Experiment No. ~~3~~ 04 **Date:-** 30/03/2021

(Module 3) Study of Zener Diode as a Voltage Regulator.

FEC102.3: Interpret the basic knowledge of semiconductor physics in understanding the working of semiconductor devices.

AIM: - To study the voltage regulation of a Zener diode.

APPARATUS: -Unregulated Power supply (0-30V), Zener diode (6.8V, 1A), Bread board, Resistor (1KΩ, 100Ω), Decade Resistance box, Multimeter, Connecting wires.

THEORY: A p-n junction is formed by bringing p-type semiconductor material in contact with the n-type semiconductor material and can be characterized in terms of its depletion region. This is because the width of the depletion region varies in accordance with the bias applied at the terminals, deciding the V-I characteristics of the p-n junction (Figure 1). The span of the depletion region is a function of both the applied bias as well as the level of doping. It is seen that in the forward bias condition, the width of the depletion region reduces with the increase in the applied voltage which eventually leads to an increase in the amount of current flow. On the other hand, if the p-n junction is revers biased, an increase in the applied voltage increases the width of the depletion region. However, even then there will be a little amount of current flow through the semiconductor due to the minority charge carriers. Moreover the width of the depletion region is observed to be narrow for heavily doped semiconductors and wide for lightly doped semiconductors.

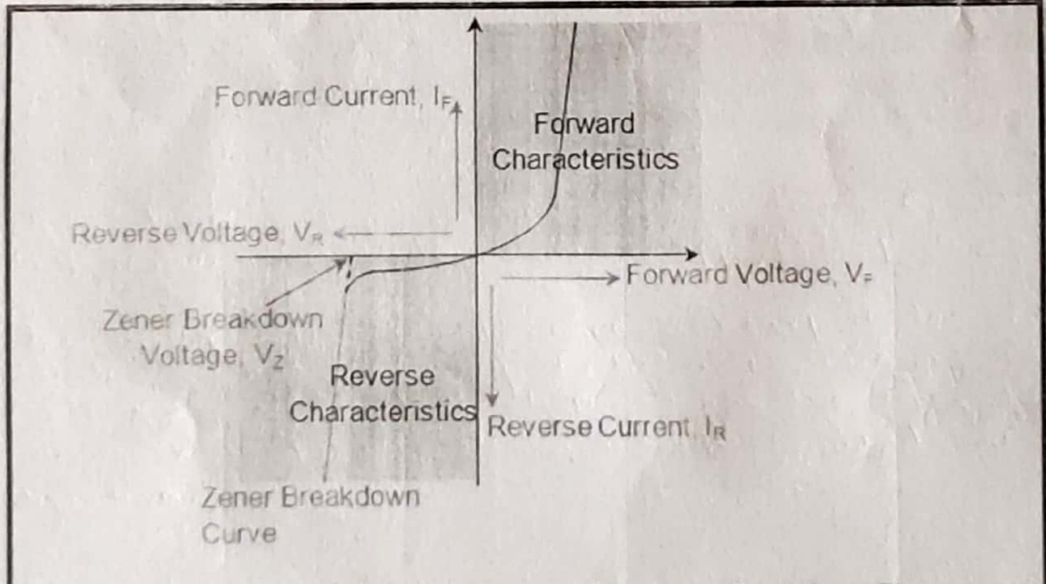

Figure 1 V-I Curve for a P-N Junction Depicting Zener Breakdown Phenomenon

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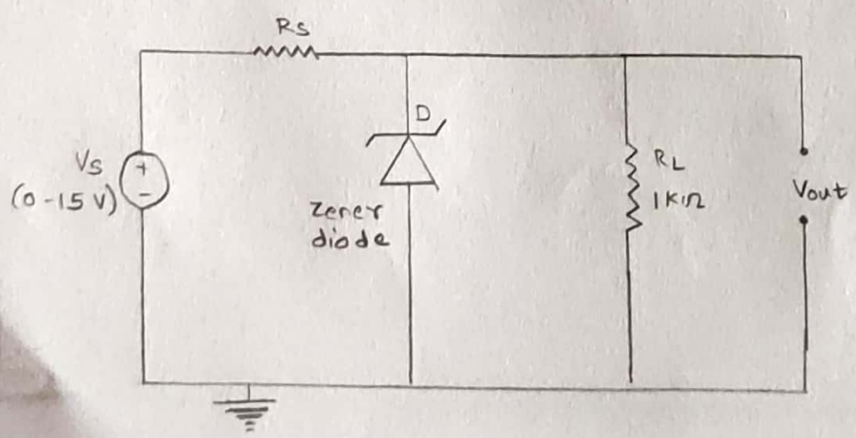
Now, consider a heavily doped semiconductor subjected to the reverse bias condition. Here the width of the narrow depletion region (due to high doping) is seen to increase with an increase in the voltage applied across its terminals. This leads to an increase in the electric field developed across the p-n junction as the electric field is the negative potential gradient. Due to this highly intensified electric field, a few of the covalent bonds in the p-n junction break-off releasing their valence electrons. Such free electrons will get excited and move into the conduction band leading to an abrupt increase in the current flow through the device. This phenomenon is referred to as Zener Breakdown and the corresponding voltage is called Zener Breakdown Voltage (V_Z), shown in red color in Figure 1. The phenomenon was first observed and explained by Dr. Clarence Zener in 1934 and is thus named after him.
Further it is to be noted that the Zener effect is a controllable phenomenon as the number of charge carriers generated can be effectively controlled by controlling the electric field applied. Typically Zener breakdown causes the diode junctions to breakdown below 5V and will not damage the device unless there is no provision made to release the heat generated. Moreover, the Zener breakdown voltage has negative temperature coefficient meaning that the Zener breakdown voltage reduces with the increase in the junction temperature. However, it is to be noted that the voltage at which the Zener breakdown occurs is adjustable during the device manufacture. Lastly it should be kept in mind that the working of widely used Zener diode is based upon the Zener effect.

VOLTAGE REGULATOR

Voltage regulator is an electronic circuit which keeps o/p voltage constant irrespective of changes in line voltage & load current.

CIRCUIT DIAGRAM:



CIRCUIT DIAGRAM FOR ZENER DIODE AS A VOLTAGE REGULATOR

(WORKING PRINCIPLE)

The figure shows the Zener voltage regulator, it consists of a current limiting resistor R_S connected in series with the input voltage V_S and Zener diode is connected in parallel with the load R_L in reverse biased condition. The input voltage should be greater than V_z, then only Zener diode will work in Zener region. The output voltage is always selected with a breakdown voltage V_z of the diode.

If V_s is higher than V_z the current through Zener diode increases & I_L decreases and we will get constant o/p voltage. If I_L changes, then I_z changes in such a way that at the o/p we get constant dc voltage.

PROCEDURE:-

I) Line regulation

1) Identify the components required and make the connections on bread board as per circuit diagram.
2) Keep load resistance fixed value; vary DC input voltage from 5V to 20V and note down the value of output load voltage V_L.

Plot the graphs for V_S vs V_L.

II) Load regulation

3) Identify the components required and make the connections on bread board as per circuit diagram.
4) Keep input voltage constant say 10V.
5) Vary R_L in steps of 1KΩ and note down the value of output load voltage V_L.
6) Plot the graphs for Log R_L vs V

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OBSERVATION TABLE:-

I) Line Regulation

R_L= 1 KΩ

Sr. No.	V_{in} (Volts)	V_{out} (Volts)
1	1	1.02
2	2	2.04
3	3	3.05
4	4	4.08
5	5	5.05
6	6	6.01
7	7	6.71
8	8	6.77
9	9	6.82
10	10	6.88
11	11	6.92
12	12	6.96
13	13	7.02
14	14	7.10
15	15	7.16

II) Load Regulation

V_{in} = 10 V

Sr.No.	$R_L(\Omega)$	$Log_{10} R_L$	V_{out} (Volts)
1	50	1.689	3.75
2	100	2.000	5.32
3	200	2.3010	6.71
4	300	2.4771	6.74
5	400	2.6020	6.76
6	500	2.6989	6.80
7	600	2.7781	6.82
8	700	2.8450	6.83
9	800	2.9030	6.85
10	900	2.9542	6.85
11	1000	3.0000	6.86
12	2000	3.3010	6.88
13	3000	3.4771	6.88
14	4000	3.6020	6.88
15	5000	3.6989	6.88
16	6000	3.7781	6.89
17	7000	3.8450	6.89
18	8000	3.9030	6.89
19	9000	3.9542	6.89
20	10000	4.0000	6.89

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RESULT: -

1. Line Regulation: From Graph 1 the input voltage (V_{in}) at which the Zener diode acts as a voltage regulator is V_{in} = 7 Volts

2. Load Regulation: From Graph 2,
Load resistance (R_L) at which the Zener diode acts as a voltage regulator is
Log R_L = 2·3010
R_L = 200Ω

COMMENTS: -

1. What is break down voltage?

Breakdown voltage is the minimum reverse voltage that makes the diode conduct appreciably in reverse.

2. State one distinctive difference between ordinary diode and a Zener diode.

The major difference between ordinary diode and zener diode is that ordinary diode allows current to pass only in the forward direction, wheras the zener diode allows the current to flow in both, forward and reverse direction.

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D.J.S.C.E. (Physics)		
Journal		
Knowledge	3	
Documentation	3	
Punctuality	3	
Virtual Lab (Performance & Documentation)	6	
Total	15	

Date	Signature of the faculty

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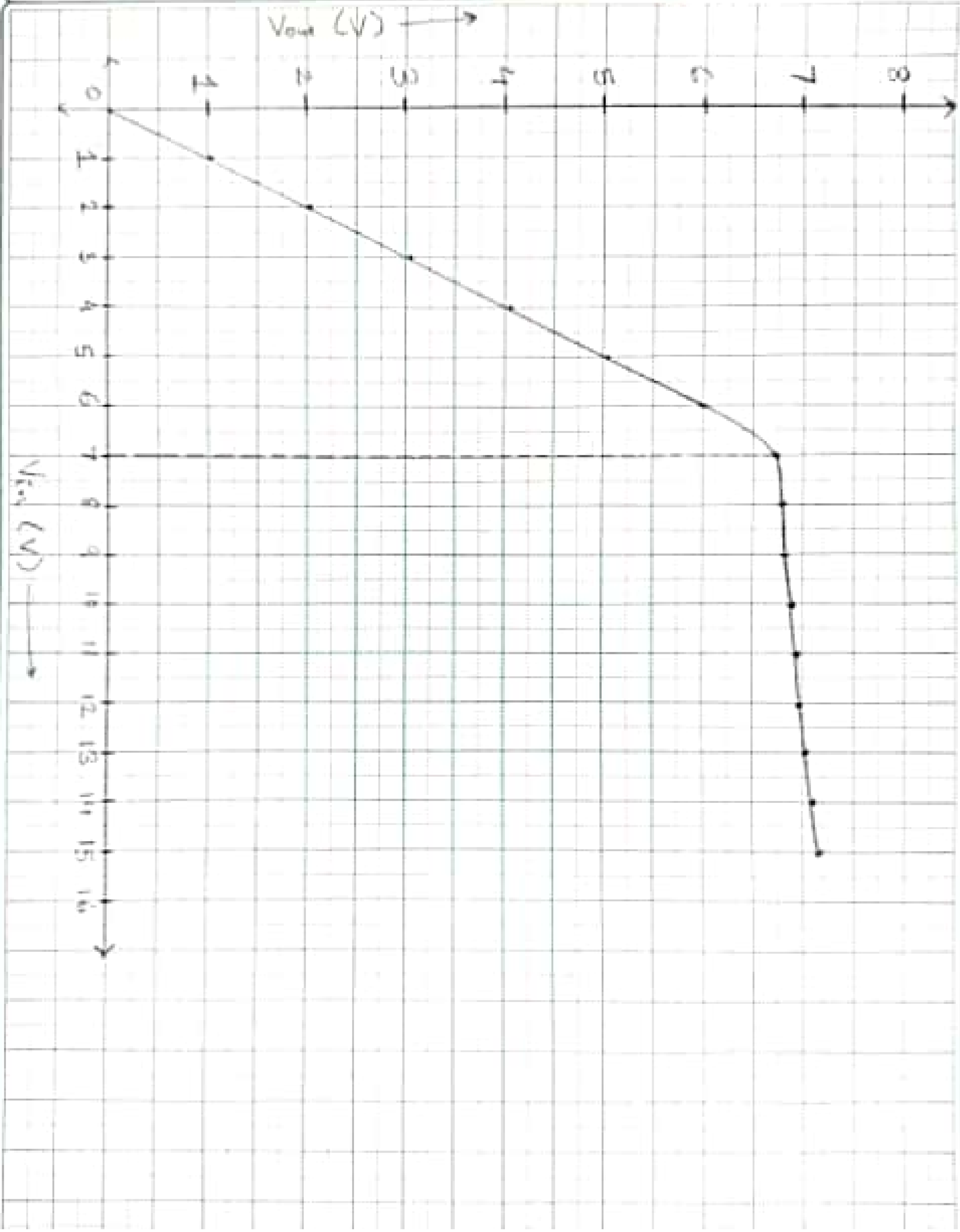
V_{out} v/s V_{in}

SCALE:
X-axis: 1 cm = 1V
Y-axis: 1 cm = 1V



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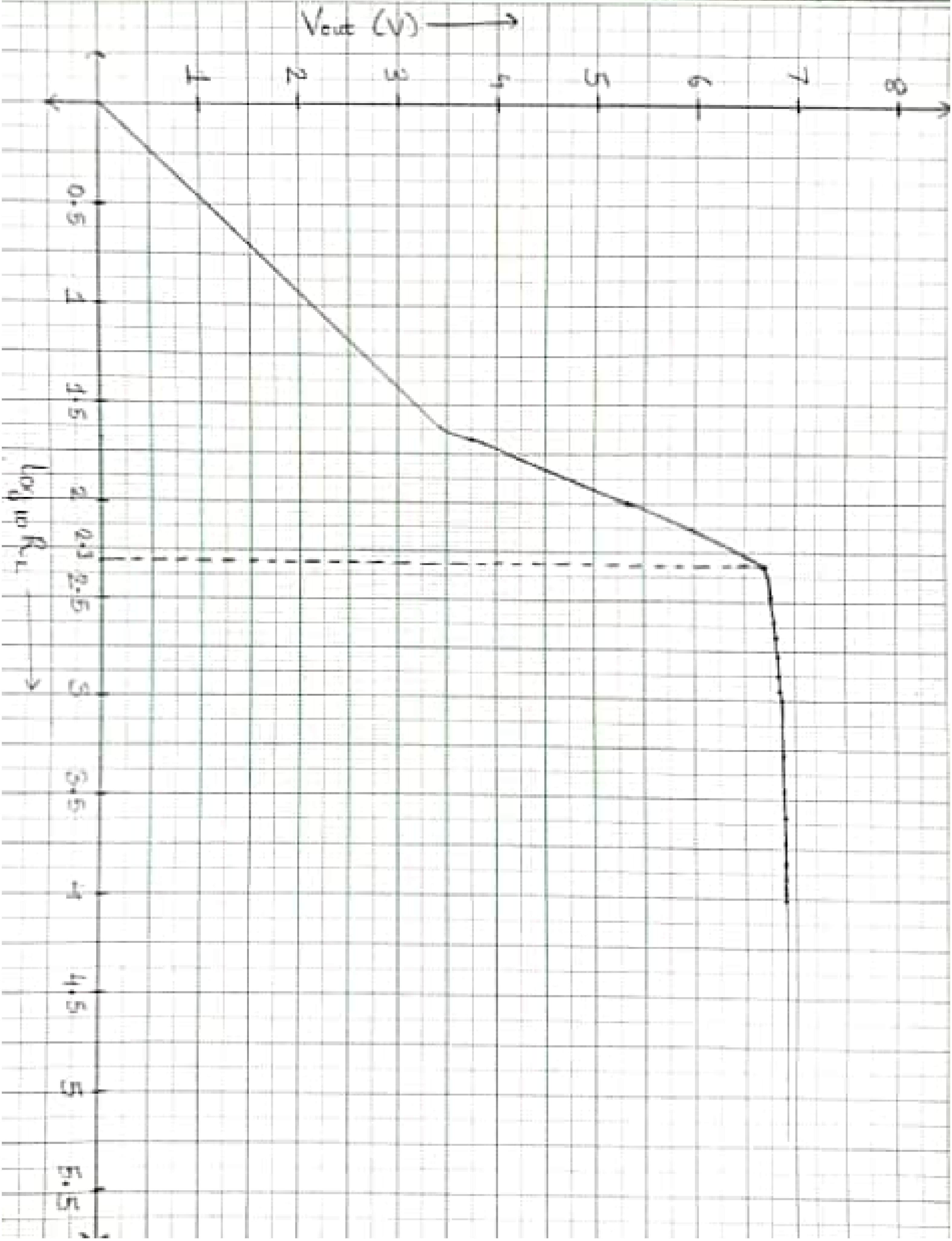
Vout v/s $\log_{10} R_L$

SCALE :-
x-axis : 2cm = 0.5 unit
y-axis : 2cm = 1 V



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