Baku Higher Oil School

Course: ANALOG ELECTRONICS

LABORATORY REPORT

Experiment Title: <u>**BJT Amplifiers**</u>

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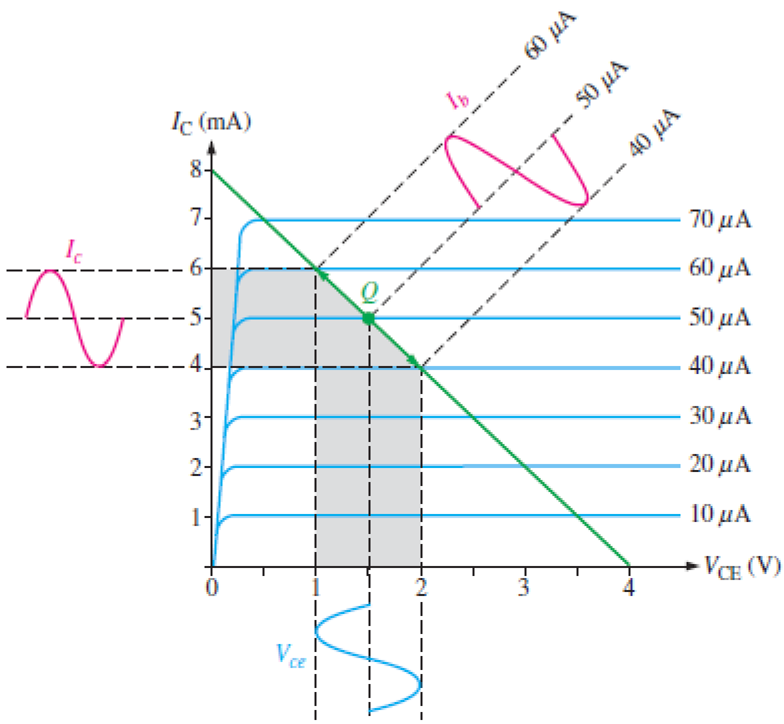
Contents

Introduction

The primary objective of this report is to provide information about lab work namely “BJT Amplifiers”. The major aim of the experiment carried out by me is to compute the DC and AC parameters for a common-emitter (CE) BJT amplifier. I build the amplifier and measure some parameters such as $V_B, V_C, V_E, V_{CE}, V_b, V_c, V_e$. We carried out this experiment via help of different equipment and devices (BJT, resistors, capacitors and etc.) and they should be as accurate as possible. Our goal was getting amplified signal in the output while we put weaker signal in the input. In this report, I will introduce how experiment is carried out. Additionally, some issues and problems will be considered in the report. There are some errors in measurements because of the non-ideal condition, however we try to understand how all changes happen. At the end, there will be some discussions about values, with the help of questions and answers which will be provided in this report, in order to provide report with more accurate information.

Theory

As we know, BJT is current controlled transistor device which has 3 modes: cutoff, active, saturation and this device mainly used for 2 purposes: switching and amplifying. Cutoff and saturation modes are used for switching, active mode for amplification. As our main aim in this lab work is to amplify the signal, we must tune our BJT transistor to active mode using DC source and some resistors. Of course, we need also some signal to amplify that is why we use AC source. Additionally, some capacitors (coupling and bypass capacitors) is used to isolate AC from DC effects. In troubleshooting part, we will discuss the effects of C_2, R_L, R_{E1}, R_2 on our amplifier circuit. The picture below shows the location of Q point (more accurately one of the locations of Q point) in I_C vs V_{CE} graph for active mode.



Experimental technique

Apparatus

Resistors: one 100 Ω, one 330 Ω, two 1 kΩ, one 4.7 kΩ, two 10.0 kΩ
One BC140 npn transistor
One 10 kΩ potentiometer
Capacitors: two 1.0 uF, one 10 uF

Setup

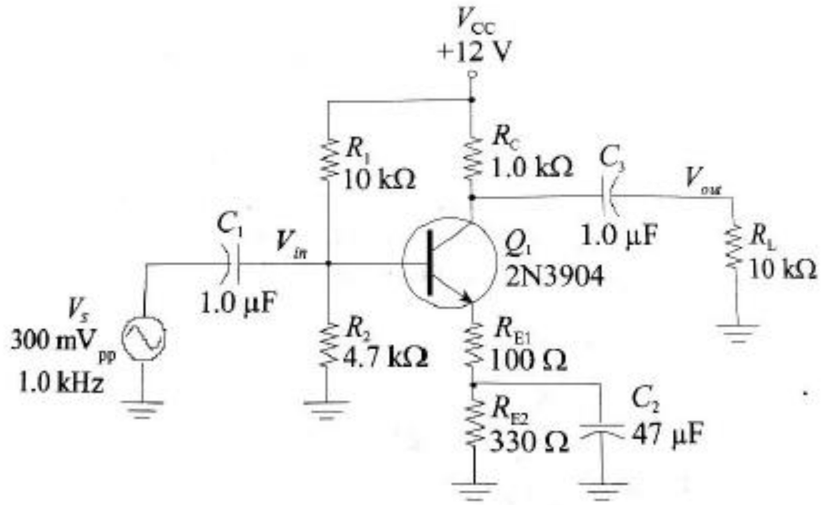


Fig.2: *Experimental setup*

Firstly, I construct the circuit above (figure 2) on the board. But, I used 10 microfarad instead of 47 microfarad for C_2 and 400 mV instead of 300 mV for V_s.

Carrying out experiment

After setting up the circuit, I must calculate and measure the DC and AC parameters $V_B, V_C, V_E, V_{CE}, V_b, V_c, V_e, I_E, r_e, A_v, R_{in(tot)}, \beta_{ac}$. In troubleshooting part, we will change the values of C_2, R_L, R_{E1}, R_2 on our amplifier circuit, then discuss the changes in measurements.

Results - Experimental and Derived

In this laboratory work, I could finish lab work successfully. Firstly, I want to write about DC circuit analysis part. For calculation, I used the equations below and got the answers as shown in table 1.

$$V_B = \frac{V_{cc} * R_2}{R_1 + R_2} \quad ; \quad V_B = V_E - 0.7 \quad ; \quad I_E = \frac{V_E}{R_{E1} + R_{E2}} \quad ; \quad I_C \approx I_E \quad ;$$

$$V_C = V_{CC} - R_C * I_C \quad ; \quad V_{CE} = V_C - V_E$$

I got approximately the same results in measurement.

DC quantity	Computed value	Measured value
V_B	3.8 V	3.76 V
V_E	3.1 V	3.078 V
I_E	7.2 mA	[redacted]
V_C	4.8 V	4.93 V
V_{CE}	1.7 V	1.835 V

Table.1: *DC analysis results*

Secondly, I want to write about AC circuit analysis part. For calculation, I used the equations below and got the answers as shown in table 2.

$$r_e = \frac{25\,mV}{I_E} \quad ; \quad R_{in(tot)} = R_1 | \, |R_2||R_{in\,base} \quad ; \quad \beta_{ac} = \frac{1}{\frac{R_{E1}+r_e}{R_{in(tot)}} - \frac{R_{E1}+r_e}{R_1} - \frac{R_{E1}+r_e}{R_2}} \quad ;$$

$$R_C = R_c||R_L \quad ; \quad A_v = \frac{R_C}{R_{E1}+r_e} \quad ;$$

AC quantity	Computed value	Measured value
V_b	0.141 V (rms value)	0.115 V
V_e		0.110 V
r_e	3.5 Ohm	[redacted]
V_c	1.244 V (rms value)	1.006 V
A_v	8.8	8.7
$R_{in(tot)}$	[redacted]	2.63k Ohm
β_{ac}	[redacted]	143

Table.2: *AC analysis results*

In troubleshooting part, I measured the values below.

AC / DC quantity	Remove C_2	$R_L = 1k\ Ohm$	Shorted R_{E1}	Shorted R_2
V_b / V_B	0.116 V (AC)	0.116 V (AC)	2.958 V (DC)	0 V (DC)
V_c / V_C	0.247 V (AC)	0.567 V (AC)	3.436 V (DC)	12 V (DC)
V_e / V_E	0.114 V (AC)	0.111 V (AC)	3.214 V (DC)	0 V (DC)

Table.3: *Troubleshooting results*

Discussion of the results

Firstly, I want to mention that measured values are not significantly different from the calculated results which is positive sign for our experiment. However there are some little difference between them because of the non-ideal conditions and errors in equipment (resistances, capacitors, multimeter each has its own error). From the DC analysis I got some figures which proofs that, our transistor is in active mode (additionally we can draw the location of Q point on $I_C\ vs\ V_{CE}$ graph). I also calculated and measured the AC values of the circuit and found that, the gain of our amplifier is approximately 9 which means that, input amplified 9 times.

In troubleshooting part I got some insight about each component. For example, when we short R_2 our transistor went to cutoff region because V_B became zero. For another case, when we short R_{E1} our transistor went to saturation region and that is why became useless for amplification. By removing C_2 (which causes the resistance of emitter to increase) or changing R_L only V_c changes (eventually A_v changes), V_b ***and*** V_e not affected.

Questions

1. Does the load resistor have any effect on the input resistance? Explain your answer.

Answer: No. Changing R_L we can only change the gain because of the formulas of $R_C = R_c||R_L$ and $A_v = \frac{R_C}{R_{E1}+r_e}$. It is also can be seen from the table of troubleshooting part that, after changing R_L , V_b does not change, $R_{in(tot)}$ also constant in this case.

2. What is the purpose of the unbypassed emitter resistor RE1? What design advantage does it offer?

Answer: Unbypassed emitter resistor R_{E1} are used to adjust the gain A_v . From the formula of $A_v = \frac{R_c}{R_{E1}+r_e}$ it is clear that if we increase R_{E1}, the gain will decrease. Gain will reach its peak value when we short the R_{E1} .

3. When the bypass capacitor, C_2, is open, you found that the gain is affected. Explain why.

Answer: C_2 is used to short the second emitter capacitor, that is why bypassed capacitor C_2 is replaced with open circuit the resistance of emitter increase. From the formula of $A_v = \frac{R_c}{R_{E1}+r_e}$ in our case (C_2 $shorted$) gain will be

$A_v = \frac{R_c}{R_{E1}+r_e+R_{E2}}$ it is clear that if we increase the denominator, gain will decrease.

Conclusion

Briefly, I want to add my personal feelings about the experiment carried out by me and have to express that such kinds of experimentations make us learn more profoundly, deep dive the corresponding subject and do some research in order to grasp what is going on behind the process. Furthermore, the most important factors in carrying out this experiment is troubleshooting part which is the about the determination of the effects of change the values of C_2, R_L, R_{E1}, R_2 on our amplifier circuit. The major thing that is derived from this experiment for us is that whenever we take shortages and errors into account we get our results more or less the same as we expected.

Reference

Leaflet of the Laboratory experiment

Electronic devices (Floyd 9th edition), page 271-291