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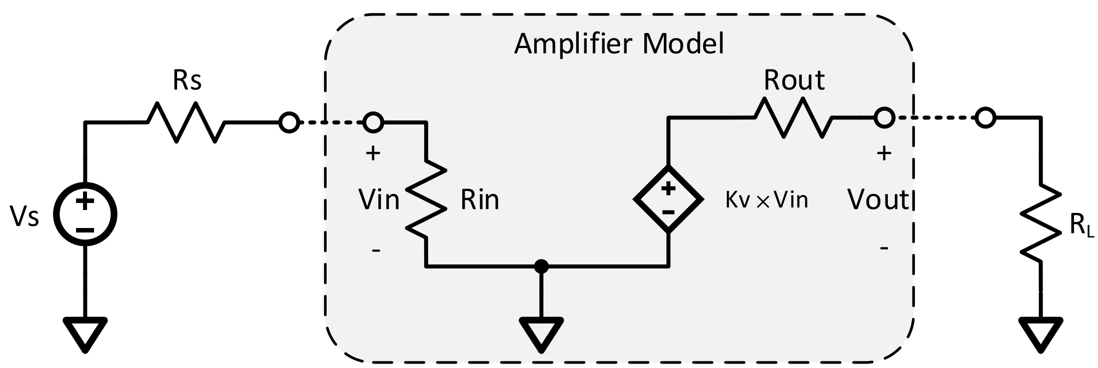
EHB 262E: ELECTRONICS II
Homework 1
Due date: March 24, 2021 23.59

Important note! : Please do not attempt to upload the questions to Chegg or similar websites! I always check the solutions on the Chegg and compare them with your answers. If I find any similarities (and most of the time, there will be an adequate similarity to understand if you copied the solutions completely) then your grade will be zero. So, do not risk it. If you have any problem, any difficulties or if you need any advice, just ask me. I am always welcome to help you. The main purpose of the homework is to teach you something or consolidate your understanding of the topic, not to grade you. High grades gotten by unethical ways, without any effort will not make you a good engineer. For any questions please send me an e-mail through bilmez@itu.edu.tr. I always check my e-mails and reply as soon as possible. Another point that I would like to clarify is that, please write your own solutions. You are allowed to cooperate but homeworks are individual. If you discussed and solved the questions together, solve them again individually without looking available solution. Otherwise, I will not able to distinguish whether you solved the homework together or you copied the solutions from someone else. If you submit the same solutions as a group, then I will divide the grade by the total number of students of that group. This is the only way to make fair grading. If you have further questions, feel free to ask.

1)

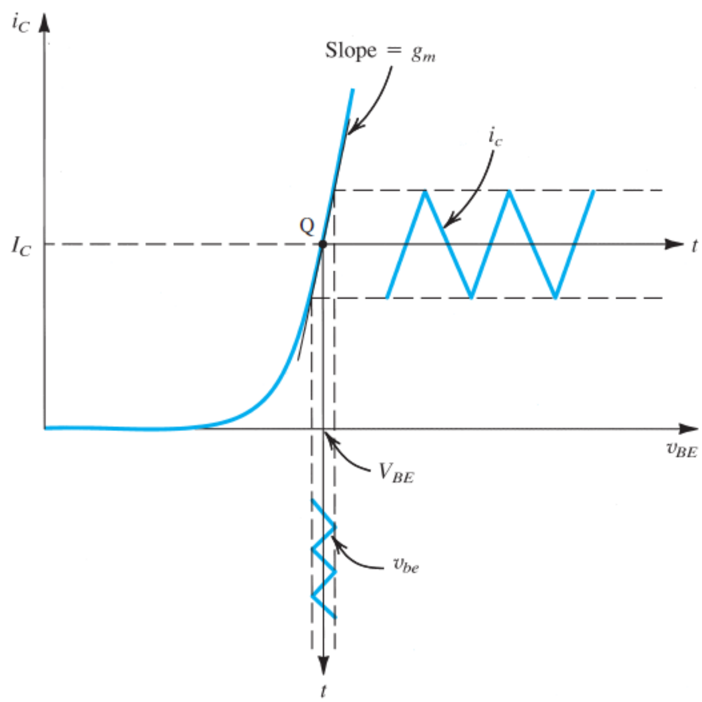


The figure above shows an amplifier model (using a voltage-controlled voltage source). Notice that, this is just one way to model an amplifier. There are different types of models of an amplifier but all models give the same input-output characteristics. You can simply obtain other models by using Thevenin/Norton conversion. We want to connect a signal source (AC, DC or a combination of them) to the input of our amplifier and a load resistor R_L to the output of our amplifier as shown by dashed lines. R_{in} is the input resistance, R_{out} is the output resistance and K_v is the voltage gain parameter of the amplifier.

a) Find an expression for V_{out}/V_s (i.e. voltage gain from signal to load) using given parameters R_s, R_{in}, R_{out}, R_L and K_v. (Hint: You can use $V_{out}/V_s = (V_{out}/V_{in}) \times (V_{in}/V_s)$)

b) Let's say $R_s = 10k\Omega$, $R_{in} = 1k\Omega$, $R_{out} = 100k\Omega$, $R_L = 100\Omega$, $K_v = 100$. Find V_{out}/V_s. Assume that we are not able to change R_s, R_L and K_v. How can we achieve higher V_{out}/V_s? Discuss whether large or small resistors values are desirable for R_{in} and R_{out} in order to obtain high voltage gain from signal to load? Explain based on your expression from part a).

2)



The figure above shows the voltage-current characteristics of a BJT and how amplification operation is obtained. For the sake of clarity, we use upper/lower case letter convention such that $v_{BE} = V_{BE} + v_{be}$ where v_{BE} shows the instantaneous value of the signal which is composed of a DC value V_{BE} and AC value v_{be} superimposed on the DC value. Through the course, we will analyze the circuits assuming the AC value is very small so that the instantaneous signal is very close to the DC value. In order words, the change of operating point values due to the AC signal is negligible. Because of that, we will use small-signal models and parameters and we will find them around the DC operating point hence we will use slope (or derivative) at that point. We call the current and voltage values at a particular DC operating point as quiescent current and quiescent voltage.

Remember that for a BJT in forward active region, $i_C = I_S e^{\frac{v_{BE}}{V_T}}$ which is the analytical expression of the given figure. Assume that we biased the BJT at the point where $V_{BE} = V_{BE,Q}$ and $I_C = I_{C,Q}$. Now we want to find the slope at that particular point and we call it as transconductance g_m. Find the expression for $g_m = \frac{\partial i_C}{\partial v_{BE}}\Big|_{\substack{v_{BE}=V_{BE,Q} \\ i_C= I_{C,Q}}}$. Your final expressions must include quiescent voltage/current values and it must agree with the characteristics given in the figure. Comment on how quiescent point values affect the transconductance. (If you change your Q point from left to right in the figure, how does g_m change? Is this expected from the slope of the characteristics?)