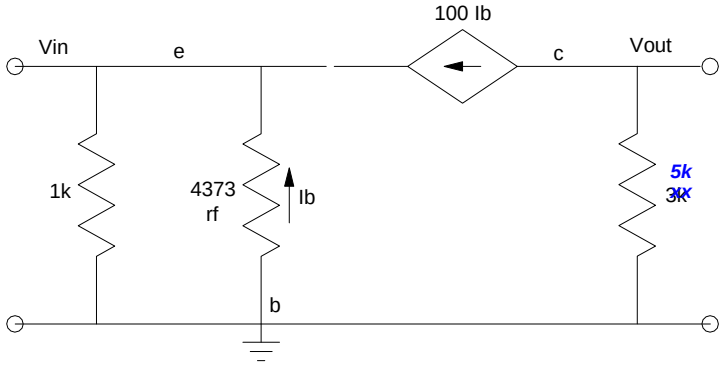
BJT Amplifier Design. Due Monday, April 25th

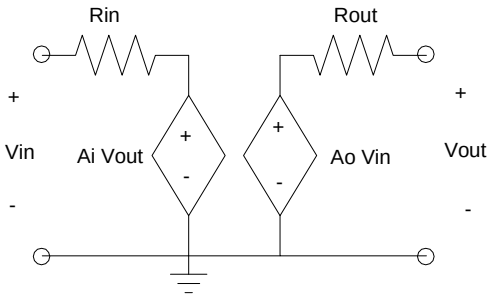
For each problem, use the following circuit. Assume an ideal silicon diode with $\beta = 100$



Problem 1-3: BJT Amplifier in Common Base or Common Collector Configuration

1a) Draw the small-signal model for this circuit in common base configuration.





1b) Determine the 2-port model for this circuit in common base configuration.

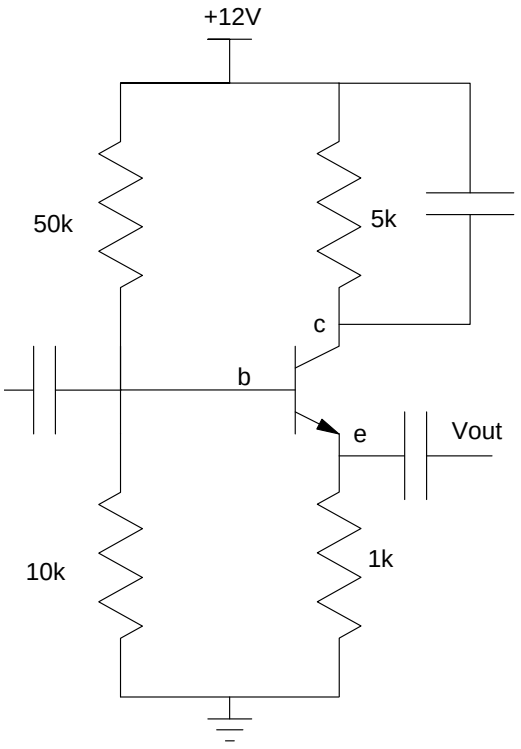
Rin: 1k || 4373 || 4373/100 = 41.5 Ohms

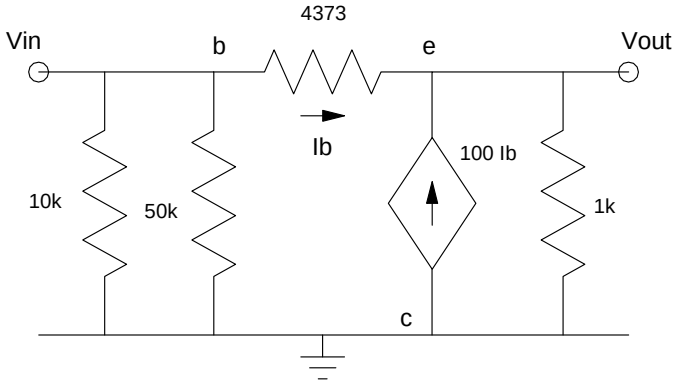
Ai: 0

Rout: 5k

Ao: $\left(\frac{5k \cdot 100}{4373}\right) = +114$

2a) Draw the small-signal model for this circuit in common collector configuration.





2b) Determine the 2-port model for this circuit in common collector configuration.

Rin: 10k || 50k || 4373 = 2688

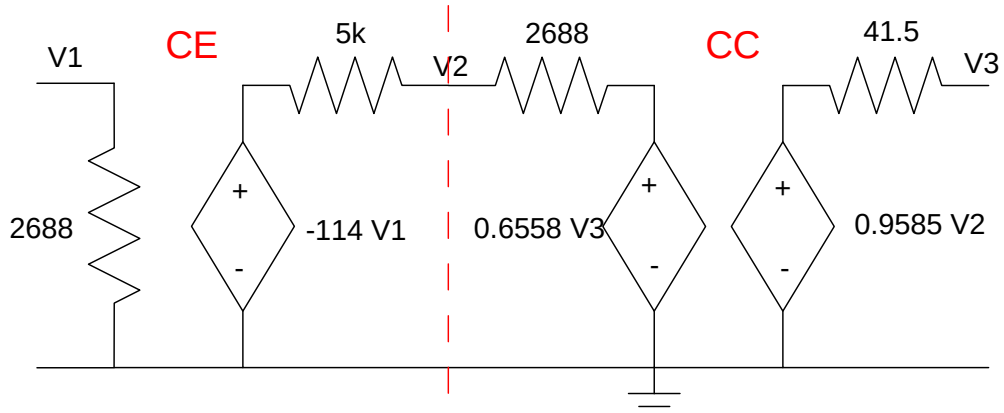
Ai: $\left(\frac{10k||50k}{10k||50k+4373}\right) = 0.6558$

Ao: $\left(\frac{X-1}{4373}\right) + 100\left(\frac{X-1}{4373}\right) + \left(\frac{X}{1000}\right) = 0$

$X = A_o = 0.9585$

Ro: 1k || 4373 || 4373/100 = 41.5

3) Determine the 2-port model for a common emitter : common collector amplifier.



Rin = 2688 Ai = 0 Rout: Short V1. Apply 1V to V3. Compute the current

V1 = 0

$$V_2 = \left(\frac{5k}{5k+2688}\right)0.6558V = 0.4265V$$

$$0.9585V_2 = 0.4088V$$

$$I_{in} = \left(\frac{1V-0.4088V}{41.5\Omega}\right)$$

$$R_{out} = \frac{1}{I_{in}} = \left(\frac{41.5\Omega}{1V-0.4088V}\right) = 70.2\Omega$$

Ao: Apply 1V to V1. Compute V3

$$V_2 = \left(\frac{2688}{2688+5000}\right)(-114V) + \left(\frac{5k}{5k+2688}\right)(0.6558V_3)$$

$$V_3 = 0.9585V_2$$

Solving 2 equations for 2 unknowns

$$V_2 = 67.42V$$

$$V_3 = A_o = 64.62$$

MOSFET Amplifier: Assume for the MOSFET amplifier (next page) that

- $V_{tn} = 2V$
- $k_n = 0.001\frac{A}{V^2}$

4) Determine R1 and R2 so that the Q point is Vds = 6V and R1 || R2 = 100k Ohms

$$I_{ds} = \frac{12V-6V}{10k+1k} = 545.5\mu A$$

$$V_s = 1000 I_{ds} = 545.5mV$$

$$I_{ds} = \frac{k_n}{2}(V_{gs} - V_{th})^2$$

$$V_{gs} = 3.044V$$

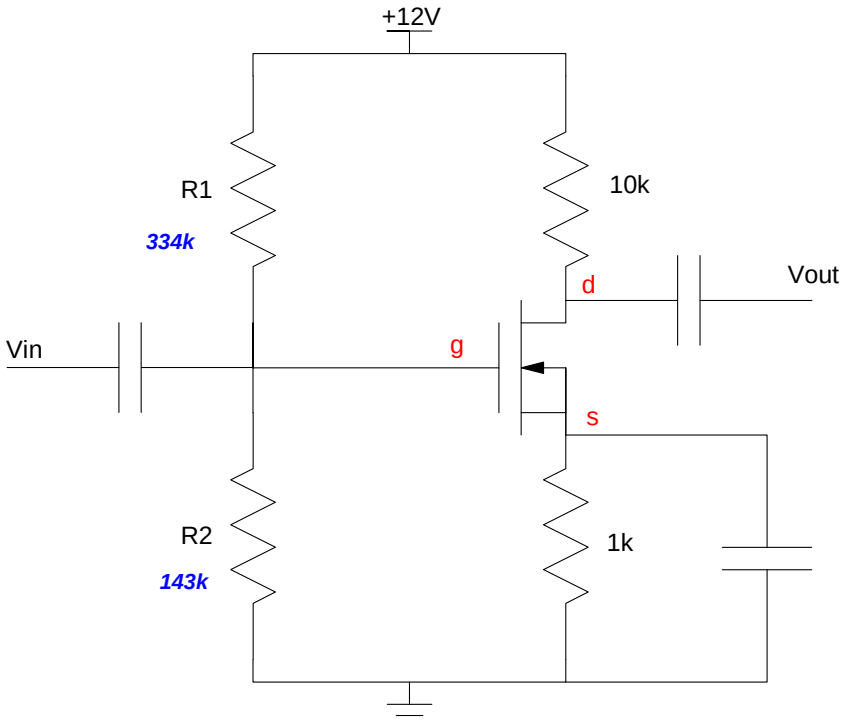
$$V_g = 3.590V$$

$$\left(\frac{R_2}{R_1+R_2}\right)12V = 3.590V$$

$$R_1 || R_2 = 100k$$

$$R_1 = 334k$$

$$R_2 = 143k$$



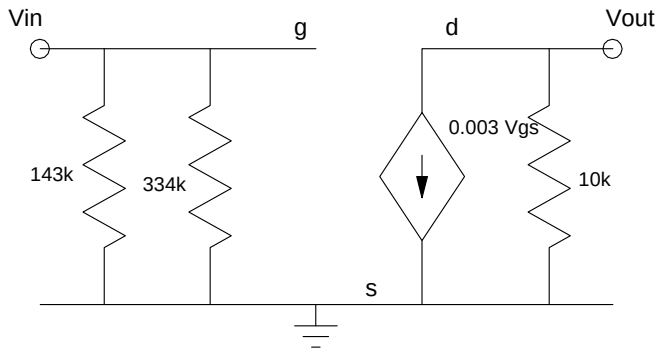
Problem 4-5: Common Source Amplfiier

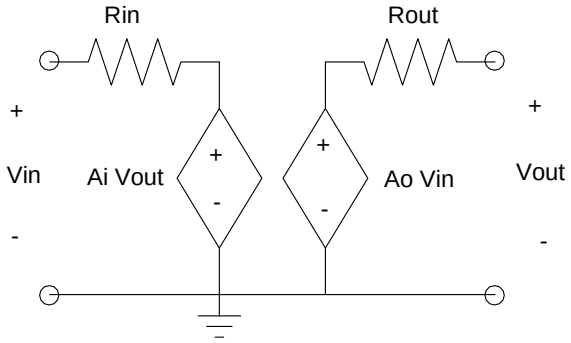
5) Determine the 2-port model for this MOSFET amplfiier in common source configuration.

$$g_m = \frac{dI_{ds}}{dV_{gs}} = \frac{d}{dV_{gs}}\left(\frac{k_n}{2}(V_{gs} - V_{th})^2\right)$$

$$g_m = (k_n(V_{gs} - V_{th}))$$

$$g_m = 0.003044\frac{A}{V}$$





Rin: 143k || 334k = 100k

Ai: 0

Rout: 10k

Ao: $-10k \cdot g_m = -30.44$

6) Use CE / CC / CB / CS amplifiers to design a multi-stage amplifier to meet the followin requiremeints:

Input:

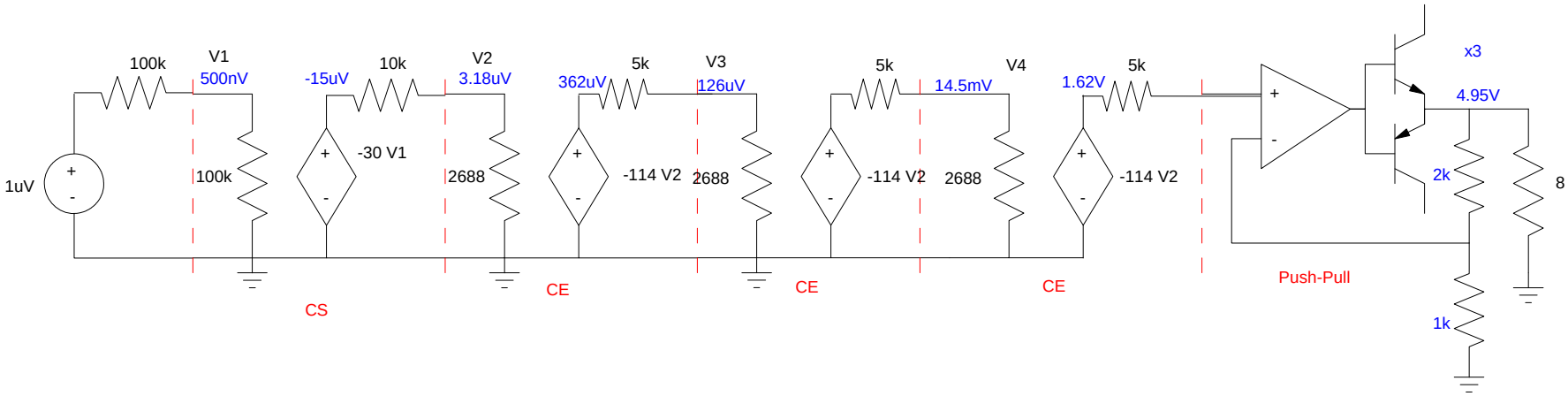
- 1uVpp sine wave at 1kHz, output impedance = 100k Ohms

Output:

- 8 Ohm Speaker

Relationship:

- 1uVpp sine wave at the input drives the 8 Ohm speaker at 4 Watts at 1kHz, +- 1 Watt



Problem 7-10) Term Project

Design, build, and test one section of your term project. Include

7) Requirements. What are the inputs, output, and how they relate.

8) Analysis: Give computations for resistors, etc. so that your circuit meets your requirements.

9) Test: Simulate in PartSim (or like program) to verify your analysis

10) Validation: Build your circuit in lab and collect data to verify it meets your requirements.