Lab 06 – Common Base

Toronto Metropolitan University

ELE404 – Electronics I

Hani Ahmed

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Introduction:

Using the 2N3904 NPN BJT, we will investigate the properties of the Common-Base (CB) amplifier in this lab. In contrast to its Common-Emitter equivalent, the CB amplifier offers a low input resistance and is distinguished by its high intrinsic gain and moderate output resistance. Because of this characteristic, it is perfect for specialized applications where impedance matching is essential, such as the input stage of high-frequency amplification chains. Furthermore, the CB amplifier is preferred because to its excellent frequency response, placing our study in the nexus of specialist high-frequency amplification and technical expertise.

Objective:

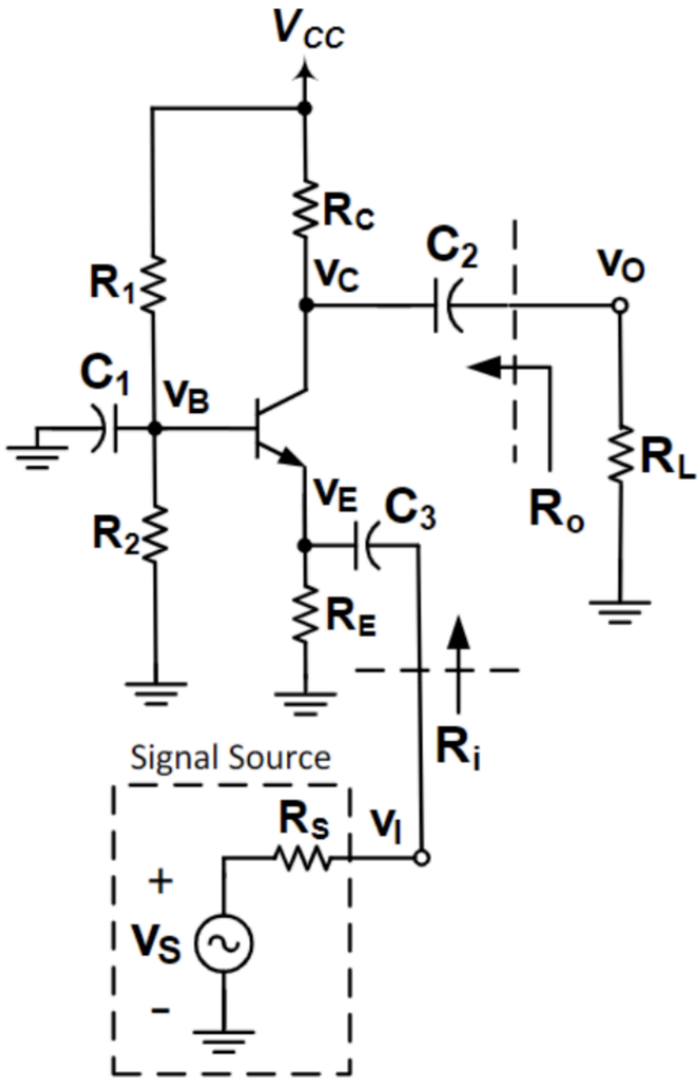
Our team's goal in this lab is to learn more about the 2N3904 NPN BJT by investigating the Common-Base (CB) amplifier, paying particular attention to its unusually low input resistance. By precisely measuring the input and output resistances of the CB amplifier, biasing the BJT in its active mode, and investigating how low input resistance affects impedance matching in high-frequency applications, we want to improve our technical proficiency. To further comprehend their operating differences and the superior frequency response of the CB amplifier, we also intend to observe and compare the output waveform of the CB amplifier to that of a Common-Emitter (CE) amplifier. The purpose of this experience is to investigate several amplifier types and the variations in voltage gains and waveforms.

Circuit Under Test:

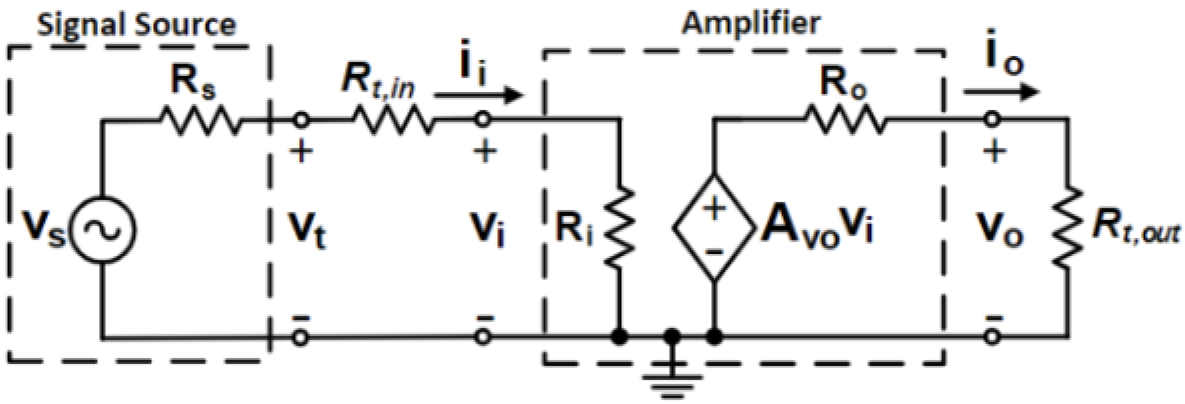
Although the circuit configuration for this experiment is somewhat similar to that of our last experiment, there are a few minor but important changes. Repositioning the input signal source and removing the RE2 resistor are two noteworthy modifications. Furthermore, we modified the voltage divider part by using a capacitor to connect the base to the ground. Our experiment is based on this improved circuit architecture.

We modified a transistor with resistors at the emitter and collector terminals to improve base voltage control using a voltage divider, building upon a basic circuit structure. Our circuit was later evolved into an operational amplifier after moving from this basic construction. The addition of necessary parts—a load resistor coupled to the collector via a series capacitor and an input signal introduced at the emitter via a series capacitor—made this innovation possible. These changes made it possible to investigate the amplifier's performance in greater detail.

Since the DC voltages in this experiment iteration were identical to those in our prior lab, we decided not to measure them at first. Rather, we focused our efforts on evaluating the input and output voltages in terms of dB (decibels) and Vrms (root mean square). The complete circuit is displayed below.

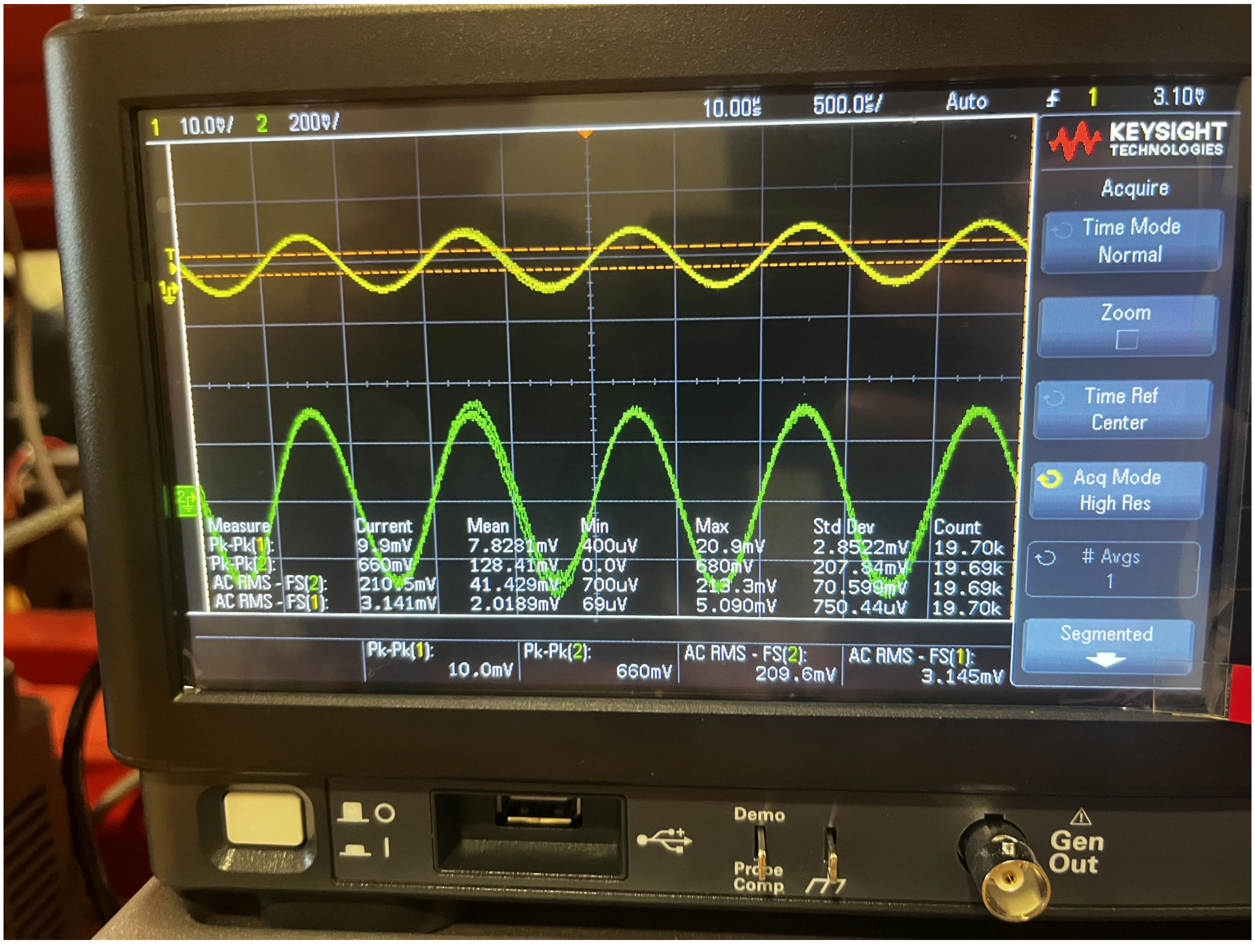


We used a circuit arrangement that was exactly the same as the setup originally described in our follow-up experiment to find the output resistance, with one significant exception: we added a test resistor, Rt,in. Between the signal generator's output terminal and the amplifier's input terminal, this resistor was positioned carefully. Because of this modification, we were able to accurately assess the circuit's output resistance by examining how the inserted test resistor affected the dynamics of the entire circuit.



Experimental Results:

We began this experiment by building the Common-Base (CB) amplifier on our breadboard using all of the capacitors and resistors we got from lab 5. After that, we linked the oscilloscope and signal generator to the amplifier in order to record the vi and vo waveforms. Next, we determined Vi and VO in both rms and DB using the multimeter. We computed the Av for both rms and DB using this. After that, we followed the same procedure while removing the resistor load. After that, we replaced the load resistor and placed a test resistance, Rt,in, between the amplifier's input terminal and the signal generator's output terminal. This allowed us to determine Vt and Vi in rms using the multimeter. Lastly, we substituted a short link for the input test resistance, a test resistance, Rt,out, for the load resistance, and we used the multimeter to determine Vo in rms both with and without a load.



1 10.0V/ 2 200V/
10.00s 500.0s/ Auto 1 3.10V
KEYSIGHT TECHNOLOGIES
Acquire
Time Mode Normal
Zoom
Time Ref Center
Acq Mode High Res
Avgs 1
Segmented
Measure Current Mean Min Max Std Dev Count
Pk-Pk(1): 7.8281mV 400uV 20.9mV 2.8522mV 19.70k
Pk-Pk(2): 660mV 0.0V 680mV 19.69k
AC RMS - FS(2): 41.429mV 700uV 70.599mV 19.69k
AC RMS - FS(1): 3.141mV 2.0189mV 69uV 5.090mV 750.44uV 19.70k
Pk-Pk(1): 10.0mV
Pk-Pk(2): 660mV
AC RMS - FS(2): 209.6mV
AC RMS - FS(1): 3.145mV
Demo
Probe Comp
Gen Out

Table E2(a). Input and output AC voltages and gain of the CB amplifier, with $R_L = 10\ k\Omega$.

$V_i\ [Vrms]$	$V_O[Vrms]$	$A_v[V/V]$	$V_I[dB]$	$V_O[dB]$	$A_v\ [dB]$
3.117 mV	0.26165	64.69	-23.36	13.236	36.596

Table E2(b). Input and output AC voltages and gain of the CB amplifier, with $R_L = \infty$.

$V_i\ [Vrms]$	$V_O[Vrms]$	$A_{vo}[V/V]$	$V_I[dB]$	$V_O[dB]$	$A_{vo}\ [dB]$
3.133 mV	0.50465	161.02	-23.097	21.052	44.149

Table E3. Parameters of the CB amplifier for determining its input resistance.

$R_{t,in}\ [k\Omega]$	$V_t[Vrms]$	$V_i[Vrms]$	$R_i[k\Omega]$
91 Ω	3.837 mV	1.894 mV	88.705

Table E4. Parameters of the CB amplifier for determining its output resistance.

$R_{t,out}\ [k\Omega]$ (i.e., the load)	$V_O[Vrms]$ without load (i.e., $A_{vo}v_i$)	$V_o[Vrms]$ with load	$R_o[k\Omega]$
15	0.304	0.256 V	15.031 08551

Conclusion & Remark:

C1:

Table C1. Calculated and measured AC parameters for the CB amplifier of **Figure 1**.

	$A_v[V/V]$	$A_{vo}[V/V]$	$R_i[k\Omega]$	$R_o[k\Omega]$
Calculated Values (from Table P1(b))	69.6	174	85.714	15
Measured Values (from Tables E2, E3, and E4)	64.69	161.02	88.705	15.031
Percent Error, $e\%$	7.59	8.06	3.37	0.21

fixed prelab values

$$A_{vo} = g_m R_c = (0.0116)(15k\Omega) = 174$$

$$A_v = g_m (R_c \| R_L) = (0.0116)(6k\Omega) = 69.6$$

All three percent errors are around or under 8%, showing that this part of the experiment was conducted fairly well to obtain these results. The discrepancies can be attributed to various factors such as component inconsistencies or capacitor sensitivity.

C2:

C2.

$$i_i = \frac{V_t - V_i}{R_{t,in}} = \frac{3.837\,mV - 3.133\,mV}{91\,\Omega} = 7.692 \times 10^{-6}\,A$$

$$i_o = \frac{V_o \leftarrow \text{with load}}{R_{t,out}} = \frac{0.256\,V}{15.031\,k\Omega} = 1.703 \times 10^{-5}\,A$$

$$A_i = \frac{i_o}{i_i} = \frac{1.703 \times 10^{-5}\,A}{7.692 \times 10^{-6}\,A} = 2.214$$

$$A_p = A_v A_i = (69.6)(2.214) = 154.094$$

Remark

Using a 2N3904 NPN BJT, we were able to understand the importance of the common base (CB) amplifier in this lab. We also looked at how it differs from a CE amplifier in terms of operation.

Additionally, we personally witnessed the low input resistance of the CB amplifier in contrast to the CE amplifier. All things considered, this lab improved our comprehension of these electronic ideas.