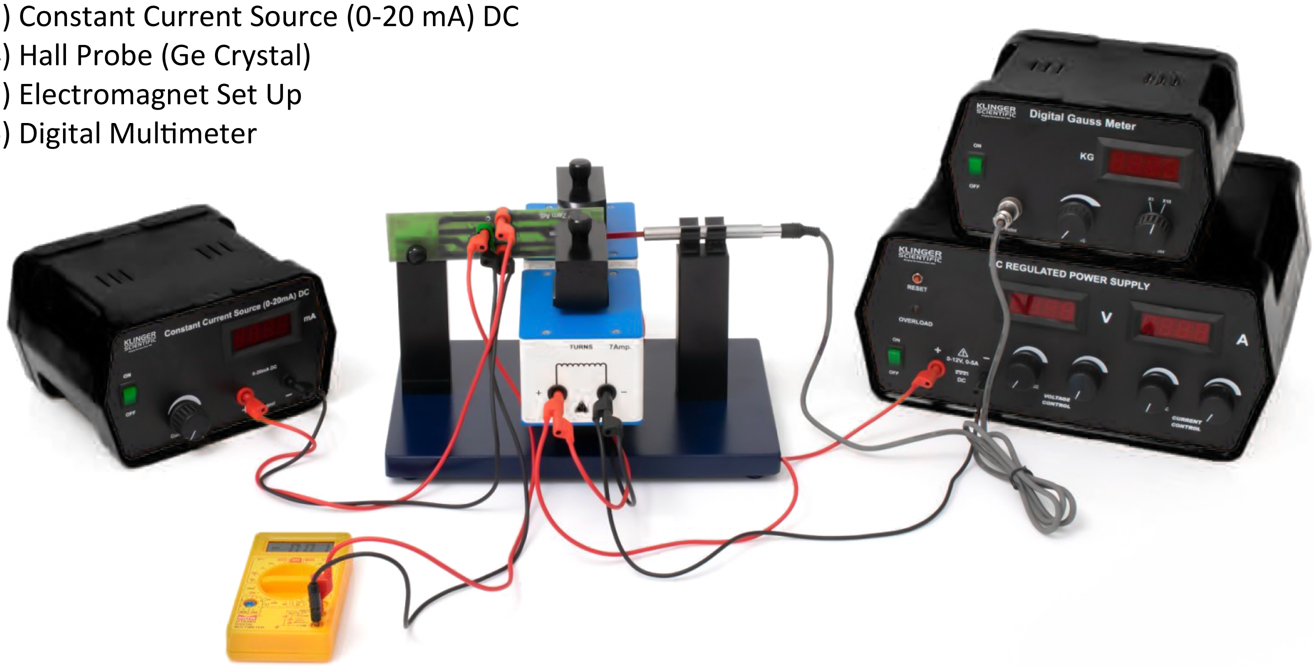
HALL EFFECT - KSCIHLEF

DESCRIPTION: Hall Effect Setup is designed to find the Hall coefficient and hence to estimate the carrier concentration in semiconductors using Hall Effect setup.

Hall Effect set up consists of
(1) 12V / 5A DC Variable Regulated Power Supply
(2) Digital Gauss Meter.
(3) Constant Current Source (0-20 mA) DC
(4) Hall Probe (Ge Crystal)
(5) Electromagnet Set Up
(6) Digital Multimeter



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(1) 12V / 5A DC Variable Regulated Power Supply

DC power supply is specially designed for scientific research and product development in laboratories, universities, colleges and electronic production lines. This instrument is widely used due to its high precision, reliable performance, and perfect overload protection circuit. This power supply provides a continuous DC output voltage with excellent load and line regulation. These power supplies have complete control for both voltage and current output. Dual displays (digital) help continuously monitor both output voltage and current. The power supply has short circuit and overload protection. Power supply operates on 220 V, 50 Hz input. Output Volts 0-12 Volts, Output Current 0-5 Amp.

(2) Digital Gauss meter

It operates on the principle of Hall Effect in Semiconductors. A semiconductor carrying current develops an electromotive force, when placed in a magnetic field, in a direction perpendicular to the direction of both electric current and magnetic field. The magnitude of this e.m.f. is proportional to the field intensity if the current is kept constant. This e.m.f. is called the Hall Voltage. The small Hall Voltage is amplified through a high stability amplifier so that a mill voltmeter connected at the output of the amplifier can be calibrated directly in magnetic field unit (gauss).

(3) Constant Current Source (0-20 mA) DC

This power supply specially designed for Hall Probe provides 100 percent protection against crystal burn-out due to excessive current. The basic scheme is to use the feed - back principle to limit the load current of the supply to a pre - set maximum value. Variations in the current are achieved by a potentiometer. The supply is a highly regulated and practically ripple free D.C source. The current is measured by the digital panel meter.

SPECIFICATIONS
Current range: (0 - 20 mA)
Resolution: 10 µA
Accuracy: ±0.2% of the reading ±1 digit
Load regulation: 0.03% for 0 to full load
Line regulation: 0.05% for 10% changes.

(4) Hall Probe (Ge Crystal)

Ge single crystal with four clip type pressure contacts is mounted on a Printed Circuit Board strip. Two Red and Two Green 4mm sockets are provided for connections with measuring devices. Red sockets for constant current source and green sockets for mill voltmeter.
Contacts: Clamp type
Hall Voltage: 0.1 - 1 Volt/100mA/KG
Thickness of Ge Crystal: 0.78 mm
Resistivity: @ 10 W cm.

(5) Electromagnet

A U shape soft iron core fitted on a wooden base with a pair of high current carrying coils. A pair of soft iron chrome plated blocks to generate high magnetic field are provided with the instrument. A pair of U shape clamps with long screw and fly nut is provided to clamp the soft iron chrome plated blocks on U shape soft iron core. There are two PVC poles fitted on the wooden base to hold the Gauss meter sensor probe and the Hall Probe (Ge Crystal)

Experiment: To find the Hall coefficient and hence to estimate the carrier concentration in semiconductors using Hall Effect setup.

Apparatus Required

Constant current power supply, an electromagnet, gauss meter, a digital milliammeter, a digital millivoltmeter, a voltmeter, a clamp, Hall probes and stand to hold the sample and magnetic probe, connecting wires

Theory

Hall Effect is a magneto-electric effect. When a current carrying conductor or semiconductor is placed in a magnetic field, then a potential difference is generated, known as Hall potential. This effect is known as Hall Effect. The sign of the Hall potential depends on the nature of the charge carriers and can be used to find whether the sample is p-type or n-type.

The Hall coefficient is given by the relation

$$R_H = \frac{1}{ne}$$

Where n is the number of charge carriers and e is the electron's charge (e = 1.6 x 10^{-19} coulomb)

Experimentally Hall coefficient can be calculated using the relation

$$R_H = \frac{V_H.l}{I.B_z} \text{ meter}^3/\text{coulomb}$$

where V_H is the Hall voltage, *l* is the thickness of the crystal, I is current flowing and B_z =μB is the applied magnetic field.

The number of charge carriers per unit volume in the semiconductor crystal, i.e., electron concentration in n-type semiconductor and hole concentration in p-type semiconductor is given by the relation

$$n = \frac{1}{R_H.e} \text{ meter}^{-3}$$

where e (= 1.6 x 10^{-19} coulomb) is the charge of an electron

Procedure: (1) Place the specimen in the magnetic field of the strong electromagnet and make other connections

.(2) Pass some current to flow through the semiconductor crystal. Measure the current with ammeter and the Hall voltage with millivoltmeter.

(3) Change the value of current I in steps and note the corresponding Hall voltage. Take many readings. Plot a graph between I and V_H. The plot comes out to be a straight line whose slope gives the value of $\frac{V_H}{I}$.

(4) Measure the magnetic field B with a gauss meter and find the actual value of magnetic field B_z (=μB) in the crystal.

Observations:

Permeability of the specimen μ = ……….

Magnetic field B = …….gauss = ……..weber/m^2

Actual field in the crystal B_z = μB = ……….. gauss = ……..weber/m^2

Width of the crystal d = …..meter

Measurement of Hall voltage

Sr. No.	Current I (ampere)	Applied Voltage (volt)	Hall voltage V_H (volt)
1.			
2.			
3.			
4.			

Calculations: From the plot between I and V_H, calculate the value of $\frac{V_H}{I}$ then calculate the Hall coefficient using the relation $R_H = \frac{V_H.l}{I.B_z}$ = ……...meter^3/coulomb

Now calculate the number of charge carriers using the relation

n= $\frac{1}{R_H.e}$ **= …….**meter^{-3}

To Take Care of: The Hall voltage developed is very small and hence should be measured accurately with the help of a millivoltmeter.The current through the crystal should be strictly within the permissible limits.

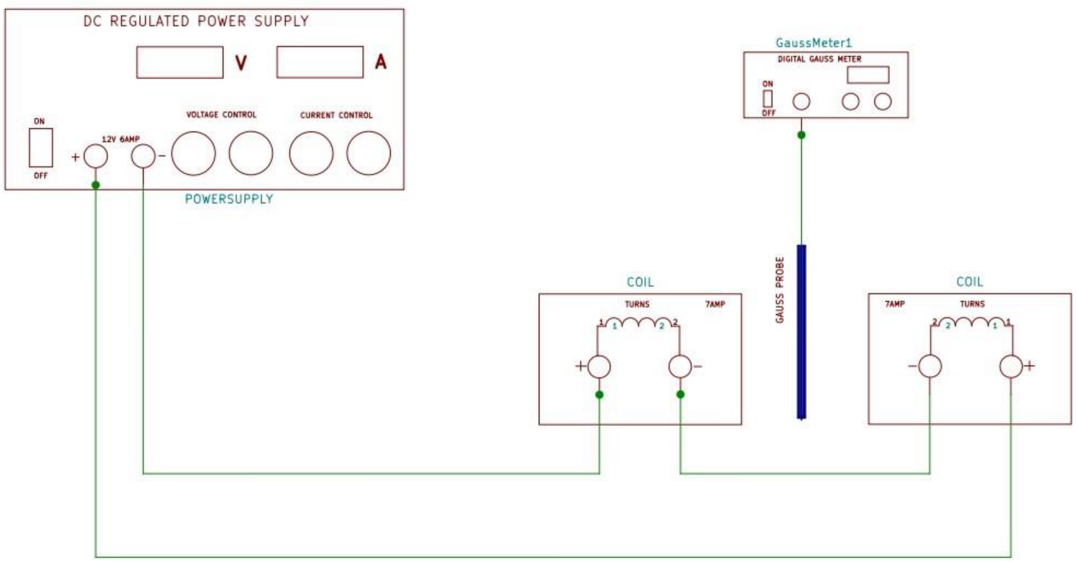

Image1. Wiring Diagram for calibration of magnetic field using gauss meter.

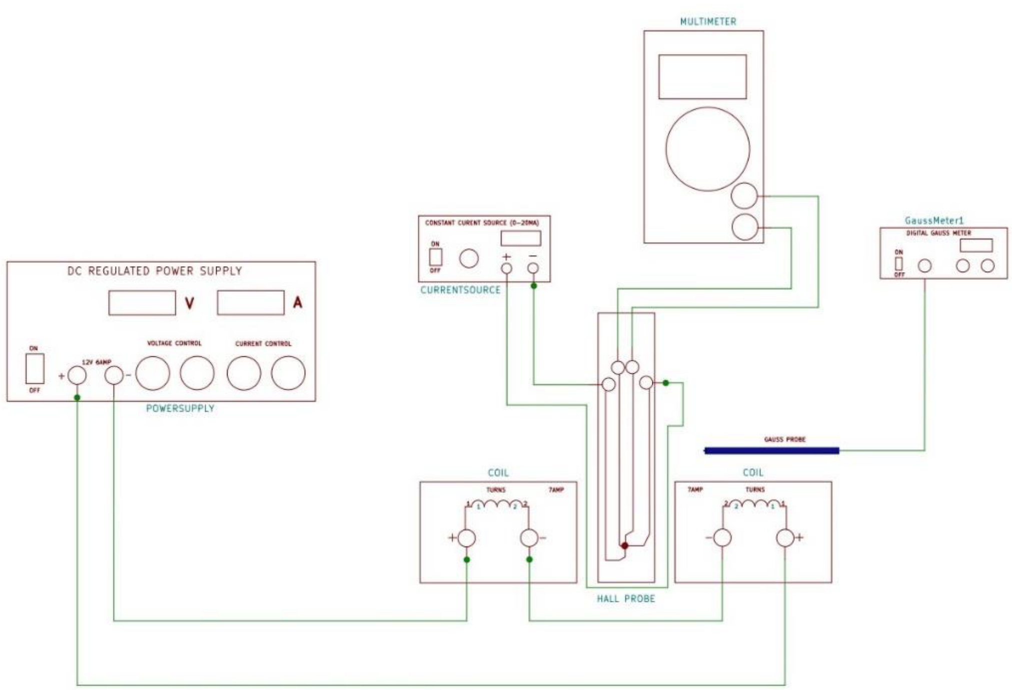

Image2. Wiring Diagram to find hall voltage of crystal.