classmate

Date
Page

20CSE1030 Zubin Shah

HALL EFFECT

Aim: To study Hall effect and to determine the Hall voltage, Hall coefficient of given semiconductor material, charge carrier density, charge carrier type (P type or n-type)

Operators: Hall probe, Guass meter, Power supply, multimeter, constant power source.

Introduction:

- E H Hall (1879) has observed this effect. He placed a current carrying conductor perpendicular to magnetic field, a voltage is observed perpendicular to both magnetic field and current.

- When magnetic field is applied perpendicularly to the specimen a voltage is developed in the specimen which has a direction of mutually perpendicular force on charges so there will be potential difference between the ends of the specimen. This is called Hall potential.

- We know that a current flows in response to an applied electric field with its direction as conventional and it is either due to the flow of holes in the direction of current or the movement of electrons backward.

- From the Lorentz force $F_m = q(v \times B) = qvB\sin\theta$

$= qvB$

(Since the angle between both fields are $90°$)

classmate

Date
Page

- Since the charges cannot escape from the material, a vertical charge imbalance builds up. This charge imbalance produces an electric field.

$$F_E = qE$$

- At equilibrium position $F_E = F_M = qE = qvB$, where E is produced electric field, B applied magnetic field, v is drift velocity of charge carriers.

- Current can be expressed as $J = I/A$ where A is cross sectional area of the sample, n is the number of charge carriers, J current density

$$I = neAv$$

- The Hall voltage can written as

$$V_H = EW$$

$$V_H = vBW$$

$$v = \frac{I}{neA}$$

$$V_H = \frac{BWI}{neA} = \frac{BWI}{newt}$$

$$V_H = \frac{IB}{net}$$

$$V_H = \frac{R_H IB}{t}$$

$$R_H = \frac{V_H t}{IB}$$

where 't' is the thickness of the sample.

Concentration of charge carriers per unit volume

$$n = \frac{1}{eR_H} \text{ carriers } m^{-3}$$

Where t is the

- R_H is the Hall coefficient, n is charge carrier density.
- We need to draw the graph between V_H and I and find the slope mean value. It should be straight line.
- Some of the specimen values : t = 0.5 mm, b = 6 mm, ℓ = 7 mm
- B = 2300 Gauss = 0.23 Tesla.

Procedure:

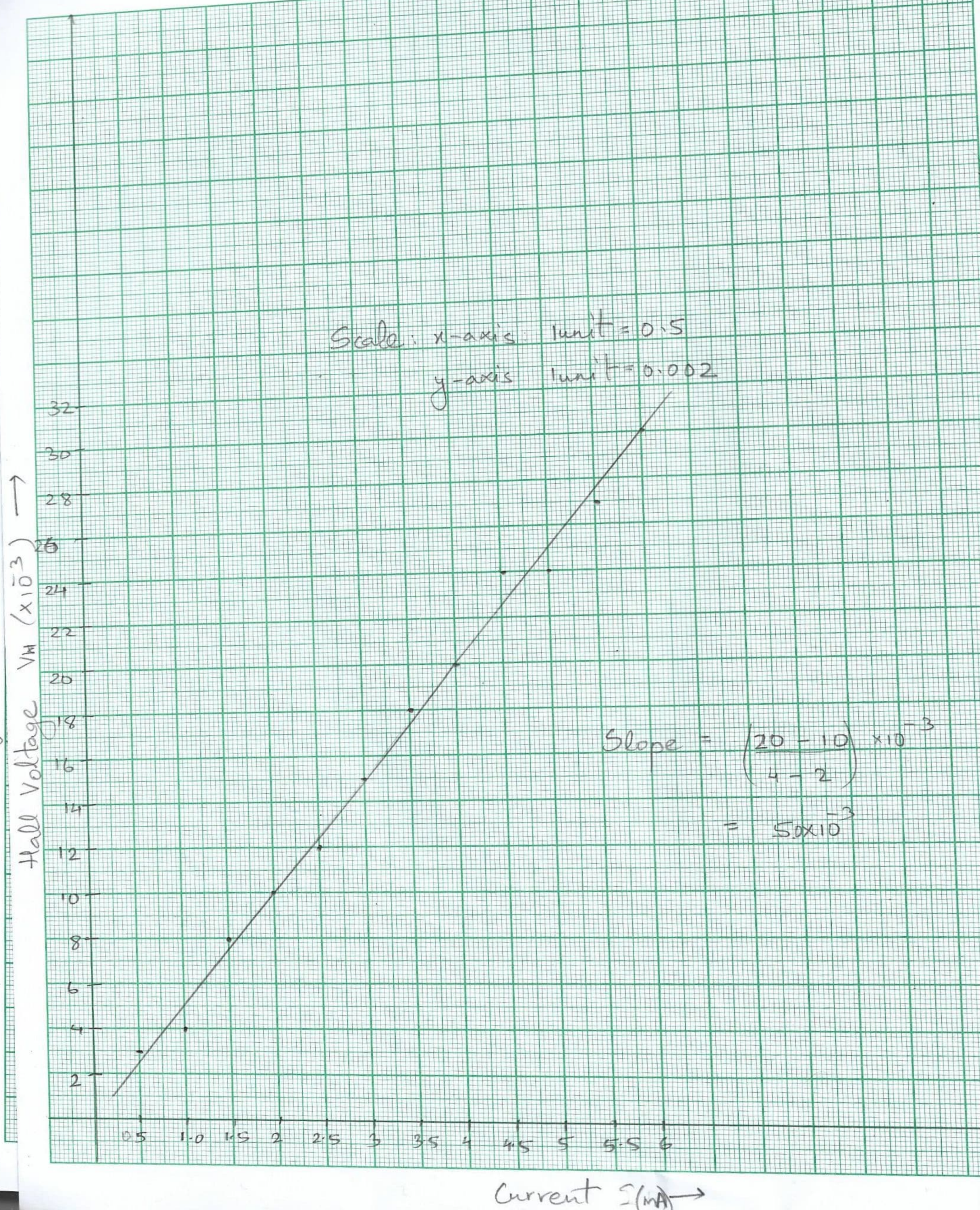
1. Connect all the apparatus as shown in figure.
2. Then start keeping the current be zero and also voltage to be zero.
3. Fix a particular magnetic field.
4. By changing the values of the current note the corresponding values of voltage. This voltage is called Hall potential.
5. Then reverse the current direction and note the voltage in table.

Observation table:

Sr. No.	Current (mA)	Hall Voltage (mV) Forward	Hall Voltage (mV) Backward	Mean V_H mV	V_H/I ohms
1	0.5	3	3	3	6.0
2	1.0	5	4	4	4.0
3	1.5	8	7	8	5.3
4	2.0	11	9	10	5.0
5	2.5	13	11	12	4.8
6	3.0	16	14	15	5.0
7	3.5	19	16	18	5.1
8	4.0	21	18	20	5.0
9	4.5	24	25	24	5.3
10	5.0	26	22	24	4.8
11	5.5	29	25	27	4.9
12	6.0	32	27	30	5.0

Mean $\frac{V_H}{I}$ = 5.0 ohms

Calculations:



Scale: x-axis 1unit = 0.5
y-axis 1unit = 0.002
Slope = $\left(\frac{20-10}{4-2}\right) \times 10^{-3}$
$= 5.0 \times 10^{-3}$
Hall Voltage V_H $(\times 10^{-3})$ →
Current I(mA) →
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0.5
1.0
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6

Calculations:

$\frac{V_H}{I}$ from table = 5.0ohms

$\frac{V_H}{I}$ from graph slope = 5.0 ohms

mean $\frac{V_H}{I} = \frac{5+5}{2} = 5.0$ ohms

$$R_H = \left(\frac{V_H}{I}\right) \times \frac{t}{B}$$

$$= \frac{5.0 \times 0.5 \times 10^{-3}}{0.23}$$

$$R_H = 1.08 \times 10^{-2} \ m^3 C^{-1}$$

since R_H +ve crystal is of p-type

charge carrier density $n = \frac{1}{e R_H}$

$= \frac{1}{1.6 \times 10^{-19} \times 1.08 \times 10^{-2}}$

$n = 5.78 \times 10^{20}$ carriers/m^3

Conclusions:

- The graph curve shows a linear relation exists between current and hall voltage.
- The given semiconductor crystal is of p-type.

Results:

- Hall coefficient $R_H = 1.08 \times 10^{-2}\ m^3 C^{-1}$
- Charge carrier density $n = 5.78 \times 10^{20}$ carriers m^{-3}
- The semiconductor is of p-type.