BIRZEIT UNIVERSITY

Department

Of electrical and computer

Engineering

ENEE2103

CIRCUITS AND ELECTRONICS LABORATORY

Experiment No.7 Report

Report#1

Instructor: Dr. Alhareth Zyoud

Made By: Yousef Hammad

ID: 1170625

Partners: 1) Islam Jihad

2) Wejdan Aljamal

TA: MR. Ismail Abualia

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Abstract

The aim of the Experiment is to show the properties of a BJT transistor when it's connected in common emitter, common collector or common base.

The experiment also shows the output when only applying a DC source to the base and collector of the NPN BJT Transistor, and the output when applying an additional sinusoidal signal to the base.

Contents

List of figures and tables

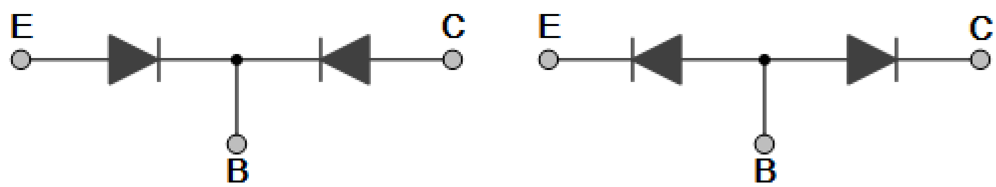
Theory

Transistors in general are used as electrical switches but they can also be used as amplifiers, especially BJT transistors as they offer either a current gain, voltage gain or even both.

In this part of the report, the types of the BJT and its function as an amplifier are going to be explained.

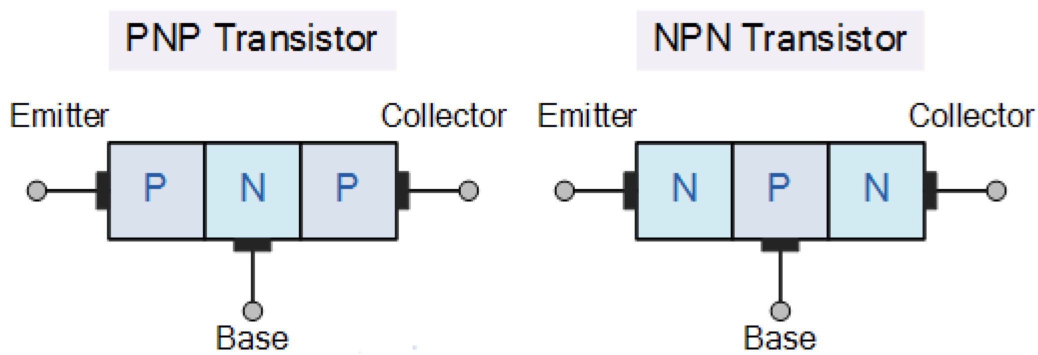
BJT transistors

Connecting two diodes in series creates a 2 PN junction which can have three connections; this connection creates BJT short for Bipolar Junction Transistor.



[1]

Figure 1. 1 PNP and NPN diode analogy



[2]

Figure 1. 2 PNP and NPN physical construction

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[1]

[2] https://www.electronics-tutorials.ws/transistor/tran_1.html

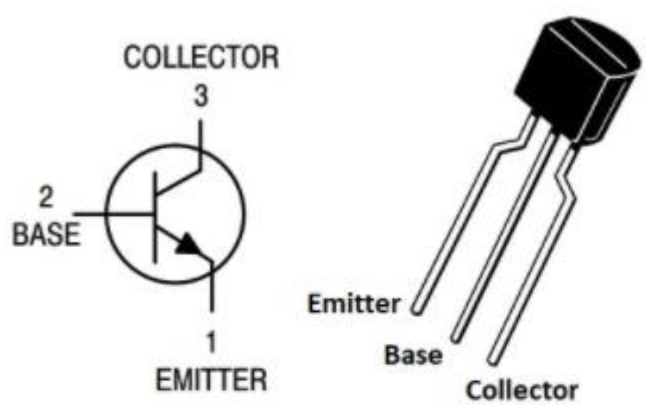
A transistor can act as an insulator or a conductor based on the voltage applied to the base of it, thus creating an active device that has two basic functions: switching and amplification.

The BJT transistor can be in 1 of 4 operating regions:

1. Cut-off: when the transistor acts as an insulator.
2. Active region: when the transistor acts as an amplifier
3. Saturation region: when the current cant increase more than "I(saturation)"
4. Break-down: when the transistor breaks from high current or high voltage

NPN transistors

This is the type of transistors that will be used in the experiment. in NPN transistors $I_E=I_C+I_B$, but $I_C=\beta I_B$. this means that I_E will only have a current flowing when $I_B > 0$.



[3]

Figure 1. 3 NPN Pin out

BJT transistors as Amplifiers

The BJT transistor is a 3 terminal device which means it can be connected in the circuit in 3 different ways, each connection configuration makes one terminal of the transistor common between the input and the output.

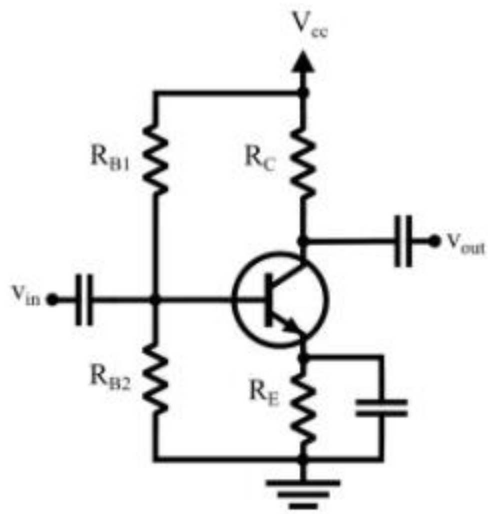
The 3 connection are called:

1. Common Emitter Amplifier
   In this configuration the Emitter is common between the input and the output, The R_{load} will be connected in series with the Collector.

[3] https://protosupplies.com/product/transistor-npn-general-purpose-pn2222-5-pack/

$I_C = \beta I_B$; β= current gain

This means that this configuration will give a current gain but **no** voltage gain.



[4]

Figure 1. 4 Common emitter example circuit

2. Common Collector Amplifier
   In this configuration the Collector is common between the input and the output, R_{load} will be connected in series with emitter.

   $I_E = (1+\beta) I_B$; $1+\beta$= current gain

   A very little voltage gain so a voltage buffering happens, but it also configuration provides a good current gain.

[4] https://www.youtube.com/watch?v=9325TKD4dfY

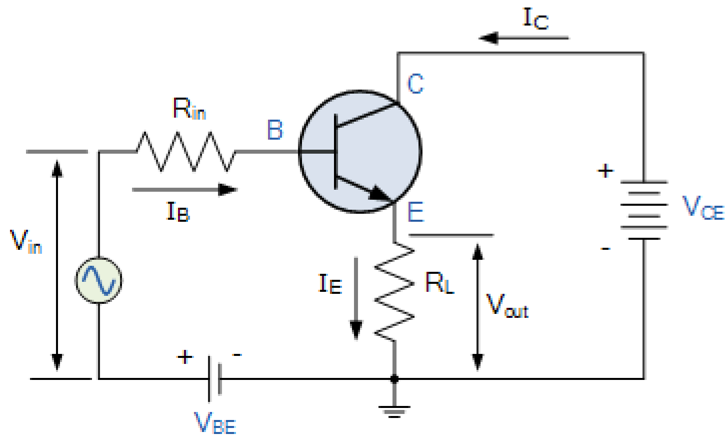


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Figure 1. 5 Common Collector example circuit

3. Common Base Amplifier
   In this configuration the Base is common between the input and the output, R_{load} will be connected in series with emitter.

   $I_C = \beta I_B$; β= current gain

   But the voltage gain will also be high

$$Av = \frac{Vout}{vin} = \frac{Ic \cdot Rl}{Ie \cdot Rin}$$

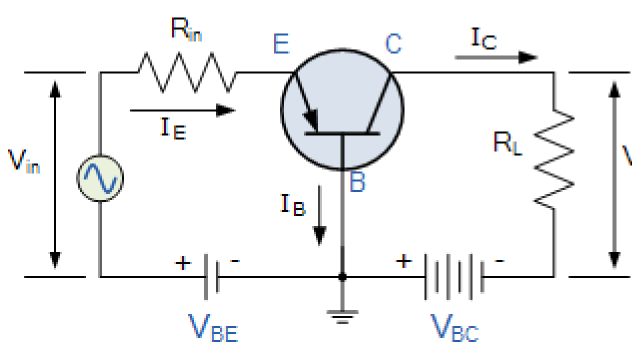

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Figure 1. 6 Common Base example circuit

[5] https://www.electronics-tutorials.ws/transistor/tran_1.html

[6] https://www.electronics-tutorials.ws/transistor/tran_1.html

Procedure and data analysis

In this experiment the 3 types of configurations for BJT transistors are going to be built in the lab, and the expected results of the experiment will be compared to the simulated and theoretical results.

Connections:

1. Common Emitter Amplifier
    - The circuit should be connected as in figure 2.1

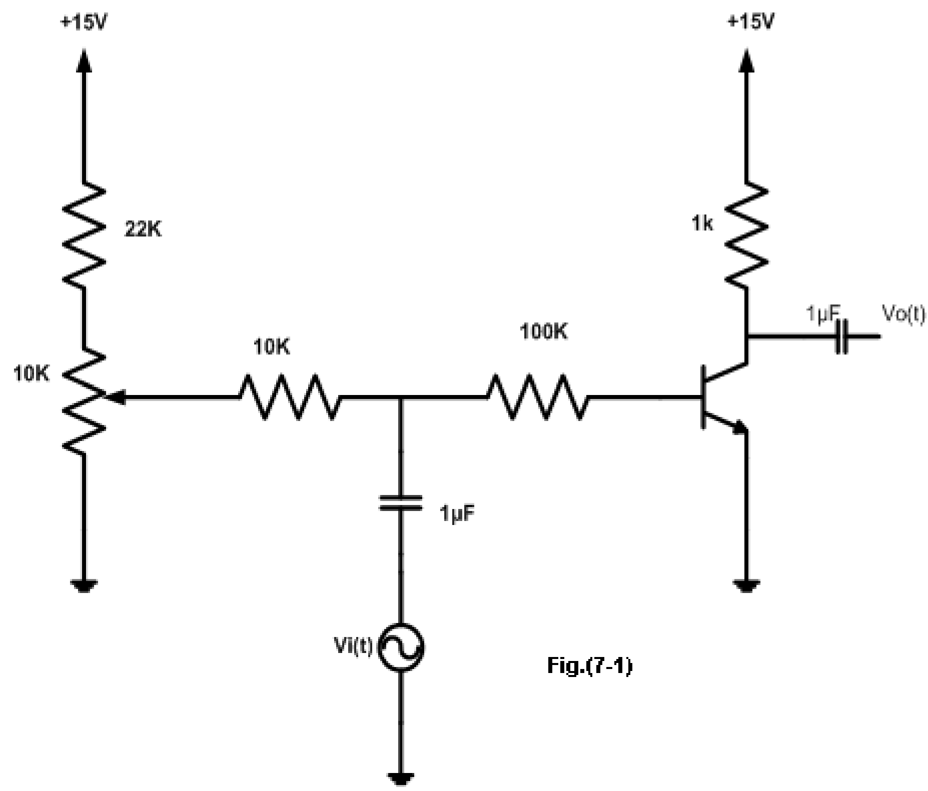

Figure 2. 1 CE Amplifier

- The power supply should be turned on
- The function generator frequency should be set to 1kHz sine wave and the amplitude to 0
- The potentiometer should be adjusted until V_o=8V. I_C, I_B, V_{CE}, V_{BE}, V_{BC} should be recorded.
  I_C=7.183mA
  I_B=0.265mA
  V_{CE}=7.783V
  V_{BE}=0.661V
  V_{BC}=-6.992V

- The oscilloscope should be switched on and connected to the base and the output of the circuit
- The function generator amplitude should be turned up until $V_{o,p\text{-}p}$=8, record $V_{in,p\text{-}p}$,V_B

$V_{in,p\text{-}p}$=3.04V

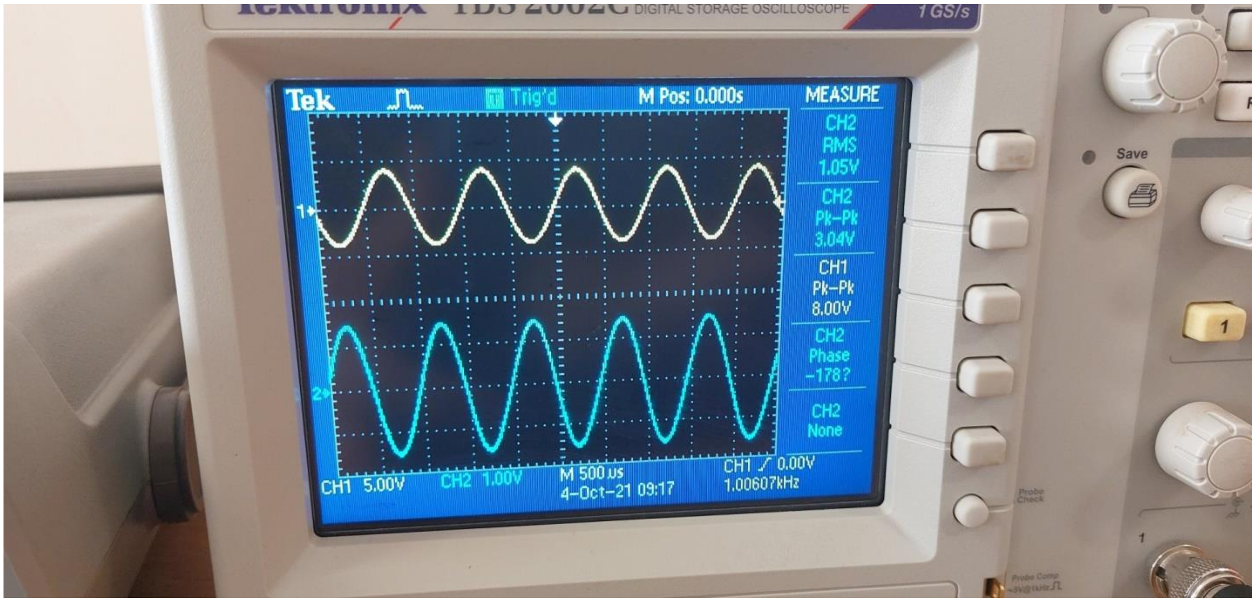

Figure 2. 2 $V_{in,p\text{-}p}$ when $V_{o,p\text{-}p}$=8

V_B=52mV

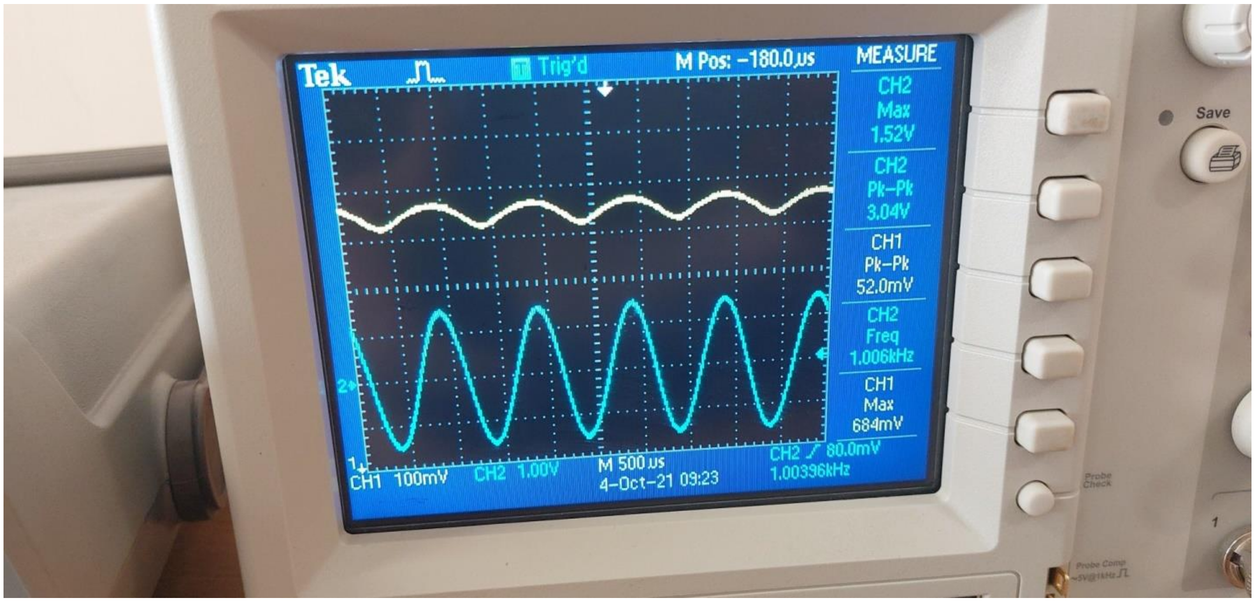

Figure 2. 3 V_B when $V_{o,p\text{-}p}$=8

- The voltage gains should be calculated

Av1=8V/52mV=153.846
Av=8V/3.04V=2.632

- The base and the collector currents should be measured using DMM
  I_B=10.43mA
  I_C=2.74mA
- The current gain and the input impedance Zi should be calculated
  Ai= i_o/i_i=2.78mA/0.675mA=4.119
  Zi=V_i/I_i=(3.04/2√2)/0.675mA=1592.23
- Calculate the voltage gain when the 100k resistor is removed
  Av=15.4/2.96=5.203

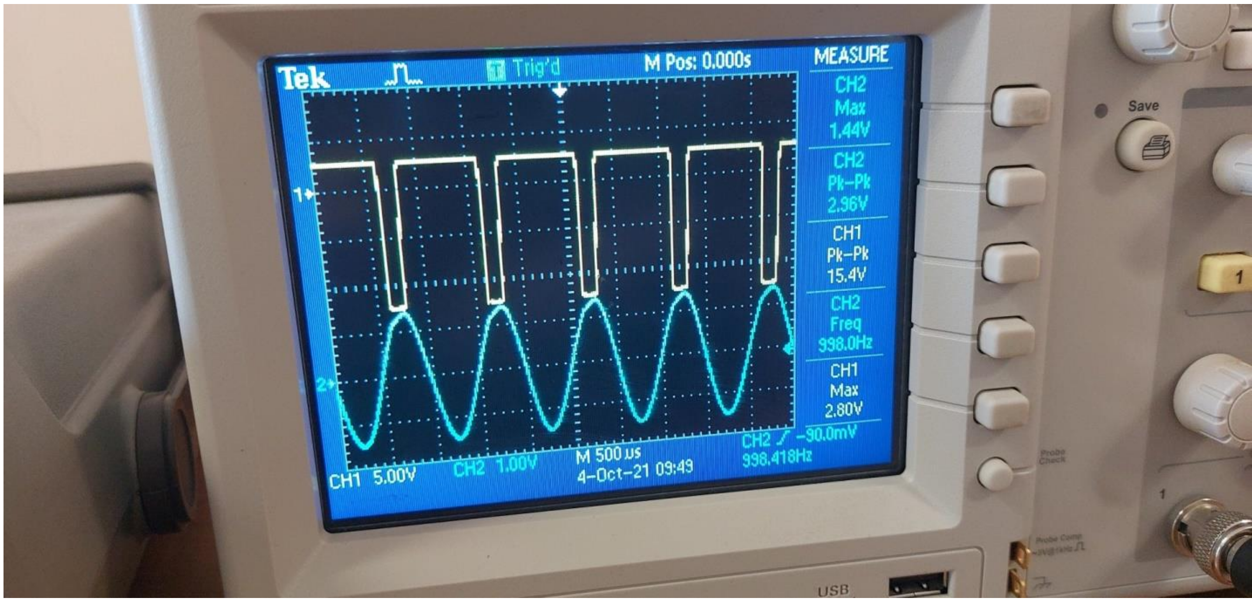

Figure 2. 4 V_o after removing the 100k resistor

2. Common Collector Amplifier
   - The circuit should be connected as in figure 2.5

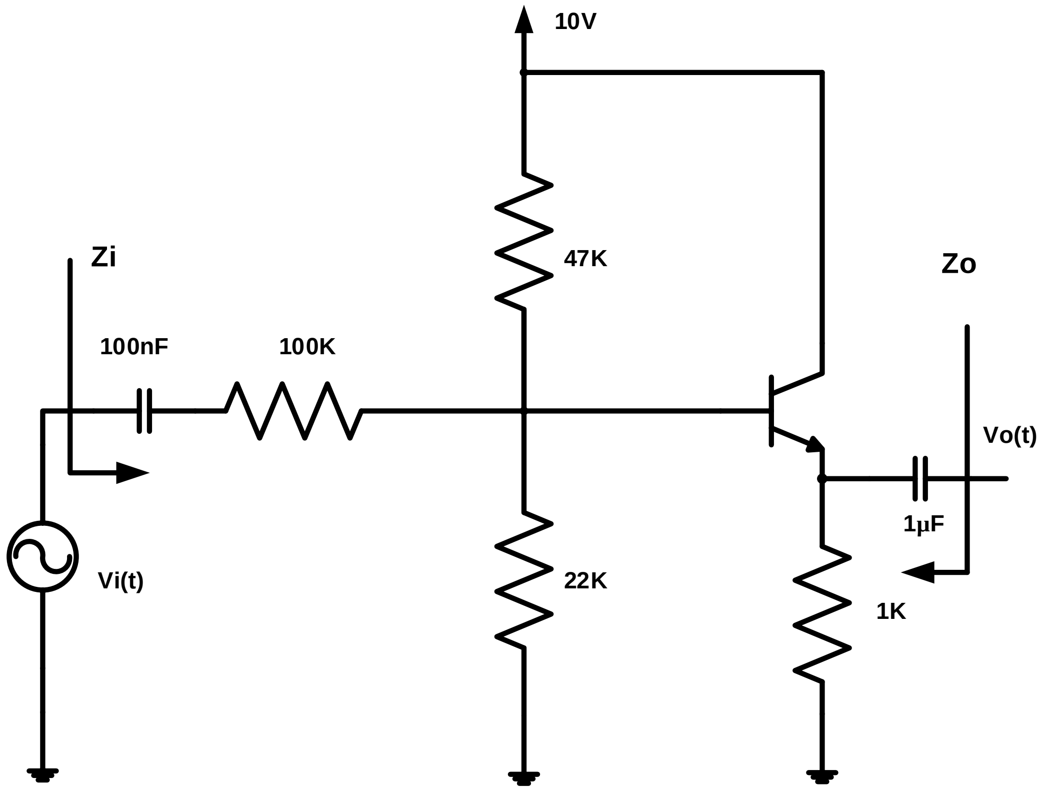

Fig.(7-2)

Figure 2. 5 CC Amplifier

- The variable dc control knob should be at minimum
- The power supply should be turned on and the variable dc voltage should be adjusted to give a +10V
- The sin wave generator amplitude should be set to zero and the frequency to 1kHz
- V_E and V_B should be measured using DVM
  V_E=2.41V
  V_B=3.07V
- The sin wave generator's amplitude should be increased until the output amplitude is about 2 volts peak to peak
- The ac input voltage needed should be measured
  $V_{in,p-p}$=15.8V
- The voltage gain Av should be calculated
  Av=2/15.8=0.1266
- The ac voltage across the 100kΩ resistor should be measured
  V_{100k}=4.8rms
- The input current should be calculated using V_{100k}
  $I_{in}=4.8*10^{-5}$

- The output current should be calculated using V_o and R_{load}
  I_{out}=2/1k=0.002A
- The current gain should be calculated
  Ai=0.002/(4.8*10^{-5})=41.667
- Z_{in} should be calculated
  Z_{in}=15.8/(4.8*10^{-5})=319166.66
- Z_{out} should be measured by changing the sine wave generator with a short circuit and then connected to the output by a capacitor.
  Z_{out}=Vtest/Itest=1/(4.4*10^{-3})=227.27

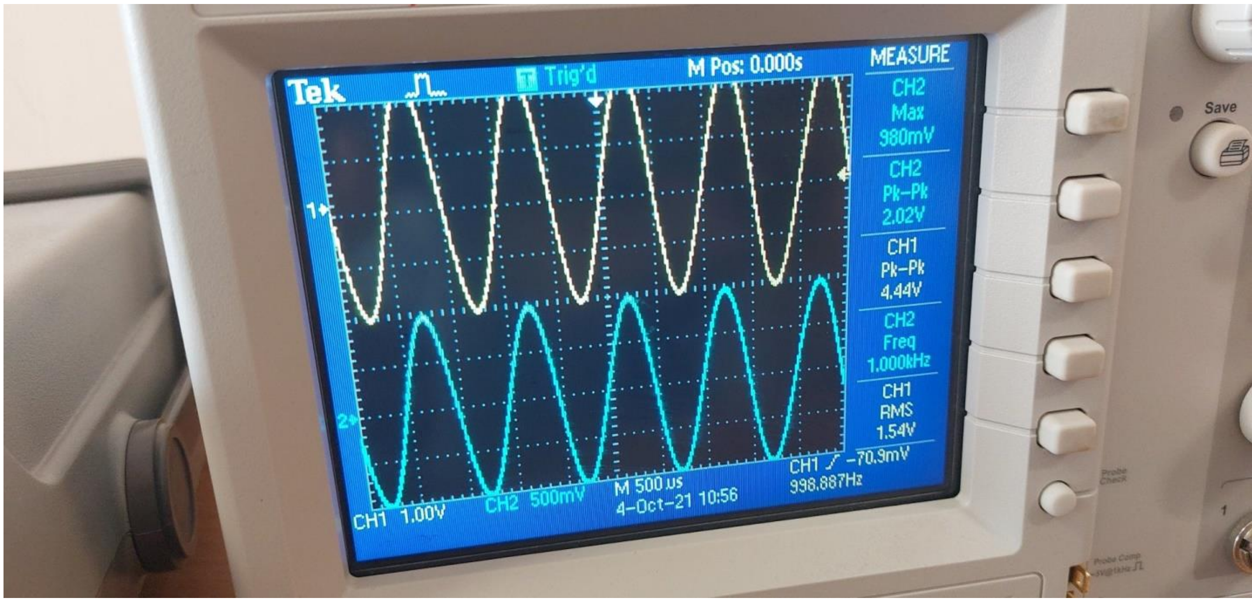

Figure 2. 6 Vtest to find Zout

- The table should be filled with the data

Quantity	Measured values
V_{in}	15.8V
V_{out}	2V
i_{in}	4.8*10^{-5}A
i_{out}	0.002A
	Calculated values
$A_V=V_{out}/V_{in}$	0.1266
$A_i=i_{out}/i_{in}$	41.667

$Z_{in}=V_{in}/i_{in}$	319166.66
Z_{out}	227.27

Table 1. 1 results of CC amplifier

Questions:

- How is the output quiescent voltage related to the input?
  The voltage gain is less than 1 since the output is less than the input voltage
- How do the parameters compare with those of the common emitter stage?
  The output voltage in the common emitter is higher than the input voltage but in the common collector the output voltage is less than the input voltage

3. Common Base Amplifier
   - The circuit should be connected as in figure 2.6

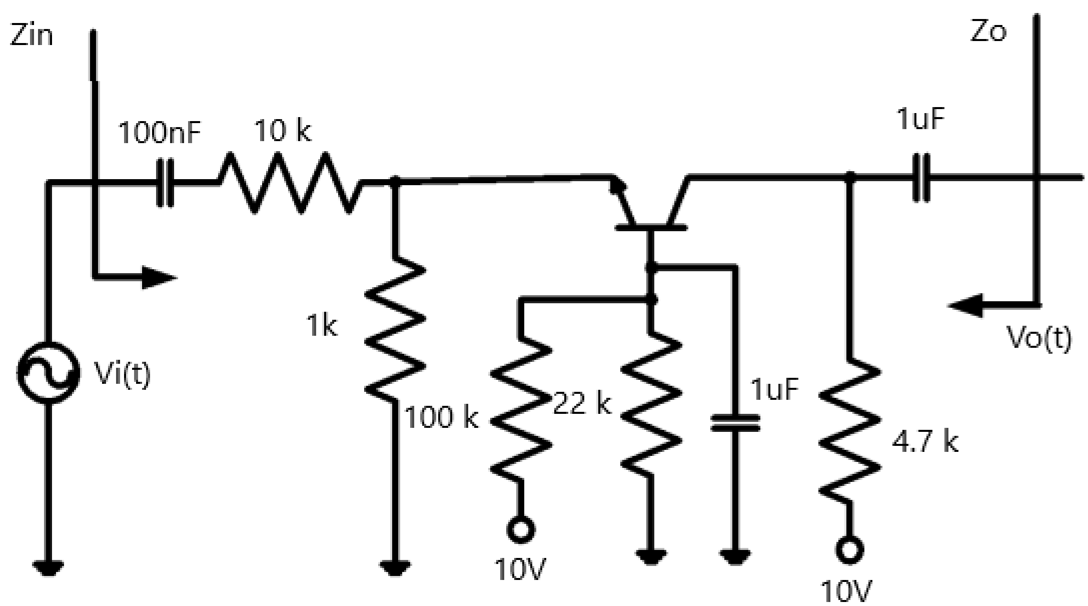

Figure 2. 7 CB Amplifier

- The variable dc control knop should be at minimum
- The power supply should be turned on and the control knop should be adjusted until +10V is given.
- The sine wave generator's amplitude should be set to zero and it's frequency should be set to 1kHz
- The quiescent bias voltages and currents I_B, I_C, V_{BE}, V_{BC} and V_{CE} should e measured and recorded using DVM.

I_B=-4.79uA
I_C=-1.118mA
V_{BE}=0.645V
V_{BC}=-3.08V
V_{CE}=1.91V

- The output amplitude of the sine wave generator should be increased until the output from the amplifier is about 2V peek to peek.
  $V_{in,p-p}$=4.44
- The voltage gain should be calculated
  Av=2/4.44=0.4505
- The ac voltage across the 10kΩ resistor.
  V_{10k}= 1.037 rms
- The input current should be calculated
  $Ii=1.037/(10*10^3)=0.1037*10^{-3}$
- The ac output current should be calculated
  $Iout=2/(4.7*10^3)=0.425*10^{-3}$
- The current gain should be calculated
  Ai=4.1
- the input impedance Zin should be calculated
  $Zin=4.44/(0.1037*10^{-3})=43657.82$

Quantity	**Measured values**
$\mathbf{V_{in}}$	4.44V
$\mathbf{V_{out}}$	2V
$\mathbf{i_{in}}$	$0.1037*10^{-3}$
$\mathbf{i_{out}}$	$0.425*10^{-3}$
	Calculated values
$\mathbf{A_V=V_{out}/V_{in}}$	0.4505
$\mathbf{A_i=i_{out}/i_{in}}$	4.1
$\mathbf{Z_{in}=V_{in}/i_{in}}$	43657.82
$\mathbf{Z_{out}}$	

Table 1. 2 results of CB amplifier

Questions:

- How is the output quiescent voltage related to the input?
  The voltage gain is less than 1 since the output is less than the input voltage
- How do the parameters compare with those of the common emitter stage?
  The output voltage in the common emitter is higher than the input voltage but in the common collector the output voltage is less than the input voltage

Conclusion

BJT transistor when used as amplifiers can have different configurations, which provides current gain or voltage gain or both. This makes BJT transistors the building block of electronic amplifiers

The properties of BJT transistors when used as amplifiers where shown, the experiment also showed the way each of amplifier types is connected.

References

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https://www.electronics-tutorials.ws/transistor/tran_1.html

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https://uk.rs-online.com/web/generalDisplay.html?id=ideas-and-advice/bipolar-transistor-guide