Experiment No. 3

ZENER REGULATOR

AIM: To setup and study a zener diode shunt regulator and to plot its line and load regulation characteristics.

COMPONENTS REQUIRED: Zener diode, resistor, rheostat, voltmeter, ammeter, DC source and bread board.

THEORY: A zener diode functions as an ordinary diode when it is forward biased. It is a specially designed device to operate in the reverse bias. When it is in the reverse breakdown region, the zener voltage V_z remains almost constant irrespective of the current I_z through it. A series resistor R_s is used to limit the zener current below its maximum current rating. The current through R_s is given by the expression $I_s = I_z + I_L$, where I_L is the current through the load resistor R_L. The value of R_S must be properly selected to fulfil the following condition requirements.

When the input voltage, V_I increases I_L remains the same, I_S and I_Z increases. Similarly if input voltage decreases, I_L remains the same, I_S and I_Z decreases. But if I_Z falls lower than the minimum zener current enough to keep the zener in the breakdown region, the regulation will cease and output voltage decreases. A low input voltage can cause the regulator fail to regulate. The series resistance should be selected between R_{Smax} and R_{Smin} which are given by the expressions,

$$R_{Smin} = [V_{Imax} - V_Z]/I_{Zmax}$$

$$R_{Smax} = [V_{Imin} - V_Z]/[I_{Zmin} + I_L]$$

PROCEDURE:

1. Wire up the circuit on the bread board after testing all the components.
2. Keep the load constant. Note down the output voltage varying input from 8V to 14V in steps of 1V. Plot the line regulation graph with V_i along x-axis and V_o along y-axis. Calculate percentage line regulation using the expression $(\Delta V_o/\Delta V_i)$x100%.
3. 3. Keep the input voltage constant (say 10V) and note down the output voltage for various values of load current starting from 0 to 5 mA, by varying R_L using a rheostat. Plot the load regulation graph with I_L along x-axis and V_o along y-axis.
4. To calculate percentage load regulation, mark V_{NL} and V_{FL} on y-axis on the load regulation graph. V_{NL} is the output voltage in the absence of load resistor and V_{FL} is the output voltage corresponding to rated I_L (here, 5 mA). Calculate the percentage load regulation V_R as per the equation,

$$V_R = \frac{V_{NL} - V_{FL}}{V_{NL}} x100\%$$

DESIGN

Assume $V_o = 5.6\,V$, $I_{Lmax} = 5mA$ Input voltage is in the range 8-14V.

Select 5.6V zener [$P_o = 400mW$, $V_Z = 5.6V$, $r_d = 8\Omega$ at $I_Z = 10mA$].

Use 2.4 k rheostat as load resistance load current can be varied from 2.4 mA and upwards.

$$I_{Zmax} = \frac{P_{max}}{V_Z} = \frac{0.4}{5.6} = 71.42mA$$

$$I_{Zmin} = 10\%\ of\ I_{Zmax} = 0.1\ x\ 71.42 = 7.142mA$$

$$R_{Smax} > R_S > R_{Smin}$$

$$R_{Smax} = [V_{Imin} - V_Z]/[I_{Zmin} + I_{Lmax}] = \frac{(8-5.6)V}{(7.142+5)mA} = 197.6\Omega$$

$$R_{Smin} = [V_{Imax} - V_Z]/I_{Zmax} = \frac{(14-5.6)V}{71.42mA} = 117.6\Omega$$

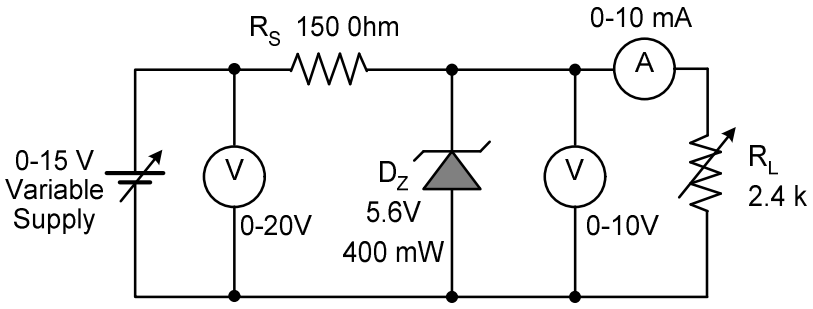
Select $R_S = 150\Omega$

Power rating of R_S

Max current through $R_S = I_m = [V_{Imin} - V_Z]/R_S = \frac{(14-5.6)V}{150\Omega} = 56mA$

Power rating of $R_S = I_m{}^2\ x\ R_S = 0.4704W$ >> Select 150 ohms 0.5W resistor

CIRCUIT DIAGRAM



TABULAR COLOUMNS

LINE REGULATION

Keeping load current constant at $I_L = 5mA$, The input voltage is varied from 8 V to 14V and corresponding observations are made.

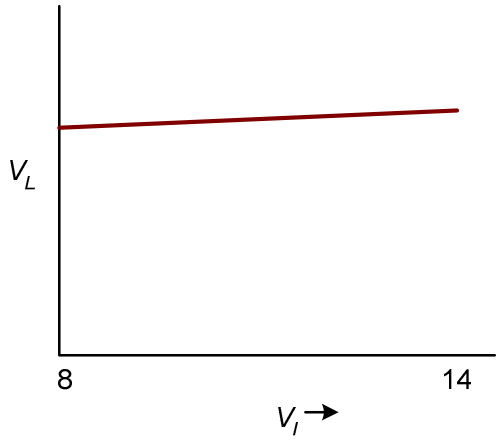
V_{in}(volts)	V_o (volts)

LOAD REGULATION

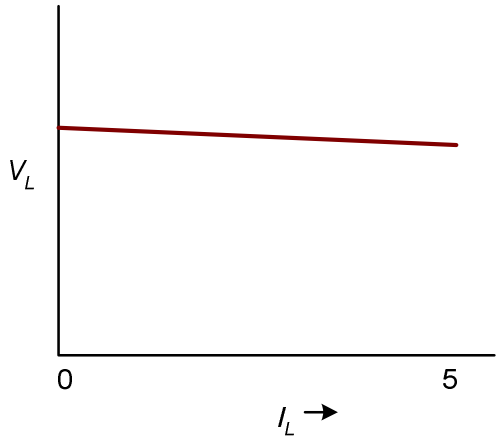
Keeping input voltage at 10V, the load current is varied from 0 to 5 mA and observations are made. For taking reading corresponding to no load (I_L = 0), the loading rheostat may be disconnected.

I_L mA	V_o(volts)

EXPECTED OUTPUT PLOTS



Line Regulation



Load Regulation