Laboratory: Transistors

Objective:

1. To study the characteristic of transistor.
2. To study the functions of transistor used as amplification and electronic switch.

Student preparation:

- Before going to the lab, students must wear a workshop suit. **A student with improper dress will not be allowed in the laboratory room.**
- Each group must prepare **three multimeters(analog or digital)** used to measure signals.
- Each group must prepare **one small flat-blade screwdriver** used to adjust the variable resistors.
- Each group must have **one breadboard** used to build circuits.
- Scientific calculator should bring in.

Since transistor is one of sensitive devices therefore students must carefully re-check all connection before connecting the supply voltage.

Introduction:

A transistor is a semiconductor device used to amplify and switch electronic signals. It is composed of semiconductor with at mostly three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals changes the current through another pair of terminals. Two main functions of transistors are amplification and electronic switch. Nowadays, transistors are packaged individually, but many more are found embedded in integrated circuits.

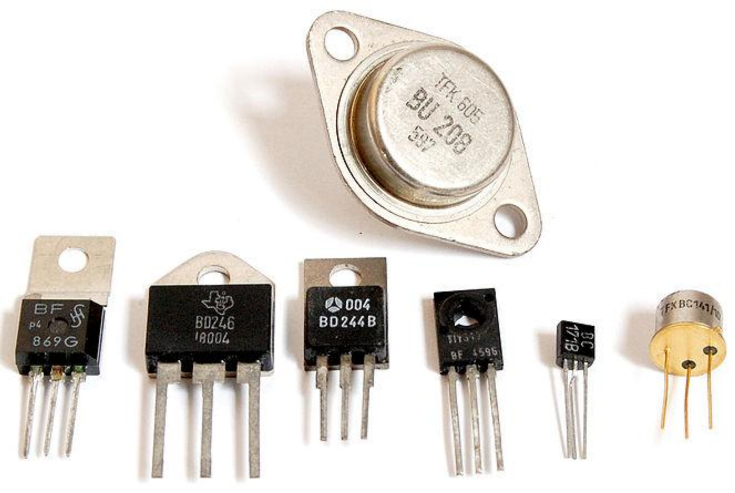
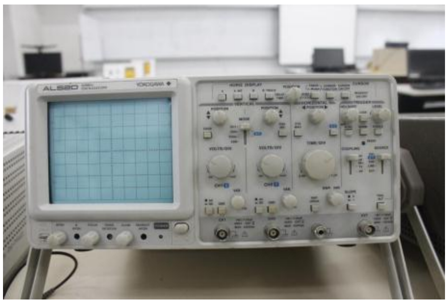


Figure 1. Different types of Transistors

Apparatus:

1. Oscilloscope+Probes



2. Function Generator

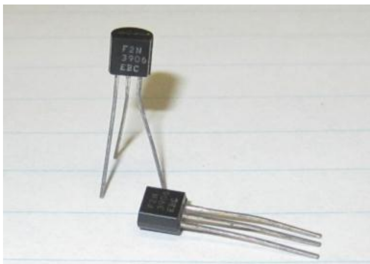
3. DC power supplies

4. 3 Multimeters (Bring by students)

5. Small flat-blade screwdriver

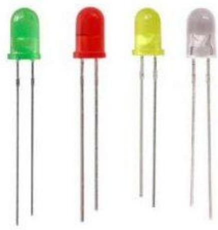
6. Jumper wires

7. Transistors BC549B

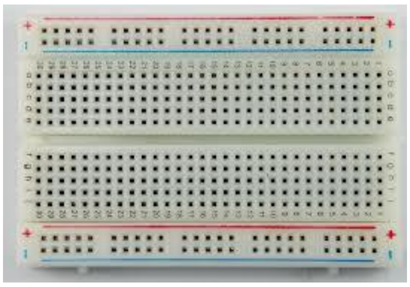


8. Resistors,Capacitors,Diodes

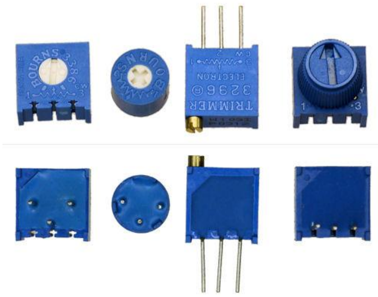
9. LED



10. Breadboard (Bring by student)



11. Trimmer Potentiometer(Variable Resistors)



Recommendations:

- **Appendix 1 contains the guideline of devices used for connections in this laboratory.**
- When using oscilloscope for measurements, the vertical input couplings should set to **DC.**
- When using both CH1 and CH2 to measure signals simultaneously, ensure that ground leads of both probes are connected at the same position.

Procedures:

Experiment 1(DC current gain)

1.1 From Figure 1, by assuming $V_{BE(ON)}$= 0.7 V and $V_{CE(SAT)}$= 0.2 V, **calculate** the maximum i_b and i_c .

i_b (max) = _________ µA

I_c (max) = _________ mA

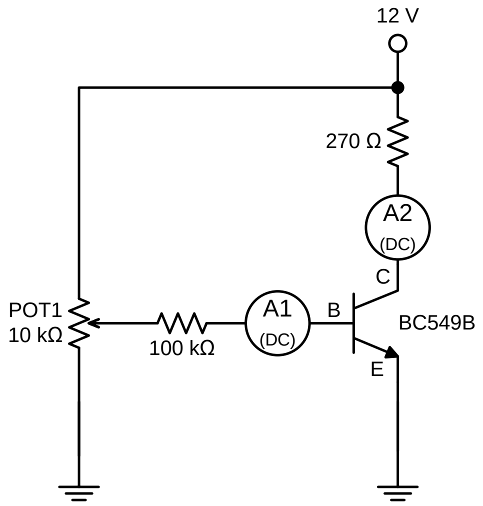


Figure 1.

1.2 Set the proper measuring ranges (**DC** current mode) of two multimeters to measure these currents. Build the circuit as shown in Figure 1 on the breadboard.

1.3 Slowly adjust POT1 for setting i_b according to Table 1, measure i_c and calculate β_{DC}.

i_b	i_c	β_{DC}
25 µA		
50 µA		
75 µA		
100 µA		

Table 1.

1.4 From the datasheet of BC549B obtained from the internet, β_{DC} = ___________.

Experiment 2 (BJT input characteristic)

2.1 Connect the circuit as shown in Figure 2.

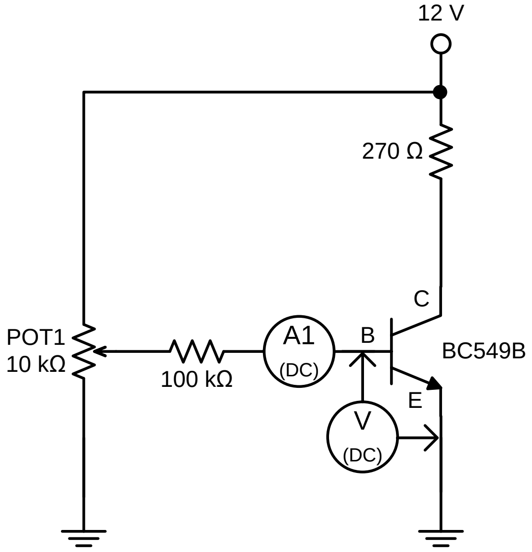


Figure 2.

2.2 Slowly adjust POT1 for setting i_b according to Table 2, record V_{BE}.

i_b	V_{BE}	i_b	V_{BE}
0 μA		30 μA	
5 μA		35 μA	
10 μA		40 μA	
15 μA		45 μA	
20 μA		50 μA	
25 μA			

Table 2.

2.3 Plot V_{BE} (x-axis) against I_B (y-axis) as input characteristic of transistor. Note. Students can do the plot at home (after the laboratory).

<u>Experiment 3 (BJT output characteristic)</u>

3.1 Build the circuit as given in Figure 3.

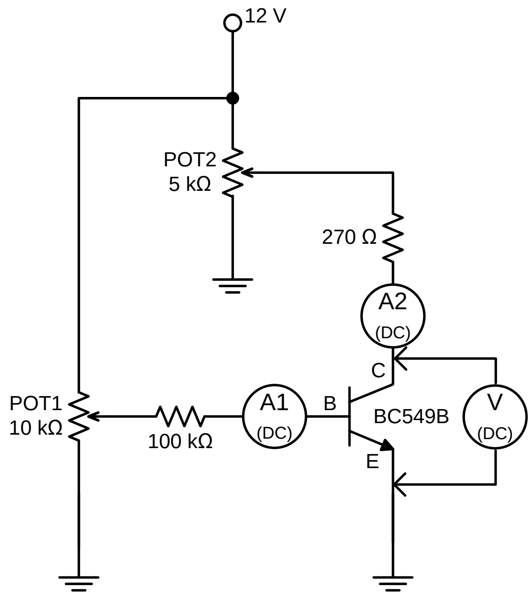


Figure 3.

3.2 Slowly adjust POT1 for setting i_b and then POT2 for V_{CE} according to Table 3, record i_C .
(Recommended to adjust POT1 first to set i_b)

	V_{CE}(Volt)														
i_b (μA)	0	0.25	0.5	0.75	1	1.25	1.5	1.75	2	3	4	5	6	7	8
10															
20															
30															
40															
50															

Table 3

3.3 Plot V_{CE} (x-axis) against I_C (y-axis) for different fixed i_B . This is an output characteristic of transistor as studied in the theory. **Note. Students can do the plot at home (after the laboratory).**

<u>Experiment 4 (BJT amplifier)</u>

4.1 Build the circuit as shown in Figure 4. Connect the middle leg of POT1 to one end and set the function generator to generate sinusoidal signal (V_{AC}) .

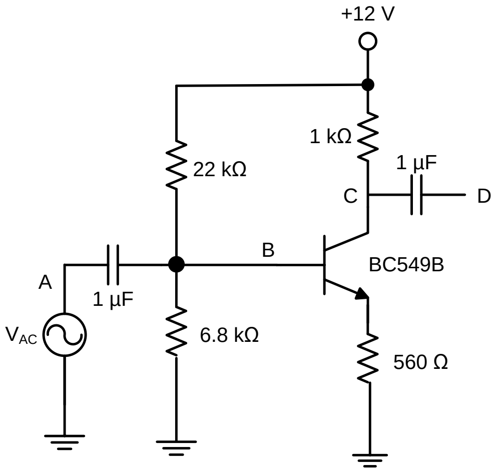
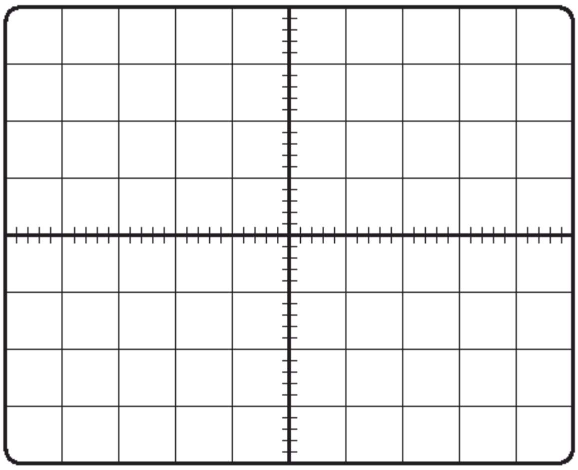


Figure 4.

4.2 Set V_{AC} to 1 $V_{P\text{-}P}$, 1 kHz . Make sure that DC coupling mode is used for measurements.

4.3 Record waveforms at point D, C, B and A to the graph provided.

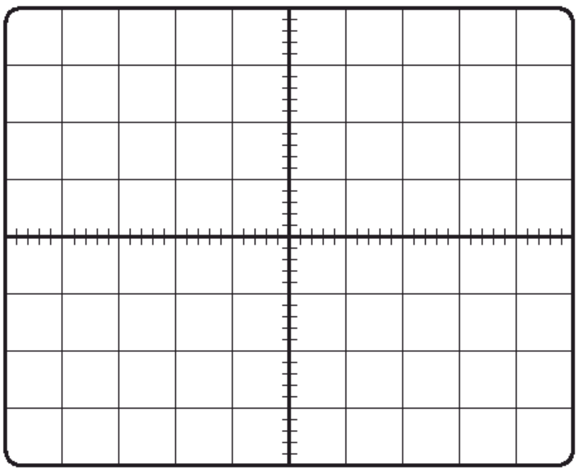


Signal at point A

DC Coupling

Y=________ VOLTS/DIV

X=________TIME/DIV

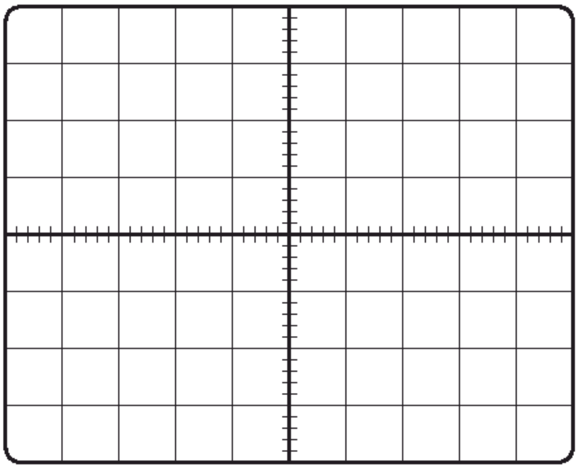


Signal at point B

DC Coupling

Y=________ VOLTS/DIV

X=________TIME/DIV

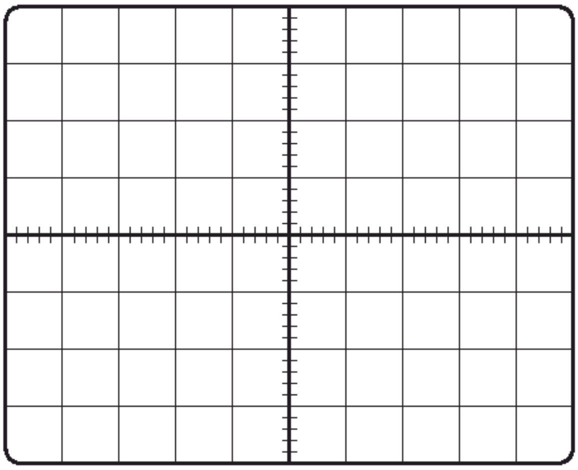


Signal at point C

DC Coupling

Y=_______ VOLTS/DIV

X=_______TIME/DIV



Signal at point D

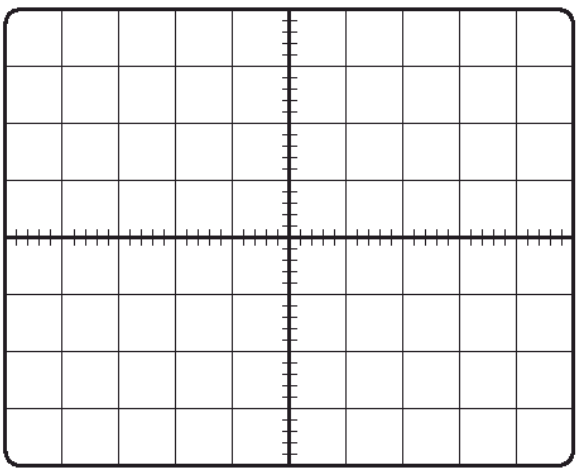
DC Coupling

Y=_______ VOLTS/DIV

X=_______TIME/DIV

4.4 Set V_{AC} to 2 V_{P-P} , 1 kHz . Make sure that DC coupling mode is used for measurements.

4.5 Record waveforms at point D, C, B and A to the graph provided.

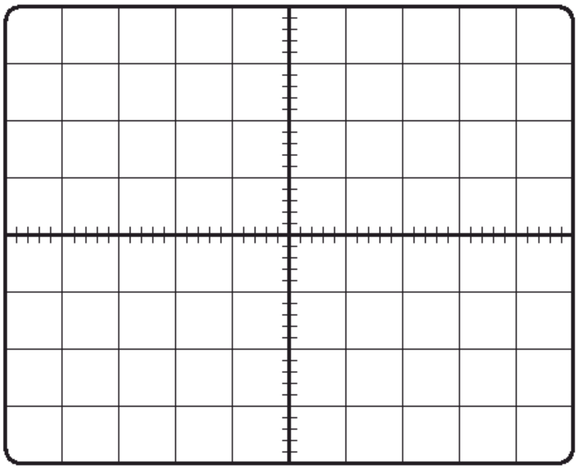


Signal at point A

DC Coupling

Y=_______ VOLTS/DIV

X=_______TIME/DIV

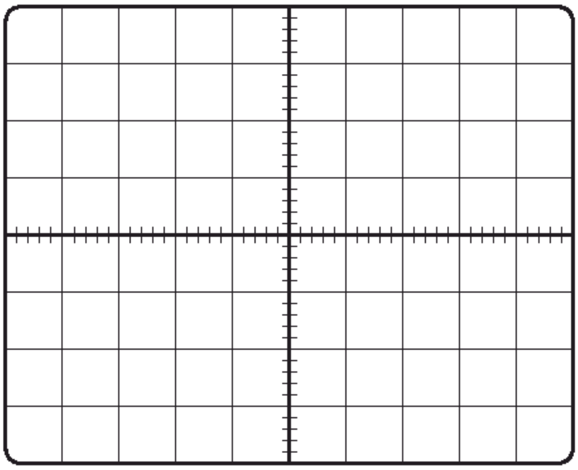


DC Coupling

Y=_______ VOLTS/DIV

X=_______TIME/DIV

Signal at point B

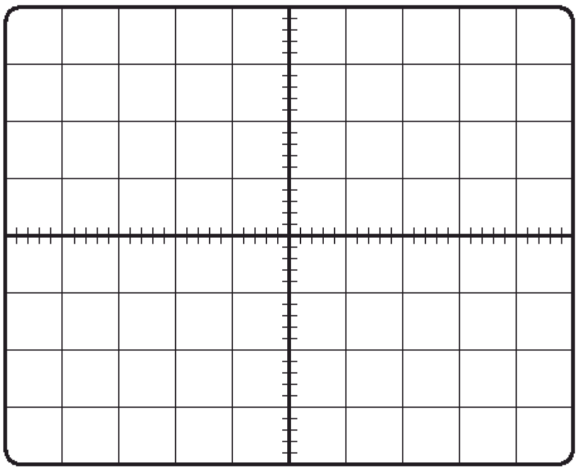


DC Coupling

Y=_______ VOLTS/DIV

X=_______TIME/DIV

Signal at point C



DC Coupling

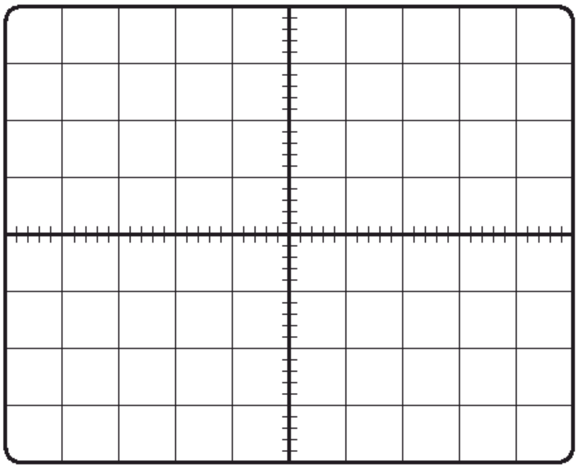
Y=_______ VOLTS/DIV

X=_______TIME/DIV

Signal at point D

4.6 Set V_{AC} to 12 $V_{P\text{-}P}$, 1 kHz . Make sure that DC coupling mode is used for measurements.

4.7 Record waveforms at point D, C, B and A to the graph provided.

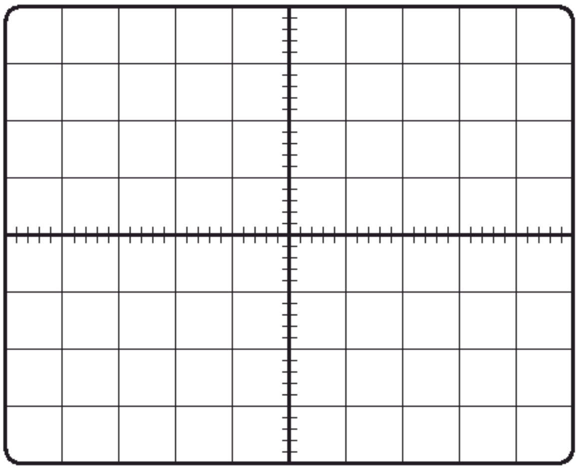


Signal at point A

DC Coupling

Y=_______ VOLTS/DIV

X=_______TIME/DIV

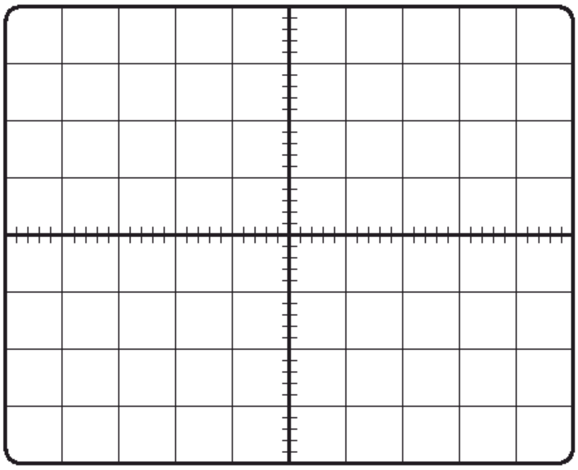


Signal at point B

DC Coupling

Y=_______ VOLTS/DIV

X=_______TIME/DIV

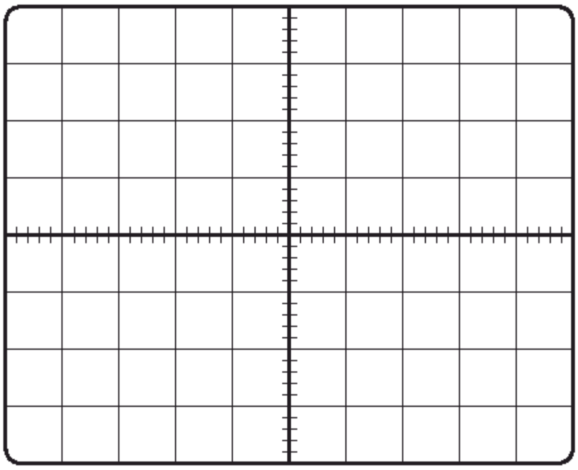


Signal at point C

DC Coupling

Y=_______ VOLTS/DIV

X=_______TIME/DIV



Signal at point D

DC Coupling

Y=_______ VOLTS/DIV

X=_______TIME/DIV

<u>Experiment 5 (BJT as an electronic switch)</u>

5.1 Build the circuit as shown in Figure 5. Press SW1 and measure i_B , i_C and V_{CE} using multimeter. Also measure V_{LED} (voltage across LED). Observe the brightness of LED and fill the table with a tick mark (✔).

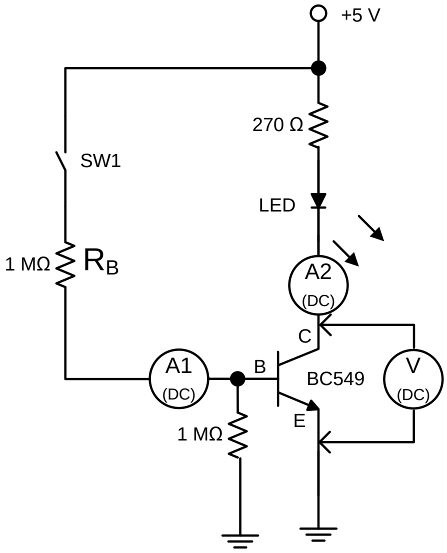


Figure 5.

5.2 Disconnect Vcc using SW1 then change R_B to 330 kΩ , 220 kΩ , 100 kΩ , 47 kΩ and 10 kΩ. Repeat step 5.1 and complete Table 5.

					LED brightness(✔)			
R_B	i_B (mA)	i_C(mA)	V_{CE} (V)	V_{LED} (V)	Superbright	Bright	Dark	$\beta_{dc} = i_C/i_B$
1 MΩ								
330 kΩ								
220 kΩ								
100 kΩ								
47 kΩ								
10 kΩ								

Table 5

Questions for Experiment 5.

1. What is the name of transistor configuration shown in Figure 5? ___________________________

2. From the results, what is $i_{c(SAT)}$? ______________mA

3. Plot DC load line using the results from the experiment and compare with that from the theory (using a datasheet of BC549B).

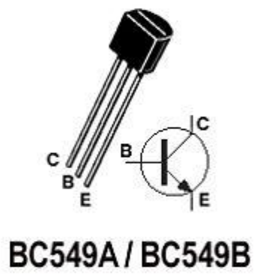
Note. The report should include:

1. All results obtained from the experiment.
2. Discussion and Conclusion on the results.
3. Answers on all questions.

The report is due by next week after the laboratory.

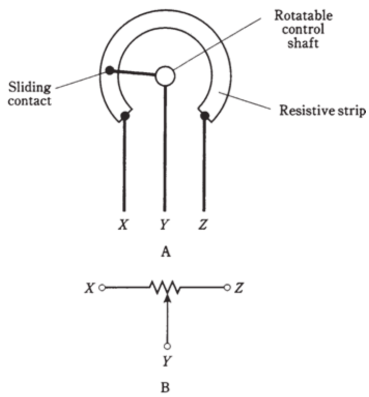
Revised by WL on 4/11/2015

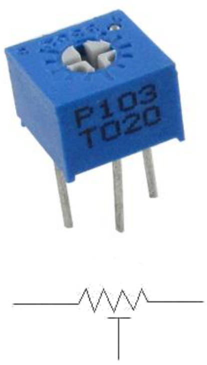
Transistors Pin configurations



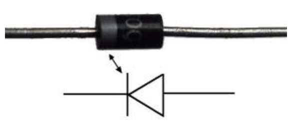
Trimmer Potentiometers(Variable Resistors)

Trimmer pot is a miniature adjustable variable resistors (potentiometer). There are two types of trimmer pot: single turn and multi-turn. It has three terminals which **the middle leg (normally using as output)** is the wiper or slider used to change its resistance Students must be careful when using screwdriver to adjust the resistance. Don't screw too hard and should stop screw when hearing a "**click**" sound which means it reaches the minimum or maximum resistance. The maximum resistance can be obtained by reading its value (i.e. 103 = 10×10^3 = 10 kΩ) or measuring both ending terminals.





Diodes



LEDs(Light Emitting Diodes)