University of Asia Pacific (UAP)

Department of Electrical & Electronic Engineering

Circuit Lab - 1 (R # 707)

Lab sheet of course on

Electrical& Electronic Engineering I Sessional

(Course Code: EEE – 122) (CSE)

List of the Experiment's

Exp. No.	Name of the Experiment
1 .	Verification of Ohm's Law.
2(a).	Verification of Kirchhoff's Voltage Law (KVL).
2(b).	Verification of Kirchhoff's Current Law (KCL).
3.	Verification of Superposition Theorem.
4.	Verification of Thevenin's Theorem & Maximum Power Transfer Theorem.
5.	Use of different types of switches
6.	Study of I-V Characteristics of General-purpose Diodes (Rectifying Diodes) and Zener Diodes
7.	Study of diode rectifiers.
8.	Study of MOSFET as a switch.

University of Asia Pacific
Dept. of CE/CSE/EEE

Course Name: _____

Course Code: _____

Experiment Name: _____

Experiment No.: ____

Date of experiment: ___/___/20__

Date of submission: ___/___/20__

Individual Report

Name: _____

ID: _____

Section: __ __ [e.g. A2]

Group: __ [e.g. 3]

Group members IDs: _____, _____, _____ ...

Group Report

Section: __ __, Group: __

Sl	ID	Name
1		
2		
3		
4		
5		

1. <u>Objective</u>: Write about the purpose of the experiment
[Use bullet points]
~~eg~~ [Write in your own words]

2. <u>Equipment</u>: [List of equipment used in the experiment]
- ----- [Write name & quantity of devices used]
- ----- [Include values (with unit) of anything relevant]
- ----

3. <u>Circuit Diagram</u>: [Draw the circuit diagram(s) <u>used</u> in the experiment, clearly]
[Label properly] [Include position of multimeter]
[Include measured parameters]

4. <u>Experimental Procedure</u>: [If lab sheet procedure is followed, then write "Lab Manual Procedure was followed."]
[For changes to lab sheet procedure, include what was done differently for which step]
e.g. {At step 2, we took 6 values instead of 10}
{We did not follow step 5} etc.

5. <u>Data Table</u>.
[Include DMM values of resistors, voltage sources]
[Draw tables for each set, including units and any calculated / theoretical value]

6. <u>Calculations</u>: (if any)
[Include calculation steps for at least 1 set of theoretical values OR calculation column]

7. Verification:

a). Experimental Verification:

[Compare experimental values to show that the theory is correct]

[e.g. For KCL, if currents entering a node, as measured by an ammeter, is equal to the sum of the currents leaving; then KCL is experimentally verified]

[State which experimental values you are comparing and show the calculation. Also state why your chosen values verify the theory]

b) Theoretical verification:

[Compare a set of theoretical value with its measured value to verify the theory]

[Show which values used & why]

c) Reasons for difference between experimental and theoretical/calculated values:

[State why they could be different, assuming NO mistakes were made in equipment use]

8. Graph: [Add graphs, if any]

[Show any calculation (eg. slope), if required]

[Label axes, including units, graduate axes properly]

9. Discussion: [write bullet points]

[What ~~do the~~ did you learn from this experiment]

[What problems did you face? Describe each problem clearly] [OR, What problems could have arisen?]

[How did you solve the problem]

[Why did the problem occur?]

10. [Add signature Sheet]

<u>Note:</u>

- if copying is detected, then no marks for both groups
- Submit report at the beginning of class, no writing of report while class is going on.
- Inform me if you cannot come to class. You can then makeup the missed lab with another section or in a later review class.
- If I am not informed, then no marks for that Lab.
- For missed Lab, submit application with advisor's signature.
- Call me only during business hours. Outside business hours send SMS or email.

University of Asia Pacific

Department of Computer Science and Engineering

Course Title: Electrical& Electronic Engineering I Sessional

Course Code: EEE 122

EXPT. No. 01

Name of the Experiment: Verification of Ohm's Law.

Objective:

- To get familiarize with the basic measuring instruments used in DC Circuit.
- To verify the Ohm's Law.
- To understand significance of Ohm's Law.

Theory:

Electricity is the flow of electric charge carriers. It is measured quantitatively by amount of electric current I(Amperes), through the circuit element of interest. In order to create electricity through a circuit element a potential difference ΔV (Volts), must be created across that element.

Ohm's law basically dictates the relationship between potential difference ΔV (Volts) and electric current I(Amperes) in an *ideal conductor*. The statement of this law is:

The potential difference (voltage) across an ideal conductor is proportional to the current through it.

Mathematically this can be expressed as:

$$\Delta V \propto I$$

$$\Delta V = IR$$

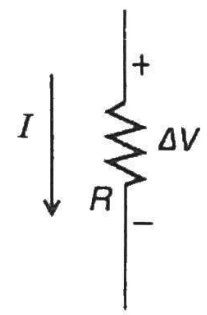


Figure: 01 Circuit symbol of a resistor. Direction of I is given according to passive sign convention.

The constant of proportionality is called the "resistance",

R (measured in ohms or Ω),

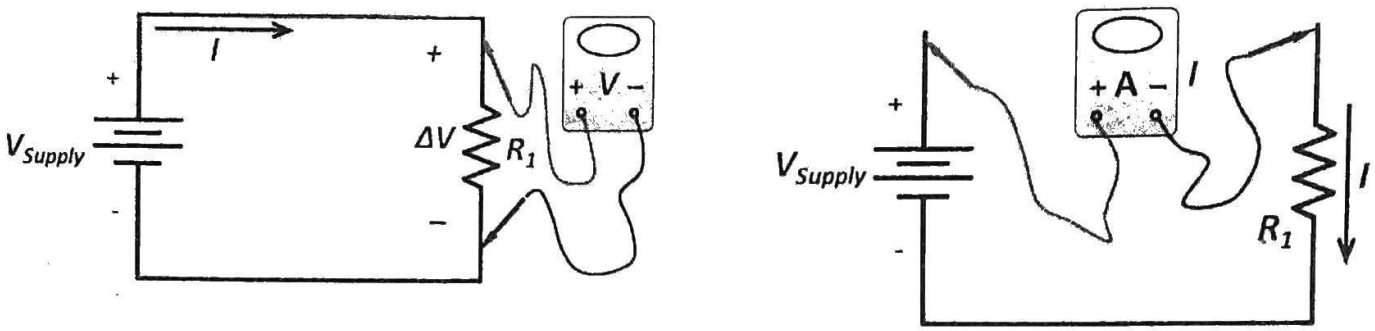
ΔV = Potential difference across the resistor (volts),

I = Current or electric current through the resistor (amperes).

Equipment:

#	Trainer Board	1 piece
#	DC Voltage Supply	1 unit
#	Resistors (1kΩ and 2.2kΩ)	1 piece each
#	Multimeter	1 unit
#	Chords and wire	as required

Circuit Diagram:



(a) Usage of Voltmeter to measure ΔV.

(b) Usage of Ammeter to measure I.

Figure: 02 Circuits for verification of ohms law.

Procedure:

1. With the help of the Course Instructor, get yourself familiarized with various DC components: DC power supply (how to change its value including 'Fine' change, significance of 'Current Limit Indicator/ Overload Indicator', Digital Multimeter, DMM (learn different modes of it specially 'Voltmeter Mode', 'Ammeter Mode', 'Ohmmeter Mode'), bread board (specially its connections) etc.
2. Take a resistor, measure it resistance by observing the 'Color Code' on it and verify it measuring the value using DMM in 'Ohmmeter Mode'.
3. Learn with care how a DMM is to be connected in 'Voltmeter mode'. Also observe the effect if it is connected in series.
4. Learn with great caution how a DMM is to be used in 'Ammeter Mode'. Also observe the effect if it is connected in parallel (***Note: Don't do it without the supervision of the instructor. Because you may burn it out***)
5. Measure the resistance values of the given resistors and note down these values in the specified blanks below (Data collection section). (Use multimeter as an ohmmeter).
6. Make sure the variable dc power supply is at 0V.
7. Connect the circuit in Fig. 2(a). For a particular supply voltage, measure the potential difference across R_1. For this purpose you have to use the multimeter as a voltmeter. (Caution: check that the

multimeter jacks are in appropriate positions and the proper range is selected). Note down the value of the potential difference in Table 1.1.

8. Now construct the circuit in Fig. 2(b), without changing the supply voltage measure the current through the resistor. You now have to convert the multimeter into an ammeter. (Caution: check that the multimeter jacks are in appropriate positions for current measurement and the proper range is selected). Note down the value of the electric current in Table 1.1.
9. You have to vary the supply voltage from 0V to 10V in 1V step. For each value of the supply voltage follow step 03 followed by step 04.
10. Now repeat the steps 2, 3, 4 and 5 for the second resistor R_2, and this time note the data in Table 1.2.

Data Collection & Observation Sheet

Value of R_1 = _____ kΩ Value of R_2 = _____ kΩ

Table-1.1: For R_1

V_{SUPPLY} (Volts)	ΔV (Volts)	I (mA)	ΔV/I (kΩ)
.....			

***For the verification of the law, check out whether the values of column 04 (i. e. ΔV/I) are all almost same (i.e. a constant) and also check out whether this constant is equal to the measured value of the resistance of R_1.

Table-1.2: For R_2

V_{SUPPLY} (Volts)	ΔV (Volts)	I (mA)	ΔV/I (kΩ)
.....			

***For the verification of the law, check out whether the values of column 04 (i. e. $\Delta V/I$) are all almost same (i.e. a constant) and also check out whether this constant is equal to the measured value of the resistance of R_2.

Report:

- Attach your tabulated data.
- Did your measured currents match with the calculated currents? What is your inference here?
- On the same graph paper plot the I-ΔV characteristics for both R_1 and R_2. The graph for the resistor having lower resistance possesses the greater slope – Explain.
- Discuss on what you learnt from this experiment.

University of Asia Pacific

Department of Computer Science and Engineering

Course Title: Electrical& Electronic Engineering I Sessional

Course Code: EEE 122

EXPT. No. 02 (a)

Name of the Experiment: Verification of Kirchhoff's Voltage Law (KVL)

Objective: The objective of this experiment is to verify Kirchhoff's Voltage Law (KVL).

Theory:

When any source of electromotive force (e.g. battery) is connected across a close circuit, it drives electric charges through various branches by pushing on charge carriers. This continuous pushing mechanism requires the battery to provide energy in an uninterrupted fashion. Since energy is conserved, so the total energy dissipated in various circuit elements must be equal to the total energy supplied by the sources of e.m.f. Since the potential difference actually represents amount of work done per unit charge, therefore the conservation of energy actually requires that the total rises (supply) in potentials must be exactly equal to the total amount of potential drops (dissipations), and this is the basic idea behind KVL.

KVL states that the voltage rise must be equal to the voltage drops around a close loop.

An alternate statement of which is:

The algebraic sum of the voltage (potential) differences in any loop must equal zero.

Mathematically this can be expressed as:

$$\sum_{n=1}^{k} \Delta V = 0, \text{ around any closed loop,}$$

(Where, k is the total number of elements present in that particular loop).

While taking algebraic sums, the signs of potential differences should be taken very carefully. In order to write down KVL, around a closed loop, following steps can be followed.

1. Currents should be assumed in each branch, if not specified.
2. In case of resistors the magnitude of potential drop is the current through that resistor multiplied by the resistance. Then signs of potential drops should be given as per the passive sign convention. This in short implies that, the higher potential side (marked by +ve sign) will be the side through which the current is entering the resistor.
3. After the assigning of the proper signs for all the elements, the specified loop can be traversed either in clockwise fashion or in anticlockwise fashion.
4. While crossing an element the sign that is seen first can be taken.

Equipment:

- DC Power Supply
- Digital Multimeter
- Rheostats (470 Ω, 100 Ω, 50 Ω)
- Wires and cords.

Circuit Diagram:

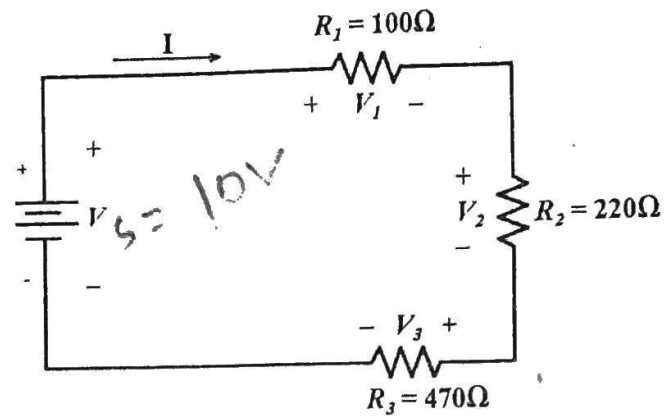


Figure: 02 Circuit for verification of KVL.

Procedure:

1. Measure R_1, R_2&R_3, as given in Fig: 2 and note down the exact values of the different resistances in *both* rows of Table 2.1.
2. Make the circuit connection of Fig: 2 to verify KVL.
3. Measure the value of V and note down in *both* rows of Table 2.1.
4. Measure the values of V_1, V_2& V_3 and note down in *experiment observation* row in Table 2.1.
5. Measure the value of*I* and note down in *experiment observation* row in Table 2.1. *(Caution: Put the multimeter in 'ammeter mode' very carefully, before measuring current.)*
6. For the verification of KVL check out whether the sum of V_1, V_2& V_3 (i.e. drops) is almost same as V (i.e. rise).
7. In order to calculate the theoretical values, at first apply KVL to the circuit in Fig-02 (replacing each resistor with its exact value). From the KVL expression, calculate the current *I* (note this value in the table). Now use ohm's law to find the theoretical values of V_1, V_2& V_3 and note them in the Table 1.

Data Collection & Observation Sheet:

Table-2.1:

Observation	$R_1(\Omega)$	$R_2(\Omega)$	$R_3(\Omega)$	V(volt)	V_1 (volt)	V_2 (volt)	V_3(volt)	I(mA)
Experimental								
Theoretical								

Report:

- Fill up the table.
- Compare the measured data with those calculated. Comment on whether the KVL is verified. Mention the possible reasons of discrepancy if any.
- Discuss on what you learnt from this experiment.

University of Asia Pacific

Department of Computer Science and Engineering

Course Title: Electrical& Electronic Engineering I Sessional

Course Code: EEE 122

EXPT. No. 02 (b)

Name of the Experiment: Verification of Kirchhoff's Current Law (KCL)

Objective: The objective of this experiment is to verify Kirchhoff's Current Law (KCL).

Theory:

Just like the law of conservation of energy there is a principle of conservation of charge, in physics. According to this principle electric charge can neither be created nor destroyed. The net quantity of electric charge in the universe is always conserved.

When we are dealing with electrical circuits (and also electronic), we have to admit that charges are flowing through different branches and find their ways to various nodes (junction points), by virtue of the electric current. Now let us merge this idea with the conservation of charge. If the net inflow of charges at a particular node would have been larger than the outflow, then it would mean that the charges are getting destroyed at that node. On the other hand, a greater outflow would require that the charges got created at the node. Both of these possibilities are ruled out by the principle of conservation of charge. So it is clear that the amount of charges entering a particular node and leaving that node at any given time must be equal. Since the flow rate of electric charges is measured by the electric current I (amperes), therefore, we can decide that

- **The net current entering into a node must be equal to the net current leaving that node**, and this is the basically the KCL.

For example if we apply KCL to a typical node as showed in Fig. 01, then we can write-

$$I_1 + I_4 = I_2 + I_3 + I_5 \quad ----(1)$$

Here, I_1 and I_4 are entering and I_2, I_3 and I_5 are leaving.

Again we can write equation (1) into two different forms –

$$I_1 + I_4 + (-I_2) + (-I_3) + (-I_5) = 0 \quad ----(2)$$

$$\text{And, } I_2 + I_3 + I_5 + (-I_1) + (-I_4) = 0 \quad ----(3)$$

From (2) we can also state that the algebraic sum of all currents entering a node is zero, and similarly from (3) it can be stated that the algebraic sum of all currents leaving a node is zero.

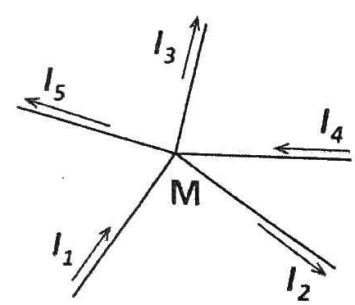


Figure: 01 A typical node. Here the node is named as 'M'.

These two are the alternate statements of KCL. So KCL can be written in three different formats, in total.

Equipment:

#	Trainer Board	1 piece
#	DC Voltage Supply	1 unit
#	Resistors (330Ω, 470Ω, 560Ω and 1kΩ)	1 piece each
#	Multimeter	1 unit
#	Chords and wire	as required

Circuit Diagram:

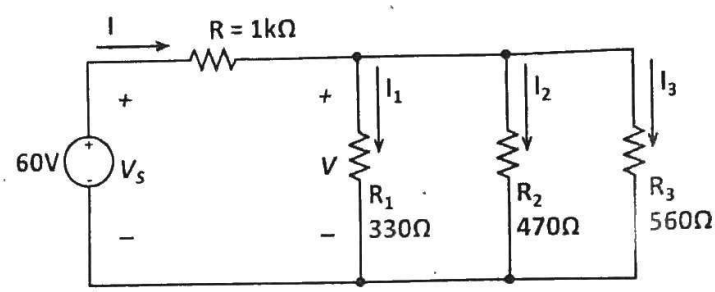


Figure: 02 Circuit for verification of KCL.

Procedure:

1. Measure R, R_1, R_2&R_3, as given in Fig: 2 and note down the exact values of the different resistances in *both* rows of table 3.1.
2. Make the circuit connection of Fig: 2 to verify KCL.
3. Measure the values of V and V_S. Note these down in *experimental observation* row of Table 3.1.
4. Measure the values of I, I_1, I_2&I_3 and note down in *experimental observation* row in Table 3.1. *(Caution: Put the multimeter in 'ammeter mode' very carefully, before measuring current)*
5. For the verification of KCL check out whether the sum of I_1, I_2&I_3 (i.e. net outflow) is almost same as I (i.e. net inflow).
6. In order to calculate the theoretical values, at first reduce the given circuit by replacing the parallel resistors by their equivalent resistance R_{eq}. Apply KVL to the reduced circuit to calculate I, then calculate V. Using this results and ohm's law, calculate I_1, I_2 and $I_3$and note them in the Table 3.1.

Data Collection & Observation Sheet:

Table- 3.1:

Observation	$R(\Omega)$	$R_1(\Omega)$	$R_2(\Omega)$	$R_3(\Omega)$	V_s(volt)	V(volt)	I (mA)	I_1 (mA)	I_2 (mA)	I_3 (mA)
Experimental										
Theoretical										

Report:

- Fill up the table.
- Compare the measured data with those calculated. Comment on whether the KCL is verified. Mention the possible reasons of discrepancy if any.
- Discuss on what you learnt from this experiment.

University of Asia Pacific

Department of Computer Science and Engineering

Course Title: Electrical& Electronic Engineering I Sessional

Course Code: EEE 122

EXPT. No. 03

Name of the Experiment: Verification of Superposition Theorem.

Objective: The objective of this experiment is to verify Superposition theorem.

Theory:

In physics and systems theory, the superposition principle, also known as superposition property, states that, **for all linear systems, the net response at a given place and time caused by *two or more* stimuli is the sum of the responses which would have been caused by each stimulus individually**.

Although superposition principle is not obvious, this principle is consistent with all our experimental results. This principle has many applications in physics and engineering because many physical systems can be modeled as linear systems.This theorem is only applicable for linear bilateral networks, to which vast networks belong to.

Superposition theorem states that, **the current through or voltage across an element in a linear bilateral network having multi sources is equal to the algebraic sum of currents or voltages (of the same element) produced separately by each independent sourcewith rest of others being deactivated.**

Now in order to determine the response of only a particular source we have to make sure that the other sources are deactivated. 'Deactivation' for ideal sources can be visualized as follows:

Figure: 01 Turning off procedure for ideal sources. The ideal voltage source has to be replaced by a short circuit and the ideal current source has to be replaced by an open circuit.

Equipment:

#	Trainer Board	1 piece
#	DC Voltage Supply	1 unit
#	Resistors (220Ω, 470Ω and 560Ω)	1 piece each
#	Multimeter	1 unit
#	Chords and wire	as required

Schematic Diagram:

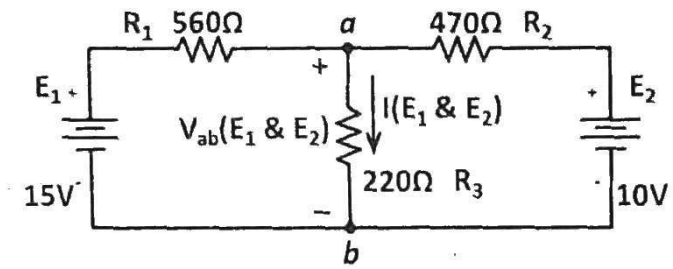


Figure: 02 Circuit for verification of Thevenin's theorem.

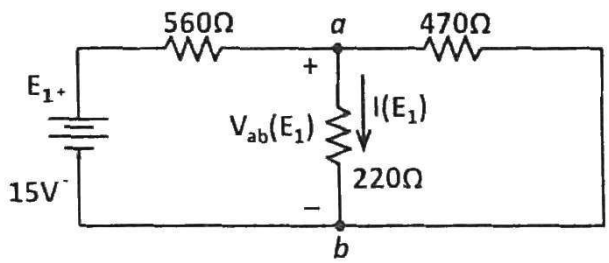


Figure: 03 Only E_1 is activated.

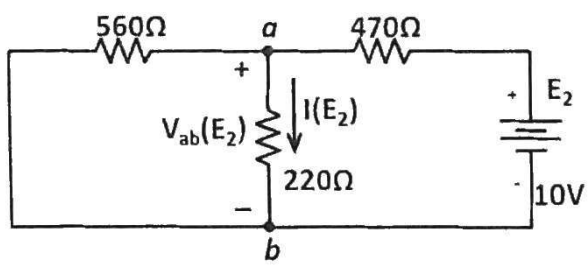


Figure: 04 Only E_2 is activated.

Precaution: Before giving supply show your connection to your teacher.

Procedure:

1. Measure R_1, R_2&R_3 as given in Fig: 2 and note down the exact values of the different resistances in *both* rows of tables 4.1, 4.2, 4.3 and 4.4.
2. Make the circuit connection of Fig: 2 to verify superposition theory.
3. Measure the values of V_{ab}&I and calculate power dissipated in R_2. Note these down in *experimental observation* row of table 4.1.

4. Activate E_1 only assuming E_2 to be an ideal voltage source (Fig: 3). Repeat step 3, and note down the corresponding experimental values in table 4.2.
5. Activate E_2 only assuming E_1 to be an ideal voltage source (Fig: 4). Repeat step 3, and note down the corresponding experimental values in table 4.3.
6. Calculate the theoretical values, fill up the table 4.4. Compare the rows of table 4.4 with the corresponding rows of table 4.1 for the verification of superposition theorem for voltage and current. Notice that this theorem doesn't hold for power calculation.

DataCollection & Observation Sheet:

Table- 4.1: (E_1 and E_2 both active)

Observation	$R_1(\Omega)$	$R_2(\Omega)$	$R_3(\Omega)$	$V_{ab}(E_1 \& E_2)$ (volt)	$I(E_1 \& E_2)$ (mA)	$P_{R2}(E_1 \& E_2)$ (mW)
Experimental						
Theoretical						

Calculation: (For theoretical values): C.W.

Table- 4.2: (Only E_1 is active)

Observation	$R_1(\Omega)$	$R_2(\Omega)$	$R_3(\Omega)$	$V_{ab}(E_1)$ (volt)	$I(E_1)$(mA)	$P_{R2}(E_1)$ (mW)
Experimental						
Theoretical						

Calculation: (For theoretical values): C.W.

Table- 4.3: (Only E_2 is active)

Observation	$R_1(\Omega)$	$R_2(\Omega)$	$R_3(\Omega)$	$V_{ab}(E_2)$ (volt)	$I(E_2)$(mA)	$P_{R2}(E_2)$ (mW)
Experimental						
Theoretical						

Calculation: (For theoretical values): C.W.

Table- 4.4: (Verification of Superposition Theorem)

Observation	$R_1(\Omega)$	$R_2(\Omega)$	$R_3(\Omega)$	$V_{ab}(E_1)+V_{ab}(E_2)$ (volt)	$I(E_1)+I(E_2)$ (mA)	$P_{R2}(E_1)+P_{R2}(E_2)$ (mW)
Experimental						
Theoretical						

Report:

- Fill up the table.
- Compare the measured data with those calculated. Comment on whether the superposition theorem is verified. Mention the possible reasons of discrepancy if any.
- Discuss on what you learn from this experiment.

University of Asia Pacific (UAP)

Department of Computer ScienceandEngineering

Course Title: Electrical& Electronic Engineering ISessional

Course Code: EEE 122

Experiment - 4

Name of the Experiment: Verification of Thevenin's Theorem & Maximum Power Transfer Theorem

Objective: The objectives of this experiment are to verify Thevenin's theorem & Maximum Power Transfer Theorem.

Theory: Thevenin's theorem states that the voltage across or current through an element of a network can be calculated by constructing a Thevenin's equivalent circuit. This circuit is represented by a voltage source called Thevenin's Voltage & an equivalent resistance called Thevenin's resistance & the elements itself – all connected in series. After removing the element Thevenin's Voltage &Thevenin's resistance are calculated where the open circuit terminals represents Thevenin's resistance (Rth).

The maximum power transfer theorem states that the maximum power can be transferred to the load when the load resistance is equal to the equivalent resistance looking through the terminals where the load is connected.

Equipment:

- DC Power Supply
- Digital Multimeter
- Resistor 220 Ω (4 pieces)
- Rheostat (1K) – 1 piece
- Trainer board.
- Wires

Schematic Diagram:

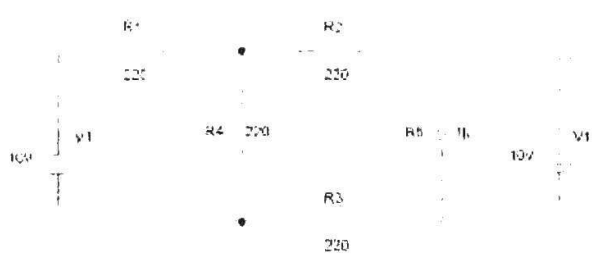


Figure : 1

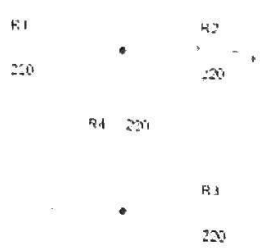


Figure : 02

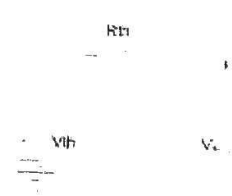


Figure : 0:

Procedure:

- Remove the load rheostat as shown in Fig :02.Measure the open circuit voltage. This represents the Thevenin's Voltage (Vth).
- Now measure the equivalent resistance by using a multimeter which represents the Thevenin's Equivalent Resistance (Rth). Write down the values in table 4.1
- Finally connect Thevenin's equivalent circuit as shown in Fig: 03.Now calculate VL& $I_L$from this circuit, varying RL from 100 Ω to 1000Ω with a stepping of 100 Ω. write down the values in table 4.2.

Table 4.1: Thevenin's Equivalent Circuit

Observation	V (Volt)	V_{th}(Volt)	R_{th} (Ω)
Experimental			
Theoretical			

Table 4.2: Maximum Power Transfer Theorem $P_L = I_L^2 R_L$ (W)

Load Resistance, R_L (Ω)	V_L (Volt)	I_L (Amp)	$P_L = V_L^2 / R_L$ (W)	$P_L = I_L^2 R_L$ (W)

Report:

- Fill up the table 4.1 and 4.2.
- Compare the measured data of table 4.1 with those calculated. Comment on whether the $V_L$of the Thevenin's equivalent circuit matches with that of the original circuit. Mention the possible reasons of discrepancy if any.
- Plot data of table 4.2 as $P_L$vsR_L. Mention the maximum power and the value of the load resistance for the maximum power. Comment on whether the Maximum Power Transfer theorem is verified.
- Discuss on what you learnt from this experiment.

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Experiment - 5

Name of the Experiment: Use of different types of switches

Objective: Different types of switches are used in electrical circuits. Each type of switch has a particular feature & its uses obviously depend on its inherent property. The different types of switches are as follows –

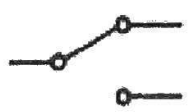
- SPST : Single Pole Single Throw switch
- SPDT : Single Pole Double Throw switch
- DPST : Double Pole Single Throw switch
- DPDT : Double Pole Double Throw switch

Equipment:

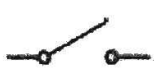
- Lamp Board
- Switches : 2 SPST, 2 SPDT, 1 DPST, 1 DPDT
- Chord & Wires

Schematic Diagram:

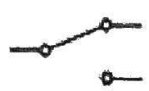
SPST

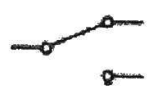


SPDT



DPST





DPDT

Precaution: Before giving supply show your connection to your teacher.

Procedures:

- Connect the circuit of fig. 1(a) and operate the lamp by a SPST switch after being checked by your teacher.
- Connect the circuit of fig. 1(b) and operate two lamps simultaneously by a SPST switch after being checked by your teacher.
- Connect the circuit of fig. 1(c) and operate two lamps individually by a SPDT switch after being checked by your teacher.
- Connect the circuit of fig. 1(d) and operate the lamp by a DPST switch after being checked by your teacher.

Report:

- Mention what type of switch is most commonly used for our domestic purposes.
- Write down whether our domestic appliances are usually connected in series or in parallel and mention the reasons.
- Design a circuit so that, a bell can be operated individually from three different rooms. You can use push button switches for this purpose.

University of Asia Pacific (UAP)

Department of Computer ScienceandEngineering

Course Title: Electrical& Electronic Engineering ISessional

Course Code: EEE 122

Experiment –6

Name of the Experiment: Study of I-V Characteristics of General-purpose Diodes (Rectifying Diodes) and Zener Diodes.

Objective:

- To understand the importance of I-V characteristic study of an element
- To study the characteristic of diodes from experimentally obtained I-V curve
- To use the characteristic curve to solve diode oriented circuits

Equipment:

i) P-n junction diode-1pc
ii) Zener diode-1pc
iii) Resistor(1K)-1pc
iv) Dc power supply
v) Multimeter

Theory:

A diode is a two terminal device that acts as an one-way conductor. It's action depends on the polarity at which it is connected in circuit. When the diode is connected across a voltage source with positive polarity of the source connected to p-side of the diode and negative polarity to n-side, the diode is said to be forward biased. It acts like a closed (short circuit) switch and ideally it offers no resistance to the current path as shown in fig. 1(a). If the polarity is reversed, the diode is said to be reversed biased and it acts like open switch and ideally it does not allow any current to pass through.

However, a practical diode does not comply with the ideal one. The general characteristics of a diode can be expressed by an equation known as Shockley diode equation, and it is given by

$$I_D = I_S\left\{e^{\frac{KV_D}{T_K}} - 1\right\}$$

Where, I_D is the forward current through diode; V_D is the applied forward voltage; I_S is the leakage or reverse saturation current; K=11600/n where n is the ideally factor and 1≤n≤2 and ,T_K is the absolute room

temperature. If the voltage across the diode is varied and the current through diode corresponding to each voltage are taken, the plot of current ,(I_D) vs voltage (V_D) will be as shown in fig 1(b).

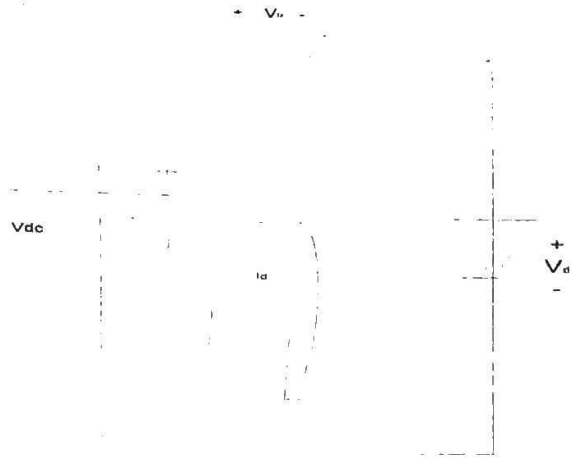


Figure: 1(a)

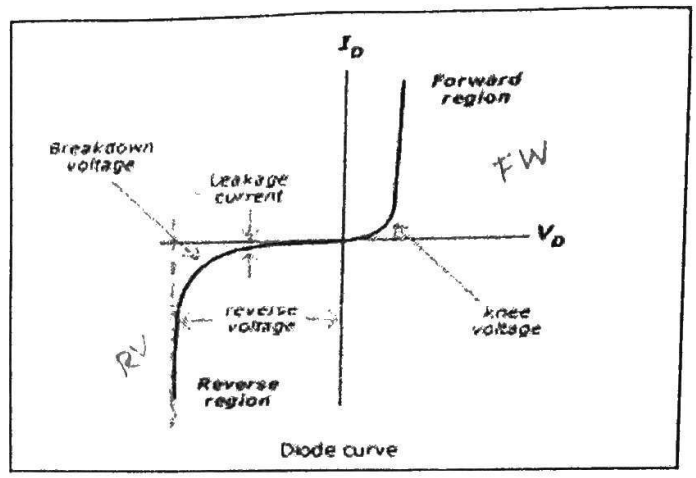


Figure: 1 (b)

Fig1(a) Forward biased diode (b) Diode characteristics curve

From the characteristics the following can be observed:

The right side of the curve(V_D>0) represents the forward bias

#The left side of the curve(V_D<0) represents the reversed biased diode.

In forward biased mode the current increases gradually at low values of V_D, then rises sharply after a particular value of V_D. This suggests that we can think a forward biased diode as a closed switch only beyond that particular voltage. This voltage which is represented by the knee portion of the curve is known as cut-in or threshold voltage, V_T . Particularly $V_T = 0.7$V (for Si)

In the reverse bias portion the diode current is almost zero up to a modest range of voltage. Beyond that the current increases almost indefinitely due to breakdown. This situation is known as reverse breakdown of diode and is always avoided. The current can be limited using resistor in diode current. If the slope $\frac{dI_D}{dV_D}$ is very steep, Zener diode can be used in regulator circuit.

Normally, all diodes can't be reached to breakdown region. To operate in that region a special type of diode is fabricated known as Zener Diode. It is specified by a voltage that signifies that the diode will start conducting current but in the opposite direction as this the reverse voltage of the diode crosses this voltage.

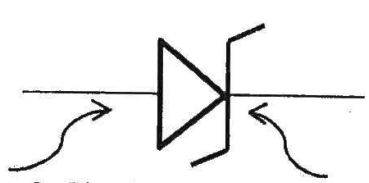


Figure 2: Circuit Symbol of Zener Diode

Circuit Diagram:

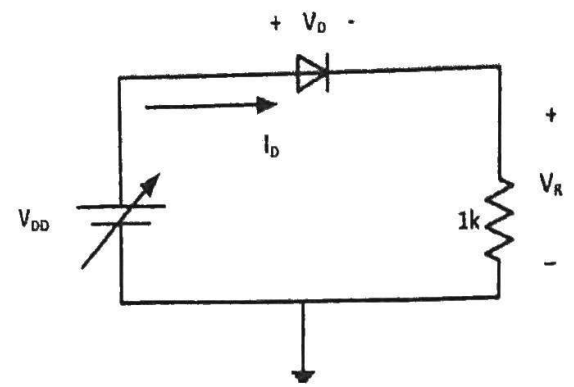


Fig3: Circuit diagram for forward diode characteristics

Procedure:

1. Measure resistance accurately using multimeter. Construct the circuit as shown in fig.3. Vary input voltage (V_{DC}) and measure V_D, V_R for values V_{DC}= 0.1V,0.2V,0.4V,0.6V,0.7V,0.8V,1V,5V,10V,15V and so on.(Note that I_D=$\frac{V_R}{R}$) Fill the table.

2. Construct the circuit as shown in fig 3 replacing diode by Zener diode. Repeat step 1 for values V_{DC}=0.5V, 1V,1.5V,2V,2.5V and so on up to the maximum value obtainable without increasing V_{DC} beyond 25V. Fill the table.

Report:

1. Write the value of the resistance R in fig 3.
2. Fill up the Table.

Sl. No.	V_{DC}(volt)	V_D(volt)	V_R(volt)	$I_D = V_R/R(mA)$

3. Plot I-V characteristics of the diode (attach the graph).
4. Discussion

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Experiment –7

Name of the Experiment: Study of diode rectifiers.

Objective:

- To understand the process of AC to DC conversion
- To comparatively study the different processes of rectification
- To study the effect of adding capacitors in the rectifier outputs

Equipment:

1. Trainer board
2. Multimeter
3. Oscilloscope
4. Resistor(10k)
5. Capacitor(1μF, 47μF)
6. Diode (no of diode: 4)

Theory:

A rectifier converts an AC voltage into a DC voltage. From the diode characteristic curve it is known that a diode works like a switch. In the forward bias condition it becomes ON and OFF in the reverse bias condition. If an AC voltage is applied across a diode only one half-cycle will be conducted due to the ON action, other half will be clipped off. In theoutput the load will get DC.

Diode rectifier can be two types. They are

a) Half-wave rectifier
b) Full-wave rectifier

Half Wave (HW) Rectification:

In this process the one of the cycles of the AC signal is passed to the load and the other is rejected. Here diode used acts as a voltage controlled switch.

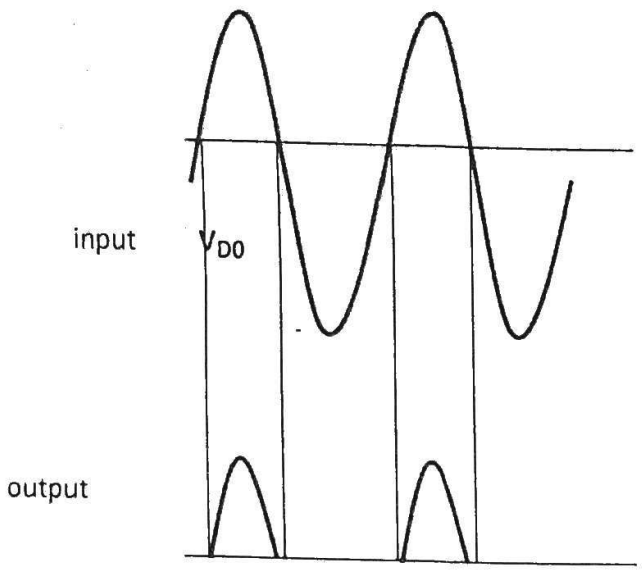


Fig: 1 HW Rectification

As seen from the figure, at least half of the input energy is not being participated in the conversion process. That's why there occurs much loss of energy.

Full Wave Rectification:

In this process one of the cycles of AC is passed through as it is but the other one is passed to the load after inverting it. In this process multiple diodes are required.

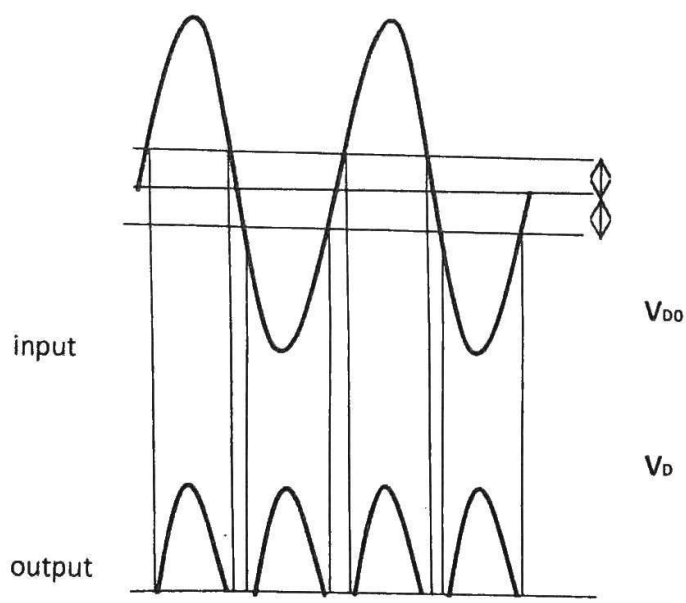
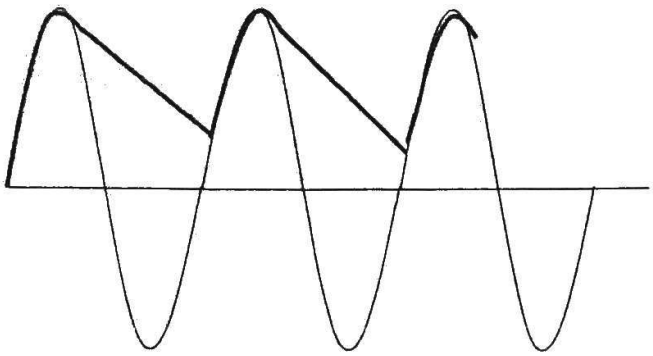


Fig: 2 FW Rectification

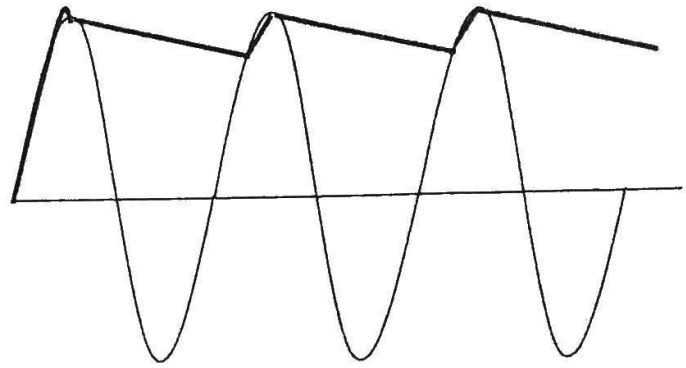
In this process, both cycles are utilized resulting efficient use of energy. That's why FW rectifiers are mostly used in practical purposes.

The process followed by rectification is filtering. The output of either rectifier is not changing polarity but their magnitudes are not fixed but oscillating. To lessen its oscillation filtering is required. Generally a capacitor is connected parallel with the load to serve this purpose. This capacitor acts as a low pass filter.

The following two figures show the output of a rectifier circuit with two different capacitors.



Output signal with smaller capacitor



Output signal with larger capacitor

The use of capacitor helps to removes/lessens the oscillation in the output known as ripple by getting charged and discharged alternately. And as the value of capacitor increases the discharging time increases, i.e. the capacitor discharges slowly resulting less ripple, better dc output.

Circuit Diagrams: -

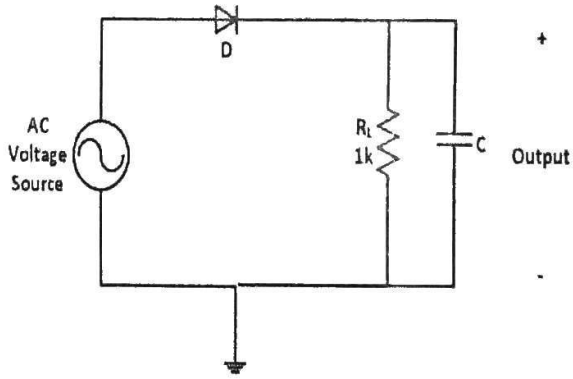


Figure 3: Circuit Diagram for HW Rectification

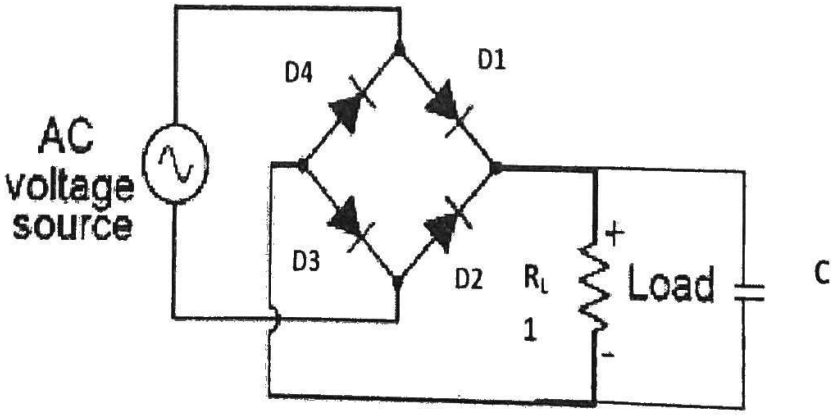


Figure 4: Circuit diagram for FW Bridge Rectifier

Procedure:

1. Construct circuit as in Fig: 3, without the capacitor. Apply 10V amplitude to the AC signal and set the frequency to 1 kHz . Observe the input voltage (V_{in}) and the output voltage (V_{out}) wave shapes in 'Dual Mode' on the oscilloscope display. Clearly draw the wave shapes.
2. Now keeping your oscilloscope in DC Voltage mode measure the output voltage and keep a record. It signifies the amount of DC content in the output signal. Is there any DC content in input signal? Compare them and understand how the DC amount increases in this rectification process.
3. Now add a capacitor of 1μF across the load and repeat step-1 and step-2. Has the DC contents in output increased than the output without capacitor? Compare and understand.
4. Replace 1uf Capacitor with 10uF and repeat step-1 and step - 2. Compare your results with the results of step-3.
5. Now connect the circuit as in Fig: 4 and repeat all the above steps and observations again.

Data Collection & Observation Sheet

Rectifier	Input / Output Waveshape	Vdc (Multimeter reading across output)
HW (without capacitor)		
HW (with 1μF capacitor)		
HW (with 10μF capacitor)		
FW (without capacitor)		
FW (with 1μF capacitor)		

FW (with 10μF capacitor)		

Report Questions:

1. Theoretically explain the operations of circuit shown in Fig: 3 and Fig: 4 considering the diodes in constant voltage drop model.

2. How have you connected the oscilloscope probes to view the output wave shape for the full wave rectifier circuit? Why is this special treatment?

3. From experimental data explain the effect of adding capacitor in the rectifier circuits.

4. From your experimental data explain the differences between the performances of HW and FW rectifier circuits. Which of them, according to your data give better performance?

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Experiment –8

Name of the Experiment: Study of MOSFET as a switch.

Objective:

- To understand the basic idea behind the operation of MOSFET as switch.

Equipment:

- Project Board
- Resistors
- LED
- n MOSFET (IRF – 740/ IRF – 540N)
- DC Power Supply
- Multimeter
- Chords and wire

Theory:

MOSFET and BJT are the most widely used electronic devices. The circuit operation of both of these is very similar. They both are 3-terminal devices and can be used as switch or as amplifier. MOSFET is the acronym for Metal Oxide Semiconductor Field Effect Transistor. It was invented by by John Atalla and DahwonKahng, from the Bell Telephone Laboratories, in 1959. It is broadly classified into Depletion type MOSFETs and Enhancement type MOSFETs. Both of these types are further classified into p-Channel MOSFETs (pMOS) and n-Channel MOSFETs (nMOS). The depletion mode MOSFET is equivalent to a"Normally Closed" switch. The enhancement mode MOSFET is equivalent to a "Normally Open" switch. Although the MOSFET is a four-terminal device with source (S), gate (G), drain (D), and body (B) terminals, the body (or substrate) of the MOSFET often is connected to the source terminal for normal operations, making it a three-terminal device. The circuit symbols are depicted in Fig – 1(a) and 1 (b). In today's experiment an *n*-channel enhancement mode MOSFET will be used.

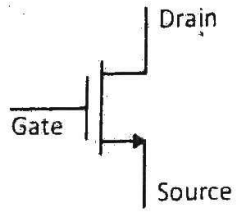


Fig – 1(a) Circuit symbol for *nMOS* transistor

(Enhancement Mode)

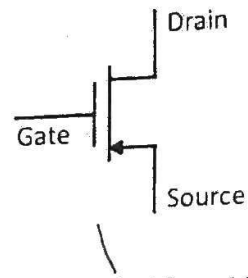


Fig – 1(b) Circuit symbol for *pMOS* transistor

(Enhancement Mode)

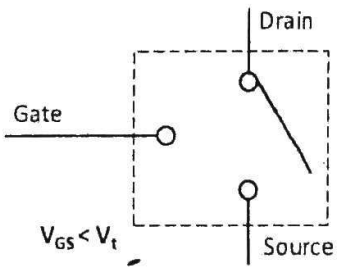


Fig – 2(a) nMOS transistor in OFF state

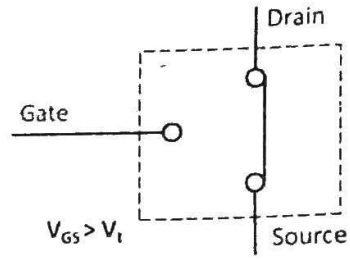


Fig – 2(b) nMOS transistor in ON state

Just like an *n-p-n* transistor you can imagine that, there is a SPST switch in between the *D* and *S* terminals and this switch can be turned on or off using the *G* terminal (Figure - 2). But unlike BJT, MOSFETs are *voltagecontrolled devices*. For an*n*MOS transistor, V_{GS}(the gate to source potential difference) must be greater than aspecific voltage, V_t (threshold voltage) to turn the device ON.

<u>LDR:</u> LDR is the abbreviated form of Light Dependent Resistor. As the name signifies, the resistance of thisspecial type of resistor changes with change in the intensity of light. In case of a LDR, when exposed to huge amount of light the resistance becomes very low (short circuit) and in the dark the resistance becomes huge (open circuit). Note that in our lab two types of LDR are available – small sized and large sized. We will use the large sized LDRs.

Table-1: (Data table for LDR)

Time	Resistance (avg.)
During Day	1kΩ
Evening	10kΩ
Night	Above 400kΩ

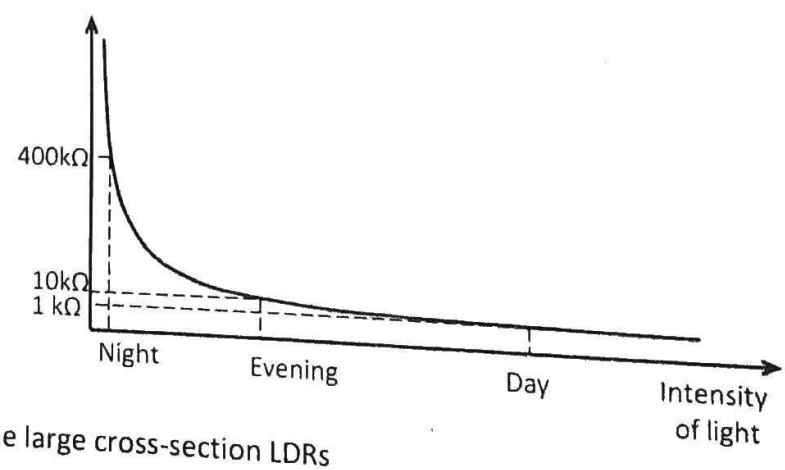


Figure 3: Characteristics of the large cross-section LDRs

LED: **LED** stands for Light Emitting diode;it's a special type of diode.They can be of different colors. Today wewill be using red LEDs. Before putting them in the circuit we need to know the approximate current and voltage ratings of typical LEDs. (Later table-2 will be used for calculation.)

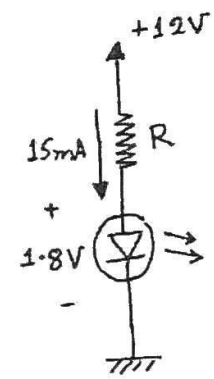
Table-2: (Data table for different colored LED)

Color	Potential drop in Volts (approx.)	Current drawn in mA (approx.)
Yellow	3.0	50
Green	3.0	6
White	2.6	2
Red	**1.8**	**15**

Task 01: Take a red LED and connect to circuit-01 12V DC supply:

Since the LED is rated at 1.8 volts, hence direct connection to the 12.0Volt supply will damage the LED. Therefore we have to place a limiter resistor *R* in series with the LED. Using the data in Table – 02, *R* can be calculated as:

$$R = \frac{12V - 1.8V}{15mA} = 680\Omega.$$



Circuit -01

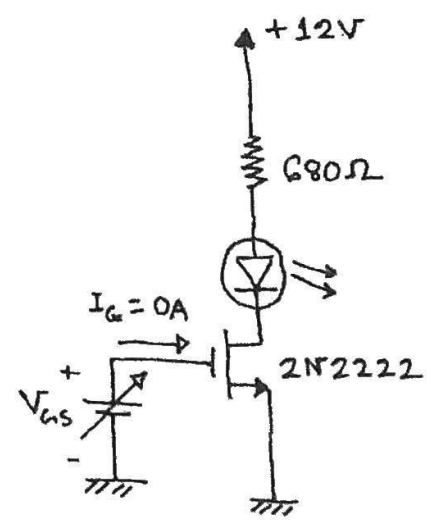
Quite luckily standard resistance of this value (i.e. 680Ω) is available. Now implement the circuit – 01 on bread board.

Task 02: Use circuit–01 to roughly determine the V_t of the nMOS:

1. The pin sequence for MOSFET is

   'G''D''S'.

2. Now implement circuit - 02.
3. Vary V_{GS} very slowly, until the LED starts glowing.
4. As soon as you see little bit of glowing, measure V_{GS}. This will be an approximate estimation of V_t.
5. Note down V_t (It should be around **2.5V**).



Circuit - 02

6. Notice if you increase V_{GS} beyond V_t, the LED glows much brighter implying that, the MOS is now fully turned ON (Around **4V** should do this).

Task 03: Designing of an automatic controller using MOSFET:

- As per table – 02, the resistance of the LDR at evening is around, R_{LDR} = 10kΩ.

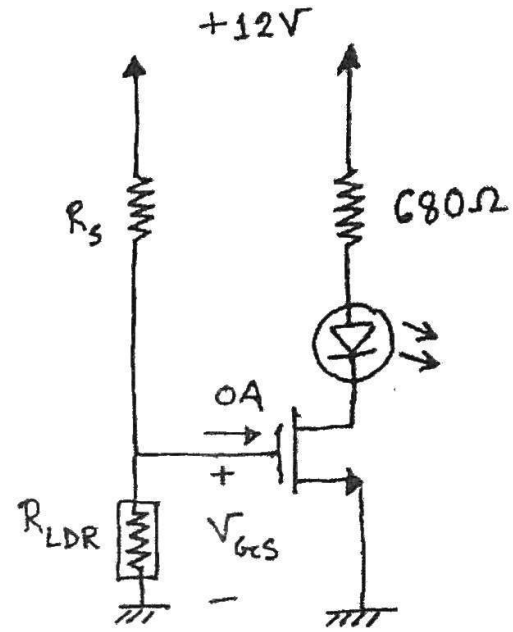
- In case of a MOSFET, I_G = 0A. Hence R_S and R_{LDR} form a voltage divider. Implying–

$$V_{GS} = \frac{R_{LDR}}{R_{LDR}+R_S} \times 12V$$

$$= \frac{10k\Omega}{10k\Omega + R_S} \times 12V \quad \cdots (1)$$

- So if we want to make the LED ON in the evening, then we have to ensure that–

- Let us make V_{GS} = 4.0V in the evening, so that the LED glows happily. ($V_{GS} > V_t$) Putting this in equation (1) results in- R_S = 20kΩ.
- But instead of 20kΩ we will use standard resistor of resistance **22kΩ**.



Circuit -03

- Notice by choosing this value of R_S we are ensuring that the LED will glow in the evening. Now try to explain, what will happen to the LED during day (R_{LDR} = 1KΩ) and during night (R_{LDR} = 400KΩ).
  Put this detail explanation with mathematics in the report.

- Using the standard value of **22kΩ** for R_S, implement circuit-03 and see what happens if you cover the LDR with your hands (i.e. you are avoiding light to come on LDR).

Report:

1. Write short notes on MOSFET.
2. Write down differences between MOSFET.
3. Mention advantages of 3-terminal devices over 2-terminal devices.