EXPERIMENT 4

Study of Zener Diode as Voltage Regulator and its Load Regulation.

- **Apparatus :-**

    i) A zener diode (typically 4.7 V, 1 W)
    ii) A variable dc power supply (typically
    iii) DC milliammeter
    iv) A digital multimeter used as a voltmeter
    v) Breadboard, wires, Rheostat
    vi) Resistance

- **Procedure :-**

    i) At first identify the anode (p) and cathode (n) of the zener diode Z (usually a coloured band is used to indicate the cathode). Note the Zener diode specifications (i.e, maximum power rating, maximum allowable Zener current, etc.) These are usually supplied or can be obtained from manufacture's manual. Be

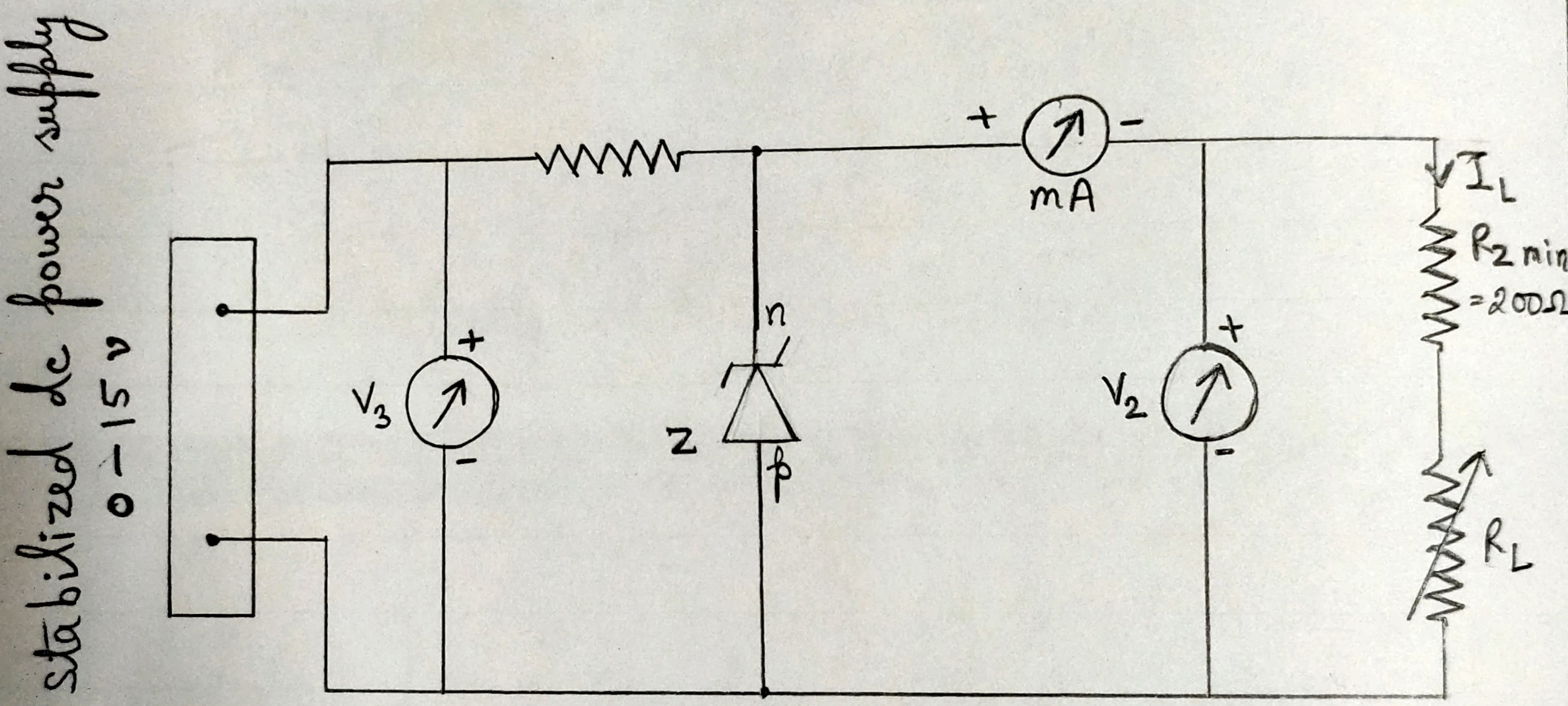


Fig 1: Circuit for studying regulation

sure that a series limiter resistance R_S of suitable value is there.

ii) Make the circuit connections. Keeping the control knob of the power supply to the minimum position switch on the ac mains operating the power supply. Now increase the voltage across the ~~diode~~ diode.

- **Theory :-**

The constancy of the voltage across the Zener diode in the breakdown region makes it a useful voltage regulating device. The circuit arrangement for studying the performance of a Zener diode as a voltage regulator is shown in Fig 1. The variation of the output load voltage V_L as a function of the load current I_L for a given input voltage is known as load regulation. The degree of stabilization is usually expressed in terms of percentage ~~red~~ regulation S_L defined by

$$S_L = \frac{V_{NL} - V_L}{V_L} \times 100$$

where V_{NL} = output voltage with no load i.e with $I_L = 0$ or $R_L = \infty$,

V_L = output voltage at a particular rated load current.

Smaller is the value of S_L better is the degree of regulation.

The variation of output load voltage with the variation of input voltage for a fixed load current is known as the line regulation. Here as a measure of regulation we may introduce the input regulation factor S_i defined as,

$$S_i = \frac{\text{Change in output voltage}}{\text{Change in input voltage}}$$

Smaller is the value of S_i better is the regulation.

Calculation of the limiting resistance R_S :-

Manufacturers specify Zener diodes according to their Zener voltage V_Z and maximum power dissipation P_{zmax}. The maximum allowable Zener current I_{zm} is given by

$$P_{zmax} = V_Z - I_{zm}$$

When $I_L = 0$, the current flowing through the Zener diode becomes maximum and equal to the current through R_S,

If $V_{i,max}$ be the maximum input voltage, then $I_{zm} = \frac{V_{i,max} - V_Z}{R_S}$. Therefore, minimum value of R_S is

Let, Zener knee current =

∴ Maximum load current =

=

∴ $R_{L\,min}$ =

- Experimental Data :-

A) Specifications of the Zener diode and meters used :

Type of Zener diode = IN4732

Zener voltage V_Z = V

Maximum power dissipation $P_{z,max}$: W

Maximum allowable forward current =

Maximum allowable reverse current

$$I_{zm} = \frac{P_{z,max}}{V_z}$$

$$= \quad mA$$

Test current $I_{ZT} = \frac{1}{4} I_{zm}$

$$= \quad mA$$

TABLE 1

Meter used	Range	Value of one Smallest division	Zero Error (if any)
DC milliammeter (mA)	0-200 mA		
DC voltmeter (V_1)	0-20 ~~(V)~~ V		
DC voltmeter (V_2)	0-20 ~~(V)~~ V		

B) Data for load regulation curve :

TABLE 2

No. of obs.	Set I Input voltage fixed at V_i =		Set II Input voltage fixed at V_i.	
	Load current I_L in mA	Load voltage V_L in V	Load current I_L in mA	Load voltage V_L in V

c) Calculation of % regulation (S_L):

TABLE 3

Set no.	Specified load current I_L in mA	V_{NL} in v	V_L in v from graph correspon-ding to I_L	$S_L = \frac{V_{NL} - V_L}{V_L} \times 100$ in %
I $V_i = 12V$				
II $V_i = 10V$				

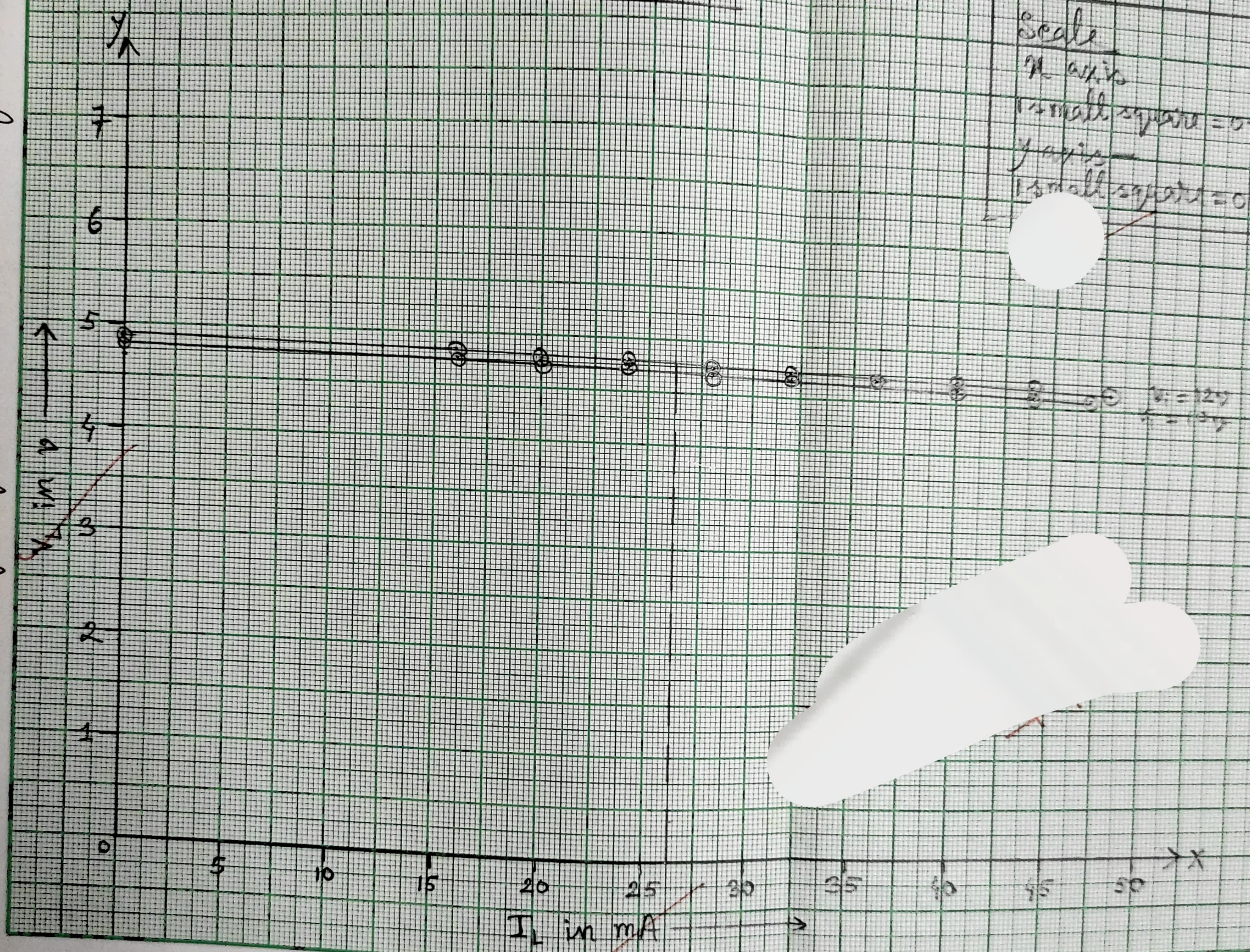
Precautions and Disscussions :—

i) Care should be taken that the current through the zener diode does not exceed the maximum rated value specified by the manufacturer. For this a series current limiter resistance R_S of proper value and wattage should be connected to avoid any accidental burn-out of the diode.

ii) The voltmeters V_1 and V_2 must have very high ~~im~~ input impedance. Otherwise they will draw

① Zener diode as a voltage regulator with its load regulation

$V_L - I_L$ GRAPH



some current and the current recorded by the milliammeter will not be equal to the current through the diode.

iii) The properties of a semiconductor device depend on temperature. So if diode currents are noted for voltage increasing and for voltage decreasing, the readings can differ widely.

iv) While studying the load regulation the load current should not be increased too much. Otherwise the Zener current may go below the 'knee' current and the diode fails to regulate the voltage.

v) Care should be taken not to short circuit the load R_L. In that case the limiter resistance R_S may burn out. To take care of it a minimum fixed load may be connected in series with R_L.

vi) In the Zener breakdown region the voltage across the diode changes very little but current varies over a wide range. So a voltmeter with very small graduation should preferably be used.

vii) While studying the line regulation the input voltage must not be decreased too much. Otherwise the Zener current may go below the 'knee' current and the diode fails to act as a voltage regulator. $V_{i,min} \approx (I_{ZK} + I_L)R_S + V_Z$, where $I_{ZK} \approx 5$ to 10% to [illegible] and I_L is the chosen fixed load current.