Basics of Electrical and Electronic Circuits

Experiment 2 **Spring 2025**

Characteristics of Common Passive Devices

In this experiment we will study the following passive devices (a) linear resistors, (ii) sensors having resistance dependent on external influence like light and temperature, (iii) rectifier diodes, light-emitting diodes (LED) and Zener diodes, which are all nonlinear resistors, (iv) linear capacitors and linear inductors. The experiment will consist of a visual identification of each device, followed by a display of the current vs voltage (***i-v***) characteristic curve of the device.

A. Resistors

Resistors used in electronic circuits are usually classified according to Composition (carbon film, metal film, wire-wound etc.), Tolerance (5%, 1% etc), and Power rating (¼ W, 1W, 5W etc.).

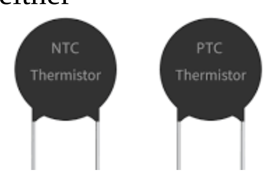
Of these three features, the first one has to be found out from the manufacturer's specifications. The value, unless printed on the resistor, is coded by three or four coloured bands. If the value is indicated by **three** bands, the 1st and 2nd bands give the significant digits, and the 3rd band gives the number of zeros after the two significant digits If the value is indicated by **four** bands, the 1st, 2nd and 3rd bands give the significant digits, and the 4th band gives the number of zeros after the two significant digits The ten colours denoting the digits 0-9 are the following: Black (0), Brown (1), Red (2), Orange (3), Yellow (4), Green (5), Blue (6), Violet (7), Grey (8), White (9). Another band, placed slightly away from the bands indicating the value, indicates the tolerance: a golden band indicating a tolerance of 5%, and a brown or a red band indicating a tolerance of 1% or 2%. Absence of a tolerance band implies a tolerance of 10% or more.

The ideal ***i-v*** characteristic curve of a linear resistor is a straight line passing through the origin, the slope of the straight line giving the value of the resistance.

B. LDR and Thermistors

A Light-Dependent Resistor (LDR) is a linear resistor with a resistance dependent on the illumination. The resistance is very high (hundreds of kΩ) when the LDR is in darkness, decreasing as the illumination is increased.

A Thermistor is a linear resistor with a temperature-dependent resistance, which can either increase or decrease with rise in temperature. Accordingly, they are called PTC (Positive Temperature Co- efficient) or NTC (Negative Temperature Co-efficient) thermistors.



The ***i-v*** characteristic of both these devices is thus a straight line like that of an ordinary linear resistor, but the slope of the characteristic changes depending on the ambient conditions.

C. Different Types of Diodes

All diodes are nonlinear resistors, with characteristic curves as shown in **Fig. 2.1** for the three different types of diodes studied in this experiment. The forward-bias voltage drop V_D has a value 0.5 – 0.6V for Rectifier Diodes and Zener Diodes, while LEDs of different colours have different values of V_D. Zener Diodes are designed for specific values of the reverse breakdown voltage V_Z.

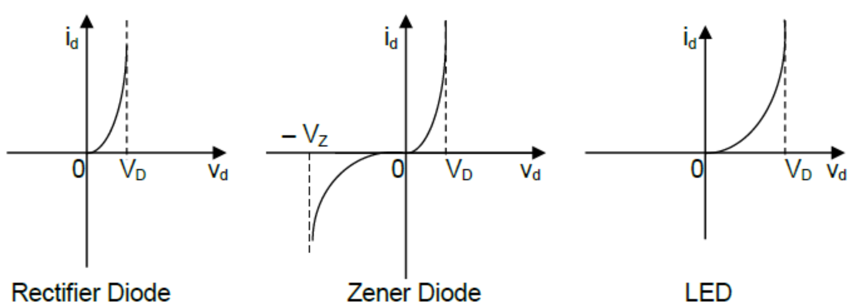


Fig. 2.1 *i-v* Characteristics of different types of Diodes

D. Capacitors

Capacitors used in electronic circuits are classified according to the dielectric material used in the fabrication of the capacitor and the range of values available varies from type to type.
Some of the commonly encountered types are listed below:

Electrolytic (≥ 1 µF) – Cylindrical body with printed value and polarity indicated by +/–; Polyester (0.001–10 µF) – Moulded body with value either printed or colour-coded; Ceramic (≤ 1 µF) – Disc-shaped body, with value printed on the body.

Capacitance value is generally printed in the format ***abn***, where ***ab*** represents a 2-digit number and ***n*** represents the exponent, the implied value being (***ab***) x10^{n} pF. These capacitors may be assumed to have 10% tolerance unless indicated otherwise.

The ideal *i-v* characteristic curve of a linear capacitor is a circle with its centre at the origin, indicating the phase difference of 90^{o} between the capacitor voltage and the capacitor current.

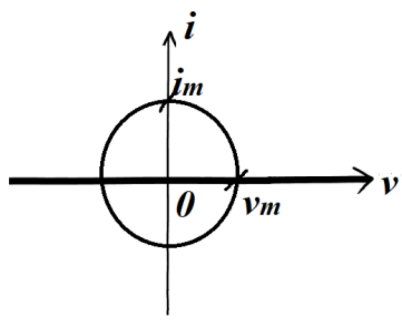


***Fig. i-v* Characteristic pattern of Ideal capacitor**

Experiment To Be Performed

1. **Capacitance Estimation from *rms measurements* using Reactance calculation:**

   a. **Use** y-t mode to **measure the desired rms voltage and current across/through the capacitor.** Calculate Reactance $X_c = v_m/i_m$ or $X_c = v_{rms}/i_{rms}$
   b. Assuming ideal capacitor, use C= 1/2πf X_c, where f is the frequency of the input voltage.
   c. **Compare your result with the printed values on it. Tabulate your results.**

Capacitor value	Vrms	Irms	Freq (10KHz)	C (measured)

2. **Display of *i-v* characteristic on a DSO.**

The circuit shown in **Fig. 2.2** will be used to display the ***i-v*** characteristic curve of the Device Under Test (DUT) on a DSO used in the ***x-y*** **mode**. This circuit generates a voltage $v_O = -iR$, where R = 1.00k-ohm and i is the current flowing through the DUT in response to the voltage ***v applied across DUT from the WAVEGEN.***

Thus the DSO produces a graph of i vs v, with the vertical (Y) axis representing current on a scale of 1V/mA. Use the INVERT option for CH2 to compensate the negative sign in the relationship $v_O = -iR$, so that the correct graph is generated.

The circuit will be pre-assembled on a breadboard for you, and you will have to make the connections to the DSO and then insert the DUT to display its ***i-v*** characteristic curve.

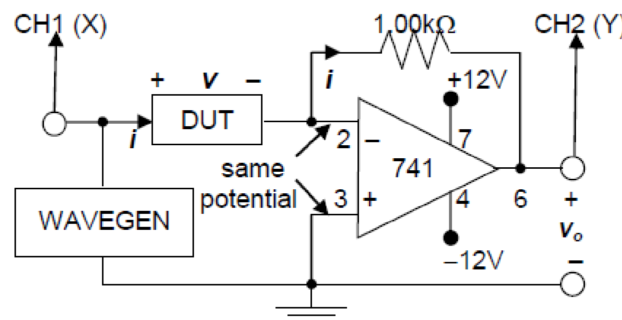


Fig.2.2 Circuit for displaying ***i-v*** characteristic

1. Set the **WAVEGEN** to generate 1-kHz sine wave having Peak-to-Peak value = **1V** and Offset = **0V**. With a 1.00k-Ohm resistor as the **DUT**, make the connections to the **DSO** as shown in **Fig. 2.2.**
2. Run the DSO on the ***y-t*** (normal) display mode, with WAVEGEN chosen as the **Trigger** Source. Observe the waveforms of the voltages v and v_O, at Ch-1 & Ch-2 respectively. Set the zero lines for both waveforms exactly midway, so that the origin of the X-Y display will be at the centre of the screen.
3. Change the DSO setting to the ***x-y*** mode, and adjust both CH1 and CH2 Voltage scales to get a full-screen display. Verify that the ***x-y*** display is a straight line through the origin, with a 45^o slope.
4. Identify each of the given passive devices from its approximate distinguishing features and note down its printed or colour-coded value and other information about the device, as applicable.
5. Display and **sketch** the ***i-v*** characteristics of all the following devices, marking the scales with proper units for the ***x*** and ***y*** axes, by inserting the devices one by one as the DUT:

   (i) $^1/_4$ W 1% 1.00k-ohm Carbon Film Resistor, (ii) $^1/_2$ W 5% 2.2k-ohm Carbon Film Resistor, (iii) 5W 100 Ohm Wire-wound Resistor, (iv) Light Dependent Resistor (LDR), (v) PTC Thermistor, (vi) NTC Thermistor, (vii) 0.01µF Polyester Capacitor, (viii) 0.1µF Ceramic Capacitor, (ix) 1µF Electrolytic Capacitor.

   - For each of the linear resistive devices (i) – (vi), adjust CH1 and CH2 Voltage scales to obtain a straight line with a 45^o slope, and calculate the resistance from the CH1 and CH2 Voltage scales. Verify for each device that the measured value is the same as specified.
   - Shine light on the LDR and note the minimum and maximum values of the resistance. The measurement of resistance of the thermistors will be done using a soldering iron for heating the thermistors, under supervision of TAs.
   - For all the diodes (x – xiv), set the WAVEGEN output for Peak-to-Peak value = **4V**, and adjust the **Offset** as necessary in **each** case to obtain the best graph according to the expected characteristic curve given in **Fig. 2.1**. Measure the values of V_D and V_Z for all the given diodes and tabulate your result. (x) Rectifier Diode, (xi) Zener Diode, (xii) Red LED, (xiii) Green LED, (xiv) White LED.
   - For each of the capacitors (vii) – (ix), go back to the WAVEGEN settings of **step 1**, and adjust the scales to obtain a graph as close to a circle as possible. Note the deviations from the ideal graph.

Input Signal…………… Freq…………… Offset…………

	Component	printed value	Calculated value	v	v_0	shape	Slope/ inclination
I.	Resistor						
II.							
III.							
IV.							
V.							
VI.							
VII.							
VIII.							
IX.	capacitor						

Input Signal…………… Freq……………

	Component	printed value	v_d	v_z	Offset
X.					
XI.					
XII.					
XIII.					
XIV.					

Results:

Conclusion: It must be in your words and be based on your understanding/ learning in the experiment.