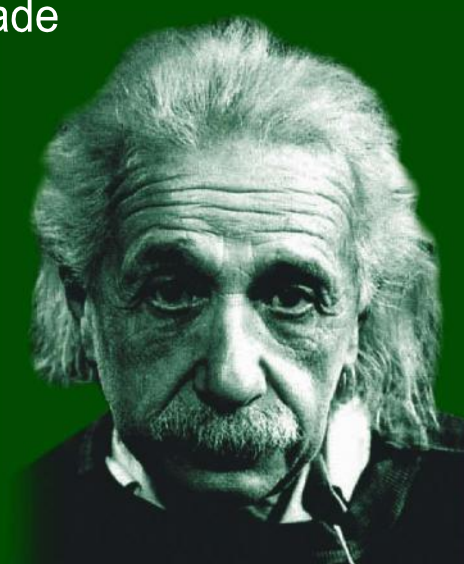
PRODUCT CATALOG

Everything should be made
as simple as possible,
but not simpler.

Albert Einstein

$$E = mc^2$$



SES Instruments Pvt. Ltd.

About us

Formerly known as Scientific Equipment & Services, we have the pleasure of introducing ourselves as a reputed manufacturers of complete laboratory experiments and precision measuring instruments for BS and MS laboratories of Physics and Electronics.

For the last 39 years, we have been catering to the needs of over 1200 institutions in over 32 countries. We, while orienting ourselves to the need of laboratories have been trying our best to develop and introduce progressively more advanced laboratory experiments and general-purpose measuring instruments.

Our strict quality control ensures uncompromising quality of our instruments, low overheads and direct sales to the customers have enabled us to keep our rates very affordable.

The product catalogue highlights some of our manufacturing activities. The technical specifications given here are meant to give an accurate statement of performance of instruments manufactured by us.

Note of thanks

We at SES Instruments Pvt. Ltd.(*Formerly Scientific Equipment & Services*), are greatful to the staff of IIT-Roorkee, particularly Professor K.C. Mittal, and Professor M.K. Srivastava, for their tremendous support all through these years by giving innovative suggestions and constructive criticism thereby helping in constantly adding new products and improving the existing ones.

Warranty

All our products are manufactured under high level of quality control. They are warranted free from defects for a period of one year from the date of purchase. We will repair or replace as find suitable, any piece of defective equipment during this period. Even after this period after sales service is undertaken at very nominal charges.

Specifications

Specifications of all products are subject to change without notice. SES Instruments Pvt. Ltd. reserves the right to make improvements to the products without incurring any obligation to incorporate these changes in products previously sold.

Power requirement

Equipment in this catalogue are designed to operate from 220V ±10%, 50Hz. All the equipment are also available for use with 110V ±10%, 60Hz power at no additional cost.

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SES Instruments Pvt Ltd.

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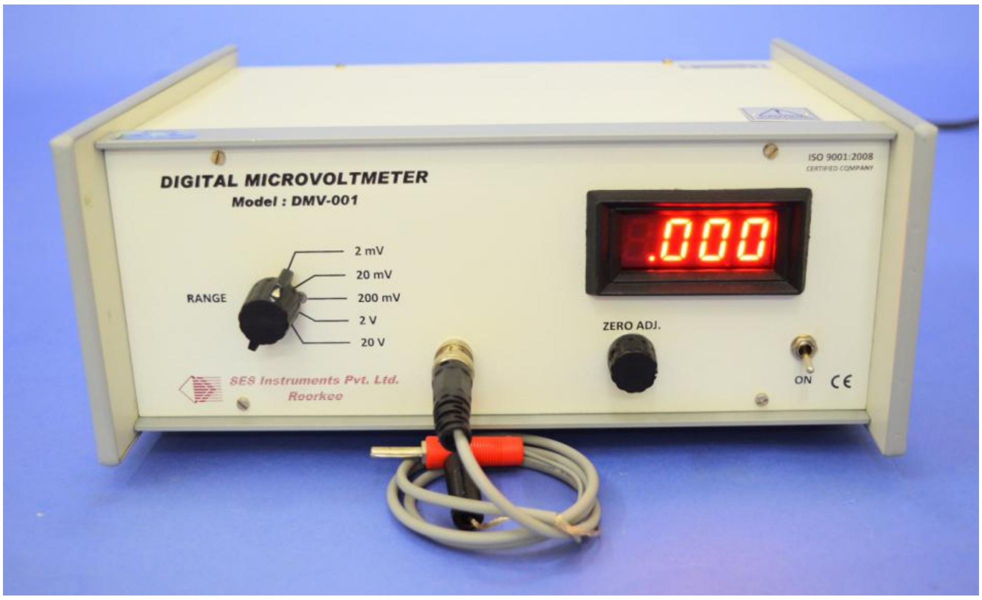
DMV-001

Digital Microvoltmeter



- Very low temperature drift
- Low dc input bias current-10pA
- Measures voltage down to 1μV
- Automatic polarity indication
- Built-in polarity indication
- Recorder facility (optional)

Introduction

Digital Microvoltmeter, DMV-001 is a very versatile multipurpose instrument for the measurement of low dc voltage. It has 5 decade ranges from 1mV to 10V with 100% over-ranging. For better accuracy and convenience, readings are directly obtained on 3½ digit DPM (Digital Panel Meter). This instrument uses a very well designed chopper stabilized IC amplifier. This amplifier offers exceptionally low offset voltage and input bias parameters, combined with excellent speed characteristics. Filter circuit is provided to reduce the line pickups of 50Hz. All internal power supplies are IC regulated.

Applications

- DC voltage measurements from high impedance sources; output of photomultiplier tubes, photo cells, radiation detector etc.
- Very low voltage measurement, direct measurement of thermocouple output to read temperatures with a resolution of 1/40th of a degree (Chromel-Alumel).
- General purpose laboratory instrument for voltages upto 19.99VDC. (Hall Effect, Four Probe, Thermoluminescence, Transistor and Diode characteristics etc.).

Specification

Range	:	1mV, 10mV, 100mV, 1V & 10V with 100% over-ranging.
Resolution	:	1μV
Accuracy	:	±0.2% ±1 digit
Stability	:	Within ±1 digit
Input Impedance	:	>1000MΩ (10MΩ on 10V range)
Display	:	3½ digit, 7 segment LED with autopolarity and decimal indication
Interfacing	:	USB (in DMV-001-C2 only)
Software	:	DACC and CAMM, both Window compatible
Power Supply	:	220V ±10%, 50Hz
Weight	:	2.5Kg
Dimensions	:	245mm X 280mm X 120mm

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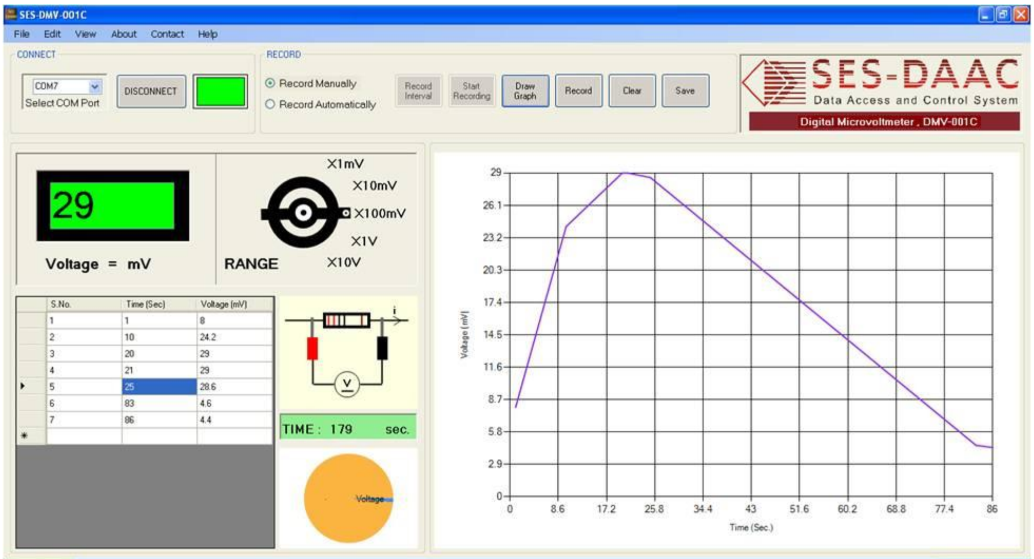
DMV-001

Digital Microvoltmeter



Computer Interface, SES-DAAC (In DMV-001-C2 only)

The unit can be connected directly to a PC through an USB. SES-Data Access And Control is a built-in interface which gives user an option to store a value as displayed on the meter and tabulate it by the click of a button on the screen. Alternatively the data may be automatically entered into a table at user selectable interval. An 'END' button on the screen terminates the automatic tabulation. The data stored in the table may then be displayed as a graph on the screen and may also be stored in an excel file for further processing. The software supplied with the unit is menu driven and is simple to operate.

SES-CAMM Compatible (In DMV-001-C2 only)

This unit can also be connected to a PC through an interface module SES-CAMM to record the voltage values. SES-CAMM is a computer aided measurement module for connecting multiple subunits of experiments, such as Four Probe Setup, to same interface on a computer. This feature is particularly useful in making this model compatible with computerized versions of complete experiments from our company.

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DNM-121

Digital Nanoammeter

- Measures current down to 100pA
- All solid state and IC design
- Accepts either polarity of input current
- Build-in computer interface

Introduction

Digital Nanoammeter, DNM-121, a rugged and low cost instrument, is a product of extensive R&D using high input impedance integrated circuits. It has 4 decade ranges with 100% over-ranging. The unit is suitable for current measurement in the range of 100pA to 200pA. For the ease, readings are directly obtained on a 31/2 digit DPM. The instrument is capable of accepting either polarity of the input current.

The very low leakage current of the input stage combined with the high linearity fast response due to high negative feedback enables accurate and easily reproducible measurements. The instrument uses a FET input operational amplifier that offers the very low input bias current, low offset voltage, low drift and noise. These characteristics have been fully utilized in the present Nanoammeter. This operational amplifier is used in low level current to voltage configuration.

Applications

- To measure current from photomultiplier tubes, photometer etc.
- Leakage currents in solid state devices. FET gate and tube grid voltages without loading errors.
- Current through very high resistance in conjunction with a power supply.
- Potentials across semiconductors, piezoelectric systems & pH electrodes.

Specifications

Range	:	100nA, 1μA, 10μA, 100μA with 100% over-ranging
Accuracy	:	0.2% for all ranges
Resolution	:	0.1nA
Input Impedance	:	25Ω, 2.5Ω, 0.25Ω, 0.025Ω
Display	:	3½ digit 7 segment LED (12.5mm height) with auto polarity and decimal indication
Input	:	Through BNC connector
Interfacing	:	USB (In DNM-121-C2 only)
Software	:	DACC and CAMM, both Window compatible (In DNM-121-C2 only)
Power Supply	:	220V ±10%, 50Hz
Weight	:	2.5Kg

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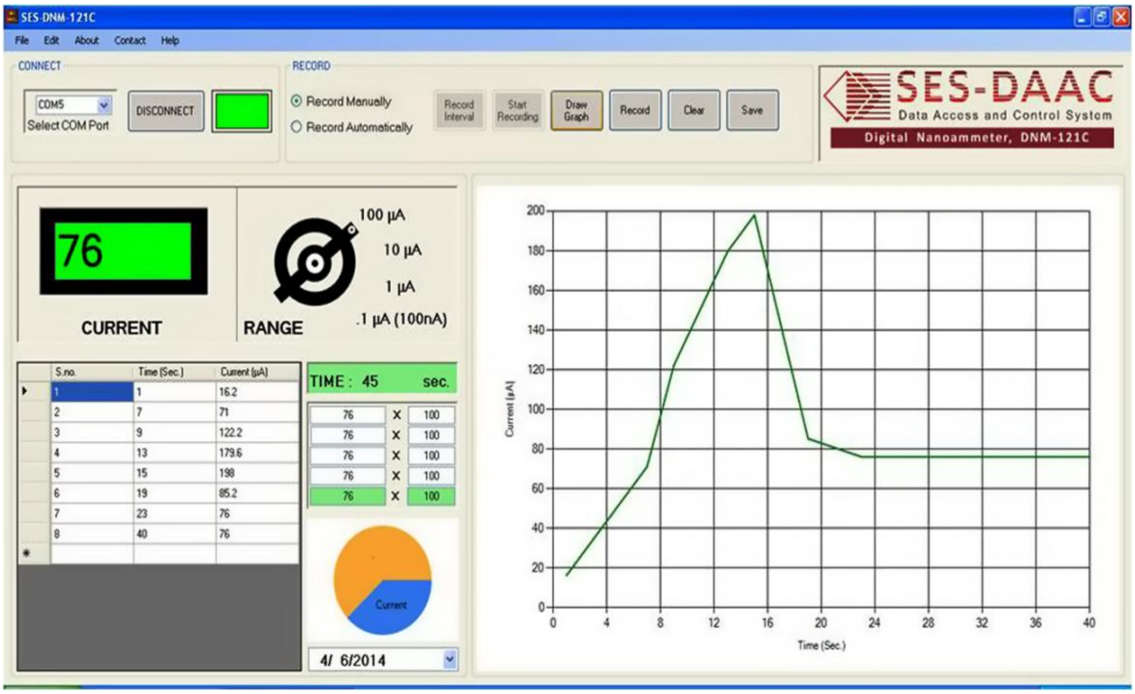

Computer Interface, SES-DAAC (In DNM-121-C2 only)

The unit can be connected directly to a PC through an USB. SES-Data Access And Control is a built-in interface which gives user an option to store a value as displayed on the meter and tabulate it by the click of a button on the screen. Alternatively the data may be automatically entered into a table at user selectable interval. An 'END' button on the screen terminates the automatic tabulation. The data stored in the table may then be displayed as a graph on the screen and may also be stored in an excel file for further processing. The software supplied with the unit is menu driven and is simple to operate.

SES-CAMM Compatible (In DNM-121-C2 only)

This unit can also be connected to a PC through an interface module SES-CAMM. SES-CAMM is a computer aided measurement module for connecting multiple subunits of experiments such as Two Probe Setup to same interface on a computer. This feature is particularly useful in making this model compatible with computerized versions of complete experiments from our company.

DPM-111

Digital Picoammeter

- Measures current down to 1pA
- All solid state and IC design
- Very low offset current
- Built-in computer interface

Introduction

This is a very versatile multipurpose equipment for the measurement of low dc currents. It has 6 decade ranges with 100% over-ranging from 10-9A to 10-4A. For the ease, readings are directly obtained on a 3½ digit DPM. The instrument uses a well designed precision FET input electrometer operational amplifier AD549, which offers the lowest input bias currents (50fA with ±5V supplies) available in any standard operational amplifier. The excellent characteristics of AD549, ultra low bias current, low offset voltage, low drift and low noise have been fully utilized to obtain best results in the present picoammeter. The first operational amplifier AD549 is used in low level current to voltage configuration and the output has been directly read on a 3½ digit panel meter. The instrument is capable of accepting either polarity of the input current. Well-regulated power supplies are incorporated to use the instrument upto 10% changes in a.c. main's voltage.

Applications

- Current from photo multiplier tubes, photometers etc.
- Leakage currents in solid state devices.
- FET gate and tube grid-currents.
- Current through very high resistance's in conjunction with a power supply. Potentials across semiconductors, piezoelectric system & pH/plon sensitive electrodes.
- Electrical conductivity of air.
- Very low current oxygen sensors.

Specifications

Multiplier	:	X1, X10, $X10^2$, $X10^3$, X104, X105
Accuracy	:	0.2% for all ranges
Resolution	:	1pA, 10pA, 100pA, 1nA, 10nA, 100nA
Input Resistance	:	2.5KΩ, 0.25KΩ, 25Ω, 2.5Ω, 0.25Ω , 0.025Ω
Display	:	3½ digit 7 segment LED
Power Supply	:	220V ±10%, 50Hz
Input	:	Through BNC connector
Interfacing	:	USB (DPM-111-C2 model)
Software	:	DACC and CAMM, both Window compatible (DPM-111-C2 model)

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DPM-111-C2

Digital Picoammeter

- Measures current down to 1pA
- All solid state and IC design
- Very low offset current
- Built-in computer interface

Introduction

This is a very versatile multipurpose equipment for the measurement of low dc currents. It has 6 decade ranges with 100% over-ranging from 10-9A to 10-4A. For the ease, readings are directly obtained on a 3½ digit DPM. The instrument uses a well designed precision FET input electrometer operational amplifier AD549, which offers the lowest input bias currents (50fA with ±5V supplies) available in any standard operational amplifier. The excellent characteristics of AD549, ultra low bias current, low offset voltage, low drift and low noise have been fully utilized to obtain best results in the present picoammeter. The first operational amplifier AD549 is used in low level current to voltage configuration and the output has been directly read on a 3½ digit panel meter. The instrument is capable of accepting either polarity of the input current. Well-regulated power supplies are incorporated to use the instrument upto 10% changes in a.c. main's voltage.

Applications

- Current from photo multiplier tubes, photometers etc.
- Leakage currents in solid state devices.
- FET gate and tube grid-currents.
- Current through very high resistance's in conjunction with a power supply. Potentials across semiconductors, piezoelectric system & pH/plon sensitive electrodes.
- Electrical conductivity of air.
- Very low current oxygen sensors.

Specifications

Multiplier	:	X1, X10, X10², X10³, X104, X105
Accuracy	:	0.2% for all ranges
Resolution	:	1pA, 10pA, 100pA, 1nA, 10nA, 100nA
Input Resistance	:	2.5KΩ, 0.25KΩ, 25Ω, 2.5Ω, 0.25Ω , 0.025Ω
Display	:	3½ digit 7 segment LED
Power Supply	:	220V ±10%, 50Hz
Input	:	Through BNC connector
Interfacing	:	USB
Software	:	DACC and CAMM, both Window compatible

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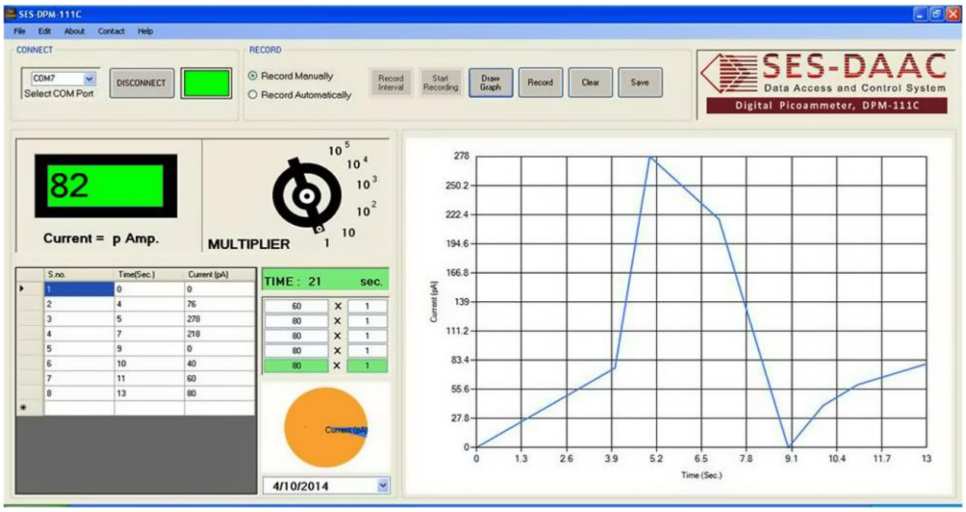
DPM-111-C2

Digital Picoammeter



Computer Interface, SES-DAAC (In DPM-111-C2 only)

The unit can be connected directly to a PC through an USB. SES-Data Acess And Control is a buit-in interface which gives user an option to store a value as displayed on the meter and tabulate it by the click of a button on the screen. Alternatively the data may be automatically entered into a table at user selectable interval. An 'END' button on the screen terminates the automatic tabulation.

The data stored in the table may then be displayed as graph on the screen and may also be stored in an excel file for further processing. The software supplied with the unit is menu driven and is simple to operate.

SES-CAMM Compatible (In DPM-111-C2 only)

This unit can also be connected to a PC through an interface module SES-CAMM to record current values. SES-CAMM is a computer aided module for connecting multiple subunits of experiments, such as Two Probe Setup, to same interface on a computer. This feature is particularly useful in making this model compatible with computerized versions of complete experiments from our company.

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EHT-11

High Voltage Power Supply

- Continuously variable
- Electronically regulated
- Fully solid state circuit
- Low power consumption
- Computer connectivity through SES-CAMM

Introduction

Power supply, EHT—11 principle of operation is entirely different from conventional supplies, and thereby eliminating many drawbacks; bulky high voltage transformer, need of high voltage components and excessive heating of components etc., associated with them.

This power supply consists of a stable power oscillator whose output is controlled by an input signal. The output of this oscillator is boosted with the help of a step-up transformer and then rectified and filtered. A portion of this output is compared with a high stability, temperature compensated reference and the error signal is used in the feedback path to control the oscillator's output. There is a built-in protection against accidental overloading.

For high reliability, compactness and ruggedness, integrated circuits are extensively used along with a few discrete silicon devices. The components are mounted in a glass epoxy printed circuit card.

Applications

EHT-11 is designed to meet the power requirements of a broad range of radiation detectors: G.M. Counters, Ionization Chambers, Scintillation Detectors, Photo multiplier Tubes and any application where a high voltage source with high degree of regulation and stability is required.

SES-CAMM Compatible (In EHT-11-C1 only)

This unit can also be connected to a PC through an interface module SE5-CAMM to record voltage values. SES-CAMM is a computer aided module for connecting multiple subunits of experiments such as Two Probe Setup to same interface on a computer. This feature is particularly useful in making this model compatible with computerized versions of complete experiments from our company.

Specifications

Output	:	0-1500V continuously adjustable
Current	:	1mA (max.)
Polarity	:	+ve or -ve, as required
Regulation	:	±0.05% for 0 to 1mA load
Stabilization	:	±0.02% for ±10% mains variation
Display	:	3½ digit, 7 segment LED DPM
Connection	:	Output through a TNC connector on the front panel
Protection	:	Fully protected against overload and short circuit by current limiting technique
Interfacing	:	Through SES-CAMM module (In EHT-11-C1 model only)
Software	:	Software provided with SES-CAMM is Window compatible (In EHT-11-C1 model only(
Power requirements	:	220V ±10%, 50Hz
Weight	:	5Kg
Dimensions	:	240mm X 390mm X 130mm

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ACM-102, ACM-103

True RMS A.C. Millivoltmeter

- Measures True RMS Voltage
- Accuracy 1%
- High Input Impedance
- High Stabilility
- Excellent Linearity

Applications

Measurement of low signal like microphone outputs e.g. in r.m.s. sound level monitoring Amplifier frequency response well beyond audio ranges RMS voltage measurement of modulated signals Power measurements with external standard resistance.

ACM-102: True RMS A.C. Millivoltmeter, ACM-102 is based on AD536. This is a completely monolithic integrated circuit which performs true rms-to-dc conversion of any waveform. The true rms value of a waveform is more useful quantity than average rectified value, since it relates directly to the power of the signal. The crest factor compensation scheme of the AD536 allows measurement of highly complex signals with wide dynamic range. The crest factor is often overlooked in determining the accuracy of an ac measurement. Crest factor is defined as the ratio of the peak signal amplitude to the rms value of the signal (C.F.=V_p/V_{rms}). Input signal is appropriately processed through a FET input wide band, extremely fast settling time, low noise amplifier.

ACM-103: In model ACM-103 besides all features of ACM-102, an IC based 1KHz oscillator followed by a buffer, is in-built. This eliminate the need of an external oscillator for purpose, such as determination of h-parameters of a transistor, bridge measurement etc., where spot frequency of 1KHz is most commonly used.

Specifications	
Voltage Range	: 20mV, 200mV, 2V and 20V
Frequency Range	: 10Hz to 200KHz
Input Impedance	: 1MΩ shunted by 25pf on all ranges
Accuracy	: 1% in the range 10Hz-100KHz; 2% in the range 100KHz-200KHz
Display	: 3½ digit, 7 segment LED (12.5mm height) with decimal and overflow indication
Power Supply	: 220V ±10%, 50Hz
Weight	: 2.5Kg & 3Kg
Accessories	: 75cm shielded cable with a coaxial connector at one end and banana plugs on the other end

ACM-103 (Additional Features)

Oscillator Output	: 0-300mV continuously variable
Frequency	: 1KHz fixed

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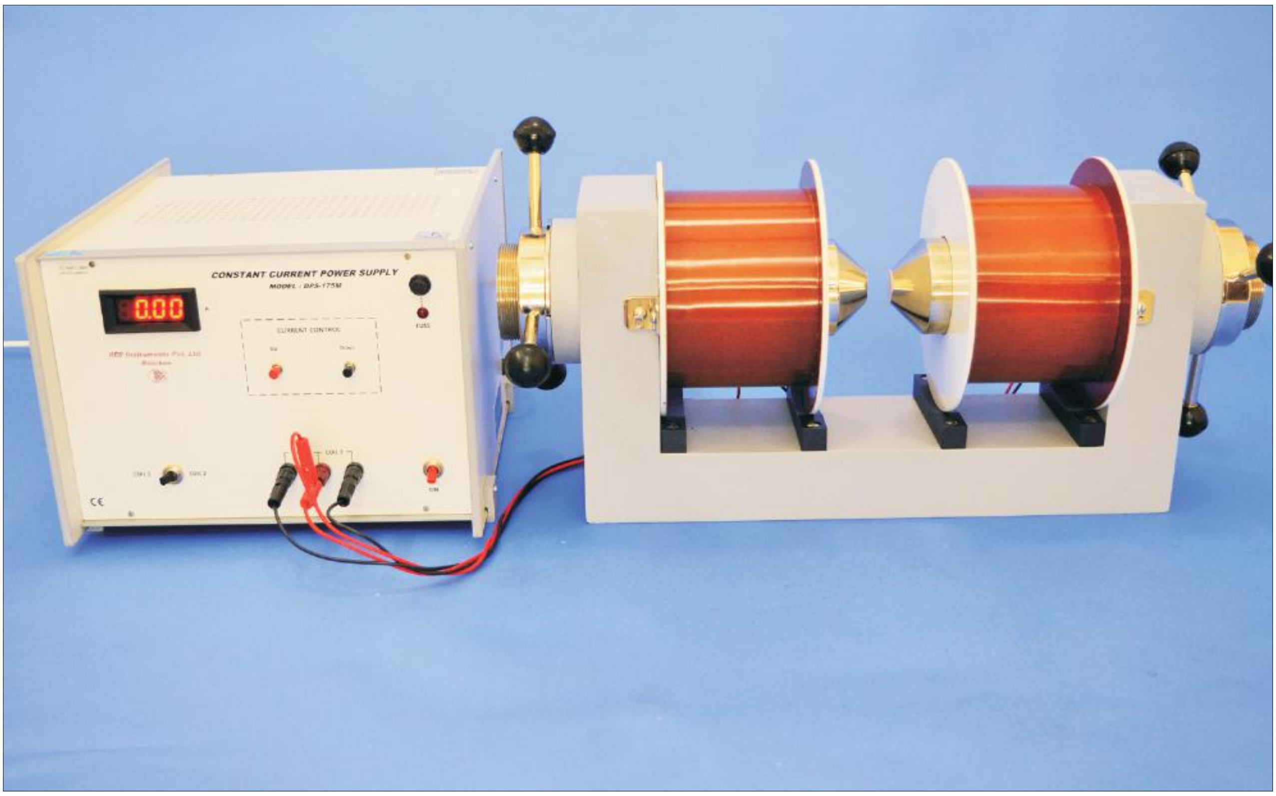
Electromagnet & Power Supply

EMU-75
DPS-175M

SES Instruments Pvt Ltd.



EMU-75 has the most widely used 'U' shaped soft iron yoke. The soft iron is of a special quality, structurally uniform, well machined and finished to meet the rigid standards.

The pole pieces are made from dead annealed soft iron blocks of the best quality available. They are well shaped, machined and finished. The air-gap is continuously variable upto 75mm with two way knobbed wheel screw adjusting system. Normally flat pole pieces are supplied. Tappered pole pieces can be supplied on special request.

The coils are wound on non-magnetic formers with uniform layers of S.E. copper wire. The new and modern design of the coils provides good thermal conductivity characteristics and eliminates troublesome hot spots even at high magnetic fields.

Specifications

- **Field Intensity**
  11KG at 10mm air-gap with flat pole pieces
- **Pole Pieces**
  75mm diameter
- **Energising Coils**
  Two, each having a resistance of about 12Ω
- **Power Requirement**
  0-90Vdc, 3A, if coils are connected in series.
  0-45Vdc, 6A, if coils are connected in parallel

DPS-175M is designed to be used with the Electromagnet, Model: EMU-75 as a constant current power supply to generate magnetic field upto 11KG. The current requirement of 3A per coil, i.e. a total of 6A is met by connecting six closely matched constant current sources in parallel. In this arrangement the first unit works as the 'master' with current adjustment control. All others are 'slave' units generating exactly the same current as the master. All the six constant current sources are individually IC controlled. The current is set by Up/ Down push button switches under the control of a microcontroller. The embedded software further ensures low power dissipation by selecting the primary and secondary tappings of the mains transformer approximately. The unit is therefore capable of continuosly operations for long periods. The supply is protected against overload, short circuit and transients caused by the load inductance.

Specifications

- **Current Range** : Up/ Down switch operated, 0-3A per coil, i.e. 6A
- **Load Regulation** : 0.1% for load variation from 0 to max.
- **Line Regulation** : 0.1% for ±10% mains variation
- **Display** : 3½ digit, 7 segment LED DPM
- **Power** : 220V ±10%, 50Hz
- **Weight** : 13Kg
- **Dimensions** : 340mm X 350mm X 235mm

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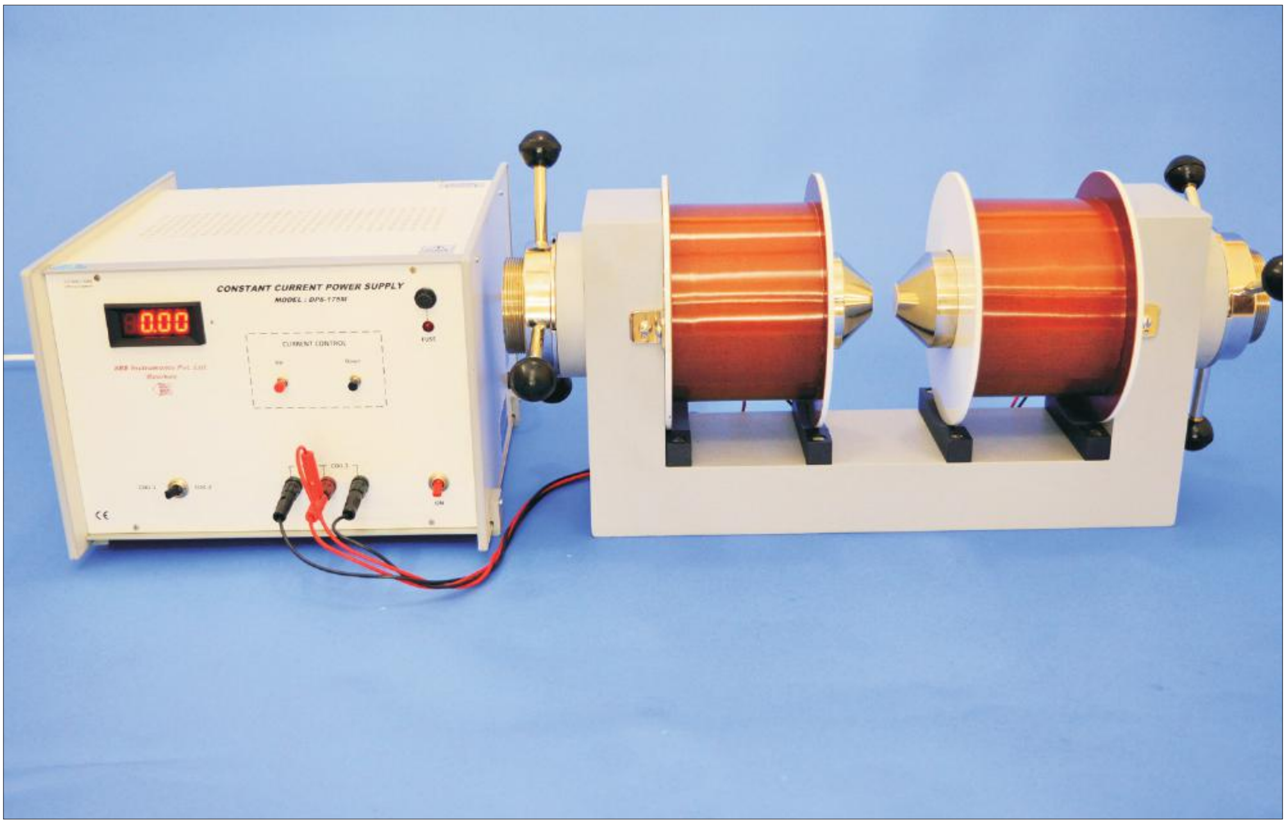
Electromagnet & Power Supply

EMU-75
DPS-175-C2

SES Instruments Pvt Ltd.



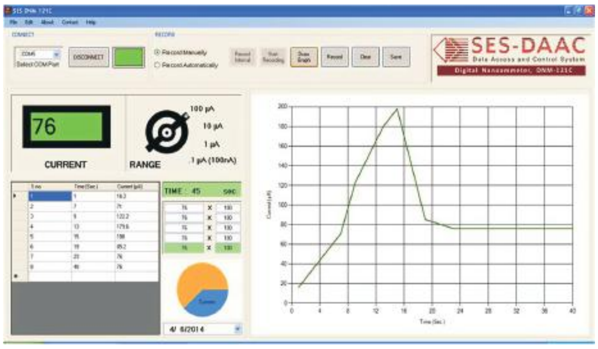
EMU-75

EMU-75 has the most widely used 'U' shaped soft iron yoke. The soft iron is of a special quality, structurally uniform, well machined and finished to meet the rigid standards.
The pole pieces are made from dead annealed soft iron blocks of the best quality available. They are well shaped, machined and finished. The air-gap is continuously variable up to 75mm with two way knobbed wheel screw adjusting system. Normally flat pole pieces are supplied. Tampered pole pieces can be supplied on special request.
The coils are wound on non-magnetic formers with uniform layers of S.E. copper wire. The new and modern design of the coils provides good thermal conductivity characteristics and eliminates troublesome hot spots even at high magnetic fields.

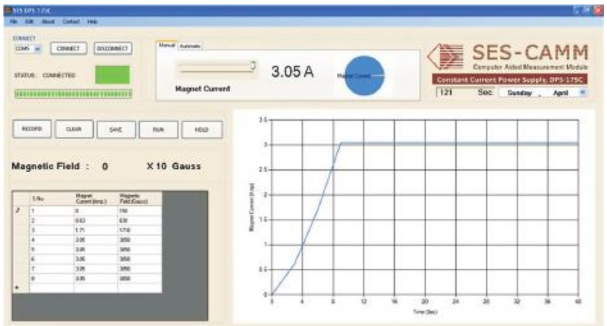
SPECIFICATIONS

Field Intensity	11KG at 10mm air-gap with flat pole pieces
Pole Pieces	75mm diameter
Energizing Coils	Two, each having a resistance of about 12Ω
Power Requirement	0-90Vdc, 3A, if coils are connected in series. 0-45Vdc, 6A, if coils are connected in parallel
Weight:	81Kg

DPS-175-C2



DPS-175-C2 is designed to be used with the Electromagnet, Model: EMU-75 as a constant current power supply to generate magnetic field upto 11KG. The current requirement of 3A per coil, i.e. a total of 6A is met by connecting six closely matched constant current sources in parallel. In this arrangement the first unit works as the 'master' with current adjustment control. All others are 'slave' units generating exactly the same current as the master. All the six constant current sources are individually IC controlled. Four options are provided for adjusting current.



1) **Manual:** Through Up/Down push button switches.

2) **External:** Controlled through a dc voltage 0-10V obtained from dSpace or otherwise.

3) **USB:** The unit can be connected directly to a PC through an USB. SES-Data Access And Control is a buit-in interface which gives user an option to store a value as displayed on the meter and tabulate it by a click of a button on the screen. Alternatively the data may be automatically entered into a table at user selectable interval. An 'END' button on the screen terminates the automatic tabulation. The data stored in the table may then be displayed as a graph on the screen and may also be stored in an excel file for further processing. The software supplied with the unit is menu driven and is simple to operate.

4) **SES-CAMM:** This unit can also be connected to a PC through an interface module SES-CAMM. SES-CAMM is a computer aided module for connecting multiple subunits of experiments, such as Two Probe Setup to same interface on a computer. This feature is particularly useful in making this model compatible with computerized versions of complete experiments from our company.

SPECIFICATIONS

Current Range	: Up/ Down switch operated, 0-3A per coil, i.e. 6A
Load Regulation	: 0.1% for load variation from 0 to max.
Line Regulation	: 0.1% for ±10% mains variation
Display	: 3½ digit, 7 segment LED DPM
Interfacing	: USB
Software	: DACC and CAMM, both Window compatible
Power	: 220V ±10%, 50Hz
Weight	: 13Kg
Dimensions	: 340mm X 350mm X 235mm

Computer is not included with the instruments.

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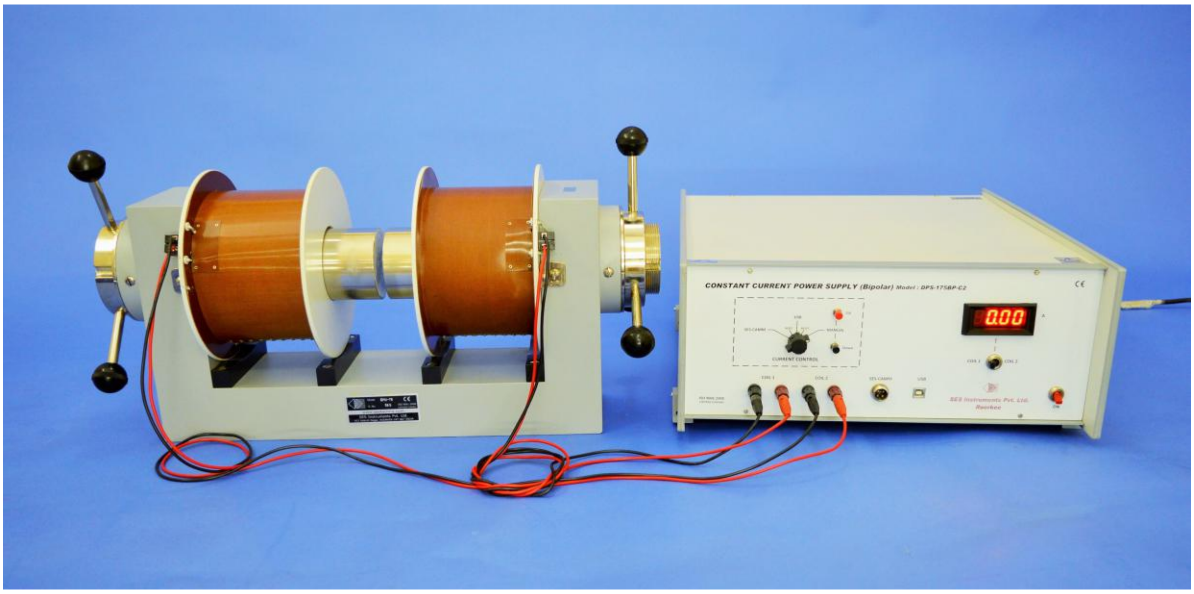
DPS-175-BPC

Electromagnet & Power Supply



DPS-175-BPC

DPS-175-BPC is designed to be used with the Electromagnet, Model: EMU-75 as a bi-polar constant current power supply to generate magnetic field up to 11KG. The current requirement of ±3A per coil, i.e. a total of 6A is met by connecting six closely matched constant current sources in parallel. In this arrangement the first unit works as the 'master' with current adjustment control. All others are 'slave' units generating exactly the same current as the master. All the six constant current sources are individually IC controlled. The supply is protected against overload, short circuit and transients caused by inductance of the magnet coil. Three options are provided for adjusting current.

1) Manual: Up/ Down push button switches.

2) USB: The unit can be connected directly to a PC through an USB. SES-Data Access And Control is a built-in interface which gives user an option to set the current, store and tabulate it by a click of a button on the screen. Alternatively the data may be automatically entered into a table at user selectable interval. An 'END' button on the screen terminates the automatic tabulation. The data Stored in the table may then be displayed as a graph on the screen and may also be stored in an excel file for further processing. The software supplied with the unit is menu driven and is simple to operate.

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ISO 9001:2015

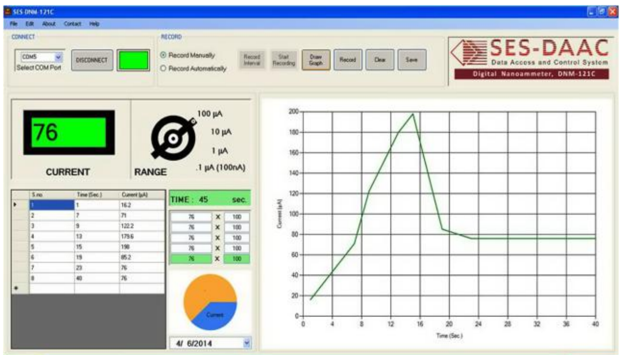
DPS-175-BPC

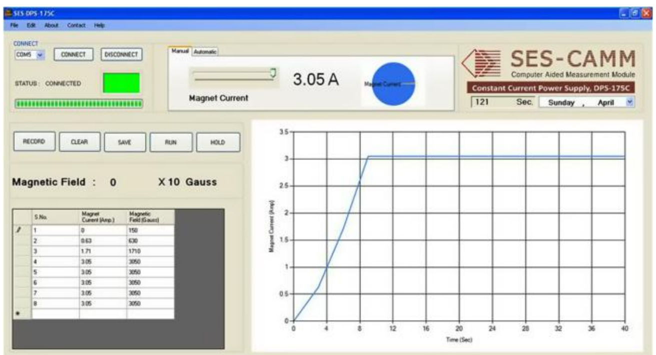
Electromagnet & Power Supply

3) SES-CAMM: The unit can also connected to a PC through an interface module SES-CAMM. SES-CAMM is a computer aided module for connecting multiple subunits of experiments. This enables the user to set a current profile on the screen and read the current, magnetic field with the help of one of our Gaussmeters and also one more arbitrary parameter. Typical application may be to automatically display the hysteresis loop of a material. This feature is particularly useful in making this model compatible with computerized versions of complete experiments from our company.

Specifications

Current Range	:	-3A to +3A each coil connected in parallel
Load Regulation	:	0.1% for load variation from 0 to max.
Line Regulation	:	0.1% for ±10% mains variation
Display	:	3½ digit, 7 segment LED DPM
Interfacing	:	USB
Software	:	DACC and CAMM, both window compatible
Power	:	220V ±10%, 50Hz
Weight	:	13Kg
Dimensions	:	340mmx350mmx235mm





Computer is not included with the instruments.

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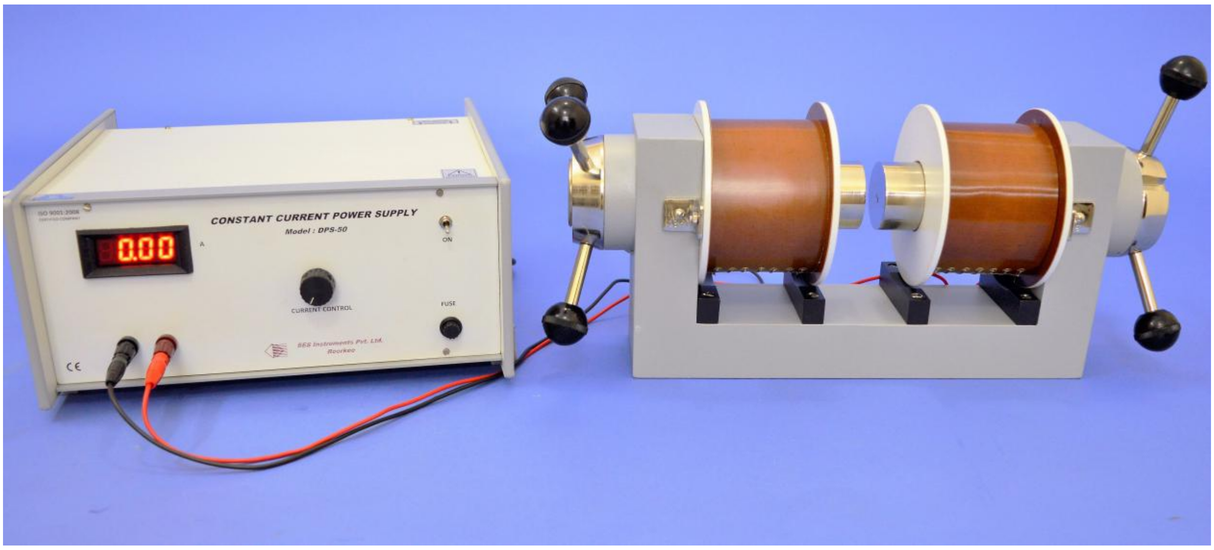
ISO 9001:2015

EMU-50

Electromagnet



EMU-50, EMU-50T

These electromagnets have the most widely used 'U' shaped soft iron yoke. The soft iron is of a special quality, structurally uniform, well machined and finished to meet the rigid standards.

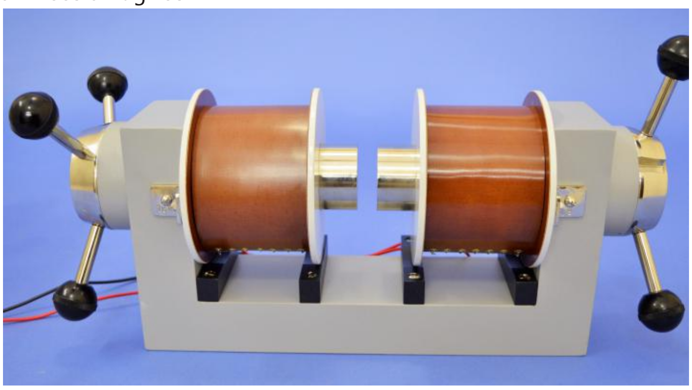
The pole pieces are made from dead annealed soft iron blocks of the best quality available. They are well shaped, machined and finished. The air-gap is continuously variable with two way knobbed wheel screw adjusting system. EMU-50V is supplied with flat pole pieces and EMU-50T is supplied with tapered pole pieces.

The coils are wound on non-magnetic former with uniform layers of S.E. copper wire. The new and modern design of the coils provides good thermal conductivity characteristics and eliminates troublesome hot spots even at high magnetic fields.

Specifications

Field Intensity	:	7.5KG at 10mm air-gap with flat pole pieces (In EMU-50V) 9.0KG at 10mm air-gap with tapered pole pieces (In EMU-50T)
Pole Pieces	:	50mm diameter
Energising Coils	:	Two, each with a resistance of about 3.0Ω
Power Requirement	:	0-30Vdc, 4A, if coils are connected in series
Weight	:	33Kg

Constant Current Power Supply, DPS-50 shown in above picture need to be purchased separately and it is not included in the cost of Electromagnet.



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ISO 9001:2015

DPS-50

Constant Current Power Supply

DPS-50, DPS-50-C1

DPS-50 is an inexpensive and high performance constant current source suitable for small and medium sized electromagnets. Although the equipment is designed for the Electromagnet, Model: EMU-50, it can be used satisfactorily with any other electromagnet provided the coil resistance does not exceed 6W.

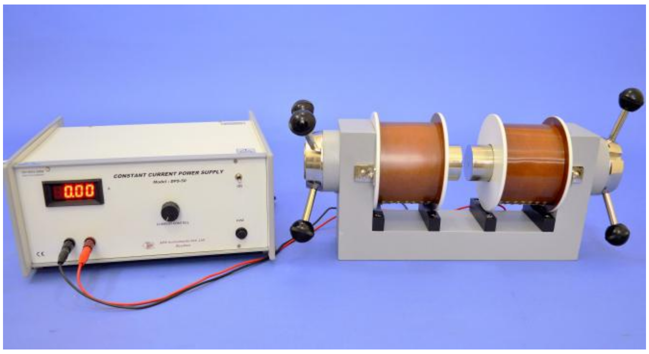
The current regulation circuit is IC controlled and hence results in the highest quality of performance. Matched power transistors are used to share the load current. The supply is protected against overload, short circuit and transient caused by the inductive load of the magnet.

Specifications

Current Range	:	Smoothly adjustable from 0-4A
Load Regulation	:	0.1% for load variation from 0 to max.
Line Regulation	:	0.1% for ±110% mains variation
Display	:	3½ digit, 7 segment LED DPM
Power	:	220V ±10%, 50Hz
Weight	:	9Kg
Dimensions	:	335mm X 305mm X 155mm

SES-CAMM Compatible (In DPS-50-C1 only)

This unit can also be connected to a PC through an interface module SES-CAMM SES-CAMM is a computer aided module for connecting multiple subunits of experiment such as Hall Effect Setup to same interface on a computer. This feature is particularly useful in making this model compatible with computerized versions of complete experiments from our company.



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ISO 9001:2015

DGM-102

Digital Gaussmeter (Basic Model)

- Mag. Field Measurement
- Excellent Linearity
- IC Controlled Circuit
- Excellent Stability

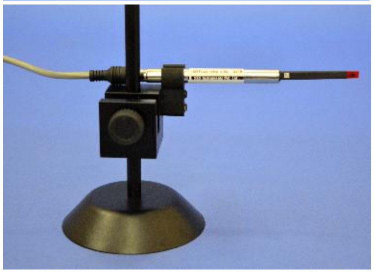
Introduction

DGM-102 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 millivoltmeter connected at the output of the amplifier can be calibrated directly in magnetic field unit (gauss).

Applications

- Wide application in industry where accurate measurements of magnetic field is required.

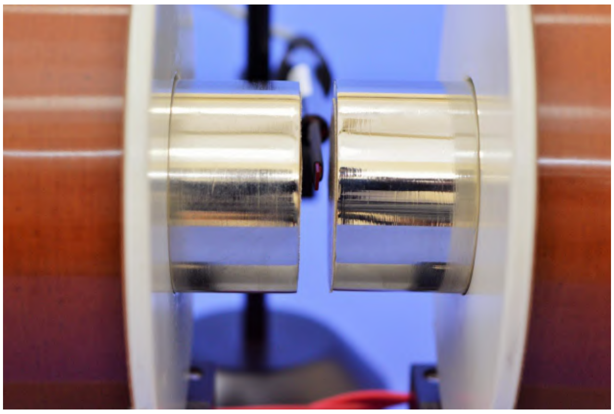
- Measurement of steady magnetic field e.g. in loud speakers, dynamos, moving coil instruments etc.



- Useful in laboratory experiments involving electromagnets.

Specifications

Range	:	0-2KG & 0-20KG
Resolution	:	1G at 0-2KG range
Accuracy	:	±0.5%
Temperature	:	Upto 50°C
Display	:	3½ digit, 7 segment LED DPM with auto polarity and overflow indication
Power	:	220V ±10%, 50Hz
Transducer	:	Hall Probe – GaAs
Special Feature	:	Indicate the direction of the magnetic field
Weight	:	3Kg
Dimensions	:	280mm X 255mm X 120mm



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ISO 9001:2015

DGM-202

Digital Gaussmeter (with interchangeable probe)

- Wide range (1G to 20KG)
- Excellent linearity
- Excellent stability
- Interchangeable Hall probes

Introduction

DGM-202 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 millivoltmeter connected at the output of the amplifier can be calibrated directly in magnetic field unit (gauss).

Applications

- Wide application in industry where accurate measurements of magnetic field is required.
- Measurement of steady magnetic field e.g. in loud speakers, dynamo, moving coil instruments etc.
- Useful in laboratory experiment involving measurement of magnetic field.
- With easy interchangeability of Hall Probe, same guassmeter can be used with both transverse and axial probe.

SES-CAMM Compatible (In DGM-202-C1 only)

This unit can also be connected to a PC through an interface module SES-CAMM. SES-CAMM is a computer aided module for connecting multiple subunits of experiments, such as Hall Effect Setup, to same interface on a computer. This feature is particularly useful in making this model compatible with computerized versions of complete experiments from our company.

Specifications

Resolution	:	1 gauss at 2 kilogauss range
Range	:	2KG and 20KG
Accuracy	:	±0.5%
Temperature	:	Upto 40°C
Display	:	3½ digit, 7 segment LED DPM with auto polarity and overflow indication
Power	:	220V ±10%, 50Hz
Transducer	:	Hall Probe-GaAs
Special Feature	:	Indicates the direction of the magnetic field
Interfacing	:	USB (In DGM-202-C1 model only)
Software	:	DACC and CAMM, both Window compatible (In DGM-202-C1 model only)
Weight	:	3Kg
Dimensions	:	280mm X 255mm X 120mm

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ISO 9001:2015

DGM-103

Digital Gaussmeter (with differential mode)

- Differential mode facility
- Wide Range (1G to 40KG)
- Excellent Linearity
- Excellent Stability
- Easy replacement of Hall Probe

Introduction

DGM-103 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 mf is called the Hall Voltage. The small Hall Voltage is amplified through a high stability amplifier so that a millivoltmeter connected at the output of the amplifier can be calibrated directly in magnetic field unit (gauss).

Applications

- Wide application in industry where accurate measurements of magnetic field is required.
- Measurement of steady magnetic field e.g. in loud speakers, dynamo, moving coil instruments etc.
- Useful in laboratory experiment involving measurement of magnetic field.
- With the differential mode facility, the instrument is especially useful for testing the homogeneity/ variation of magnetic field in a particular region.

Specifications

Range	:	0-2KG, 0-20KG & 0-40KG
Resolution	:	1G at 0-2KG range in normal mode 1G at 20KG & 40KG range in differential mode
Accuracy	:	±0.5%
Temperature	:	Upto 50°C
Display	:	3½ digit, 7 segment LED DPM with auto polarity and overflow indication
Power	:	220V ±10%, 50Hz
Transducer	:	Hall Probe – GaAs
Special Feature	:	Indicate the direction of the magnetic field
Weight	:	3Kg
Dimensions	:	280mm X 255mm X 120mm

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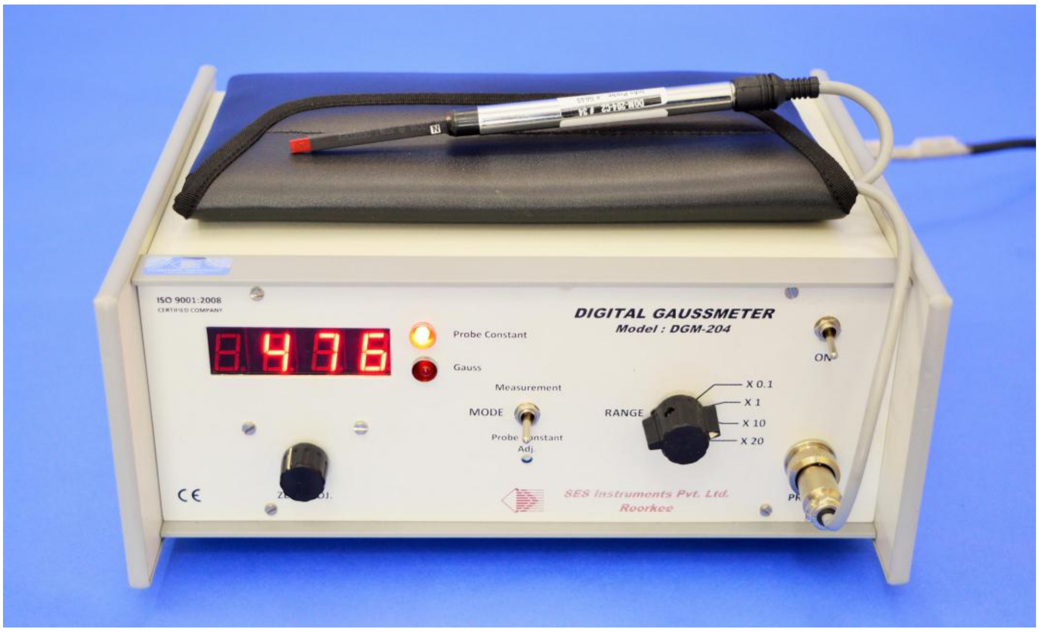
DGM-204

Digital Gaussmeter (with wide measurement range)

- Wide range (0.1G to 40KG)
- Excellent linearity
- Excellent stability
- Interchangeable Hall probes
- Built-in computer interface



Introduction

DGM-204 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. This small Hall Voltage is amplified through a high stability amplifier so that a millivoltmeter connected at the output of the amplifier can be calibrated directly in magnetic field unit (gauss).

Applications

- Current from photo multiplier tubes, photometers etc.
- Wide application in industry where accurate measurements of magnetic field is required.
- Measurement of steady magnetic field e.g. in loud speakers, dynamo, moving coil instruments etc.
- Useful in laboratory experiment involving measurement of magnetic field.
- With easy interchangeability of Hall Probe, same gaussmeter can be used with both transverse and axial probe.

Specifications

Resolution	:	0.1 gauss at 200G range
Range	:	200G, 2KG, 20KG and 40KG.
Accuracy	:	±0.5%, ±½ digit at 2KG, 20KG & 40KG range ±1%; ±1 digit at 200G range
Temperature	:	Upto 40°C
Display	:	3½ digit, 7 segment LED with autopolarity and decimal indication
Power	:	220V ±10%, 50Hz
Special Feature	:	Indicate the direction of the magnetic field
Interfacing	:	USB (In DGM-204-C2 model)
Software	:	DACC and CAMM, both Window compatible (In DGM-204-C2 model)
Weight	:	3Kg
Dimensions	:	280mm X 255mm X 120mm

Computer interface available in DGM-204-C2 Model.

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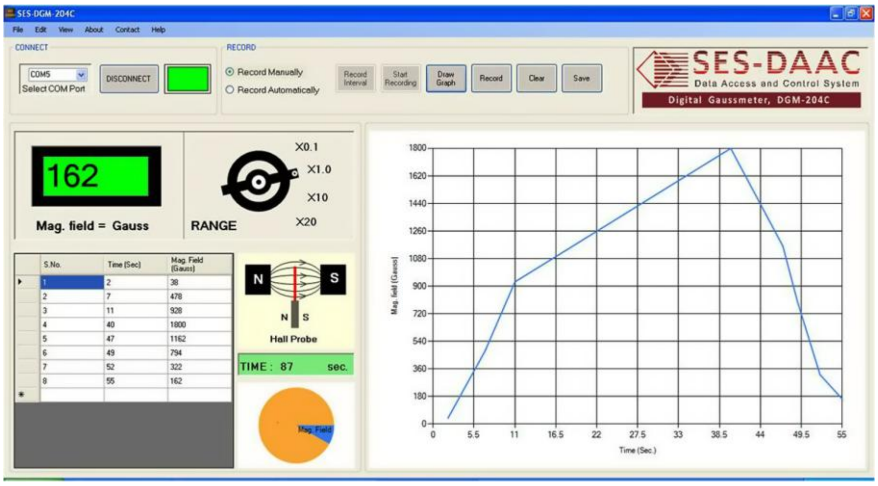
DGM-204

Digital Gaussmeter (with wide measurement range)



Computer Interface, SES-DAAC (In DGM-204-C2 only)

The unit can be connected directly to a PC through an USB port. SES-Data Access And Control is a built-in interface which gives user an option to store a value as displayed on the meter and tabulate it by the click of a button on the screen. Alternatively the data may be automatically entered into a table at user selectable interval. An 'END' button on the screen terminates the automatic tabulation.

The data stored in the table may then be displayed as a graph on the screen and may also be stored in an excel file for further processing. The software supplied with the unit is menu driven and is simple to operate.

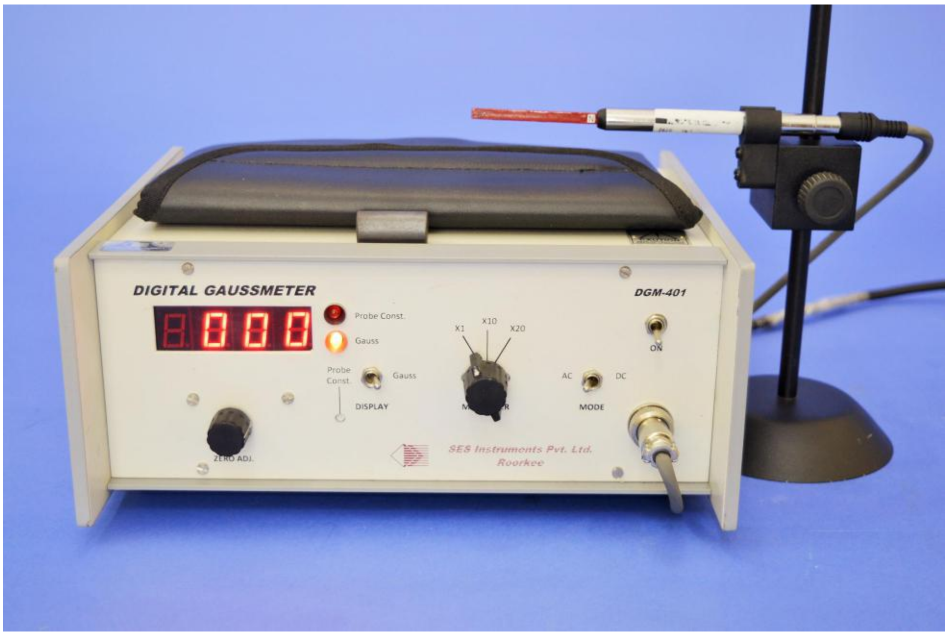
SES-CAMM Compatible (In DGM-204-C2 only)

This unit can also be connected to a PC through an interface module SES-CAMM to record magnetic field values. SES-CAMM is a computer aided module for connecting multiple subunits of experiments such as Hall Effect Setup to same interface on a computer. This feature is particularly useful in making this model compatible with computerized versions of complete experiments from our company.

DGM-401

Digital Gaussmeter (Measure a.c./d.c. magnetic field)

- AC and DC Mag. Field
- Wide Range (1G to 40KG)
- Excellent Linearity
- Excellent Stability
- Interchangable Hall Probe



Introduction

DGM-401 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 millivoltmeter connected at the output of the amplifier can be calibrated directly in magnetic field unit (gauss). In the AC range and rms to dc conversion circuit displays the rms value of the field.

Applications

- Wide application in industry where accurate measurements of magnetic field is required.
- Measurement of steady magnetic field e.g. in loud speakers, dynamo, moving coil instruments etc.
- Useful in laboratory experiment involving measurement of magnetic field.
- With easy interchangebility of Hall Probe, same guassmeter can be used with both transverse and axial probe.
- Both ac and dc magnetic fields may be measured.

Specifications

Resolution	:	1G at 2KG range & 10G at 20KG/ 40KG range
Range	:	2KG, 20KG and 40KG
Accuracy	:	±0.5%, ±½ digit at 2KG to 40KG range for both AC and DC measurements
Temperature	:	Upto 50°C
Display	:	3½ digit, 7 segment LED DPM with auto polarity and overflow indication
Power	:	220V ±10%, 50Hz
Transducer	:	Hall Probe – GaAs
Special Feature	:	Indicate the direction of the magnetic field
Weight	:	3Kg

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ISO 9001:2015

Digital Gaussmeter

DGM-HH-02

SES Instruments Pvt Ltd.

- **Long Battery Life**
- **Measurement range (1G to 20KG)**
- **DC to 50 kHz frequency range**
- **Max. and Min. field capture**
- **20 data storage location**
- **Self calibration of Hall Probe**

Introduction

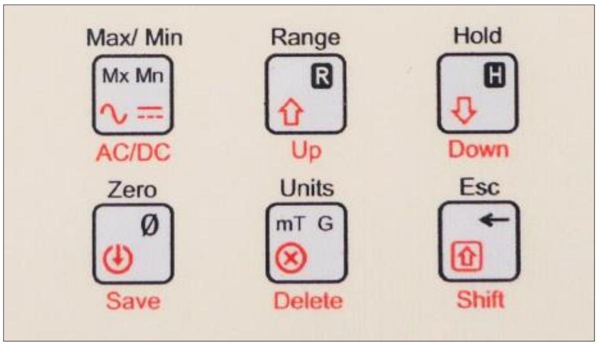
DGM-HH-02 operates on the principle of Hall Effect in semiconductors. A semiconductor carrying current develops an electromotive force when placed in a magnetic field. The direction of this emf is perpendicular to both the electric current and the magnetic field directions. Also this emf, called hall voltage, is proportional to the intensity of the magnetic field if the current is kept constant. The small Hall Voltage is amplified in the unit by highly stable amplifiers so that its value could be read on an 16x2 LCD. The complete unit operates from a 3200mAH Li-ion battery pack, ensuring 7-8 hrs of continuous operation. Charging cable comes with the unit.

Specifications

Resolution	1G at 2KG range & 10G at 20KG/ 40KG range
Range	2KG, 20KG
Display Units	Gauss (G), millTesla (mT)
Field	DC/ AC magnetic fields
Measurement Feature	Selectable Range, Max/Min Hold
Memory	Upto 20 data sample storage
Accuracy	±0.5% ±½ digit
Temperature	Upto 60°C (typical) (Sensor temperature can go higher)
Display	16x2 digit, backlit LCD
Power	Li-ion 3200mAH in-built chargeable battery
Transducer	Hall Probe – GaAs (Included)
Special Feature	Indicate the direction of the magnetic field

Applications

- Wide application in industry where accurate measurements of magnetic field are required.
- Laboratory experiments involving electromagnets.
- Extremely convenient magnetic field measurement in industrial environment. Can operate on battery for long durations without recharging.
- Multiple measurements can be stored and checked later.
- To check maximum and minimum fields of a surface.



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Digital Gaussmeter

DGM-HH-02C

SES Instruments Pvt Ltd.

- **Long life rechargeable battery**
- **Measurement range (1G to 20KG)**
- **DC to 30kHz frequency range**
- **Max. and min. field capture**
- **25 data storage location**
- **Self calibration of Hall Probe**
- **Computer link with software**

Introduction

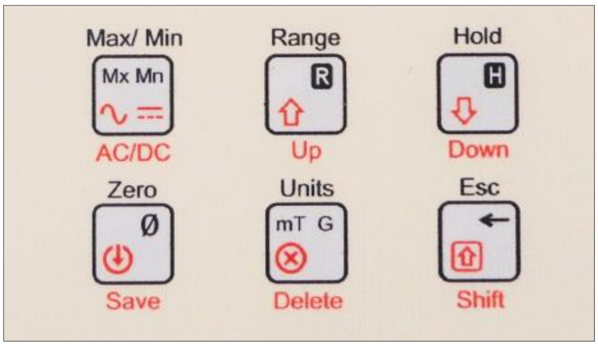
DGM-HH-02 operates on the principle of Hall Effect in semiconductors. A semiconductor carrying current develops an electromotive force when placed in a magnetic field. The direction of this emf is perpendicular to both the electric current and the magnetic field directions. Also this emf, called hall voltage, is proportional to the intensity of the magnetic field if the current is kept constant. The small Hall Voltage is amplified in the unit by highly stable amplifiers so that its value could be read on an 16x2 LCD. The complete unit operates from a 3200mAH Li-ion battery pack, ensuring 7-8 hrs of continuous operation. Charging cable comes with the unit.

Specifications

Resolution	1G at 2KG range & 10G at 20KG range
Range	2KG, 20KG
Display Units	Gauss (G), millTesla (mT)
Field	DC/ AC magnetic fields
Measurement	Selectable Range, Max/Min Hold Feature
Memory	Upto 20 data sample storage
Accuracy	±0.5% ±½ digit
Temperature	Upto 60°C (typical) (Sensor temperature can go higher)
Display	16x2 digit, backlit LCD
Power	Li-ion 3200mAH in-built chargeable battery
Transducer	Hall Probe – GaAs (Included)
Connectivity	USB connectivity for data transfer
Special Feature	Indicate the direction of the magnetic field
Calibration	Auto-Calibration

Applications

- Wide application in industry where accurate measurements of magnetic field are required.
- Laboratory experiments involving electromagnets.
- Extremely convenient magnetic field measurement in industrial environment. Can operate on battery for long durations without recharging.
- Multiple measurements can be stored and checked later.
- To check maximum and minimum fields of a surface.



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Teslameter

TM-400

Teslameter/ Gaussmeter

- **AC/ DC field measurements**
- **Wide range (0.1G to 40KG)**
- **Differential mode**
- **Maximum/ Minimum**
- **Hold function**
- **Built-in computer interface**

Introduction

TM-400 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. This small Hall Voltage is amplified through a high stability amplifier, the output of which is processed through a microncontroller and displayed on a graphical LCD display.

Specifications

- Range-1: 0 to ±4 Tesla (0 to ±40 KiloGauss)
- Range-2: 0 to ±2 Tesla (0 to ±20 KiloGauss)
- Range-3: 0 to ±200 milliTesla (0 to ±2 KiloGauss)
- Range-4: 0 to ±20 milliTesla (0 to ±200 Gauss)
- Display : 4 digit dot matrix graphic LCD, with appropriate decimal placement
- Units: Tesla, Gauss
- Functions: DC, AC (Freq. limited by hall probe)
- Accuracy : ±0.5% ±1digit
- Hall Probe: GaAs, upto 500KHz
- Mode: Normal, Differential
- Hold: Maximum, Minimum
- Refresh Rate: 3 samples per second
- Operating Temperature : Upto 40ºC
- Memory Type: Non Volatile, upto 25 samples
- Computer link: USB
- Software : DACC and CAMM, both Window compatible
- Power : 220V ±10%, 50Hz
  110V ±10%, 50Hz (optional)

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PID-TZ

PID Controlled Oven

Introduction

Small ovens are frequently used in class room experiments for the determination of temperature coefficients of resistances, capacitances, zener diodes, and also for studying the leakage currents of semiconductor devices at various temperatures. Conventional arrangement with oven fed from an auto transformer and thermometer type temperature measurement is unsatisfactory due to the long time it takes the oven to heat or cool, large time constant of mercury thermometers and difficulty in setting and maintaining a particular temperature.

Description

The unit is a high quality PID controller wherein the temperatures can be set and controlled easily. The P, I and D parameters are factory set for immediate use however the user may adjust these for specific applications as well as auto-tune the oven whenever required. The steps for these are given in the user manual. The controller can be used for both small oven, up to 200°C or a larger oven up to 600°C. The controller uses thermocouple as temperature sensor.

Above is 200° oven which is supplied with this unit.
600°c oven is also available on order.

Specifications Of The Oven Controller

The controller is designed around Autonics Temperature Controller Model TZN4S. Although this is a very versatile piece of equipment, below is a summary of the specifications that are relevant to the present application.

Temperature Range	:	Ambient to 600°C (as per order)
Power Supply	:	00-240VAC; 50/60Hz
Display Method	:	7 Segment LED display [Process value (PV):Red, Set value (SV):Green]
Input Sensor	:	Thermocouple (Chromel - Alumel)
Control Method	:	PID, PIDF, PIDS
Display Accuracy	:	±0.3%
Setting Type	:	Setting by front push bottons
Proportional Band (P)	:	0 to 100.0%
Integral Time (I)	:	0 to 3600 Sec
Derivative Time (D)	:	0 to 3600 Sec
Control Time (T)	:	1 to 120 Sec
Sampling Time	:	0.5 Sec
Setting (P, I & D)	:	Manual / Auto-tuned

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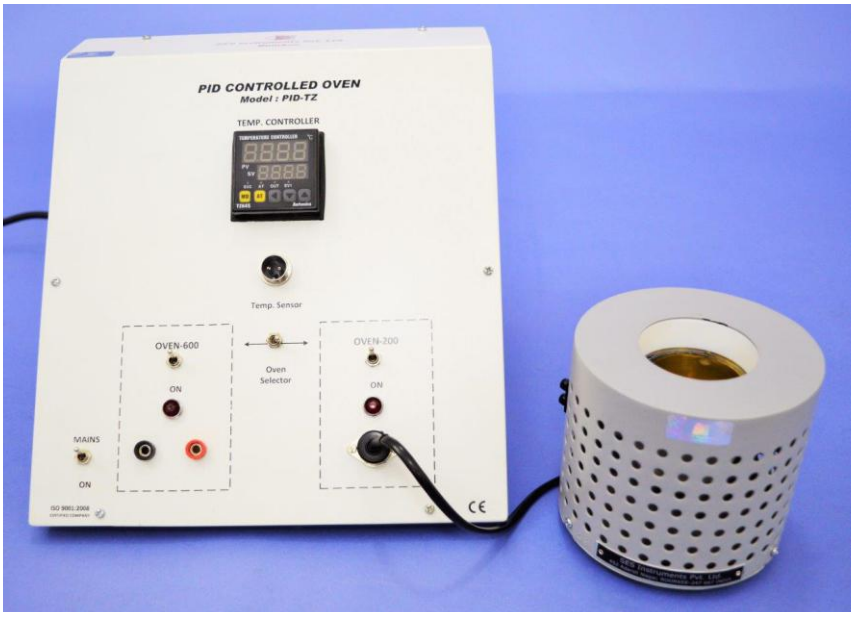
ISO 9001:2015

PID-TZ-C1

PID Controlled Oven (with computer interface)

Introduction

Small ovens are frequently used in class room experiments for studying the different parameters of various devices/ materials at various temperatures. Conventional arrangement with oven fed from an auto transformer and thermometer type temperature measurement is unsatisfactory due to the long time it takes the oven to heat or cool, large time constant of mercury thermometers and difficulty in setting and maintaining a particular temperature.



Description

The unit is a high quality PID controller wherein the temperatures can be set and controlled easily. The P, I and D parameters are factory set for immediate use however the user may adjust these for specific applications as well as auto-tune the oven whenever required. The steps for these are given in the user manual. The controller can be used for both small oven, up to 200°C or a larger oven up to 600°C. With present setup small oven is provided by default. The controller uses thermocouple as temperature sensor. The setup comes with computer output which can be connected to SES-CAMM unit for further interface to a computer.

Specifications Of The Oven Controller

The controller is designed around Autonics Temperature Controller Model TK4S. Although this is a very versatile piece of equipment, below is a summary of the specifications that are relevant to the present application.

Specification

Temperature Range	:	Ambient to 600°C (of controller only)
Power Supply	:	100-240VAC; 50/60Hz
Display Method	:	7 Segment LED display [Process value (PV):Red, Set value (SV):Green]
Input Sensor	:	Thermocouple (Chromel - Alumel)
Control Method	:	PID, PIDF, PIDS
Display Accuracy	:	±0.3%
Setting Type	:	Setting by front push bottons
Proportional Band (P)	:	0 to 100.0%
Integral Time (I)	:	0 to 3600 Sec
Derivative Time (D)	:	0 to 3600 Sec
Control Time (T)	:	1 to 120 Sec
Sampling Time	:	0.5 Sec
Setting (P, I & D)	:	Manual / Auto-tuned
Interface	:	Computer Interface through SES-CAMM unit

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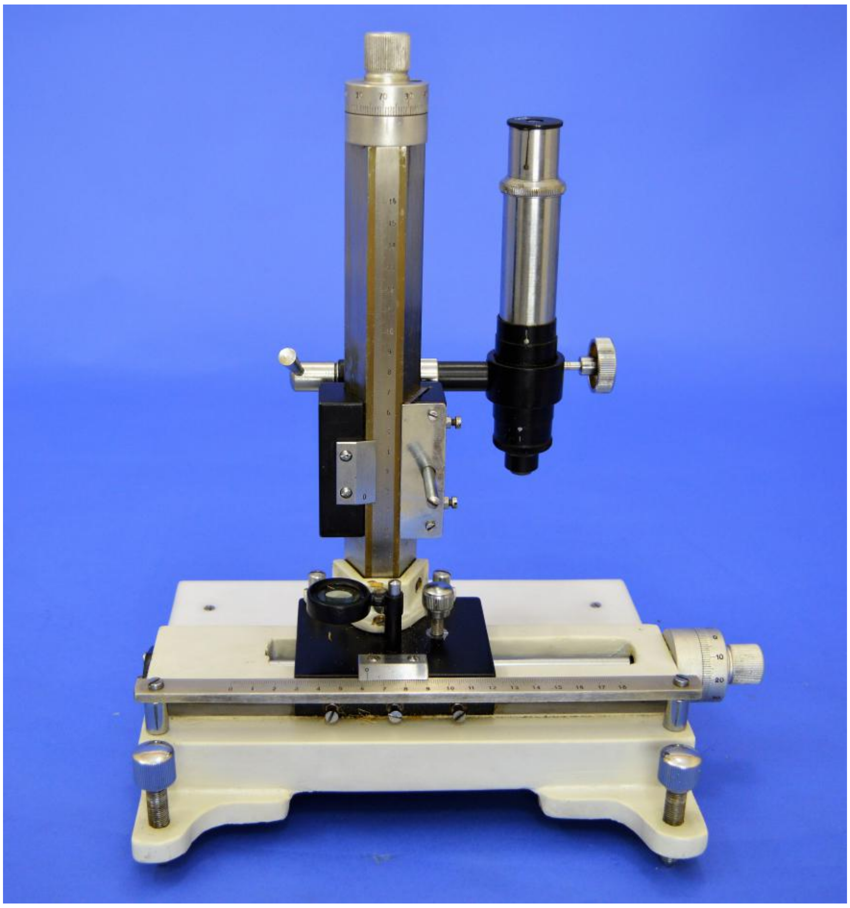
TVM-02

Traveling Microscope

Introduction

The bed is of a heavy casting, thoroughly aged and machined, is fitted with leveling screws. On the dovetail guide ways slides the horizontal carriage which can be clamped at any position by means of a thumbscrew. A second sliding carriage slides along a gunmetal vertical pillar fitted on the horizontal carriage. The slow motion guide bars are made of sturdy material and the motion is very smooth. For reading convenience, screw gauge arrangement is provided with a large dial.

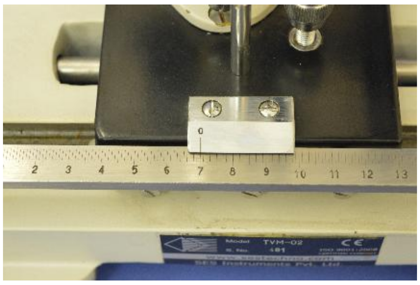


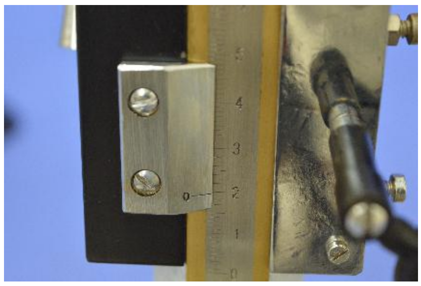
Microscope Tube

inclinable in any angle. True vertical and horizontal positions marked focusing.

Guide Ways

The guide ways over which slides the carriage is made of gunmetal and this makes the instrument Rust Proof, because this is the part which is directly exposed to the weather.





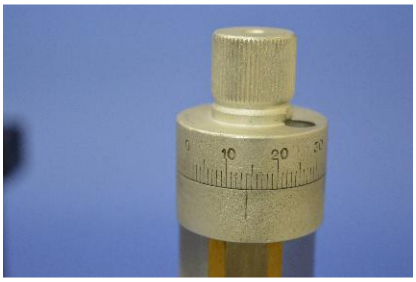
Scale and Verniers

Made of lifetime Stainless Steel.

Optics

(i) True achromatic objective with 7.5 cm. focussing distance from object

(ii) 10X Ramsden Eyepiece with fine cross wire



Scale and Verniers

(i) Horizontal scale : 18cm divided at 1mm interval

(ii) Vertical scale : 16cm divided at 1mm interval

(iii) Screw gauge dial : 100 divisions with a least count of 0.01mm

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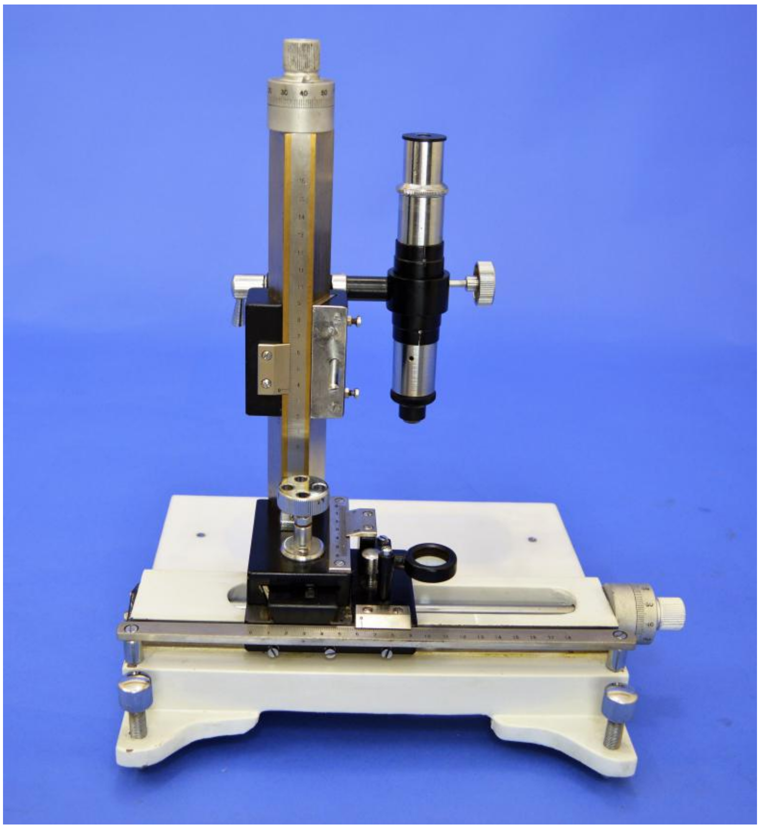
TVM-03

Traveling Microscope

Introduction

The bed is of a heavy casting, thoroughly aged and machined, is fitted with leveling screws. On the dovetailed guide ways slide the carriage which can be clamped at any position by means of a thumbscrew. A sliding carriage slides along a gunmetal Vertical pillar fitted on the horizontal carriage. The slow motion guide bars are made of sturdy material and the motion is very smooth. For reading convenience, screw gauge arrangement is provided with a large dial.



Microscope Tube

inclinable in any angle. True vertical and horizontal positions marked focusing.

Guide Ways

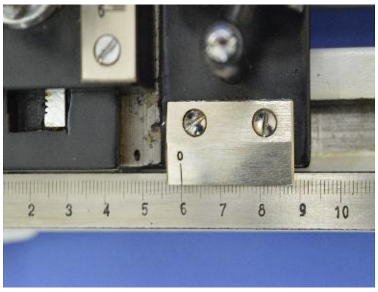
The guide ways over which slides the carriage is made of gunmetal and this makes the instrument Rust Proof, because this is the part which is directly exposed to the weather.

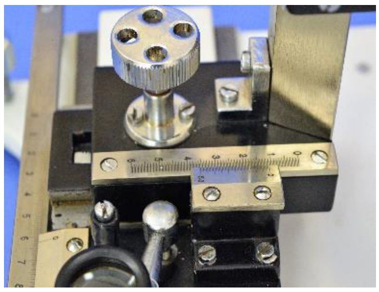
Scale and Verniers

Made of lifetime Stainless Steel.

Optics

True achromatic objective with 7.5 cm. focusing distance from object 10X Ramsden Eyepiece with fine cross wire is provided.





Scale

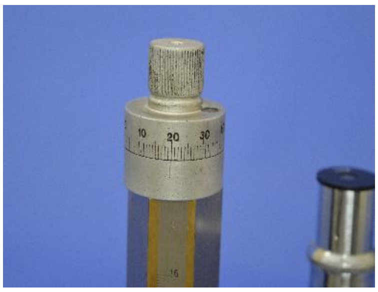
20 cm. Horizontally, 15 cm. Vertically and 6 cm Lateral.

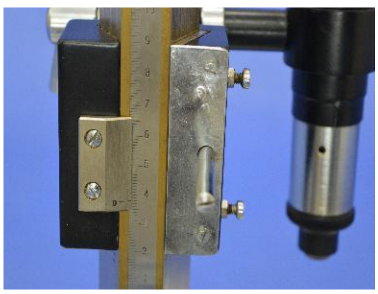
Scale and Verniers

(I) horizontal scale : 20cm divided at 1mm interval (Screw gauge dial 100 divisions with a least count of 0.01 mm)

(ii) Vertical scale : 15cm divided at 1mm interval

(iii) Lateral scale : 6cm divided at 1mm interval





Scale and Verniers

Horizontal scale : 0.001 cm.

Lateral Scale : 0.001 cm.

Vertical scale : 0.001 cm.

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PS-12

IC Regulated Power Supply

Introduction

PS-12 is general purpose power supply consists of four independent fixed voltage regulated sources viz. +12 V, -12 V, +5 V and -5 V referred to a common ground. The current rating for each is specified at 300 mA, although it is possible to exceed this limit safely when all four sources are not operating simultaneously. The compact power supply unit is well suited for any general laboratory which uses linear and digital circuits and IC's. At the same time the excellent performance of the 3- terminal regulators enables the supplies to be used equally satisfactorily for sophisticated inst-rumentation applications. The built-in protection of the regulator in the form of over current and safe area shutdown ensure continued fault free operation of the unit without any maintenance.

Specifications

Output voltage	:	+ 12 V, - 12 V, + 5 V, - 5 V fixed
Current	:	300 mA (each supply)
Line Regulation	:	± 0.05 % for 10 % variation of mains voltage.
Load Regulation	:	± 0.1% for a full load of 300 mA
Protection	:	Thermal and overcurrent.
Dimensions	:	210 m.m. X 180 m.m. X 100 m.m.
Weight	:	2.25 Kg

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FG-01

Function Generator

- 4-digit counter based frequency display-Maximum error ONE LSB
- Square, sine and triangular output upto 2 MHZ
- IC based circuit - high stability, low distortion
- Regulated power supply

Specifications

Waveforms	:	Square/ Sine/ Triangular (switch selectable)
Frequency	:	10 Hz - 2 MHz in five ranges
Amplitude	:	Square 0-3V (p-p) Triangular 0-3V (p-p) Sine 0-3V (p-p)
Output Impedance	:	50 W
Frequency Readout	:	4-digit, counter based, automatic decimal point
Power Supply	:	220V±10%, 50 Hz

Introduction

This is an economically priced signal source for a wide variety of applications in electronics, communication and control systems laboratory. The IC used is a high frequency function generator that produces low distortion sine, triangular, sawtooth and square waveforms from frequencies less than a Hz. To 20MHz. A minimal of external components are needed which make the unit very reliable and robust. The desired output waveform is selected by logic control and may therefore be done electronically as well.

Basic principal of function generation used is the relaxation oscillation with periodic charging and discharging of a capacitor through constant current source. The charging/discharging currents are accurately controllable and the associated circuits support high frequencies very well. A sine shaping circuit coverts the triangular waveform to sine wave of constant amplitude. The sine wave is useful for frequency response studies of amplifiers, filters and other electrical systems, while the square wave finds applications in transient response studies. Triangular wave is a standard input signal for the study of steady state error in feedback control systems. All power supplies are IC regulated.

JDS-6600

DDS Function Generator

15MHZ Digital Control Dual-channel DDS Function Signal Generator/frequency meter

- 2.4" Color TFT display
- Precise stable, low distortion output
- Dual channel output
- Storage Feature
- Counter function
- USB interface
- A ritary waveform editing function

Introduction

This is a dual—channel high precision multifunctional signal generator. It adopts large scale of FPGA integrated circuits, high—speed MCU microprocessor and high precision oscillator, which make the signals highly stable. It contains two independent dual—channel DDS signal and TI'L level output and is capable of generating sine/triangle/square/sawtooth/pulse wave, white noise, etc. This is a multifunction instrument capable of generating signal, scanning waveform and measuring various electrical parameters. With frequency range of upto 15MHz, it has built-in functions including amplitude modulation and frequency sweep function etc. Output signal amplitude and frequency are continuously displayed. It's a great testing/ measuring instrument for electronics engineers, electronic laboratory, teaching and research.

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JDS-6600

DDS Function Generator

Specifications

Frequency Characteristics

Sine frequency range	:	15MHz
Square/Triangle frequency range	:	15MHz
Pulse frequency range	:	6MHz
Square rise time	:	25nS

Waveform Characteristics

Waveform	:	Sine, Square, Triangle, Pulse), Partial Sine, DC level, Half-wave, Full-Wave, Positive Ramp, Negative Ramp, and many other user defined waveforms
Waveform length	:	2048 points
Waveform sampling rate	:	266 MSamples/s
Waveform vertical resolution	:	14 bits

External Measurement Function

Frequency meter function	:	1Hz-100MHz
Counter function	:	0-4294967295 counts
Input signal voltage range	:	2Vpp-20Vpp
Pulse width measurement	:	0.01us (resolution),
Period measurement	:	20s (max measuring time)

General technical parameters

Display	:	2.4 inch TFT color LCD
Interface	:	USB to serial interface
Communication speed	:	115200bps
Communication protocol	:	Command-line mode, Open protocol
Power supply voltage	:	5V±0.5V DC
Manufacturing process	:	Surface-mount technology, FPGA design, high reliability, long service life

Environmental conditions

Temperature	:	0-40C, Humidity:<80%

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XDE-01

X-Ray Diffraction Simulation Experiment

Identification of Lattice and Determination of Lattice Constant by X-Ray Diffraction

Introduction

Regular arrangement of atoms in molecules and extended solids is very common. In crystalline solids the atoms are arranged in repeating three-dimensional arrays or lattices. Information regarding atomic bond distances and angles is fundamental to understanding the chemical and physical properties of materials. Since atomic dimensions are of the order of angstroms (10^{-10}m), unraveling the relative atomic positions of a solid requires a physical technique that operates on a similar spatial scale, Diffraction experiments involving X-ray, electron and neutron sources have therefore played a very crucial role in unraveling these structures. The significance of these experiments in science and engineering courses has been recognized. However, the cost of the equipment and the hazards associated with these experiments have made them very difficult to be integrated and included in a teaching laboratory setting.

The present set-up overcomes these limitations. An increase in scale by thousands from short wavelengths of X-rays to the long wavelengths of visible light, and by hundreds of thousands from an array of atoms in a crystal or an extended solid to an array of dots, allows us to replicate the basic features of a structural determination experiment in a teaching laboratory.

In place of Bragg diffraction whose results are to be simulated, we use Fraunhoferdiffraction. Visible laser light passes through an array of scattering centers (dots) on a 35 mm slide. The diffraction pattern is viewed at what is effectively infinite distance (a meter or so). This arrangement is capable of illustrating many of the essential features of the standard X-ray experiment. Mathematically, the equations for Fraunhofer and Bragg diffraction have a similar functional dependence on the interatomic distance, wavelength and the scattering angle. The symmetry of the diffraction pattern is same as the symmetry of the lattice causing the diffraction.

The central piece of the set-up is a slide (transparency) with eight (A-H) different arrangements of scattering centers (dots) on different portions of the slide (Figure 3). The examples presented here serve to illustrate how the spacings, symmetries, spot intensities and systematic absences in a diffraction pattern are related to the lattice from which it is derived. Although these are two—dimensional lattices, they mimic what would be observed for diffraction from particular three-dimensional structures that are viewed in projection perpendicular to a face.

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Setup

A mains operated constant current laser light, mounted on a stand is put at one end of an optical bench. The slide is mounted on another stand (Figure 1) which is kept at about 10-20 cm away from the laser such that the laser light falls normally on the slide. The slide on this stand can be moved sideways and vertically so that the laser light falls on different portions of the slide. The diffraction pattern is observed on a perspex screen (Figure 2) fixed normal to the laser light at the other end of the optical bench. The whole set-up is put in a darkened room where the experiment is performed.

Figure1

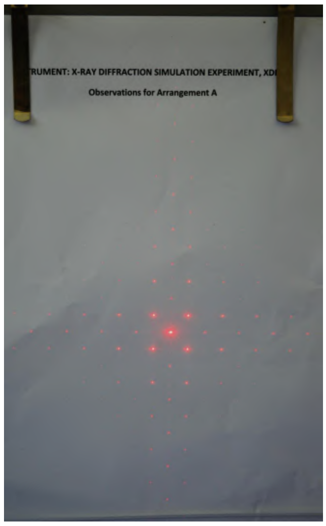


Figure2

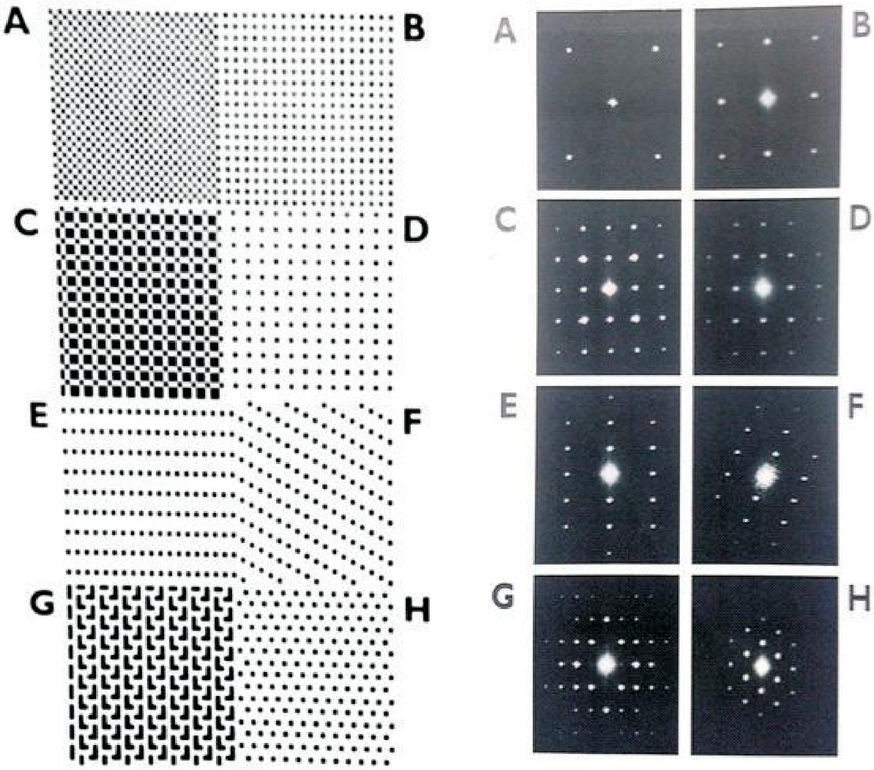


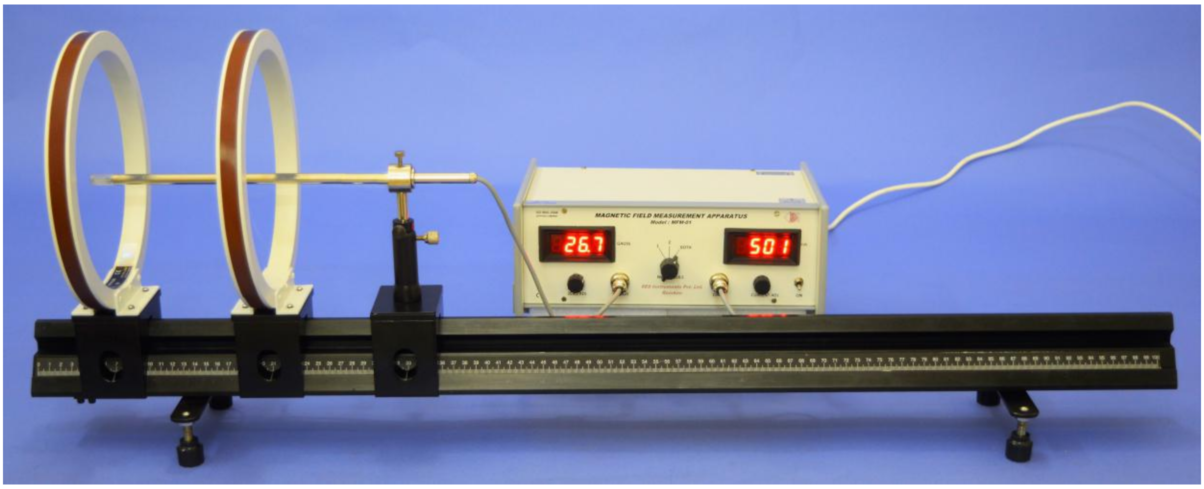
Figure3: Shows the diffraction pattern obtained with different arrangements in the slide.

Aim

The basic aim of the experiment is to identify the lattice and to determine its lattice constant.

MFM-01

Magnetic Field Measurement Appartus (Biot Savart's Law Set-up)



Introduction

The experiment consists of two coils, Constant Current Power Supply and Gaussmeter. The Gaussmeter probe is mounted on a rail with a scale. It can move smoothly and precisely for measurement of magnetic field along the centre of the coils.

The following studies Biot Savart's Law can be carried out with the set-up:

1. Study of magnetic field due to one coil and calculation of its diameter.

2. Study of Principal of super-imposition of magnetic field due to 2 coils by keeping the distance between the coils at a, >a and <a, where a is the radius of the coil.

Legend

Line 1	:	Magnetic Profile when the distance between the coils is >a
Line 2	:	Magnetic Profile when the distance between coils is =a
Line 3	:	Magnetic Profile when the distance between coils is <a Superimposition overlaps completely

Apparatus consists of the following

1. Digital Gaussmeter

Range	:	0-200
Resolution	:	0.1G
Accuracy	:	± 0.5%
Display	:	3½ digit 7 segment LED with autopolarity.

2. Two Coil

Diameter	:	200mm
Number of turn	:	1000

3. Constant Current Power Supply

Current	:	0-0.5A Smoothly adjustable
Line Regulator	:	± 0.2%for 10% mains variation.
Load Regulator	:	± 0.2% for 0 to full load
Display	:	3½ digit 7 Segment LED Display
Protection	:	Against overload/ short current.

The 2 coils are mounted on platform one coil is fixed and other coil move smoothly on a rail along with the axis of the coils.

The experiment is complete in itself.

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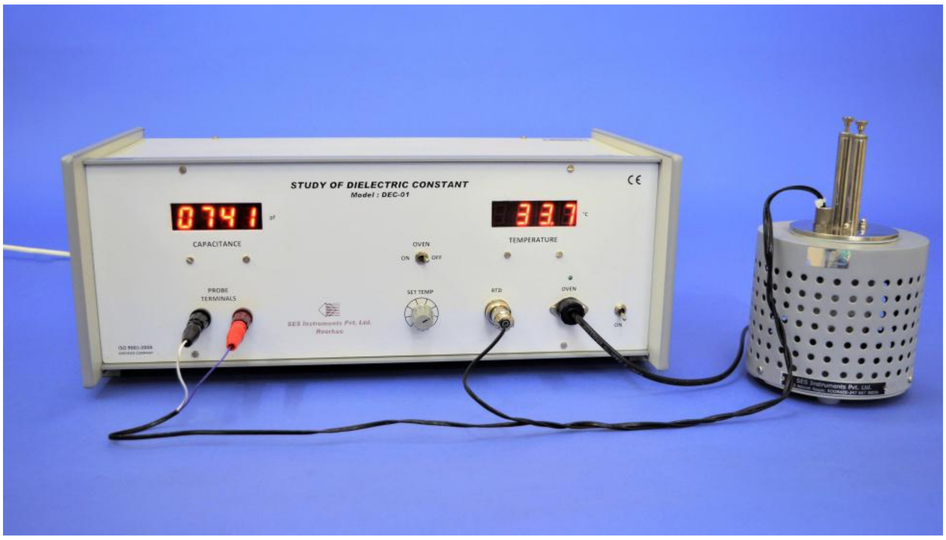
DEC-01

Study Dielectric Constant

Study of Dielectric Constant and Curie Temperature of Ferroelectric Ceramics



Dielectric or electrical insulating material are understood as the material in which electrostic field can persist for long times. Layers of such substance are commonly inserted into capacitors to improve their perfomance, and the term dielectric refers specifically to this application.

An electric field polarizes the molecules of dielectric producing concentrations of charge on its surface that create an electric field opposed (antiparallel) to that of capacitor. This reduces the electric potential. Considered in reverse, this means that, with a dielectric, a given electric potential causes the capacitor to accumulate a larger charge.

Applications

Beside the common and well known application of capacitors in electrical and electronic circuits, the capacitors with an exposed and porous dielectric can be used to measure humidity in air.

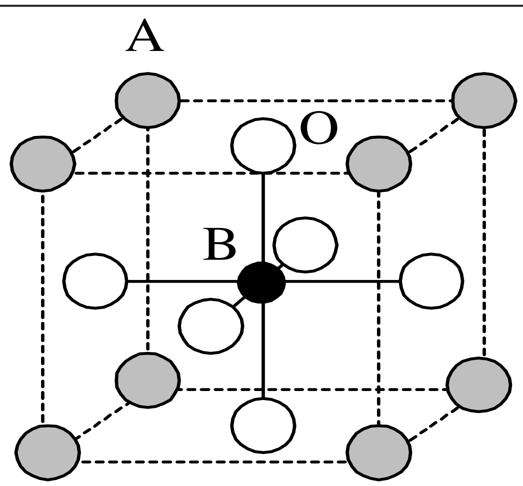


Fig 1 Perovskite ABO_3 structure with the A and B cations on the corner and body centre positions, respectively. Three oxygen anions per unit cell occupy the faces and form octahedra surrounding the B-site.

A huge leap in the research on dielectric (ferroelectric materials) came in 1950's, leading to the wide spread use of Barium Titanate ($BaTiO_3$-Perovskite Structure) based ceramics in capacitor applications and piezoelectric transducer devices. Since then, many other ferroelectric ceramics have been developed and utilized for variety of applications: various type of capacitors, non volatile memories in computers, etc.

Perovskite Structure

Perovskite is family name of a group of materials and the mineral name of calcium titanate ($CaTiO_3$) having a structure of the type ABO_3 (Fig 1)

A practical advantage of perovskite structure is that many different cations can be substituted on both A and B sites without changing the over all structure. Even though two cations are compatible in solution, their behaviour can be radically different when apart from each other. Thus it is possible to manipulate material's properties such as Curie temperature or dielectric constant with only a small substitution of given cation.

All ferroelectric material have a transition called the Curie point (T_c). At $T>T_c$, the crystal does not exhibit ferroelectricity, while for $T<T_c$ it is ferroelectric. If there is more than one ferroelectric phase, the temperature at which the crystal transforms one phase to another is called transition temperature. Near the Curie temperature point or transition temperatures, the thermodynamic properties including dielectric, elastic, optical and thermal constants show an anomalous behavior.

Fig.2 shows the variation of dielectric constant (e) with temperature for Lanthanum doped Lead Zirconate Titanate (PLZT) ceramic, which is cooled from its paraelectric cubic phase to ferroelectric rhombohedral phase.

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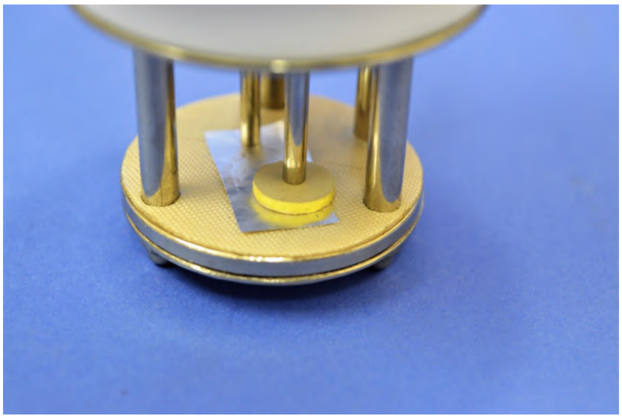
DEC-01

Study Dielectric Constant

Description of the Experimental Set-up

1. **Probes Arrangement**

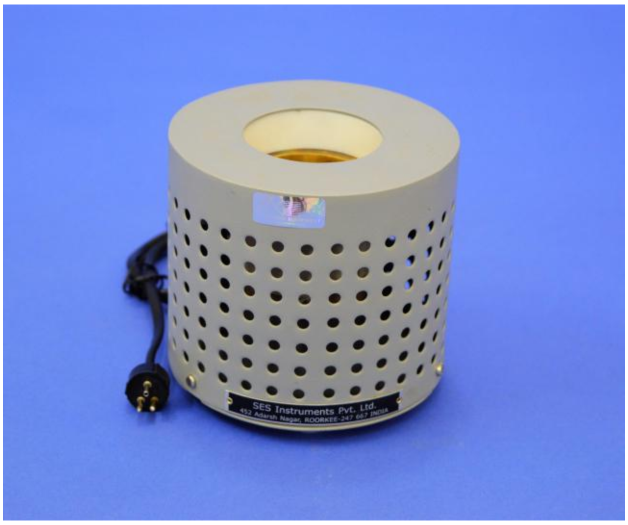


It has two individually spring loaded probes. The probes arrangement is mounted in a suitable stand, which also holds the sample plate. To ensure the correct measurement of sample temperature, the RTD is embedded in the sample plate just below the sample. This stand also serves as the lid of temperature controlled oven. Proper leads are provided for connection to Capacitance Meter and Temperature Controller.

2. **Sample**

   Barium Titanate ($BaTiO_3$)

3. **Oven**



This is a high quality temperature controlled oven. The oven has been designed for fast heating and cooling rates, which enhances the effectiveness of the controller.

4. **Main Units**

   The Set-up consists of two units housed in the same cabinet.

   (i) Oven Controller

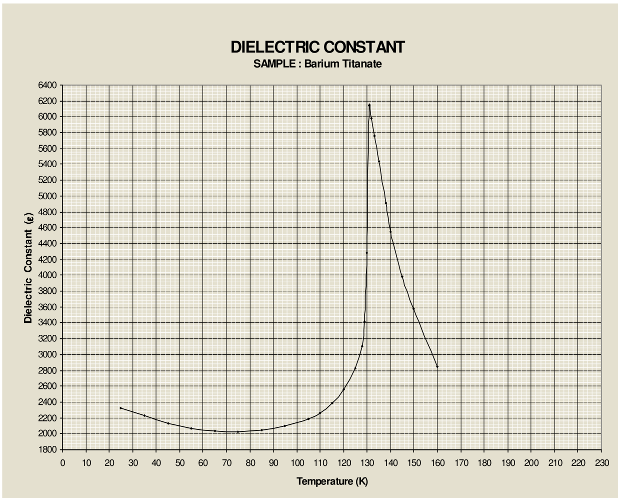
   Platinum RTD (A class) has been used for sensing the temperature. A Wheatstone bridge and an instrumentation amplifier are used for signal conditioning. Feedback circuit ensures offset and linearity trimming and a fast accurate control of the oven temperature.

Specifications		
Temperature Range	:	Ambient to 200°C
Display	:	3½ digit, 7 segment LED with autopolarity & decimal indication
Resolution	:	0.1°C
Accuracy	:	±0.5°C (typical)
Stability	:	±0.1°C
Power	:	150W

   (ii) Digital Capacitance Meter

   This a compact direct reading Instrument for the measurement of capacitance of the sample.

Specifications		
Range	:	50-6000 pf
Resolution	:	1pf
Display	:	3½ digit, 7 segment LED



Typical results obtained with the above set-up are as shown in the graph

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Frequency Dependence of Dielectric Constant

FDD-01

SES Instruments Pvt Ltd.

Frequency Dependence of Dielectric Constant

- Capacitance measurement from 1-50kHz
- Dedicated Schering Bridge with built-in oscillator
- Computation of dielectric constant and loss factor
- Samples of Barium Titanate, MLCC and conventional capacitor
- Temperature variation studies with additional equipment oven and controller (optional)
- Essential accessory a CRO, for all the experiments

Introduction

Barium Titanate, $BaTiO_3$, is a well known and widely investigated dielectric material. It is mainly used in capacitors due to its high dielectric constant. The dielectric properties of $BaTiO_3$ are controlled by purity and microstructure which are dependent on the methods of preparation. The ability of the dielectric material to store energy is attributed to the polarization which can result in an increase in capacitance. It is well known that dielectric properties of every solid are very sensitive to the local electric field distribution in the sample. The temperature and frequency dependence of dielectric constant and loss can therefore give useful information about structure changes, transport mechanism and defect behaviour of a solid.

The present experiment is designed to study the variation of capacitance and dielectric losses as a function of frequency and hence compute the change in dielectric constant, ε and loss factor, $\tan\delta$ with frequency. While the behaviour of Barium Titanate is distinctly frequency dependent, the performance of a standard multi layer ceramic capacitor (MLCC) and conventional ceramic capacitors are not as prominent. A comparison of these three therefore is an interesting part of the study.

In addition, an optional experiment to study the variation of dielectric constant with temperature at different frequencies is also possible with the help of our PID controlled oven, PID-TZ

Experiments

- Study of dielectric constant variation with frequency of a Barium Titanate sample
- Study of loss factor with frequency of a Barium Titanate sample
- Study of capacitance variation with frequency of an MLCC capacitor
- Study of capacitance variation with frequency of a conventional ceramic cap.

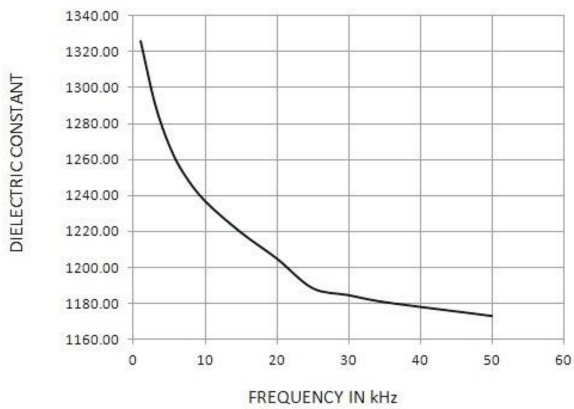

Fig 1 ε vs frequency of Barium Titanate sample

Typical result for Barium Titanate is shown in Fig 1.

Optional Experiment (Using an additional PID-TZ)

- Study of Dielectric Constant of Barium Titanate as a function of temperature (curie point experiment) and its variation with frequency

Typical results are shown in Fig 2.

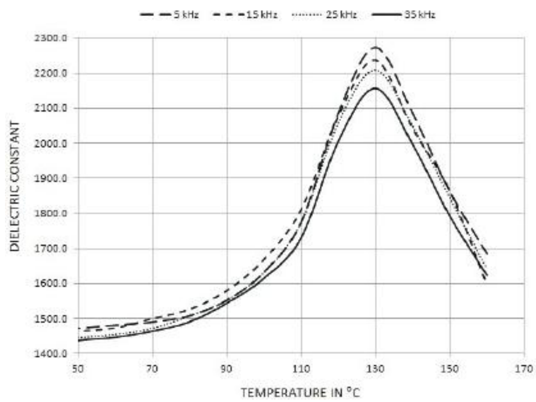

Fig 2 ε vs temperature at various frequencies of Barium Titanate sample

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DCL-01

Dielectric Measurement Setup

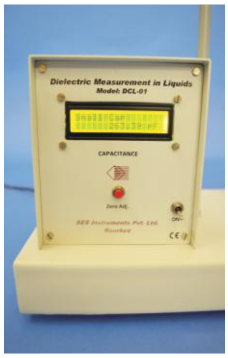
Dielectric measurement of non-conducting liquids

- High Precision
- Smooth movement
- Accurate measurement
- Easy change of sample

Introduction

Dielectric or electrical insulating materials are the substances in which electrostatic field can persist for long times. When a dielectric is placed between the plates of a capacitor and the capacitor is charged, the electric field between the plates polarizes the molecules of the dielectric. This produces concentration of charge on its surface that creates an electric field which is antiparallel to the original field (which has polarized the dielectric). This reduces the electric potential difference between the plates. Considered in reverse, this means that, with a dielectric between the plates of a capacitor, it can hold a larger charge. The extent of this effect depends on the dipole polarizability of molecules of the dielectric, which in turn determines the dielectric constant of the material.

The method for determination of dielectric constants of liquids consists in the successive measurement of capacitance, first in a vacuum, and then when the capacitor is immersed in the liquid under investigation. A cylindrical capacitor has been used here.



Description of the Experiment Set-up

1. Probes Arrangement

It consists of two polished brass cylinders fixed coaxially with insulating gaskets at the two ends. These gaskets have holes, in the lower one for allowing the experimental liquid to flow in between the cylinders, and in the upper one for communication with the atmosphere. This arrangement is mounted vertically and can be moved up and down with a rack-and-pinion set-up. It is put in a vessel containing the experimental liquid. The outer surface of the outer cylinder has a vertical scale to measure the height of the liquid with in the cylinders. Proper leads are provided for connection to the Capacitance Meter.

Sample : Carbon Tetra Chloride

2. Digital Capacitance Meter

This is a compact direct reading micro-controller based high resolution instrument for the measurement of capacitance of the sample.

Specification

Range	:	0pf – 50mf
Resolution	:	0.01pf
Display	:	16 x 2 LCD display with back light
Accuracy	:	Better than 1%
Zero Setting	:	Push button zero setting

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DSL-01

Dielectric Constant of Solids & Liquids

Determination of Dielectric measurement of different materials

- High Precision
- Smooth movement
- Accurate measurement
- Easy change of sample

Introduction

Dielectric or electrical insulating materials are the substances in which electrostatic field can persist for long times. When a dielectric is placed between the plates of a capacitor and the capacitor is charged, the electric field between the plates polarizes the molecules of the dielectric. This produces concentration of charge on its surface that creates an electric field which is antiparallel to the original field (which has polarized the dielectric). This reduces the electric potential difference between the plates. Considered in reverse, this means that, with a dielectric between the plates of a capacitor, it can hold a larger charge. The extent of this effect depends on the dipole polarizability of molecules of the dielectric, which in turn determines the dielectric constant of the material.

The method for determination of dielectric constant of liquids consist of the successive measurement of capacitance, first outside liquid and then when the capacitor is immersed in the liquid under investigation. A cylindrical capacitor has been used for liquid samples and different size parallel plate capacitors for solid samples.

1. Probes Arrangement

Three probe arrangements are provided with the setup. For solids, two different size arrangements are given, one for 10mm sample pellets and the other for 50mm sample pellets. Both consist of parallel plates set in insulated medium. Sturdy parallel wire lead is used to minimize external disturbance.

For liquids a separate arrangement is provided consisting of two polished brass cylinders fixed coaxially with insulating gaskets at the two ends. These gaskets have holes, in the lower one for allowing the experimental liquid to flow in between the cylinders, and in the upper one for communication with the atmosphere. This arrangement is mounted vertically and can be moved up and down with a rack-and-pinion set-up. It is put in a vessel containing the experimental liquid. The outer surface of the outer cylinder has a vertical scale to measure the height of the liquid within the cylinders. Proper leads are provided for connection to the Capacitance Meter.

2. Samples

Glass, Bakelite, Teflon, PZT Sample (Lead Titanate), Carbon Tetrachloride Liquid

3. Digital Capacitance Meter

This is a compact direct reading microcontroller based high resolution instrument for the measurement of capacitance of the sample.

Specifications		
Range	:	0pf – 50mf
Resolution	:	0.01pf
Display	:	16 x 2 LCD display with back light
Accuracy	:	Better than 1%
Zero Setting	:	Push button zero setting

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DEC-600

Dielectric Measurement Setup

Measurement of dielectric constant at high temperature (ambient to 600°C)

Introduction

Beside the common and well known application of capacitors in electrical and electronic circuits, the capacitors with an exposed and porous dielectric can be used to measure humidity in air. A huge leap in the research on dielectrics (ferroelectric materials) came in 1950's, leading to the wide spread use of ceramics in capacitor applications and piezoelectric transducer devices. Since then, many other ferroelectric ceramics have been developed and utilized for a variety of applications: various type of capacitors, nonvolatile memories in computers, etc.

Description of the Experiment Set-up

1. Probes Arrangement

It has two individually spring loaded probes. The probes arrangement is mounted in a suitable stand of high quality alumina which also holds the sample plate. To ensure the correct measurement of sample temperature, the thermocouple junction is embedded in the sample plate just below the sample. This stand also serves as the lid of temperature controlled oven. Proper leads are provided for connection to Capacitance Meter and Temperature Controller.

2. Sample

Modified lead titanate (test sample)

3. Oven

This is a high quality temperature controlled oven. The heating element used is a high grade Kanthal-D. It is cover. Further the top portion is also suitably covered to meet the safety standard. The oven has been designed for fast heating and cooling rates, which enhances the effectiveness of the controller.

4. Main Units

The Set-up consists of two units housed in the same cabinet.

(i) Temperature Controller
It is a high quality PID controller where the temperatures can be set and controlled easily. P, I and D can be adjusted by the user and can also be kept on Auto-tuning.

Specification

Temperature Range	Ambient to 600° C
Power Supply	100-240VAC; 50/60Hz
Display Method	7 Segment LED display [Processing value (PV) :Red, Setting value (SV) :Green]
Input Sensor	Thermocouple (Chromel - Alumel)
Control Method	PID, ON/OFF Control, P, PI, PD, PIDF, PIDS
Display Accuracy	± 0.3%
Setting Type	Setting by front push bottons
Proportional Band (P)	0 to 100.0%
Integral Time (I)	0 to 3600 Sec
Derivative Time (D)	0 to 3600 Sec
Sampling Time	0 to 120 Sec
Sampling Time	0.5 Sec
Setting (P, I & D)	Manual / Auto

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DEC-600

Dielectric Measurement Setup

(ii) Digital Capacitance Meter

It is a handheld instrument, mounted in a cabinet for convenience, It uses CMOS double level A/D convertor that is automatic in zeroing and polar selection.

Features

- LCD Display
- Data - Hold Switch (HOLD)
- Cx+, Cx - Input Jack
- Back Light Button Switch
- Rotary Switch: Use this switch to select functions and ranges
- Wide measuring range, covering 9 measuring sections from 0.1pf to 20,000µF that includes nominal value of any capacitance
- Power: One 9V battery

Specification

Range	Accuracy	Definition	Testing frequence
200pF	±0.5%	0.1pF	800Hz
2000pF	±0.5%	1pF	800Hz
20nF	±0.5%	10pF	800Hz
200nF	±0.5%	0.1pF	800Hz
2uF	±0.5%	1nF	800Hz
20uF	±0.5%	10nF	80Hz
200uF	±0. 5%	0.1µF	8Hz
2000uF	±2. 5%	1µF	8Hz

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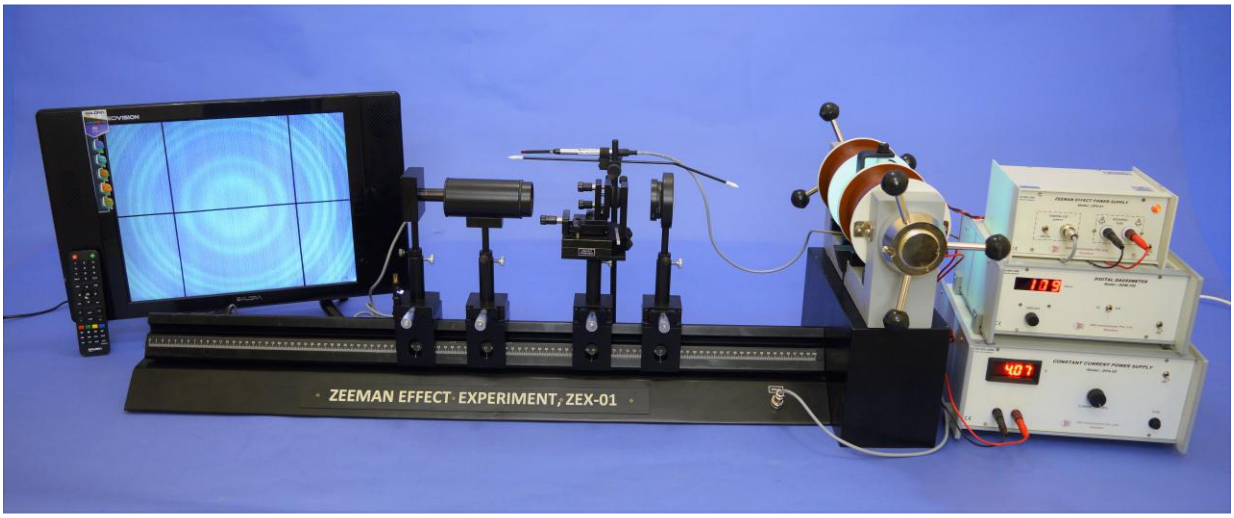
ZEX-01

Zeeman Effect Experiment



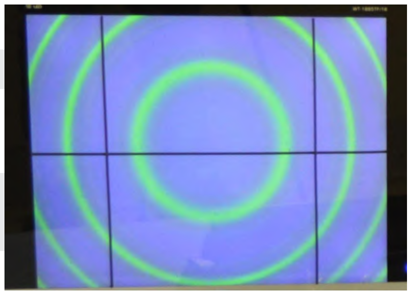
Introduction

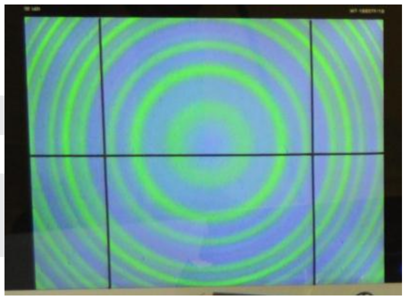
The Zeeman effect is the splitting of spectral lines of atoms when they are placed in a magnetic field. It exhibits space quantization and is one of the few fundamental atomic physics experiments which can be performed in a teaching laboratory.

Description of the Experimental Set-up

Experimentental Set-up for Zeeman Experiment

The set-up consists of the following:





1. High Resolution Fabry Perot Etalon, FP-01
2. Mercury Discharge Tube, MT-01 (Low Pressure Mercury Discharge Tube)
3. Power Supply for MT-01, ZPS-02 (High Voltage Power Supply for Discharge Tube)
4. Narrow Band Interference Filter, IF-01
   - Central Wave Length: 546nm
   - Tmax: 74%
   - HBW: 8nm
5. Polarizer with lens, PL-01
6. Optical Bench: OB-01
7. CCD Camera: CAM-700 (High Resolution CCD Camera)
8. Telescope with Focussing Lens: FL-01
9. Monitor 17": TV-17
10. Electromagnet, EMU-50T (Specifications as per datasheet)
11. Constant Current Power Supply, DPS-50 (Specifications as per datasheet)
12. Digital Gaussmeter, DGM-102 (Specifications as per datasheet)

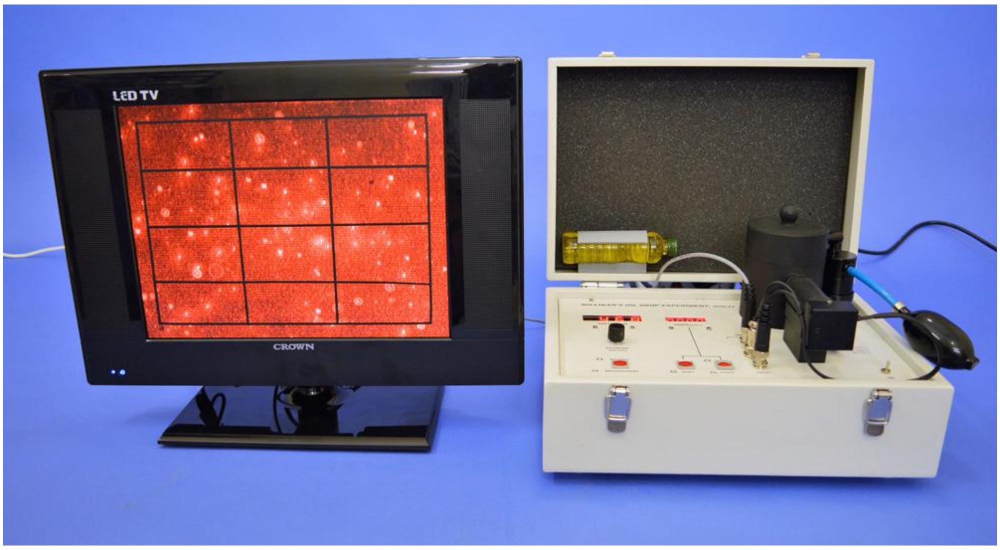
The experimental set-up is complete in all respect.

Result

The interference pattern is in the form of circular rings. These are split when the magnetic field is switched on. The amount of splitting depends on the external magnetic field, charge to mass ratio of electron and Lande's g-factors of the electronic energy levels involved in the transition. These

MOD-01

Millikans Oil Drop Experiment



Introduction

This experiment aims at measuring the charge of an electron and is perhaps the most basic of all atomic physics or modern physics laboratory experiments. It won Millikan the Nobal Prize in the year 1923.

The experiment depends on the ability to control, measure and balance very small force of the order 10^{-14}N. The set-up consists of two horizontal parallel plates separated by about 5mm. The upper plate has a small hole through which microscopic oil droplets are sprayed in between the two plates with the help of an atomizer which is like a common perfume sprayer. These droplets get charged due to the frictional force during spraying. The free fall of these droplets in the space between the plates is observed in the gravitational field. A measurement of the velocity of fall along with the use of Stokes law leads to the calculation of the mass of the droplets and their radii if the oil density is known. These are of the order of 10^{-15}kg and 10^{-6}m respectively. By applying a potential difference between the plates, a uniform electric field is produced in the space between the plates. A measurement of the velocity of the negatively charged droplets rising in the electric field allows a calculation of the electric force on the droplets and hence the charge carried by them. In the experiment the droplets which rise and fall slowly are selected as they are expected to have a fairly small charge. These droplets are made to rise and fall several times. The repetitions of measurement of the velocities of rise and fall reduce the random error of their means. A fairly large number of droplets are observed and their charges are calculated.

The analysis of the data on the total charge carried by the droplets shows that these total charges are integral multiples of a certain smallest charge which is the charge of an electron. This result also shows that the charge is quantized .

The measurement of the charge on the electron can lead to the calculation of Avogadro's number. The charge F (the Faraday) required to electro-deposit one gram equivalent of an element on an electrode during electrolysis is equal to the charge of the electron multiplied by the number of molecules in a mole. The Faraday has been found to be $F = 9.625 \times 10^{7}$ coulombs per kilogram equivalent weight. Hence Avogadro's number $N = F/e$.

Apparatus

The present set-up consists of

1. A oil drop chamber mounted on top of the panel. It has
   - (i) A pair of horizontal parallel plate electrodes separated by about 5 mm thick ebonite ring with a hole for viewing the oil droplets.
   - (ii) The upper plate has a small hole in its centre for the admission of the droplets which are produces by spraying oil with an atomizer.
   - (iii) A device to illuminate the space between the plate electrodes.
2. Three levelling screws at the base of the panel

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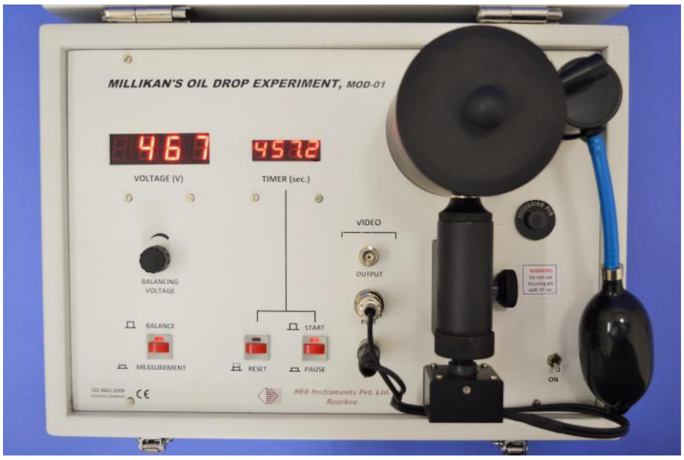
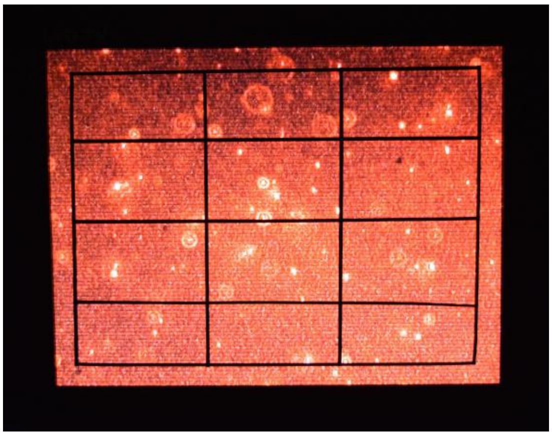
to make the parallel plate electrodes perfectly horizontal (perpendicular to the gravitational field) and a water-level placed on top of the panel to check it.

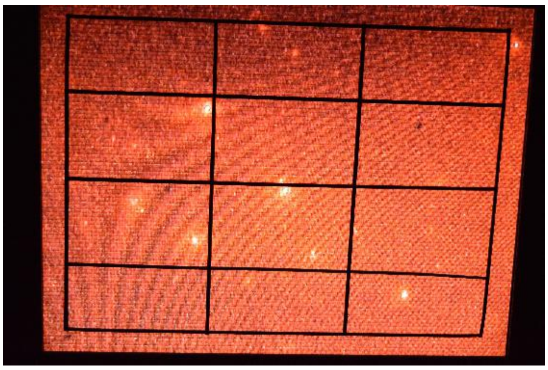
3. A microscope with CCD camera head to view and transmit image of oil droplets between the plate electrodes to the monitor.
4. A power pack to supply continuously variable voltage in the range 0 – 800 V to the upper plate electrode when the electric field is to be created between the plates. The lower plate is permanently grounded.
5. A digital voltmeter to measure the potential applied to the upper plate.
6. A 'Time Meter' to display the time for which the oil droplet is allowed to move.
7. A timing device to measure time interval between the passage of droplets through preset points. There are two keys to operate this device. Pressing the 'Clear' key, wipes out the time information. This is like a reset key. The time meter now reads '00.0' sec. Pressing the 'Start/Stop' key starts the timing device. Pressing it again stops the device. The elapsed time can be read on the meter.
8. A monitor with graduated screen. The horizontal lines on the monitor screen help in setting the distance through which the droplets move.
9. An atomizer to spray droplets.
10. A thermometer to measure the room temperature.

Method

Time for free-fall of the droplets under gravity between the preset points is measured to obtain the velocity for free-fall. For observing the effect of the electric field on the charge carried by the droplets, there are two alternatives. In the Dynamic method, the velocity for the vertical upword motion is measured for a fixed potential difference. In the Static method, the potential difference between the plates is adjusted to balance the droplets.







The result of this unit are within 5% of the standard value.

The experiment is complete in all respect.

EMX-01

e/m Experiment

MEASUREMENT OF ELECTRON CHARGE TO MASS RATIO AND
LORENTZ FORCE DEMONSTRATION
(based on Thomson's method)

Introduction

Our arrangement for measuring e/m, the charge to mass ratio of the electron is a very simple set-up. It is based on Thomson's method. The e/m-tube is bulb-like and contains a filament, a cathode, a grid, a pair of deflection plates and an anode. The tube is filled with helium at a very low pressure. Some of the electrons emitted by the cathode collide with helium atoms which get excited and radiate visible light. The electron beam thus leaves a visible track in the tube and all manipulations on it can be seen. The tube is placed between a pair of fixed Helmholtz coils which produce a uniform and known magnetic field. The socket of the tube can be rotated so that the electron beam is at right angles to the magnetic field. The beam is deflected in a circular path of radius r depending on the accelerating potential V, the magnetic field B and the charge to mass ratio e/m. This circular path is visible and the diameter d can be measured and e/m obtained from the relation

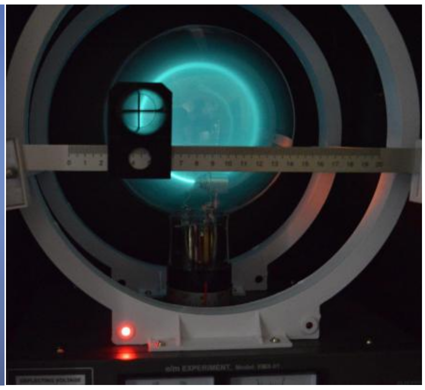
$$e/m = 8V/B^2d^2$$

This set-up can also be used to study various features of Lorentz force $\vec{F} = e\,(\vec{E} + \vec{v} \times \vec{B})$ by observing the electron beam deflection for different directions of the magnetic field and different orientations of the e/m-tube.

Description of the experimental set-up

The central part of the set-up is the e/m-tube. This is energized by

- (i) Filament current supply,
- (ii) Deflection plates voltage supply,
- (iii) Continuously variable accelerating voltage supply to the anode.



The tube is mounted on a rotatable socket and is placed between a pair of Helmholtz coils. The tube can be rotated about a vertical axis, varying the orientation of the electron beam with respect to the Helmholtz coils. This allows deflection of the beam to be

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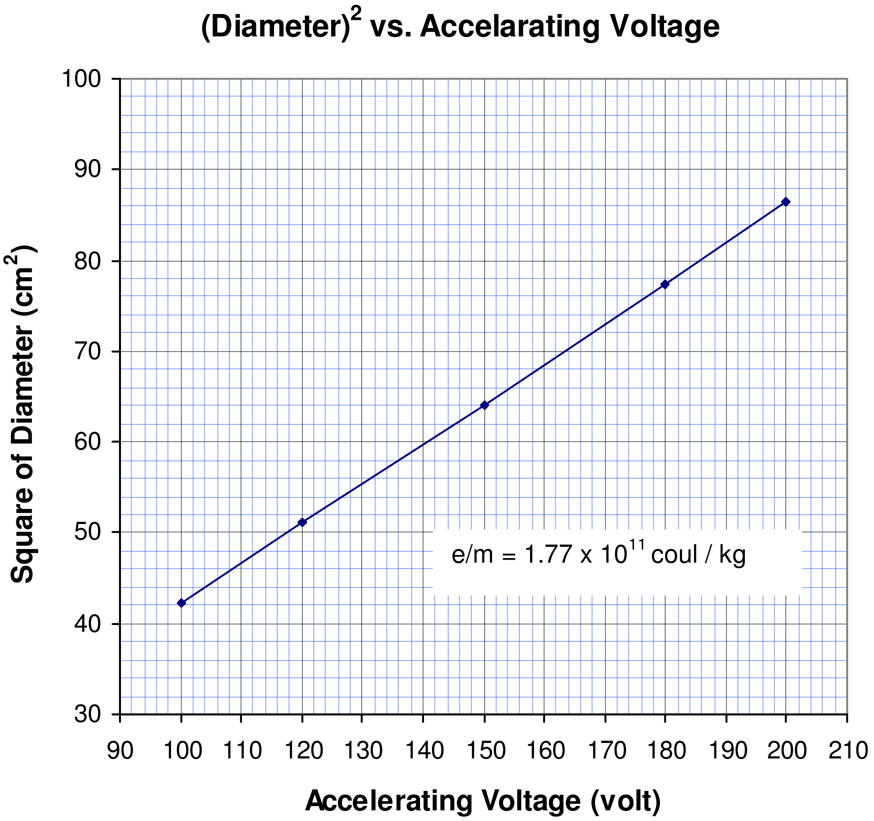
demonstrated for various orientations of the beam direction, circular, helical or undeflected paths can be seen. The direction of the current can be changed. The magnetizing current I and the accelerating voltage V are respectively measured by an ammeter and a voltmeter mounted on the front of the panel. The diameter of the electron beam path is measured by a detachable scale mounted in front of the bulb of the tube. This scale has a slider with a hollow tube (fitted with cross wires at its both ends) to fix the line of sight while making the measurements of the beam path diameter. Base of the unit contains the power supply that provides all the required potentials and the current to the Helmholtz coils. The entire apparatus is contained in a wooden case for convenient storage.

Specifications		
Helmholtz coils of radii	:	14 cm
Number of turns	:	160 on each coil
Accelerating Voltage	:	0 – 250V
Deflection plates voltage	:	50V – 250V
Operating Voltage	:	220V AC/ 50Hz

Typical results obtained with the above set-up for variation of the diameter of the electron beam path with the accelerating voltage for a current of 1A to the Helmholtz coils are shown in the following graph. They lead to e/m equal to 1.77×10^{11} coul / kg.



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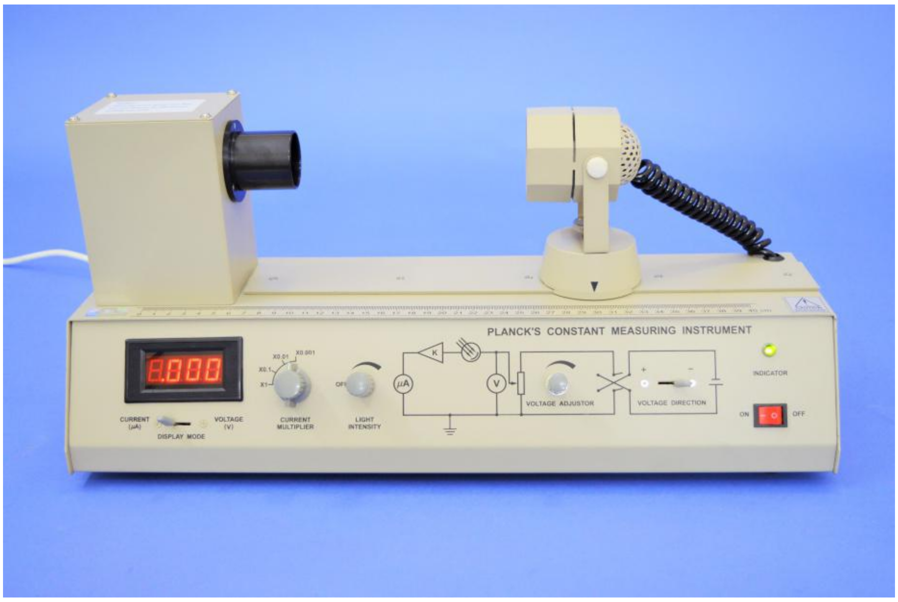
PC-101

Planck's Constant by Photoelectric Effect



1. Determination of planck's constant and work function of materials by photoelectric effect

It was observed as early as 1905 that most metals under influence of radiation, emit electrons. This phenomnon was termed as photoelectric emission. The detailed study of it has shown.

1. That the emission process depends strongly on frequency of radiation.

2. For each metal there exists a critical frequency such that light of lower frequency is unable to liberate electrons, while light of higher frequency always does.

3. The emission of electron occurs within a very short time interval after arrival of the radiation and member of electrons is strictly proportional to the intensity of this radiation.

The experimental facts given above are among the strongest evidence that the electromagnetic field is quantified and the field consists of quanta of energy $E= h\nu$ where ν is the frequency of the radiation and h is the Planck's constant. These quanta are called photons.

Further it is assumed that electrons are bound inside the metal surface with an energy $e\phi$, where ϕ is called work function. It then follows that if the frequency of the light is such that

$$h\nu > e\phi$$

it will be possible to eject photoelectron, while if $h\nu<e\phi$, it would be impossible. In the former case, the excess energy of quantum appears as kinetic energy of the electron, so that

$$h\nu=\frac{1}{2}mv^2 + e\phi \qquad (1)$$

which is the famous photo electrons equation formulated by Einstein in 1905.

The energy of emitted photoelectrons can be measured by simple retarding potential techniques as is done in this experiment. When a retarding potential V_0 is used to measure kinetic energy of electrons E_e, we have,

$$E_e=\frac{1}{2}mv^2=eV_0 \qquad \text{or} \qquad V_0=\frac{h}{e}\nu-\phi$$

So when we plot a graph V_0 as a function of n, the slope of the straight line yields h and the intercept of extrapolated point $\nu=0$ can give work function ϕ.

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PC-101

Planck's Constant by Photoelectric Effect

2. To verify inverse square law of radiation using a photoelectric cell

If L is the luminous intensity of an electric lamp and E is the illuminanscence (intensity of illumination) at point r form it, then according to inverse square law.

$$E = \frac{L}{r^2}$$

if this light is allowed to fall on the cathode of a photo-electric cell, then the photo-electric current (I) would be proportional to E.

$$E = \frac{L}{r^2} = K.I$$

Hence a graph between $\frac{1}{r^2}$ and I is a straight line, which verify the inverse square law of radiation.

The apparatus consist of the following :

1. Photo sensitive device : Vacuum photo tube.

2. Light source : Halogen tungsten lamp 12V/35W.

3. Colour filters : 635nm, 570nm, 540nm, 500nm & 460nm.

4. Accelerating voltage : Regulated Voltage Power Supply

Output	:	± 15 V continuously variable through multi-turn pot
Display	:	3 ½ digit 7-segment LED
Accuracy	:	±0.2%

5. Current detecting unit : Digital Nanoammeter is a high stability low current measuring instrument

Range	:	1000μA, 100μA, 10μA & 1μA with 100% over ranging facility
Resolution	:	1nA at 1μA range
Display	:	3 ½ digit 7-segment LED
Accuracy	:	±0.2%

6. Power requirement : 220V ± 10%, 50Hz.

7. Optical Bench : The light source can be moved along it to adjust the distance between light source and photo tube. Scale length is 400 mm. A draw tube is provided to install colour filters, a focus lense is fixed in the back end.

The set is complete in all respect, no additional accessory required.

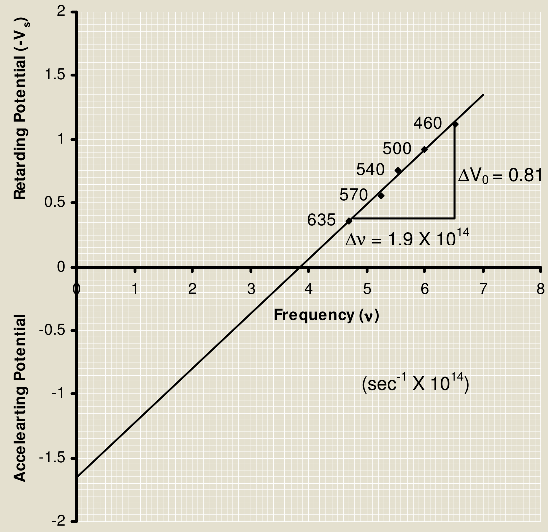

Fig.: Typical graph of V_0 (stopping potential) as a function of ν_0

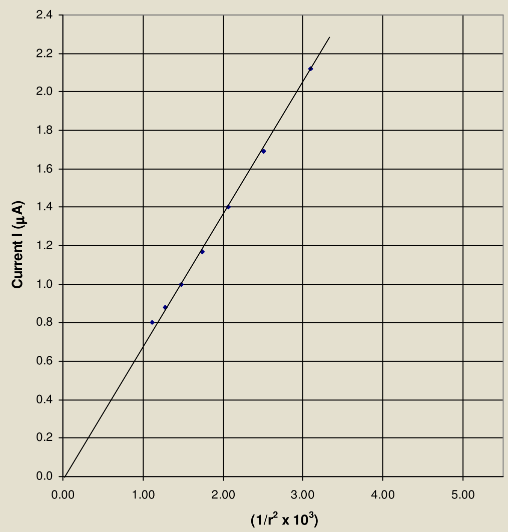

Fig.: Verification of Inverse Square Law Graph : 1/r2 vs I

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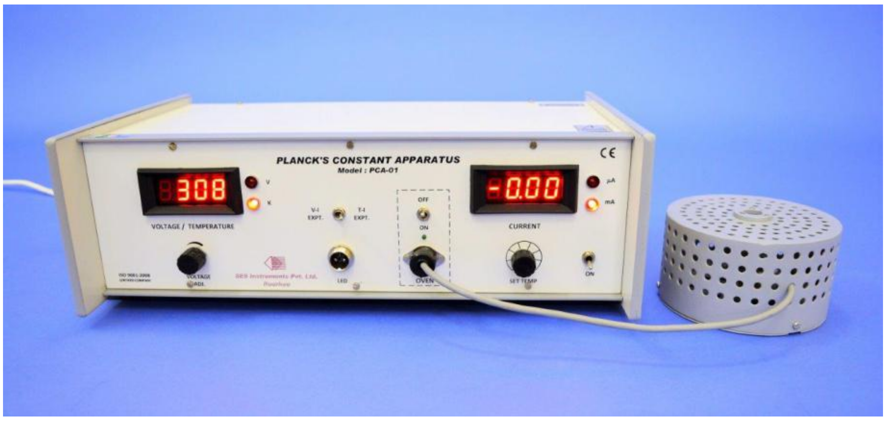
PCA-01

Determination of Planck's Constant by means of LED's

- Highly accurate results
- Precise measurement of Band-Gap
- Clear physical interpretation
- Self contained unit with no extra accessory required



Determination of Planck's Constant using LED

Several proposals to measure the Planck's Constant for didactical purposes, using the current - voltage (I-V) characteristics of a light emitting diode (LED) have been made quite regularly in the last few years. The reason is that the experiment can be done easily in any lab and the result are surprisingly good (±10%). The physical interpretation however is not completely clear and this has raised many discussions, which has been published almost with same regularity as the proposals themselves.

The present experiment is based on diode current for $V<V_o$, using the diode law.

$$I = I_o \exp [- e (V_o - V)/\eta kT]$$

where, e is electronic charge, k is Boltzmann constant, T is absolute temperature and η is material constant which depends on the type of diode, the location of recombination region, etc.

The correct method to determine the real height oi the potential energy barrier V_o is to directly measure the dependence oi the current on temperature keeping the applied voltage V slightly below V_o. The idea is that the disturbance to V_o is as little as possible. The slope of In I vs. 1/T curve gives e $(V_o - V)\eta k$ (Fig. 1). The constant η is determined from I-V characteristics oi the diode (Fig. 2) at room temperature from the relation

$$\eta = (e/kt)\ (\Delta V/\Delta \ln I)$$

Compared with previous methods, this determination of V_o is more precise and more accurate and at the same time the physical interpretation is more transparent.

The Planck's constant is then obtained by the relation

$$h = e\ V_o\ \lambda/c$$

The wavelength (λ) of the light emitted by the diode can be measured by a transmission grating spectrometer normally available in the lab.

The value of Planck's constant obtained from this method is within 5% of accepted value (6.62×10^{-34} Joules.sec)

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Experimental Set-Up

It is a self contained unit. All the necessary facilities and measuring devices are built in a single unit, as a result only minimum of external connections need to be made.

[I] Dependence of current (I) on temperature (T) at constant applied voltage (V)

The following facilities are built in for this

(a) Current Meter

A highly stable current meter with 3½ digit display

Range: 0-2mA with resolution of 1μA

(b) Oven

It is a small temperature controlled oven with built-in RTD sensor. The temperature is adjustable from ambient to 65^{O}C and displayed on 3½ digit panel meter. The stability of temperature is ±0.2^{O}C.

(c) Voltmeter

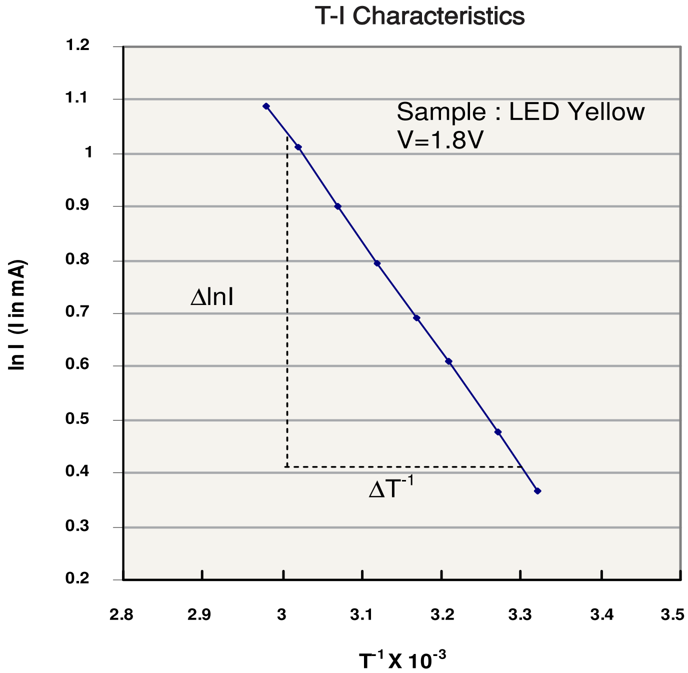
A high stability voltage source with 3½ digit display

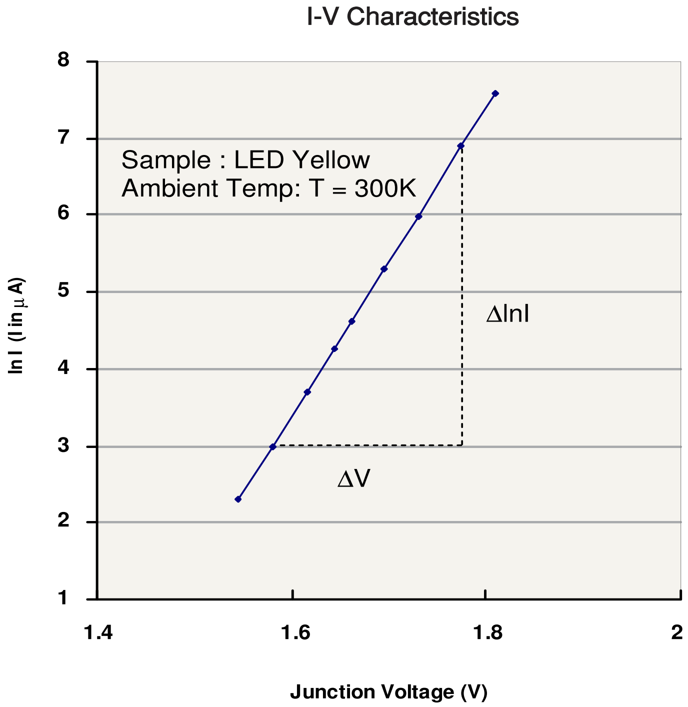
[II] Material Constant η

To draw I-V characteristics of LED for determination of η, a variable voltage source and current meter are provided with 3½ digit display.

[III] The wavelength λ of light emitted by LED

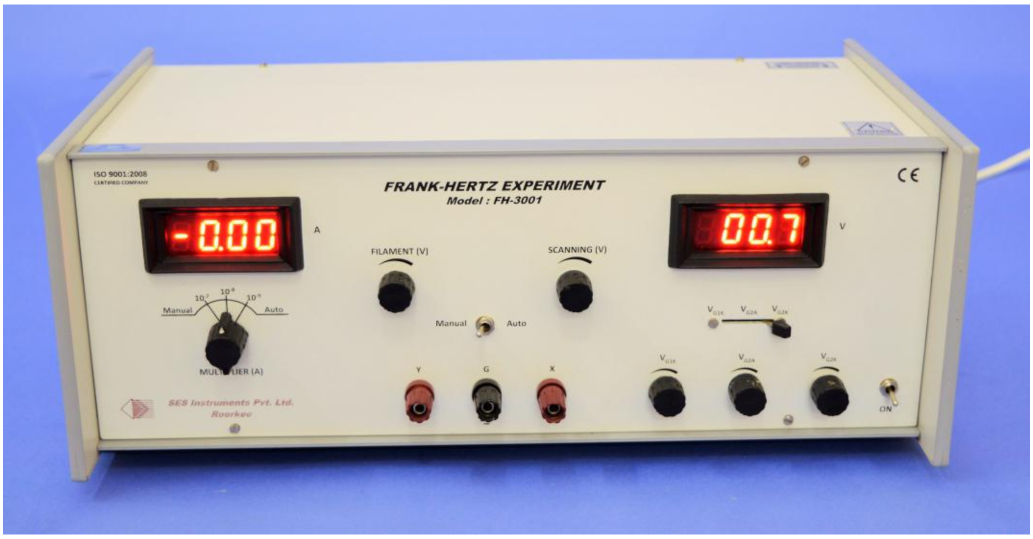
These are taken from LED datasheet or as measured by transmission grating are provided with the set of LED's





FH-3001

Frank Hertz Experiment



Introduction

From the early spectroscopic work it is clear that atoms emitted radiation at discrete frequencies; from Bohr's model, the frequency of the radiation v is related to the change of energy levels through $\Delta E = h\nu$.

It is then to be expected that transfer of energy to atomic electrons by any mechanism should always be in discrete amounts. One such mechanism of energy transfer is through inelastic scattering of low-energy electrons.

Frank and Hertz in 1914 set out to verify these considerations.

(i) It is possible to excite atoms by low energy electron bombardment.

(ii) The energy transferred from electrons to the atoms always had discrete values.

(iii) The values so obtained for the energy levels were in agreement with spectroscopic results.

Thus the existence of atomic energy levels put forward by Bohr can be proved directly. It is a very important experiment and can be performed in any college or University level laboratory.

Operating Principle

The Frank-Hertz tube in this instrument is a tetrode filled with the vapour of the experimental substance. Fig.1 indicates the basic scheme of experiment.

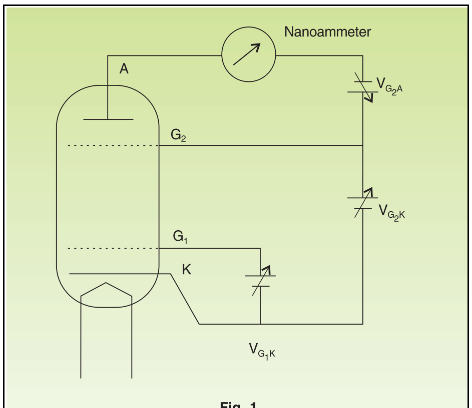


Fig. 1

The electrons emitted by filament can be accelerated by the potential V_{G_2K} between the cathode and the grid G_2. The grid G_1 helps in minimising space charge effects. The grids are wire mesh and allow the electrons to pass through. The plate A is maintained at a potential slightly negative with respect to the grid G_2. This helps in making the dips in the plate current more prominent. In this experiment, the electron current is measured as a function of the voltage V_{G_2K}. As the voltage increases, the electron energy goes up and so the electron can overcome the retarding potential V_{G_2A} to reach the plate A. This gives rise to a current in the ammeter, which initially increases. As the voltage further increases, the electron energy reaches the threshold value to excite the atom in its first allowed excited state.

In doing so, the electrons loose energy and therefore the number of electrons reaching the plate decreases. This decrease is proportional to the number of inelastic collisions that have occured. When the V_{G_2K} is

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increased further and reaches a value twice that of the first excitation potential, it is possible for an electron to excite an atom halfway between the grids, loose all its energy, and then gain anew enough energy to excite a second dip in the current. The advantage of this type of configuration of the potential is that the current dips are much more pronounced, and it is easy to obtain five fold or even larger multiplicity in the excitation of

the first level.

Frank-Hertz Experiment Set-up, Model: FH-3001, consists of the following:

Argon filled tetrode

Filament Power Supply : 2.6~3.4V continuously variable

Grids Power Supplies

- V_{G_1K} : 1.3-5 V continuously variable
- V_{G_2K} : 1.3 - 12V continuously variable
- V_{G_2K} : 0 - 95V continuously variable

All the power supplies are highly stabilised and output voltages can be read on 3 V2 digit, 7 segment LED DPM with autopolarity and decimal indication through a selector switch.

Saw tooth waveform for CRO display

- Scanning Voltage : 0-80V
- Scanning Frequency : 115±20Hz

Multirange Digital Ammeter

- Display : 3½ digit 7 segment LED
- Range Multiplier: 10-7 , 10-8 & 10-9

Power

- 220V±10% mains, 50Hz

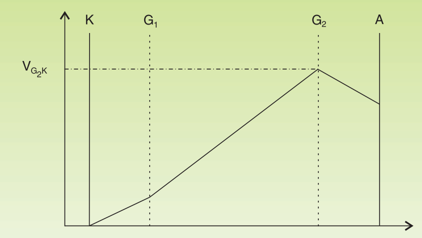


Fig. 2 Configuration of the Potential in Frank-Hertz Arrangement

The instrument can, not only lead to a plot of the amplitude spectrum curve by means of point by point measurement, but also directly display the amplitude spectrum curve on the oscilloscope screen. This instrument can thus be used as a classroom experiment as well as for demonstration to a group of students.

Analysis of the Data

Data obtained for the excitation potential point by point are shown in Fig. 3. The readings are taken for 1V changes on grid 2 (V_{G_2K}). A significant decrease in electron (collector) current is noticed every time the potential on grid 2 is increased by approximately 12V, thereby indicating that energy is transferred from the beam in (bundles) "quanta" of12eV only. Indeed, a prominent line in the spectrum of argon exists at 1048Å corresponding to eV=11.83.

The location of the peaks is indicated in Fig. 3. Average value of spacing between peaks is 11.75eV compared with the accepted value of 11.83V.

Fig. 3 Plot of Beam Current Vs. Accelarting Voltage in Frank Hertz Experiment, FH-3001

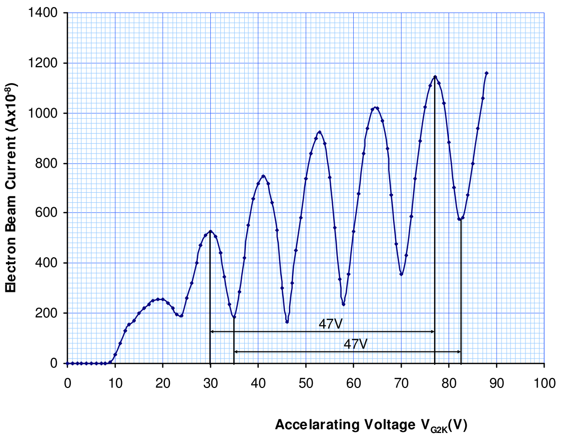
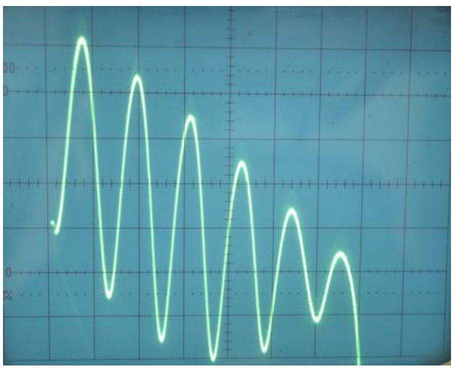


Fig. 4 Oscilloscope display of Frank-Hertz Experiment



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IP-01

Ionisation Potential

Introduction

The electrons in the atoms have discrete stationary states. Franck and Hertz in 1914 described the first observation of quantized excitation from one quantized state to another one year after N. Bohr published his theory of hydrogen atom. His method depends on detecting the on-set of inelastic collisions between electrons and atoms of the gas under study. The experimental tube in this measurement is essentially a triode filled with the vapour of the experimental substance. The electrons emitted by the heated filament of the tube are accelerated by the positive potential V_{GK} between the cathode and the grid. The grid is a wire mesh which allows the electrons to pass through. The anode A is maintained at a fixed potential V_{GA} slightly negative with respect to the grid. In the experiment the electron current is measured as a function of the voltage V_{GK}. As V_{GK} increases, the energy of the electrons increases, and more and more electrons reach the anode. The anode current increases. The collisions between the electrons and the atoms are elastic. As V_{GK} further increases, the energy of the electrons reaches the threshold for the excitation of the atomic electrons from the ground state to the first excited state, and the collisions between the electrons and the atoms become inelastic. The colliding electrons lose energy and are not able to overcome the negative potential V_{GA} and the anode current decreases. The potential V_{GK} at the decrease is equal to the first excitation potential of the atom.

Operating Principle

In the present ionization potential measurement, the traditional Franck-Hertz set-up as described above has been altered to detect the threshold for ionizing inelastic collisions. The experimental tube is a tetrode filled with argon, the experimental substance. Figure 1 shows the basic circuit diagram. The electrons emitted by the heated filament are accelerated by the potential V_{G2K} between the cathode and the grid G_2. The grid G_1 helps in minimizing space charge effects. Both the grids consist of wire mesh and allow the electrons to pass through. The anode A is maintained at a potential slightly negative with respect to the cathode. The electrons are never able to reach it. It is ready to receive positive ions if they have been created in the tube. The on-set of anode current therefore signifies the creation of positive ions, i.e. the on-set of ionizing inelastic collisions between the electrons and the argon atoms. In the experiment the electron current is measured as a function of the voltage V_{G2K}. As this voltage increases, the electron energy goes up. But as long as this energy is less than what is required to ionize the atom, the ions are not created, and the anode current remains equal to zero. The inelastic collisions leading to the excitation of argon atoms are immaterial because no ions are created there in and the anode current remains unaffected. The potential V_{G2K} at the on-set of the anode current is equal to the ionization potential. As V_{G2K} further increases, more and more electrons undergo ionizing collisions and the anode current increases. When V_{G2K} reaches a value twice that of the ionization potential, it is possible for an electron to ionize an atom half way between the grid and the cathode, lose all its energy, and then gain anew enough energy to ionize another argon atom. The anode current beginning at this value of V_{G2K} shows a faster increase with V_{G2K} as now there is a larger number of ions reaching the anode.

Ionization Potential Set-up, Model IP-001, consists of the following:

a) Argon filled tetrode
b) Filament Power Supply
c) Power Supply tor V_{G1K}
d) Power Supply for V_{KA}
e) Power Supply for V_{G2K}
f) Saw tooth wave form for CRO display
g) Multirange Voltmeter
h) Multirange Ammeter

All this is housed in a cabinet with meters and adjustment knobs on the front panel. The set-up can also directly display the anode current variation with V_{G2K} on the oscilloscope screen. It can thus be used as a laboratory experiment as well as for demonstration to a group of students.

ANALYSIS OF THE DATA

Point by point data for the anode current with V_{G2K} changing in steps of 1 V at V_{G1K} equal to 1.5 V and V_{KA} equal to 3.0 V are shown in Figure 2. The on-set of the anode current and the point where the slope of the current changes can be determined by locating the points of intersection of the lines as shown in Figure 2. These points are at 16 V and 31 V respectively. The former corresponds to the ionization potential and the later for the ionization again. The average value of the ionization potential thus found is 15.5 eV compared with the accepted value of 15.6 eV.

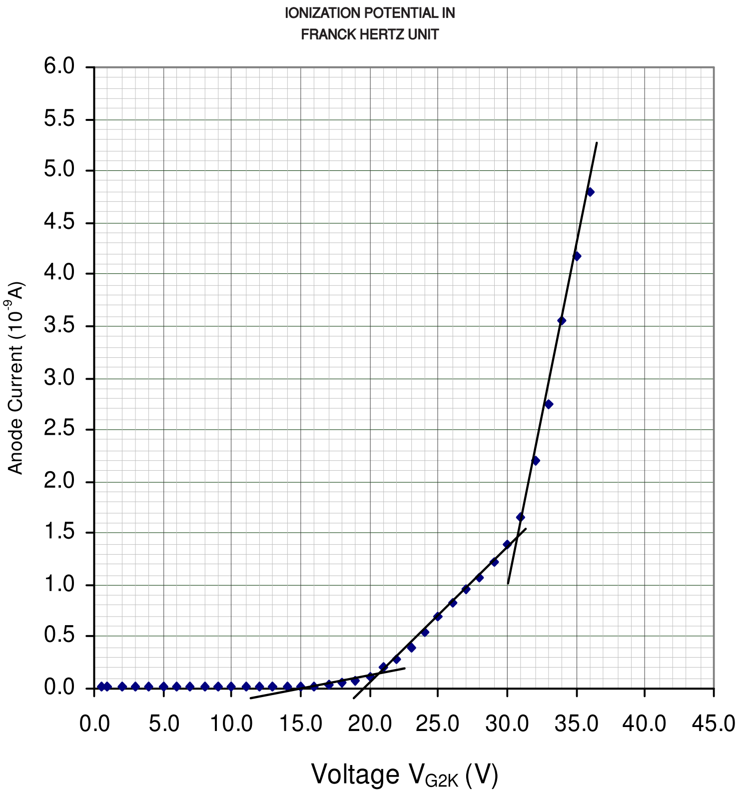

Figure 2 Plot of Anode Current vs V_{G2K} in the Ionization Potential Set-up

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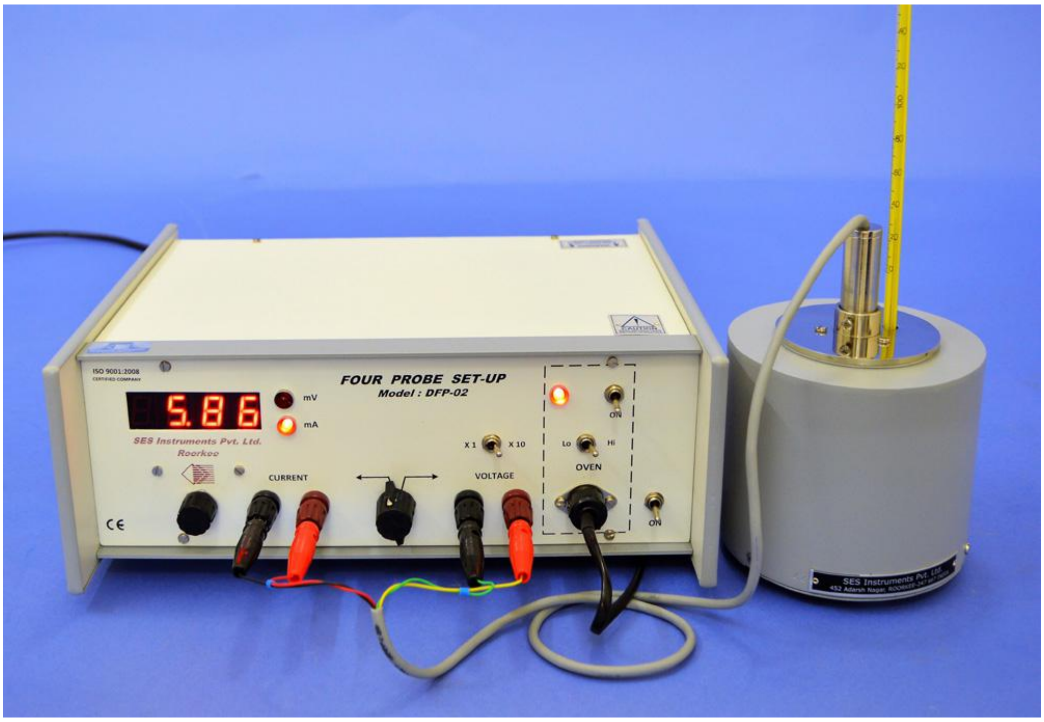
DFP-02

Four Probe Method (Basic Model)

Resistivity of Semiconductor by Four Probe Method at different temperatures and determination of the Band-gap



The Four Probe Method is one of the standard and most widely used method for the measurement of resistivity of semiconductors. The experimental arrangement is illustrated. In its useful form, the four probes are collinear. The error due to contact resistance, which is specially serious in the electrical measurement on semiconductors, is avoided by the use of two extra contacts (probes) between the current contacts. In this arrangement the contact resistance may all be high compare to the sample resistance, but as long as the resistance of the sample and contact resistances are small compared with the effective resistance of the voltage measuring device (potentiometer, electrometer or electronic voltmeter), the measured value will remain unaffected. Because of pressure contacts, the arrangement is also specially useful for quick measurement on different samples or sampling different parts of the same sample.

Description of the experimental set-up

1. Probes Arrangement

It has four individually spring loaded probes. The probes are collinear and equally spaced. The probes are mounted in a teflon bush, which ensure a good electrical insulation between the probes. A teflon spacer near the tips is also provided to keep the probes at equal distance. The whole - arrangement is mounted on a suitable stand and leads are provided for the voltage measurement.

2. Sample

Germanium crystal in the form of a chip (10X9X0.5mm)

3. Oven

It is a small oven for the variation of temperature of the crystal from the room temperature to about 200°C (max.)

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4. Four Probe Set-up, DFP-02

The set-up consists of three units in the same cabinet.

(i) Multirange Digital Voltmeter

In this unit, intersil 3½ digit single chip A/D Converter ICL 7107 has been used. It has high accuracy like auto zero to less than 10µV, zero drift of less than 1µV/ °C, input bias current of 10pA max. and roll-over error of less than one count. Since the use of internal reference causes the degradation in performance due to internal heating, an external reference has been used.

Specifications

Range	:	X1 (0-200mV) & X10 (0-2V)
Impedance	:	MΩ
Resolution	:	100µV at X1 range
Display	:	3½ digit, 7 segment LED (12.5mm height) with polarity and decimal indication
Accuracy	:	±0.1% of reading ±1 digit
Overload Indicator	:	Sign of 1 on the left & blanking of other digits

(ii) Constant Current Generator

It is an IC regulated current generator to provide a constant current to the outer probes irrespective of the changing resistance of the sample due to change in temperatures. The basic scheme is to use the feedback principle to limit the load current of the supply to preset maximum value Variations in the current are achieved by a potentiometer included for that purpose. The supply a highly regulated and practically ripple free d.c. source. The current is measured by the digital panel meter.

Specifications

Open Circuit Voltage	:	18V
Current range	:	0-20mA
Resolution	:	10µA
Accuracy	:	±0.25% of the reading ±1 digit
Load regulation	:	0.03% for 0 to full load
Line Regulation	:	0.05% for 10% changes

(iii) Oven Power Supply Suitable voltage for the oven is obtained through a step down transformer with a provision for low and high rates of heating. A glowing LED indicates, when the oven power supply is 'ON'.

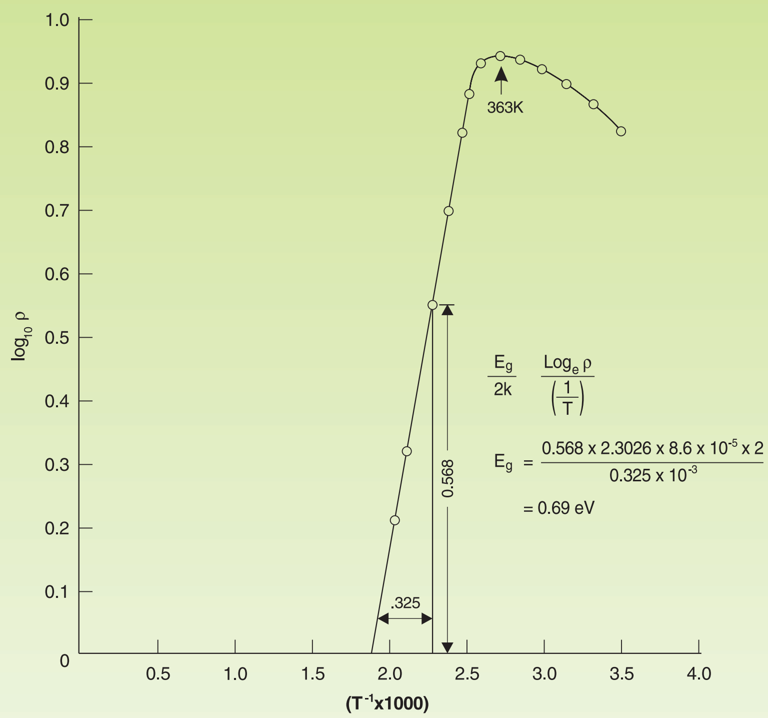
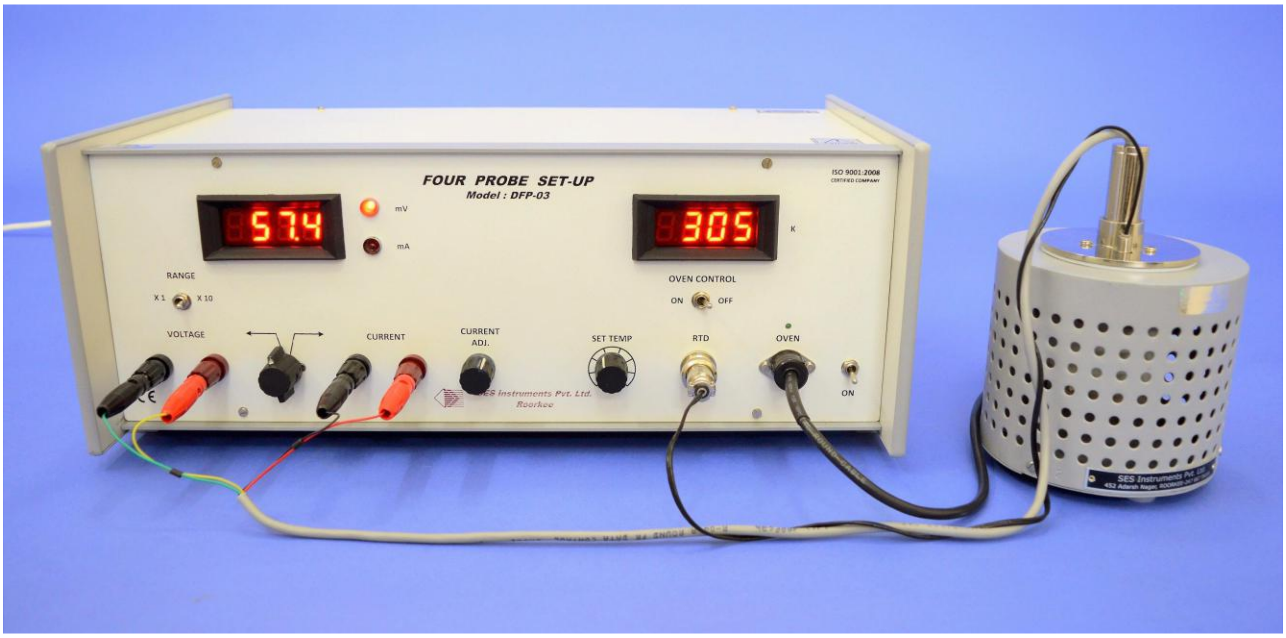


Fig. The resistivity of a Germanium crystal as a function of inverse temperature. For this sample T<363K, conduction is due mainly to the impurity carriers (Extrinsic Region). For T>363K, conduction is due to electrons transferred to the conduction band (and the corresponding holes created in the valence band). This is the Intrinsic region.

The experimental setup is complete in all respect

DFP-03

Four Probe Method (Advance Model)



Resistivity of Semiconductor by Four Probe Method at different temperatures and determination of the band-gap

The Four Probe Method is one of the standard and most widely used method for the measurement of resistivity. In its useful form, the four probes are collinear. The error due to contact resistance, which is significant in the electrical measurement on semiconductors, is avoided by the use of two extra contacts (probes) between the current contacts. In this arrangement the contact resistance may all be high compare to the sample resistance, but as long as the resistance of the sample and contact resistance's are small compared with the effective resistance of the voltage measuring device (potentiometer, electrometer or electronic voltmeter), the measured value will remain unaffected. Because of pressure contacts, the arrangement is also specially useful tor quick measurement on different samples or sampling different parts of the sample.

Description of the experimental set-up

1. Probes Arrangement

It has four individually spring loaded probes. The probes are collinear and equally spaced. The probes are mounted in a teflon bush, which ensure a good electrical insulation between the probes. A teflon spacer near the tips is also provided to keep the probes at equal distance. The probe arrangement is mounted in a suitable stand, which also hold the sample plate. To ensure the correct measurement of sample temperature, the FITD is enbeded in the sample plate just below the sample. This stand also serves as the lid of temperature controlled oven. Proper leads are provided for the current and voltage measurement.

2. SAMPLE

Germanium crystal in the form of a chip (10X9X0.5mm).

3. OVEN

This is high quality temperature controlled oven suitable for Four Probe Set-up. The oven has been designed for fast heating and cooling rates, which enhances the effectiveness of the controller.

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4. Four Probe SET-UP, DFP-03

The set-up consists of three units housed in the same cabinet.

(i) Oven Controller

Platinum RTD (A class) has been used for sensing the temperature. A wheatstone bridge and an instrumentation amplifier are used for signal conditioning. Feedback circuit ensures offset and linearity trimming and a fast accurate control of the oven temperature.

Specifications of the Oven

Temperature Range	:	Ambient to 473K
Resolution	:	1K
Stability	:	±0.5K
Measurement Accuracy	:	±1K (typical)
Oven	:	Specially designed for Four Probe Set-Up
Sensor	:	RTD (A class)
Display	:	3½ digit, 7 segment LED with autopolarity and decimal indication
Power	:	150W

(i) Multirange Digital Voltmeter

In this unit, intersil 3½ digit single chip A/D Converter ICL 7107 has been used. It has accuracy, auto zero to less than 10 μV, zero drift-less than 1 μV/ °C, input bias current of 10 pA and roll over error of less than one count. Since the use of internal reference causes the degradation in performance due to internal heating, an external reference has been used.

Specification

Range	:	X1 (0-200mV) & X10 (0-2V)
Resolution	:	100μV at X 1 range
Accuracy	:	±0.1% of reading ±1 digit
Display	:	3½ digit, 7 segment LED with autopolarity and decimal indication
Overload Indicator	:	Sign of 1 on the left & blanking of other digits.

(ii) Constant Current Generator

It is an IC regulated current generator to provide a constant current to the outer probes irrespective of the changing resistance of the sample due to change in temperatures. The basic scheme is to use the feedback principle to limit the load current of the supply to preset maximum value. Variations in the current are achieved by a potentiometer included for that purpose. The supply is a highly regulated and practically ripple free d.c. source. The current is measured by the digital panel meter.

Specification

Open circuit voltage	:	18 V
Accuracy	:	±0.25% of the reading ±1 digit
Current range	:	0-20 mA
Load regulation	:	0.05% for 0 to full load
Resolution	:	10 μA
Line regulation	:	0.05% for 10% changes

Typical results obtained from this set-up are shown in the graph.

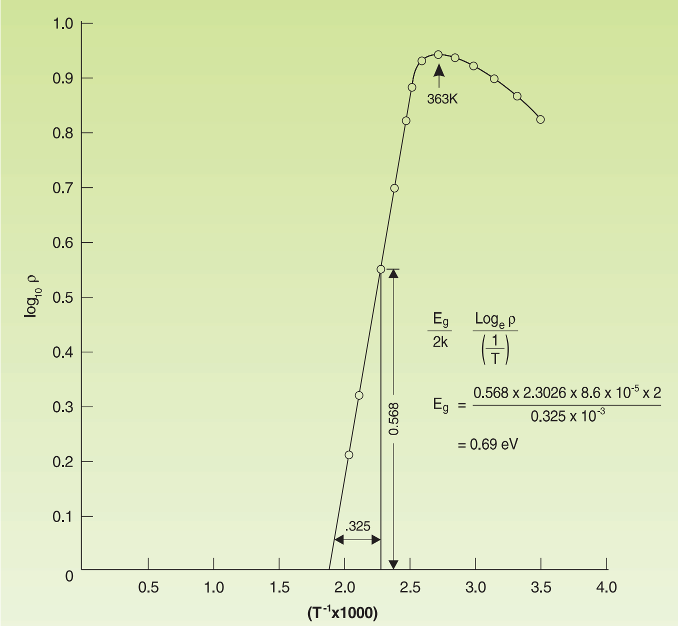

Fig. The resistivity of a Germanium crystal as a function of inverse temperature. For this sample T<363K, conduction is due mainly to the impurity carriers (Extrinsic Region). For T>363K, conduction is due to electrons transferred to the conduction band (and the corresponding holes created in the valence band). This is the Intrinsic region.

The experimental set-up is complete in all respect

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Four Probe Setup

DFP-RM-200N

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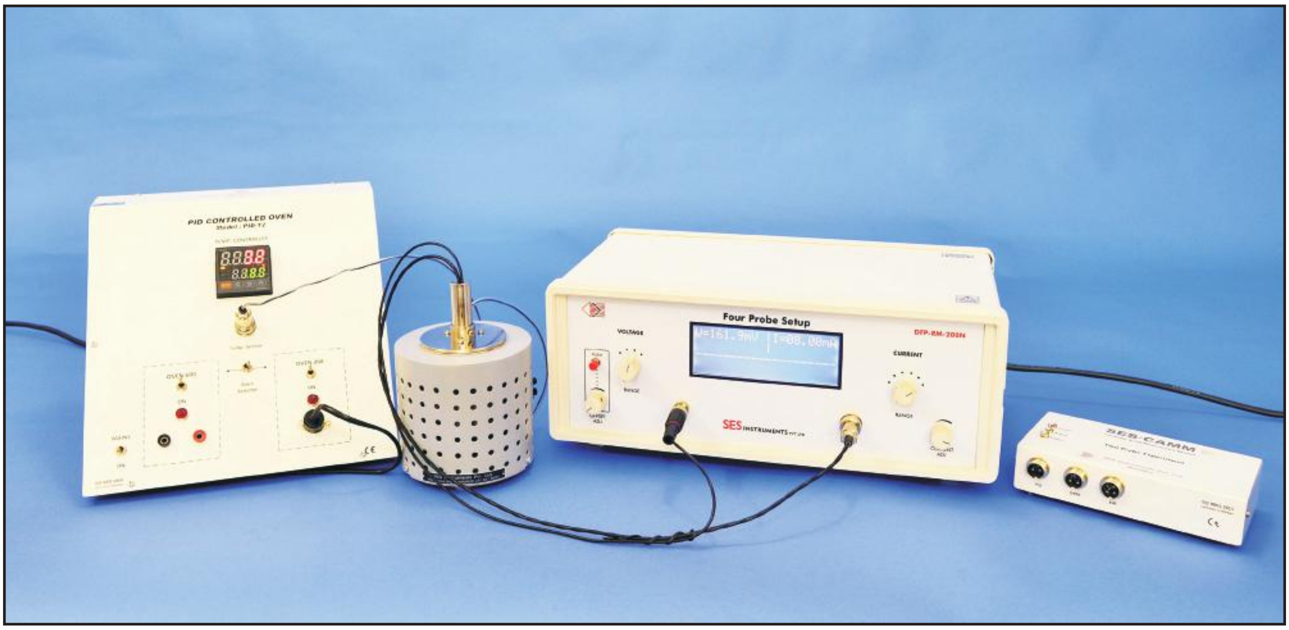
Four Probe Set-Up for measuring the resistivity of very low to highly resistive thin sheet samples at different temperatures

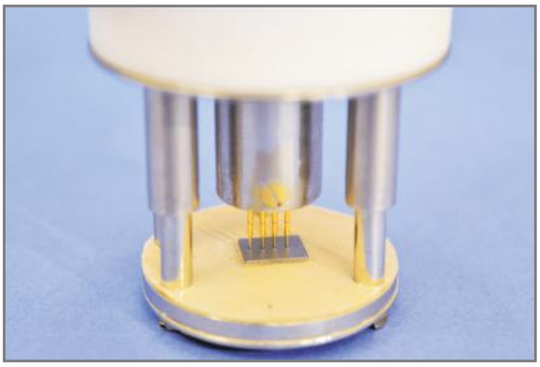


Description

The Four Probe Method is one of the standard and most widely used method for the measurement of resistivity. In its useful form, the four probes are collinear. The error due to contact resistance, which is significant in the electrical measurement on semiconductors, is avoided by the use of two extra contacts (probes) between the current contacts. In this arrangement the contact resistance may all be high compare to the sample resistance, but as long as the resistance of the sample and contact resistance's are small compared with the effective resistance of the voltage measuring device (potentiometer, electrometer or electronic voltmeter), the measured value will remain unaffected. Because of pressure contacts, the arrangement is also specially useful for quick measurement on different samples or sampling different parts of the sample.

Description of Experimental Set-up

1. Probes Arrangement



It has four individually spring loaded probes. The probes are collinear and equally spaced. The probes are mounted in a teflon bush, which ensure a good electrical insulation between the probes. A teflon spacer near the tips is also provided to keep the probes at equal distance. The probe arrangement is mounted in a suitable stand, which also holds the sample plate and thermocouple sensor. This stand also serves as the lid of PID Controlled Oven. Proper leads are provided for the current and voltage measurements.

2. PID Controlled Oven

The unit is a high quality PID controller wherein the temperatures can be set and controlled easily. The P, I and D parameters are factory set for immediate use however the user may adjust these for specific applications as well as autotune the oven whenever required. The steps for these are given in the user manual. Although the controller may be used either for our small oven, up to 200°C or a larger oven up to 600°C, however, in the present setup only small oven is to be used. The controller uses thermocouple as temperature sensor.

Specifications of the Temperature Controller

The controller is designed around Autonics Temperature Controller Model TZN4S. Although this is a very versatile piece of equipment, below is a summary of the specifications that are relevant to the present application. The PID parameters are factory set to a reasonable level (P = 1.8; I = 300; D = 80) for immediate operation of the unit.

- Temperature Range: -190°C to 200°C
- Oven: Specially designed for Four Probe Set-Up
- Display Accuracy: +-0.3°C
- Sensor: Thermocouple (Chromel-Alumel)
- Setting Type: Front push buttons
- Display: 7 segment LED, two rows
- Control Method: PID, PIDF, PIDS
- Values: Process Value, PV and Set Value, SV
- Temperature control range: Ambient to 200°C
- Power: 150W

3. Control Unit of Four Probe Setup

The unit comprises of two sections – a totally isolated constant current source, and a grounded voltage measurement system. Features of these two sections are described below in some detail.

(A) Constant Current Source

It is an IC regulated current generator that is galvanically isolated from the rest of the circuit which is a basic requirement of four probe method. The isolation is achieved by using an optically coupled amplifier and associated circuits. This circuit sends a constant Current. To the changing resistance of the sample due to change in temp.. A judicious choice of the current setting as detailed in the user manual is necessary depending on the resistance value that is measured. Brief technical details of the current section are as under:

- Current Range: 2µA, 20µA, 200µA, 2mA, 20mA and 200mA with over ranging
- Open Circuit Voltage: 15V in the lower four ranges and 9V in the upper two
- Accuracy : ±0.25% of the reading ±1digit
- 4-line LCD display with indication when current needs decreasing

(b) Digital Voltmeter Section

The voltmeter is used to read the voltage developed between the middle pins of the four probe arrangement. A primary requirement is to have very high input resistance so that the measurement is not disturbed in case of high resistance samples. The input range of the voltmeter is thus limited by avoiding the use of any potential divider. Brief technical details are as under:

- Voltage Range: 2mV, 20 mV, 200 mV, 2V with over ranging
- Manual adjustment of Offset Voltage whenever current/voltage range is changed
- Accuracy : ±0.25% of the reading ±1 digit
- 4-line LCD display with over voltage indication

Optional Attachments

Four Probe Setup as well as the PID Oven Unit may be connected to a computer for data logging purposes. Necessary hardware and software can be ordered with the system.

The setup is complete in itself

Four Probe Setup

DFP-LH

SES Instruments Pvt Ltd.

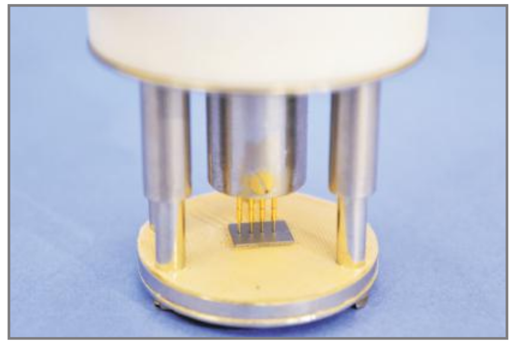
Four Probe Set-Up for Measuring the Resistivity of Different Samples at Different Temperature from -170 to 200C

Description

The Four Probe Method is one of the standard and most widely used method for the measurement of resistivity. In its useful form, the four probes are collinear. The error due to contact resistance, which is significant in the electrical measurement on semiconductors, is avoided by the use of two extra contacts (probes) between the current contacts. In this arrangement the contact resistance may all be high compare to the sample resistance, but as long as the resistance of the sample and contact resistance's are small compared with the effective resistance of the voltage measuring device (potentiometer, electrometer or electronic voltmeter), the measured value will remain unaffected. Because of pressure contacts, the arrangement is also specially useful for quick measurement on different samples or sampling different parts of the sample.

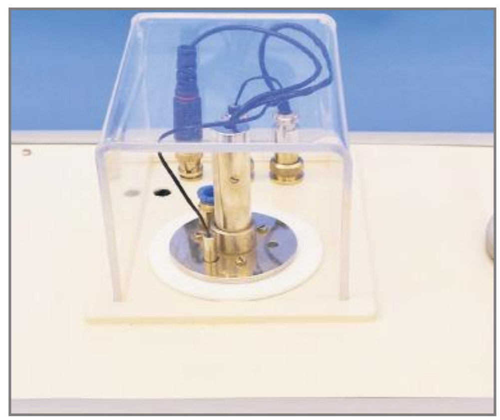
Description of Experimental Set-up

1. Probes Arrangement



It has four individually spring loaded probes. The probes are collinear and equally spaced. The probes are mounted in a teflon bush, which ensure a good electrical insulation between the probes. A teflon spacer near the tips is also provided to keep the probes at equal distance. The probe arrangement is mounted in a suitable stand, which also holds the sample plate and Thermocouple sensor. This stand also serves as the lid of PID Controlled Oven. Proper leads are provided for the current and voltage measurements.

2. PID Controlled Oven cum Cryostate



In this unit heating of sample zone is done through heating coil and cooling through controlled flow of liquid nitrogen. The necessary components such as the cryostate, the flow system etc. are included. Temperature range is from -170°C to 200°C. The unit is a high quality PID controller wherein the temperatures can be set and controlled easily. The P, I and D parameters are factory set for immediate use however the user may adjust these for specific applications as well as auto-tune the oven whenever required. The steps for these are given in the user manual.

Specifications of the Temperature Controller

The controller is designed around Autonics Temperature Controller Model TK4S. Although this is a very versatile piece of equipment, below is a summary of the specifications that are relevant to the present application.

- Temperature Range: -170°C to 200°C
- Oven: Specially designed for Four Probe Set-Up
- Display Accuracy: +-0.3°C
- Sensor: Thermocouple (Chromel-Alumel)
- Setting Type: Front push buttons
- Display: 7 segment LED, two rows
- Control Method: PID, PIDF, PIDS
- Values: Process Value, PV and Set Value, SV
- Temperature control range: Ambient to 200°C
- Power: 150W

3. Control Unit of Four Probe Setup

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It is an IC regulated current generator that is galvanically isolated from the rest of the circuit which is a basic requirement of four probe method. The isolation is achieved by using an optically coupled amplifier and associated circuits. This circuit sends a constant Current. To the changing resistance of the sample due to change in temp.. A judicious choice of the current setting as detailed in the user manual is necessary depending on the resistance value that is measured. Brief technical details of the current section are as under:

- Current Range: 2μA, 20μA, 200μA, 2mA, 20mA and 200mA with over ranging
- Open Circuit Voltage: 15V in the lower four ranges and 9V in the upper two
- Accuracy : ±0.25% of the reading ±1digit
- 4-line LCD display with indication when current needs decreasing

(b) Digital Voltmeter Section

The voltmeter is used to read the voltage developed between the middle pins of the four probe arrangement. A primary requirement is to have very high input resistance so that the measurement is not disturbed in case of high resistance samples. The input range of the voltmeter is thus limited by avoiding the use of any potential divider. Brief technical details are as under:

- Voltage Range: 2mV, 20 mV, 200 mV, 2V with over ranging
- Manual adjustment of Offset Voltage whenever current/voltage range is changed
- Accuracy : ±0.25% of the reading ±1 digit
- 4-line LCD display with over voltage indication

In addition to the above, the Four Probe Setup as well as the PID Oven cum Cryostate Unit may be connected to a computer for data logging purposes. Necessary hardware and software are optional and available separately.

The setup is complete in itself

Four Probe Setup

FP-01

SES Instruments Pvt Ltd.

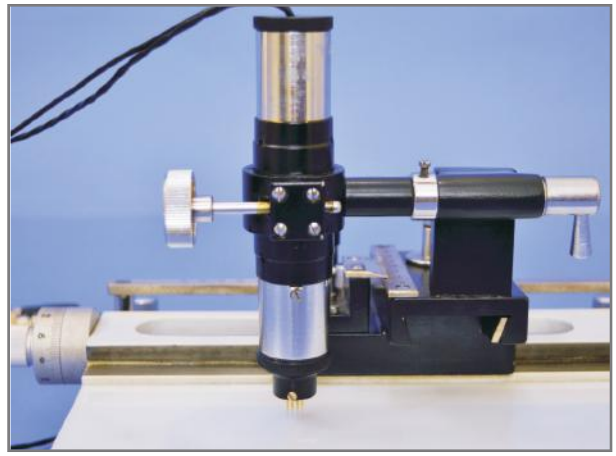
Four Probe Set-Up for Measuring the Resistivity of Different Samples at Different Temperature from -170 to 200C

Description

The Four Probe Method is one of the standard and most widely used method for the measurement of resistivity. In its useful form, the four probes are collinear. The error due to contact resistance, which is significant in the electrical measurement on semiconductors, is avoided by the use of two extra contacts (probes) between the current contacts. In this arrangement the contact resistance may all be high compare to the sample resistance, but as long as the resistance of the sample and contact resistance's are small compared with the effective resistance of the voltage measuring device (potentiometer, electrometer or electronic voltmeter), the measured value will remain unaffected. Because of pressure contacts, and 2 way motion, the arrangement is specially useful for quick measurement on large samples at room temperature.

Description of Experimental Set-up

1. Probes Arrangement



It has four individually spring loaded probes. The probes are collinear and equally spaced. The probes are mounted in a teflon bush, which ensure a good electrical insulation between the probes. A teflon spacer near the tips is also provided to keep the probes at equal distance. The probe arrangement is mounted in a tube, which also provide leads for connections to ConFour Probe Control Unit. The tube containing four probes is mounted on a travelling microscope type system, scales and verniers are made of stanless steels with following specification:

Horizontial: 20 cm least count 0.001 cm

Laterial : 6 cm least count 0.001 cm

Vertical : 15 cm least count 0.001 cm

The bed is of heavy casting, thoroughly aged and machined, is fitted with leveling screws. A large platform is provided for fixing the sample.

3. Control Unit of Four Probe Setup

The unit comprises of two sections – a totally isolated constant current source, and a grounded voltage measurement system. Features of these two sections are described below in some detail.

(A) Constant Current Source

It is an IC regulated current generator that is galvanically isolated from the rest of the circuit which is a basic requirement of four probe method. The isolation is achieved by using an optically coupled amplifier and associated circuits. This circuit sends a constant Current. To the changing resistance of the sample due to change in temp..

A judicious choice of the current setting as detailed in the user manual is necessary depending on the resistance value that is measured. Brief technical details of the current section are as under:

- Current Range: 2μA, 20μA, 200μA, 2mA, 20mA and 200mA with over ranging
- Open Circuit Voltage: 15V in the lower four ranges and 9V in the upper two
- Accuracy : ±0.25% of the reading ±1digit
- 4-line LCD display with indication when current needs decreasing

(b) Digital Voltmeter Section

The voltmeter is used to read the voltage developed between the middle pins of the four probe arrangement. A primary requirement is to have very high input resistance so that the measurement is not disturbed in case of high resistance samples. The input range of the voltmeter is thus limited by avoiding the use of any potential divider. Brief technical details are as under:

- Voltage Range: 2mV, 20 mV, 200 mV, 2V with over ranging
- Manual adjustment of Offset Voltage whenever current/voltage range is changed
- Accuracy : ±0.25% of the reading ±1 digit
- 4-line LCD display with over voltage indication

In addition to the above, the Four Probe Setup as well as the PID Oven cum Cryostate Unit may be connected to a computer for data logging purposes. Necessary hardware and software are optional and available separately.

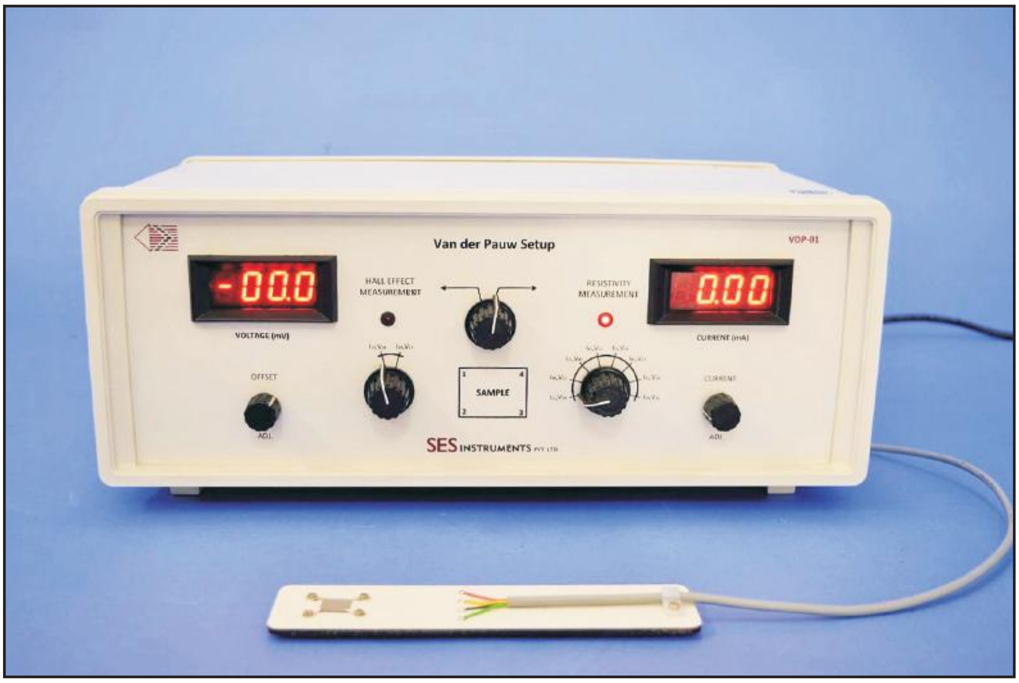
The setup is complete in itself

Van der Pauw Experiment

VDX-01

SES Instruments Pvt Ltd.

Van der Pauw Set-Up for measurement of resistivity and determination of hall coeffiecients in semiconductor samples

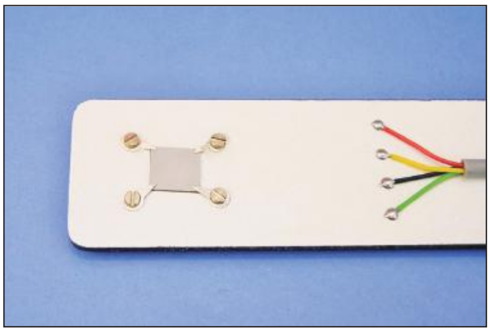


Introduction

Semiconductor material research and device testing often involve determining the resistivity and Hall mobility of a sample. The resistivity of the semiconductor material is often determined using a four-point probe technique. With a fourprobe, or Kelvin, technique, two of the probes are used to source current and the other two probes are used to measure voltage. Using four probes eliminates measurement errors due to the probe resistance, the spreading resistance under each probe, and the contact resistance between each metal probe and the semiconductor material. Because a high impedance voltmeter draws little current, the voltage drops across the probe resistance, spreading resistance, and contact resistance are very small. One common Kelvin technique for determining the resistivity of a semiconductor material is the van der Pauw (VDP) method. The van der Pauw method involves applying a current and measuring voltage using four small contacts on the circumference of a flat, arbitrarily shaped sample of uniform thickness. This method is particularly useful for measuring very small samples because geometric spacing of the contacts is unimportant. Effects due to a sample's size, which is the approximate probe spacing, are irrelevant.

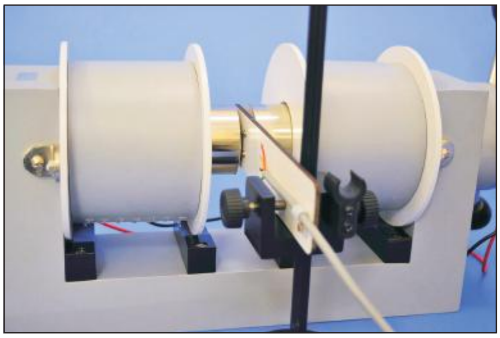
Description of Experimental Set-up

1. Probes Arrangement



Ge single crystal with four pure silver, spring type pressure contacts is mounted on a sunmica coated bakelite strip. Suitable connector is provided for connections with current source and hall voltage measuring devices.

2. Van der Pauw Set-up, VDP-01



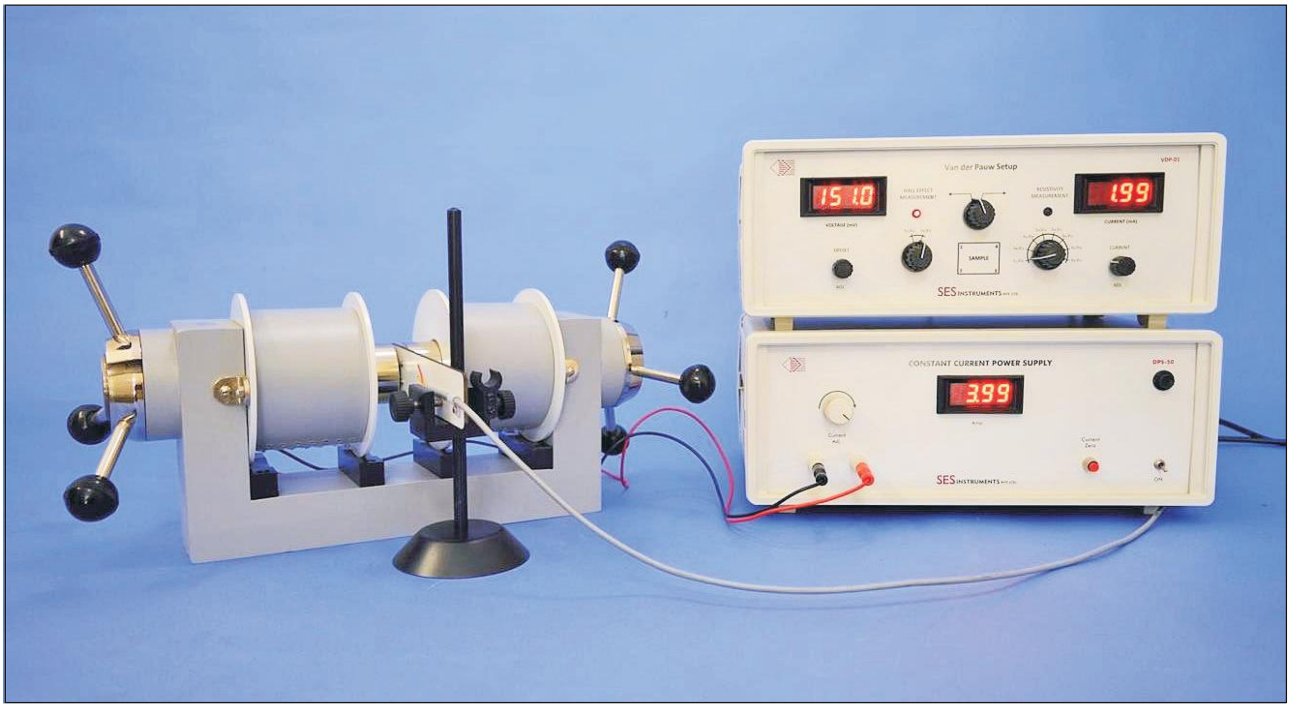
The set-up, VDP-01 consists of two sub units to handle probe current and hall voltage. While the probe current is generated and measured by a constant current source (0-20mA) having a resolution of 10μA, the hall voltage is measured by a high input resistance millivoltmeter in the range 0-200mV having a resolution of 100μV. The probe current and hall voltage are both displayed on separate 3.5 digit LED panel meters. Various combinations of Voltage and Current probe locations used in Van der Pauw measurements can be conveniently selected using bandswitch provided on the panel both for Resistivity and Hall Effect measurements.

3. Electromagnet, EMU-50V (Refer datasheet for specifications)

4. Constant Current Power Supply, DPS-50 (Refer datasheet for specifications)

5 .Digital Gaussmeter, DGM-202 (Refer datasheet for specifications)

The setup is complete in itself



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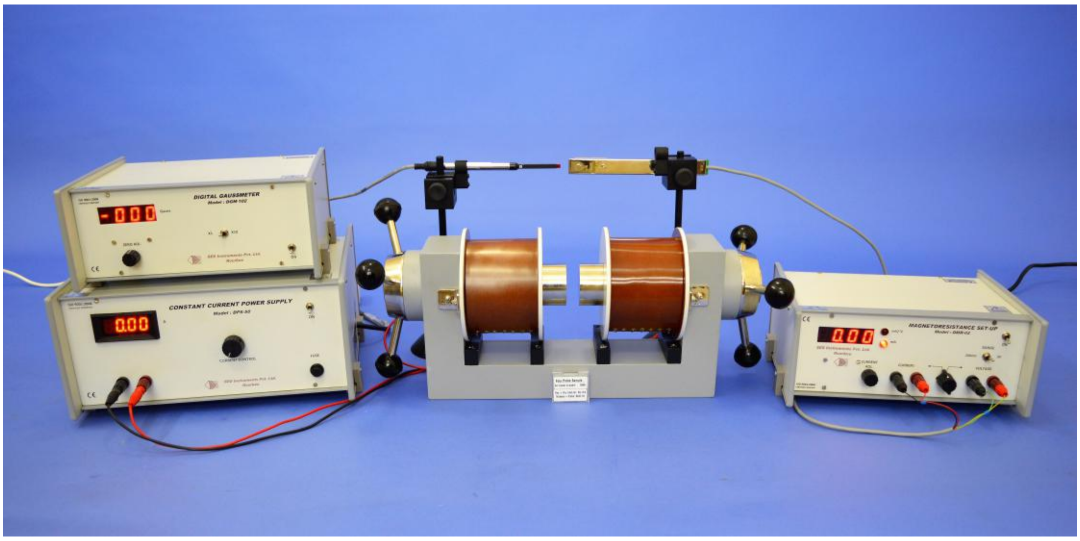
MRX-01

Measurement of Magnetoresistance of Semiconductors

Measurement of Magnetoresistance of Semiconductors



It is noticed that the resistance of the sample changes when the magnetic field is turned on. The phenomenon, called magnetoresistance, is due to the fact that the drift velocity of all carriers is not same. With the magnetic field on; the Hall voltage $V=E_y t=|v \times H|$ compensates exactly the Lorentz force for carriers with the average velocity; slower carriers will be over compensated and faster one under compensated, resulting in trajectories that are not along the applied field. This results in an effective decrease of the mean free path and hence an increase in resistivity.

Here the above referred symbols are defines as: v = drift velocity; E = applied electric field; t = thickness of the crystal; H = Magnetic field.

Experimentental Set-up for Magnetoresistance

The set-up consists of the following:

1. Four probe arrangement
2. Sample: (Ge: p-type)
3. Magnetoresistance set-up, DMR-01
4. Electromagnet, EMU-50V
5. Constant Current Power Supply, DPS-50
6. Digital Gaussmeter, DGM-102

(1) Four Probe arrangement°

It consists of 4 collinear, equally spaced (2mm) and individually spring loaded probes mounted on a PCB strip. Two outer probes for supplying the constant current to the sample and two inner probes for measuring the voltage developed across these probes This eliminates the error due to contact resistance which is particularly serious in semiconductors A platform is also provided for placing the sample and mounting the Four Probes on It.

(2) Sample

Ge Crystal (n-type) dimensions: 10 x 10 x 0.5mm.

(3) Magnetoresistance Set-up, Model DMR-01

This unit consists of a digital millivoltmeter and constant current power supply The voltage and probe current can be read on the same digital panel meter through a selector switch.

(a) Digital Millivoltmeter

Intersil 3½ digit single chip ICL 7107 have been used. Since the use of internal reference causes the degradation in performance due to internal heating an external reference have been used. Digital voltmeter is much more convenient to use, because the input voltage of either polarity can be measured.

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ISO 9001:2015

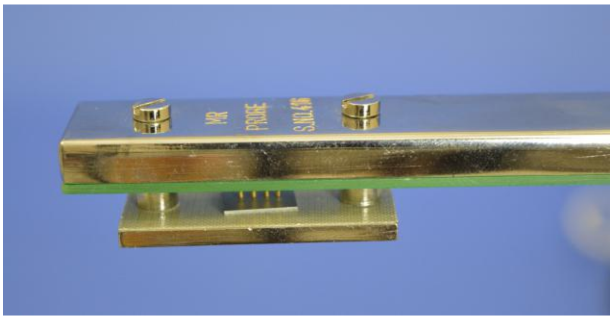
MRX-01

Measurement of Magnetoresistance of Semiconductors

Specifications

Range	:	0-200mV (100µV minimum)
Accuracy	:	±0.1% of reading ± 1 digit

(b) Constant Current Power Supply

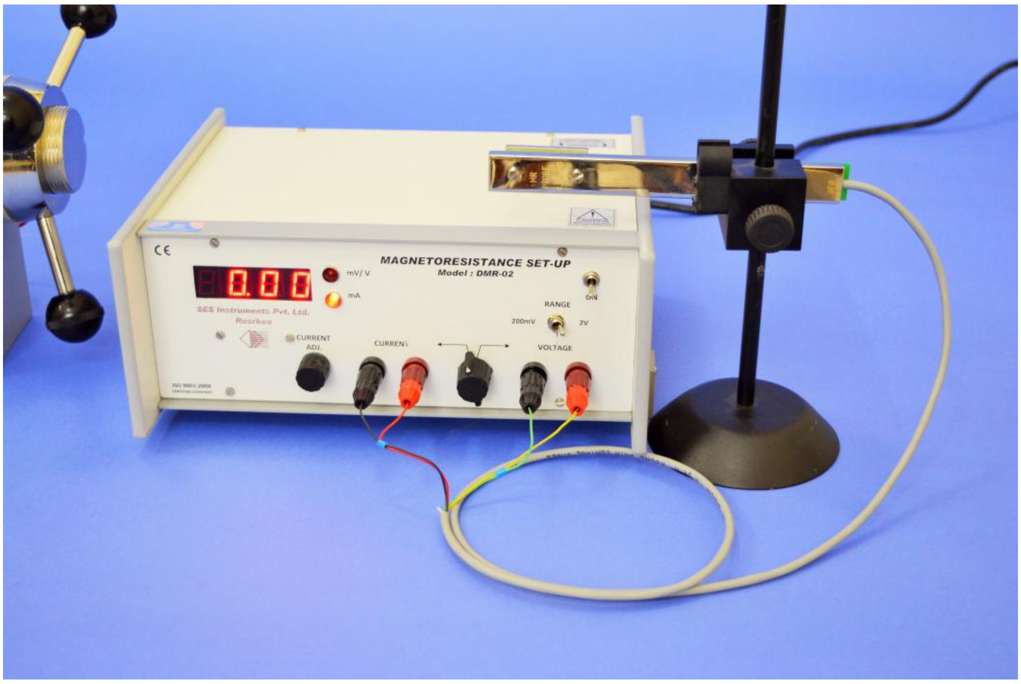


This power supply, specially designed for Hall Probe, provides 100% protection against crystal burn-out due to excessive current. The supply is a highly regulated and practically ripple free dc source.

Specifications

Current	:	0-20mA
Resolution	:	10µA
Accuracy	:	±0.2% of the reading ±1 digit
Load regulated	:	0.03% for 0 to full load
Line regulation	:	0.05% for 10% variation

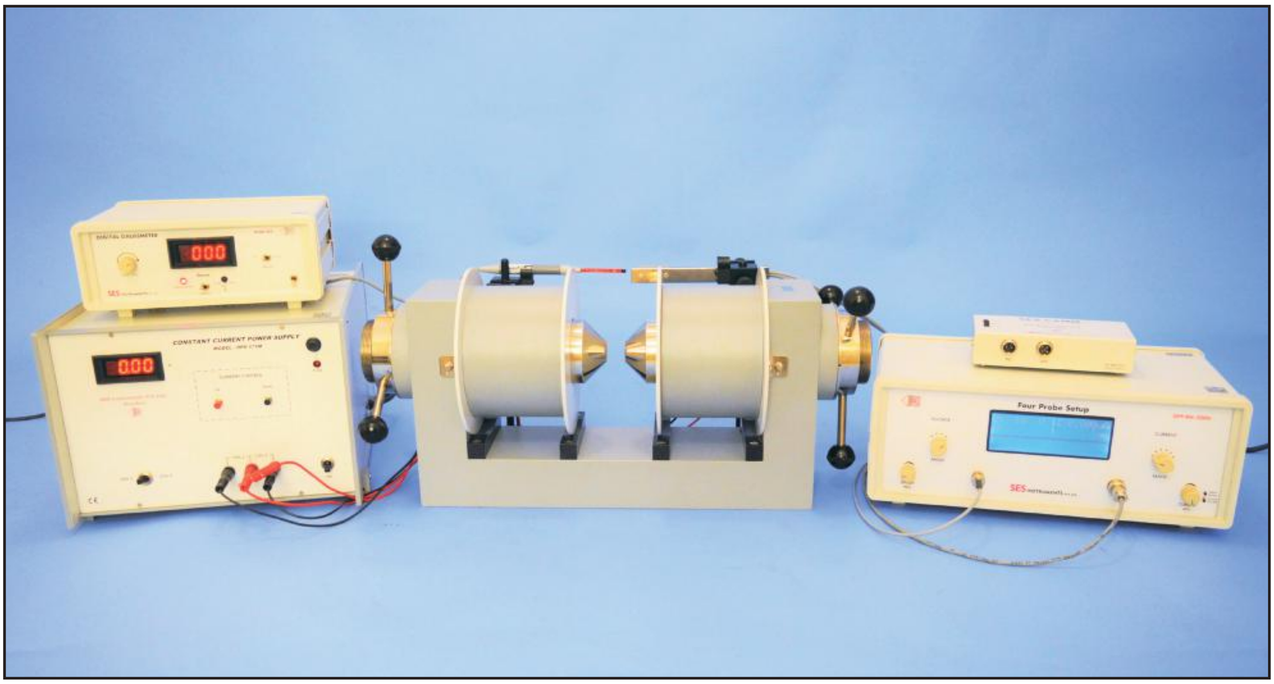
The details of other sub-units can be had from their respective data-sheets.



Magnetoresistance Setup (Research Model) MRX-RMN

SES Instruments Pvt Ltd.

MEASUREMENT OF MAGNETORESISTANCE OF WIDE VARIETY OF SAMPLES



Description

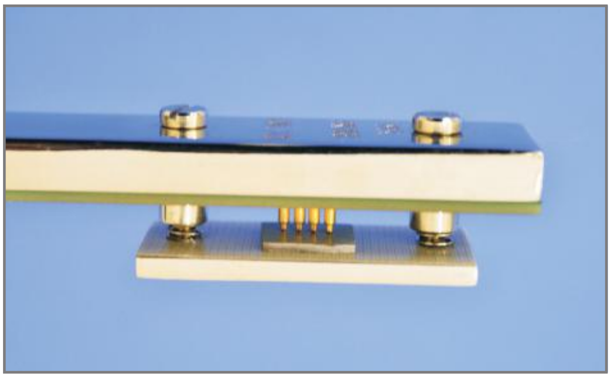
It is noticed that the resistance of the sample changes when the magnetic field is turned on. The phenomenon, called magnetoresistance, is due to the fact that the drift velocity of all carriers is not same. With the magnetic field on; the Hall voltage $V=E_y t=|v \times H|$ compensates exactly the Lorentz force for carriers with the average velocity; slower carriers will be over compensated and faster one under compensated, resulting in trajectories that are not along the applied field. This results in an effective decrease of the mean free path and hence an increase in resistivity.

Here the above referred symbols are defines as:

v = drift velocity	E = applied electric field
t = thickness of the crystal	H = magnetic field

Description of Experimental Set-up

1. Probes Arrangement



It consists of 4 collinear, equally spaced (2mm) and individually spring loaded probes mounted on a PCB strip. Two outer probes for supplying the constant current to the sample and two inner probes for measuring the voltage developed across these probes. This eliminates the error due to contact resistance which is particularly serious in semiconductors. A platform is also provided for placing the sample and mounting the Four Probes on it.

2. Control Unit of Four Probe Setup

The unit comprises of two sections – a totally isolated constant current source, and a grounded voltage measurement system. Features of these two sections are described below in some detail.

(A) Constant Current Source

It is an IC regulated current generator that is galvanically isolated from the rest of the circuit which is a basic requirement of four probe method. The isolation is achieved by using an optically coupled amplifier and associated circuits. This circuit sends a constant Current. To the changing resistance of the sample due to change in temp..

A judicious choice of the current setting as detailed in the user manual is necessary depending on the resistance value that is measured. Brief technical details of the current section are as under:

- Current Range: 2μA, 20μA, 200μA, 2mA, 20mA and 200mA with over ranging
- Open Circuit Voltage: 15V in the lower four ranges and 9V in the upper two
- Accuracy : ±0.25% of the reading ±1digit
- 4-line LCD display with indication when current needs decreasing

(b) Digital Voltmeter Section

The voltmeter is used to read the voltage developed between the middle pins of the four probe arrangement. A primary requirement is to have very high input resistance so that the measurement is not disturbed in case of high resistance samples. The input range of the voltmeter is thus limited by avoiding the use of any potential divider. Brief technical details are as under:

- Voltage Range: 2mV, 20 mV, 200 mV, 2V with over ranging
- Manual adjustment of Offset Voltage whenever current/voltage range is changed
- Accuracy : ±0.25% of the reading ±1 digit
- 4-line LCD display with over voltage indication

3. Standard Sample

Ge Crystal (n-type) dimensions: 10 x 10 x 0.5mm.

(This standard sample is included to enable the user to check the functioning of the setup)

4. Electromagnet, EMU-75T *(Refer datasheet for specifications)*

5. Constant Current Power Supply, DPS-175-C2 *(Refer datasheet for specifications)*

6. Digital Gaussmeter, DGM-202-C1 *(Refer datasheet for specifications)*

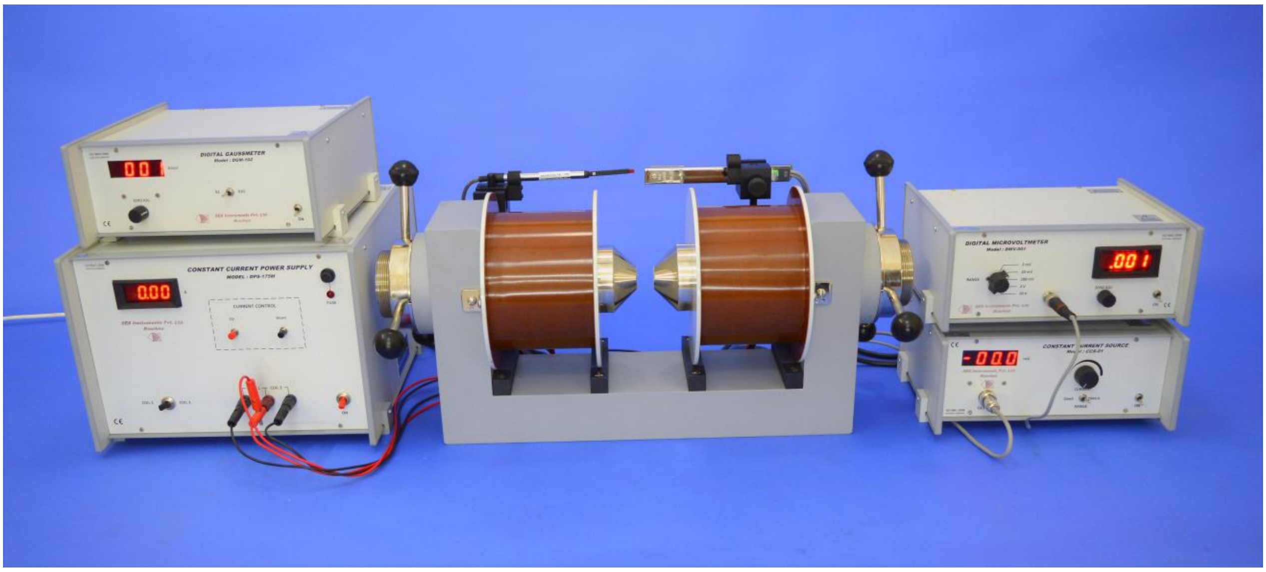
In addition to the above, this Magnetoresistance Setup may be connected to a computer for data logging purposes. Necessary hardware and software are optional and can be purchased separately .

The setup is complete in itself

MRB-11

Measurement of Magnetoresistance in Bismuth

Measurement of Magnetoresistance in Bismuth



It is noticed that the resistance of the sample changes when the magnetic field is turned on. The phenomenon, called magnetoresistance, is due to the fact that the drift velocity of all the carriers is not same. With the magnetic field on; the Hall voltage $V = E_y t = |v \times H|$ compensates exactly the Lorentz force for carriers with the average velocity; slower carriers will be over compensated and faster one undercompensated, resulting in trajectories that are not along the applied field. This results in an effective decrease of the mean free path and hence an increase in resistivity.

Here the above referred symbols are defined as: v = drift velocity; E = applied electric field; t = thickness of

the crystal; H = Magnetic field

Experimentental Set-up for Magnetorsistance

The set-up consists of the following:

1. Hall Probe: Bismuth
2. Constant Current Source, CCS-01
3. Digital Microvoltmeter, DMV-001
4. Electromagnet, EMU-75 (Specifications as per datasheet attached)
5. Constant Current Power Supply, DPS-175 (Specifications as per datasheet attached)
6. Digital Gaussmeter, DGM-102 (Specifications as per datasheet attached)

(1) Four Probe Arrangement

It consists of 4 collinear, equally spaced (2mm), gold plated and individually spring loaded probes mounted on a PCB strip. Two outer probes for supplying the constant current to the sample and two inner probes for measuring the voltage developed across these probes. This eliminates the error due to contact resistance which is particularly serious in semiconductors. A platform is also provided for placing the sample and mounting the Four Probes on it.

(2) Sample

Material : Bismuth

Dimensions: 10x10x1.2mm.

(3) Constant Current Source, CCS-01

It is an IC regulated current generator to provide a constant current to the outer probes irrespective of the changing resistance of the sample due to change in temperatures.

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The basic scheme is to use the feedback principal to limit the load current of the supply to preset maximum value. Variations in the current are achieved by a potentiometer included for that purpose. The supply is a highly regulated and practically ripples free d.c. source. The constant current source is suitable for the resistivity measurement of this films of metals/alloys and semiconductors like germanium.

Specifications

Range	:	0-20mA, 0-200mA
Resolution	:	10μA
Accuracy	:	±0.25% of reading ±1 digit
Display	:	3½ digit, 7 segment LED with autopolarity and decimal indication

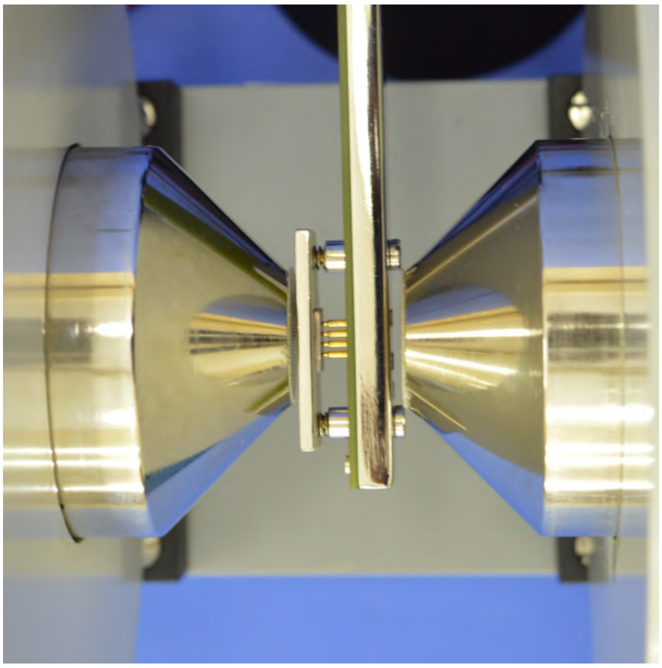
(4) Digital Microvoltmeter, DMV-001

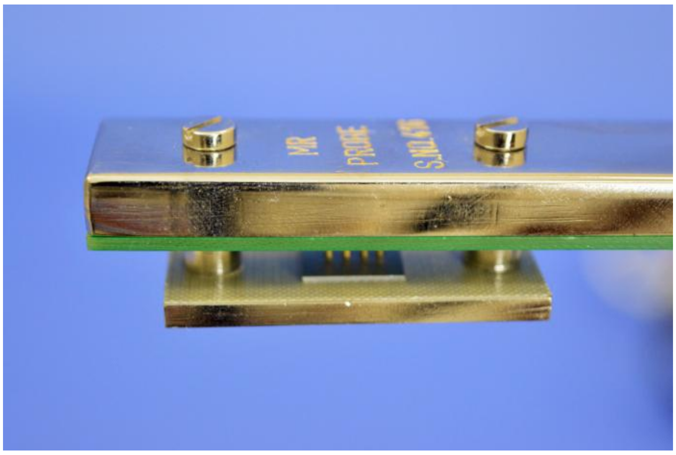
it is a very versatile multipurpose instrument for the measurement of low dc voltage. It has 5 decade ranges from 1mV to 10V with 100% over-ranging. For better accuracy and convenience, readings are directly obtained on 3½ digit DPM (Digital Panel Meter).

Specifications

Range	:	1mV, 10mV, 100mV, 1V & 10V with 100% over-ranging.
Resolution	:	1pV
Accuracy	:	±0.2% ±1 digit
Stability	:	Within ±1 digit
input Impedance	:	>1000MΩ (10MΩ on 10V range)
Display	:	3½ digit, 7 segment LED with autopolarity and decimal indication

The details of other sub-units can be had from their respective datasheets





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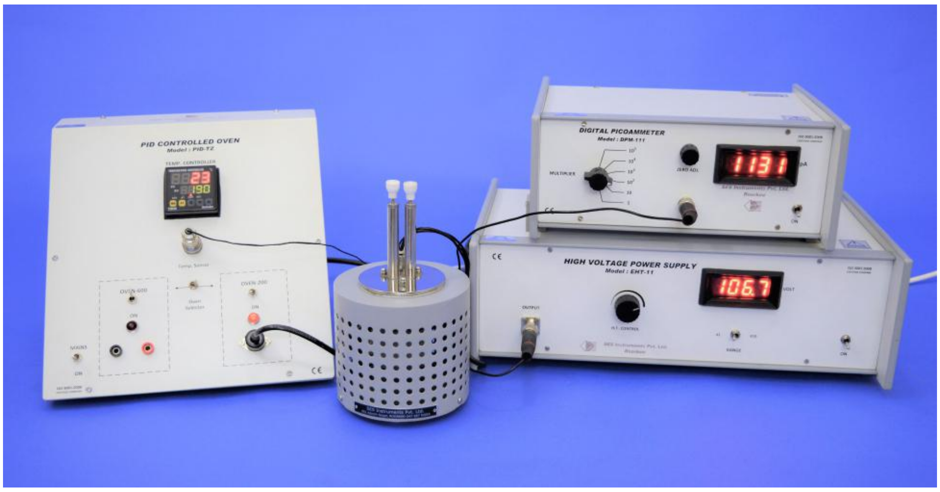
TPX-200

Two Probe Setup

Two Probe Method for resistivity measurement of insulators at different temperatures

The Two Probe Method is one of the standard and most commonly used method for the measurement of resistivity of very high resistivity samples like sheets/films of polymers. The resistivity measurement of such samples is beyond the range of Four Probe Method.



Description of the experimental set-up

1. Two Probes Arrangement, TPA-01

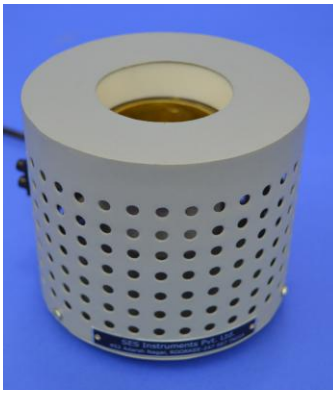
It has two spring load contact probes. These probes move in a pipe and are insulated by Teflon washers. This probes arrangement is mounted in a suitable stand, which also holds the sample plate and RTD sensor. The stand also serves as the lid of PID Controlled Oven. Teflon coated leads are provided for connecting wit High Voltage Power Supply EHT-11 and Digital Picoammeter DPM-111. With this set-up assuming max. Voltage = 1500V; current $10x10^{-12}$ A (max) and thickness of sample 1mm, the resistivity of the sample could be measured upto 10^{14} ohm.cm..

2. PID Controlled Oven, PID-TZ

The unit is a high quality PID controller wherein the temperatures can be set and controlled easily. The P, I and D parameters are factory set for immediate use, however, the user may adjust these for specific applications as well as auto-tune the oven whenever required. The steps for these are given in the user manual. Although the controller may be used either for our small oven, up to 200°C or a larger oven up to 600°C, however, in the present setup only small oven is to be used. The controller uses thermocouple as temperature sensor.

3. High Voltage Power Supply, Model EHT-11

Specifications as per datasheet attached



4. Digital Picoammeter, Model DPM-111

Specifications as per datasheet attached

The experimental set-up is complete in all respect

Specifications of the oven controller

Temperature Flange	:	Ambient to 200°C
Display Accuracy	:	±0.3°C
Setting Type	:	Front push buttons
Control Method	:	PID, PIDF, PIDS
Measurement Accuracy	:	±0.5°C (typical)
Oven	:	Specially designed for Four Probe Set-Up
Sensor	:	Thermocouple (Chromel-Alumel)
Display	:	7 segment LED, two rows
Values	:	Process Value, PV and Set Value, SV
Power	:	150W

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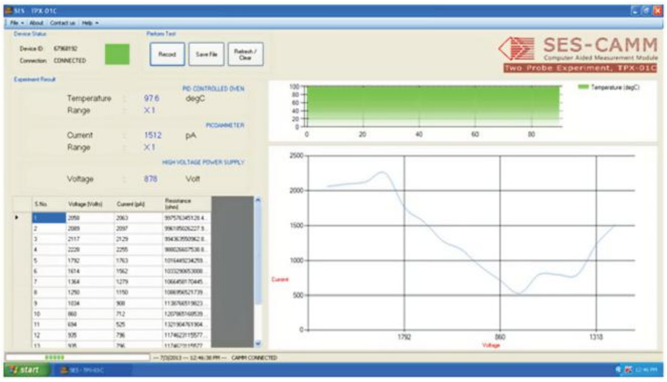
TPX-200C

Two Probe Setup

Two Probe Method for resistivity measurement of near insulators at different temperatures (ambient to 200°C) with computer interfacing facility

Introduction

The Two Probe Method is one of the standard and most commonly used method for the measurement of resistivity of very high resistivity samples near insulators. The resistivity measurement of such samples is beyond the range of Four Probe Method.



Description of the Experimental Set-up

1.Two Probes Arrangement, TPA-01

It has two spring load contact probes. These probes move in a pipe and are insulated by teflon washers. This probes arrangement is mounted in a suitable stand, which also holds the sample plate and RTD sensor. The stand also serves as the lid of PID Controlled Oven. Teflon coated leads are provided for connecting with High Voltage Power Supply EHT-11-C1 and Digital Picoammeter DPM-111-C2. With this set—up assuming maximum voltage I500V; minimum current 10^{-12} A and thickness of sample 1mm, the resistivity of the sample could be measured upto 10^{14} ohm.cm..

2. PID Controlled Oven (PID-TZ-C1)

Specifications as per datasheet attached.

3. DPM-111-C2

Specifications as per datasheet attached.

4. EHT-11-C1

Specifications as per datasheet attached.

5. Computer Interface, SES-CAMM

This interface (SES-CAMM) provides, option to user, to interface the setup with the computer for acquiring data (temperature, current and voltage) and plotting it in real time. The data can also be stored in an excel file which can be used for further analysis. The software is menu driven and can be operated very easily.

The set-up is complete in all respect, except the computer.

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TPX-600C

Two Probe Setup

Two Probe Method For Resistivity Measurement of Near Insulators at Different Temperatures (Ambient to 600°C) with computer interfacing facility

Description

Behaviour of resistivity of substarte such as polymer sheets/ films at higher temperatures is an important area of investigation due to their variety of applications. Two Probe Method is one of the standard and most commonly used method for the measurement of resistivity of very high resistivity samples like sheets/films of polymers. The resistivity measurement of such samples is beyond the range of Four Probe Method.

Description of the experimental set-up

1. Two Probes Arrangement

   It has two individually spring loaded probes. The probes arrangement is mounted in a suitable stand of high quality alumina which also holds the sample plate. To ensure the correct measurement of sample temperature, the thermocouple junction is embedded in the sample plate just below the sample. This stand also serves as the lid of temperature controlled oven. Proper leads are provided for connection to Capacitance Meter and Temperature Controller.

2. High Temperature Oven

   This is a high quality temperature controlled oven. The heating element used is a high grade Kanthal-D. It is mounted on a custom made groved, sintered alumina fixture to avoid any slippage of heating wire. Heat shield is also provided to reduce the excessive heating of outer cover. Further the top portion is also suitably covered to meet the safety standard. The oven has been designed for fast heating and cooling rates, which enhances the effectiveness of the controller.

3. PID Temperature Controller

The unit is a high quality PID controller wherein the temperatures can be set and controlled easily. The P, I and D parameters are factory set for immediate use however the user may adjust these for specific applications as well as auto-tune the oven whenever required. The steps for these are given in the user manual. Although the controller may be used either for our small oven, up to 200°C or a larger oven up to 600°C, however, in the present setup only large oven is to be used. The controller uses thermocouple as temperature sensor.

TPX-600C

Two Probe Setup

Specifications		
Temperature Range	:	Ambient to 600°C
Power Supply	:	100-240VAC; 50/60Hz
Display	:	Method 7 Segment LED display [Processing value (PV):Red, Setting value (SV):Green]
Input Sensor	:	Thermocouple (Chromel – Alumel)
Control Method	:	PID, ON/OFF Control, P, PI, PD, PIDF, PIDS
Display Accuracy	:	± 0.3%
Setting Type	:	Setting by front push buttons
Proportional Band (P)	:	0 to 100.0%
Integral Time (I)	:	0 to 3600 Sec
Derivative Time (D)	:	0 to 3600 Sec
Control Time (T)	:	1 to 120 Sec
Sampling Time	:	0.5 Sec
Setting (P, I & D)	:	Manual / Auto
Interfacing	:	USB connection through SES-CAMM

4. High Voltage Power Supply, Model EHT-11C

Specifications as per datasheet attached

5. Digital Picoammeter, Model DPM-111C

Specifications as per datasheet attached

6. Computer Interface, SES-CAMM

An interface (SES-CAMM) provides the option to the user to interface it with the computer for acquiring and storing the data (temperature, current and voltage) and plotting in real time. The data is also stored in an excel file which can be used for further analysis. The software is menu driven and can be operated very easily.

Interfacing	:	PC connectivity through USB. Individual unit connectivity through BNC connector
Software	:	Fully integrated software capable of display and storing data in different configuration . Compatible with Window XP/ 7/ 8.

The experimental set-up is complete in all respect

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ESR-105

Electron Spin Resonance Spectrometer

Features

- FET based marginal R.F. Oscillator
- Digital display of frequency
- Excellent peaks display
- Digital display of Helmoltz Coil Current
- Compatible with general purpose CRO in X-Y mode

Introduction

In recent years Magnetic Resonance has developed into a very useful and powerful tool in solid state research. In this method, use is made of the Zeeman interaction of the magnetic dipoles associated with the nucleus or electron, when placed in an external magnetic field. Accordingly, they are identified as NMR (Nuclear Magnetic Resonance) or ESR (Electron Spin Resonance). This form of spectroscopy finds many applications in the investigation of crystal structures, environmental effects, dynamic effects, defects in solids and in many diverse branches of Physics, Chemistry and Biology.

Elementary Magnetic Resonance

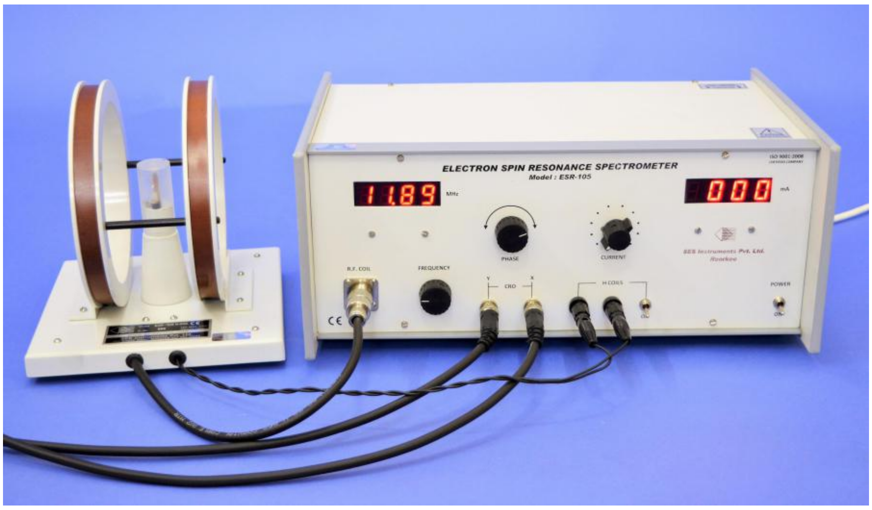
We know that the intrinsic angular momentum (spin) of the electron $\bar{S}$ couples with the orbital angular momentum of the electron $\bar{L}$ to give a resultant $\bar{J}$ and this coupling gives rise to the 'fine structure' of the spectra. Further, under the influence of an external magnetic field (H) each of the level will split into (2j+1) sub levels (Zeeman effect) and the splitting of a level will be

$$\Delta E = (g\mu_0 H)m_j$$

where μ_0 is the Bhor magneton, g is the Lande' g-factor and m_j is the magnetic quantum number. As can be seen, the splitting is not same for all levels; it depends on the J and L of the level (s=½ always for one electron). However, the sub levels will split equally by an amount

$$\Delta E = g\mu_0 H \quad \text{or} = hn_0$$

where ν_0 is the frequency of the



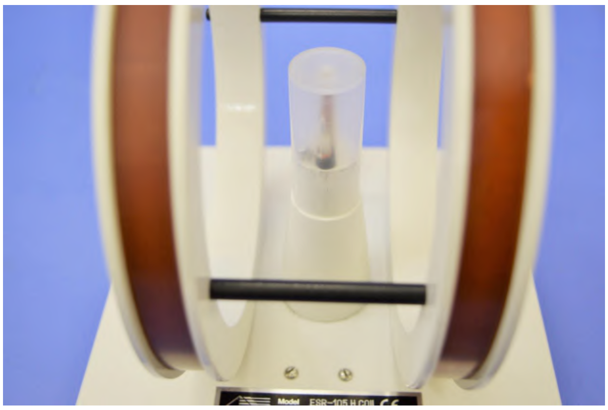
system. Now if the electron is subjected to a perturbation by an oscillating magnetic field with its direction perpendicular to the static magnetic field and its frequency ν_1 such that the quantum $h\nu_1$ is equal to $E=h\nu_0$, we say that there is a resonance between ν_1 and ν_0. This will induce transition between neighbouring sublevels ($m_j = \pm 1$) and in turn will absorb energy from oscillating field. Thus, at resonance, we get a peak due to the absorption of energy by the system.

Experimental Technique

If we consider a free electron and substitute the proper value of constants in the equation: g = 2.00, $\mu_0 = 0.927 \times 10^{-20}$ erg/gauss & h = 6.625 X 10^{-27} erg sec, we get

$$\frac{\nu_0}{H_0} = 2.8\text{MHz/gauss}$$

That is ESR can be observed at radio frequencies in a magnetic field of a few gauss or in the microwave region in a magnetic field of a few kilogauss. The latter alternate has many advantages: improved signal-to-noise ratio, high resolution etc. and is always preferred for accurate work, though it is very sophisticated and expensive. However, if the basic understanding of the subject is the main criteria as is usually the requirement of class room experiments, the observation of ESR in low magnetic field and in a radio frequency region makes it a lot simple, inexpensive and within the reach of every post-graduate laboratory.



Description of the ESR Spectrometer

A block diagram of the ESR Spectrometer is given below in Fig. 1, and a brief description follows.

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ESR-105

Electron Spin Resonance Spectrometer

Basic Circuit

The first stage of the ESR circuit consists of a critically adjusted (marginal) radio frequency oscillator with 4-digit frequency display. This type of oscillator is required here, so that the slightest increase in its load decreases the amplitude of oscillation to an appreciable extent. The sample is kept inside the tank coil of the oscillator, which in turn, is placed in the 50Hz magnetic field, generated by the Helmholtz coils. At resonance, i.e. when the frequency of oscillation equal to the Larmour's frequency of the sample, the oscillator amplitude registeres a dip due to the absorption of power by the sample. This obviously, occurs periodically four times in each complete cycle of the supply voltage. The result is an amplitude modulated carrier which is then detected using a FET demodulator and amplified by an op-amp circuit.

Highly stabilised and almost ripple free power supply for the above circuit is obtained using an integrated circuit regulator.

Phase Shifter

This can compensate the undermined phase difference which may be introduced in the amplification stages of the spectrometer and oscilloscope.

50Hz Sweep Unit

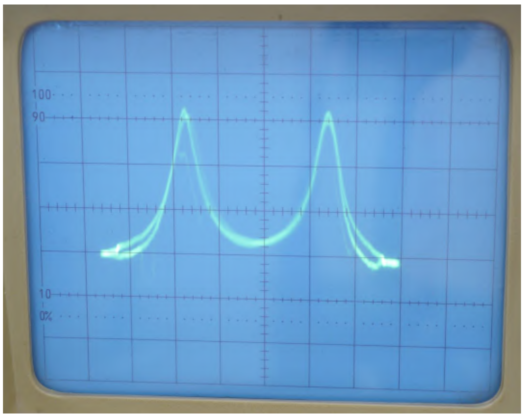
A 50Hz current flows through Helmholtz coils which provides a low frequency magnetic field to the sample. As the resonance is observed at few gauss only, no static magnetic field is applied.

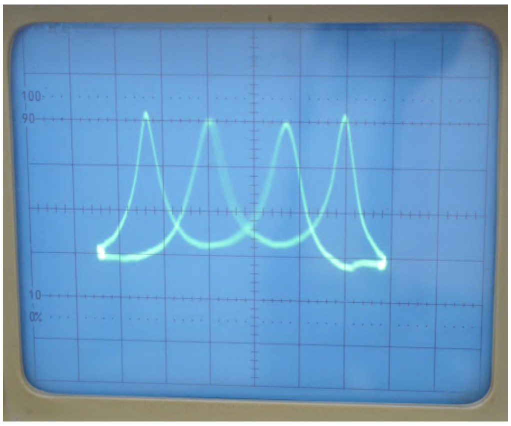
Oscilloscope (not supplied with the Spectrometer)

Any inexpensive oscilloscope normally available in the laboratory would be quite suitable.

Advantages and Limitations of our Spectrometer

1. The instrument is basically designed for postgraduate laboratories keeping in view their requirements and limitations.
2. The observation of ESR at low magnetic fields and consequently in radio-frequency region makes its instrumentation and working a lot simple and within the reach of a postgraduate students. Goodresonance peaks can be obtained as a class room exercise.
3. The spectrometer is complete in all respects including a sample DPPH (except a CRO).





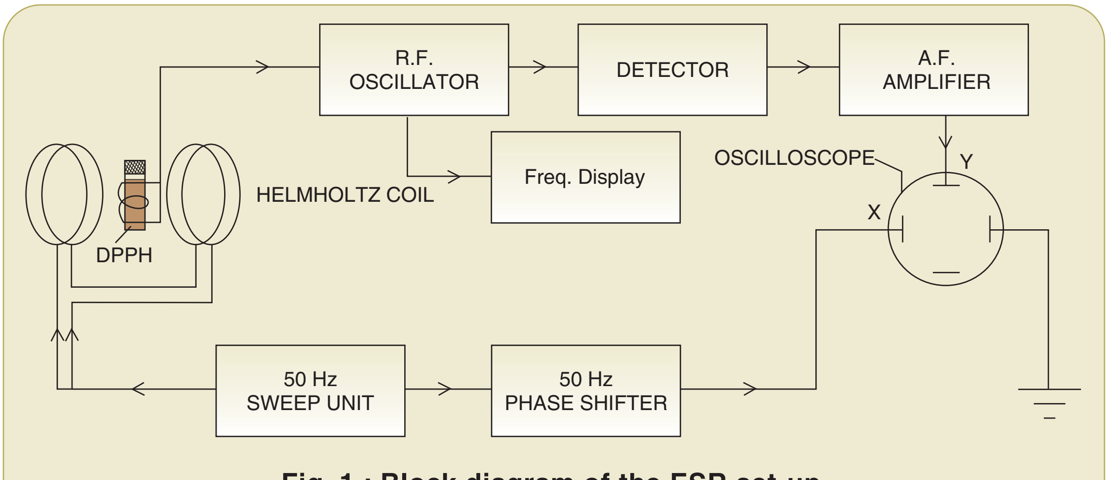


Fig. 1 : Block diagram of the ESR set-up

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NMR-01

NMR Experiment

Features

- Suitable for ^{1}H and ^{11}F nuclei
- FET based marginal Oscillator
- Digital Display of frequency and current
- Clear display of resonance peaks
- Compatible with general purpose CRO

Introduction

Nuclear Magnetic Resonance (NMR) was discovered by Bloch and Purcell in the year 1945. Over the years it has developed into a very useful and powerful tool in solid state physics, chemistry and biology. In medical application this technique, under the name Magnetic Resonance Imaging (MRI) has been developed as an excellent imaging method for clinical diagnosis.

In this method use is made of Zeeman interaction of the magnetic dipoles associated with the nucleus when placed in a external magnetic field.

Elementary Magnetic Resonance

An atom whose nucleus has a nulcear spin I will have a magnetic moment μ as follows:

$$\mu = g\mu_n I \qquad (1)$$

where μ_n is nuclear magneton, and g is g factor. Under the influence of an external static magnetic field (H), these nuclear magnets can orient in distinct directions. Each spin orientation corresponds to a particular energy level given by:

$$E = g\mu_n H m_j \qquad (2)$$

with m_j = -I, -(I-1), ...(I-1), I where m_j is magnetic quantum number

The splitting of levels will therefore be:-

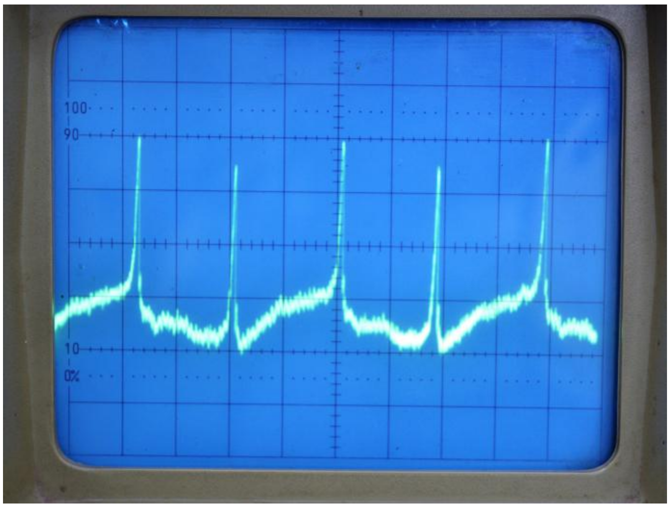
$$\Delta E = g\mu_n H \quad \text{or} \quad = h\nu_0 \qquad (3)$$

where ν_0 is the r. f. frequency applied perpendicular to the static magnetic field. Now if the spins are subjected to a purturbation by an oscillating magnetic field with its direction parallel to the static magnetic field and its frequency ν_1 such that the quantum $h\nu_1$ is equal to $\Delta E = h\nu_0$, we say that there is a resonance between ν_1 and ν_0.

This will induce transition between neighbouring sub levels (m_j = I) and in turn will absorb energy from the oscillating field. Thus, at resonance, we get a peak due to the absorption of energy by the system.

Experimental Technique

In our experiment the NMR signals of Hydrogen nuclei and Fluorine nuclei are detected .Both have only two possible orientations in reference to static magnetic field H since both have proton spin I = 1/2. The sample is placed in an r.f.coil located between the gap of homogeneous magnetic field H. In order to exactly match equation (3), H is modulated at constant frequency (50Hz in our case) by using two modulation coils. Each time when the matching (resonance) condition (Eq. 3) is fulfilled, energy is absorbed from the r.f.coil due to the spin transition.



Proton Resonance

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NMR-01

NMR Experiment

Description of the NMR Spectrometer

The block diagram of the NMR spectrometer is given below in Fig.1 and a brief description follow:-.

Basic Circuit

The first stage of the NMR circuit consists of a critically adjusted (marginal) radio frequency oscillator with 4-digit frequency display. This type of oscillator is required here, so that the slightest increase in its load decreases the amplitude of oscillation to an appreciable extent. The sample is kept inside the tank coil of the oscillator, which in turn, is placed in the 50Hz magnetic field, generated by the Helmholtz coils and a permanent magnet. At resonance, i.e. when the frequency of oscillation equal to the Larmour's frequency of the sample, the oscillator amplitude registers a dip due to the absorption of power by the sample. This obviously, occurs periodically two times in each complete cycle of the modulating magnetic field. The result is an amplitude modulated carrier which is then detected using a FET demodulator and amplified by an op-amp circuit.

Permanent Magnet

Two high field permanent magnets have been used in H structure and adjusted to produce highly uniform high magnetic field.

50Hz Sweep Unit

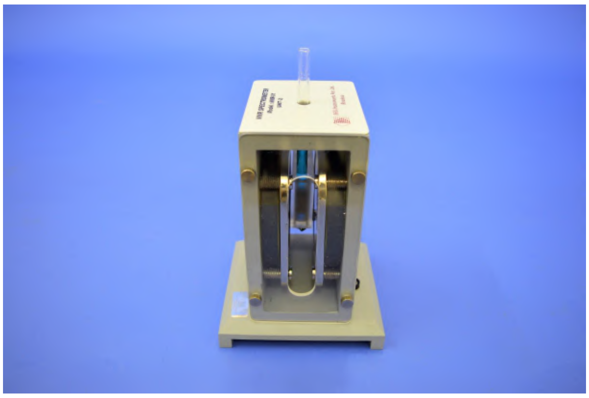
A 50Hz current flows through Helmholtz coils which provides a low frequency magnetic field to the sample.

Oscilloscope (not supplied with the Spectrometer).

Any dual trace oscilloscope normally available in the laboratory would be quite suitable.

Advantages and Limitations of our Spectrometer

1. The instrument is basically designed for postgraduate laboratories keeping in view their requirements and limitations.
2. The observation of NMR at low perturbing magnetic fields with high ~5KG static field and consequently in radio-frequency region makes its instrumentation and working a lot simple and within the reach of postgraduate students. Good resonance peaks can be obtained as a class room exercise.
3. The spectrometer is complete in all respects except a CRO.



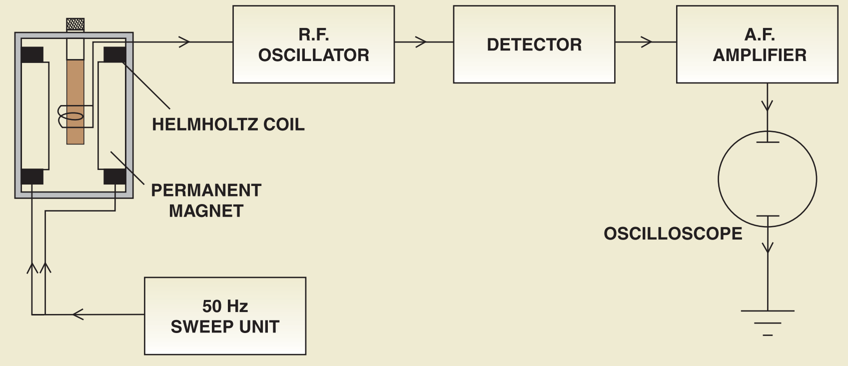


Fig. 1 : Block diagram of the NMR Spectrometer

The trace shows the resonance when proton precession matches the oscillator frequency

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TLX-02

Study of Thermoluminescence of F-Centres

Study of Thermoluminescence of F-centers in Alkali Halide Crystals

Pure alkali halide crystals are transparent throughout the visible region of the spectrum. The crystals may be colored in a number of ways

(1) by the introduction of chemical impurities

(2) by introducing an excess of the metal ion

(3) by X-ray, γ-ray, neutron and electron bombardment

(4) by electrolysis

A colour centre is a lattice defect that absorbs visible light. The simplest colour center is an F-centre. The name comes from the German word for colour, Forbs. We usually produce F-centres by heating the crystal in excess alkali vapours or by irradiation. The new crystals show an absorption band in the visible or ultraviolet, whereas the original crystals are transparent in that region. This absorption band is called F-band.

An F-centre can be regarded as a negative ion vacancy and an electron which is equally shared by the positive ions, surrounding the vacant lattice site. Conversely a hole may be trapped at a +ve ion vacancy or at a -ve ion, giving rise to V- and H-centres respectively.

Colour centres produced by irradiation with X-rays

When a X-ray quantum passes through an ionic crystal, it will usually give rise to a fast photo-electron with an energy of the same order as that of the incident quantum. Such electrons, because of their small mass, do not have sufficient momentum to displace ions and therefore loose their energy in producing free electrons, holes, excitons and phonons. Evidently these while moving near the vacancies form trapped electrons as well as trapped holes.

The trapped-electron or trapped-hole centres so formed can be destroyed (bleached) by illuminating the crystal with light of the appropriate wavelength or warming it.

Thermoluminescence

Important information about the colour centres can be obtained by measuring the changes that occur when a coloured crystal is gradually heated. As the temperature is raised electrons and holes escape from their traps at an increasing rate. The freed charges can recombine with each other or with other defects and give out luminescence by recombination. The resulting thermoluminescence or 'glow' reaches maximum and then decreases to zero as the supply of trapped electrons or holes becomes exhausted. The plot of luminescence intensity verses temperature, taken at a constant heating rate, is called the 'glow curve'. It may contain one or many glow peaks, depending upon whether there are one or several different kinds of traps.

From the glow curve one determine the trap depth; the deeper the trap, the higher the temperature of the glow peak. A correlation between the temperature at which thermoluminescence occurs and the temperature at which particular band bleach can give valuable information about specific centres.

Typical results obtained from this set-up for KCl crystal are shown in figure.

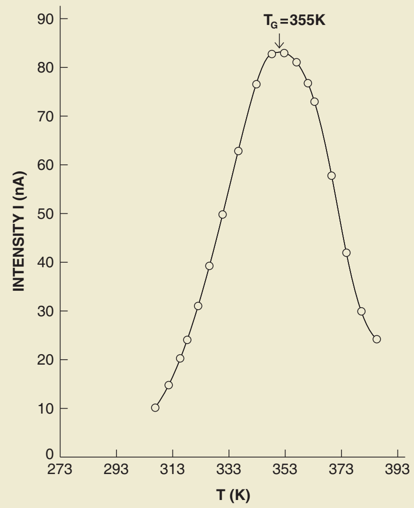

Fig. A Glow Curve of the luminescent material (KCl crystal), the heating speed is 11K/min

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TLX-02

Study of Thermoluminescence of F-Centres

The experiment consists of the following

Experimental set-up for creating thermoluminescence

(1) Sample: KBr or KCl single crystal

(2) Thermolumniscence Temperature Meter, TL-02
- Digital Thermometer
- Oven Power Supply

(3) Sample Holder

(4) Thermoluniscence Oven (0-423K)

(5) Black Box

For measurement of luminescence intensity

(1) Photomultiplier tube: R11558

(2) PMT Housing with biasing circuit and coaxial cables etc.

(3) High Voltage Power Supply, Model: EHT-11

Output	:	0-1500V variable (1mA max.)
Regulation	:	0.05%
Display	:	3½ digit 7-segment LED

(4) Nanoammeter, Model DNM-121

Range	:	100nA to 100mA full scale in 4 ranges
Accuracy	:	0.2%.
Display	:	3½ digit 7-segment LED

Photomultiplier Tube

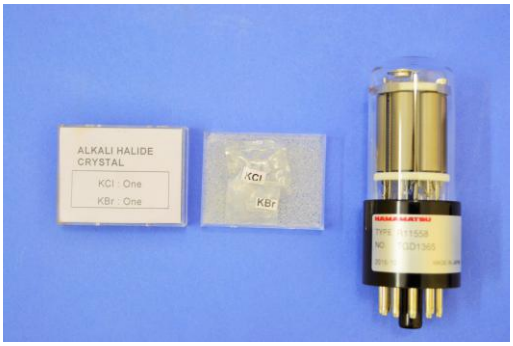
Specifications of Photomultiplier tube R11558

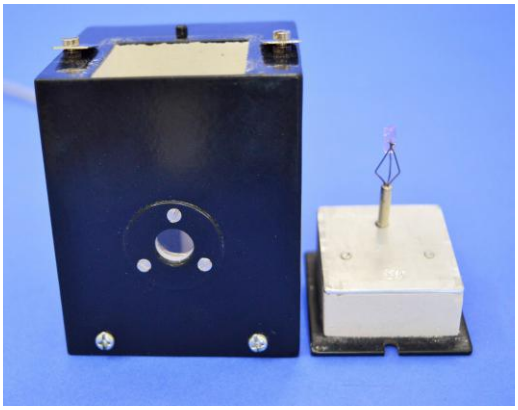
Spectral Response		
• Range	:	300 to 650(nm)
• Peak wave length	:	400nm
Photo Cathode Material	:	Bialkali
Dynode Structure/No. of Stages	:	CC/9
Maximum Cathode Voltage	:	1250Vdc
Maximum Average Anode Current	:	0.1mA
Cathode Sensitivity		
• Minimum	:	40µA/lm
• Typical	:	60µA/lm
Anode Sensitivity		
• Minimum	:	200A/lm
• Typical	:	600A/lm
Anode to Cathode Supply Voltage	:	1000Vdc
Current Amplification	:	1.0×10^7
Anode Dark Current (after 30min)		
• Typical	:	1nA
• Maximum	:	10nA

PMT Housing

The housing is designed to provide a shielding from stray light and magnetic field. The slit arrangement at the window is provide to adjust the size of the window according to the incident beam and for the safety of photomultiplier tube when not in use. For E.H.T. input and current output, amphenol connectors are provided. A general purpose biasing circuit, using low noise, metal film resistors, is mounted on the base. The housing can be mounted in any position.

The biasing circuit can be changed to customer's specification. Minor modification in design of PMT Housing is also possible.





Thermolumniscence Irradiation unit TIU-02 can also be used for this purpose.

complete in all respect, only X-ray facilities required to create F-centers in the crystal.

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TIU-02

Thermolumniscence Irradiation Unit

Irradiation unit suitable for irradiating alkali halide samples for Thermolumniscence Experiment

- Microcontroller based menu driven
- Cost effective solution
- No radiation hazard
- High quality double stage rotary pump
- Long life tesla coil
- Fully self contained

Introduction

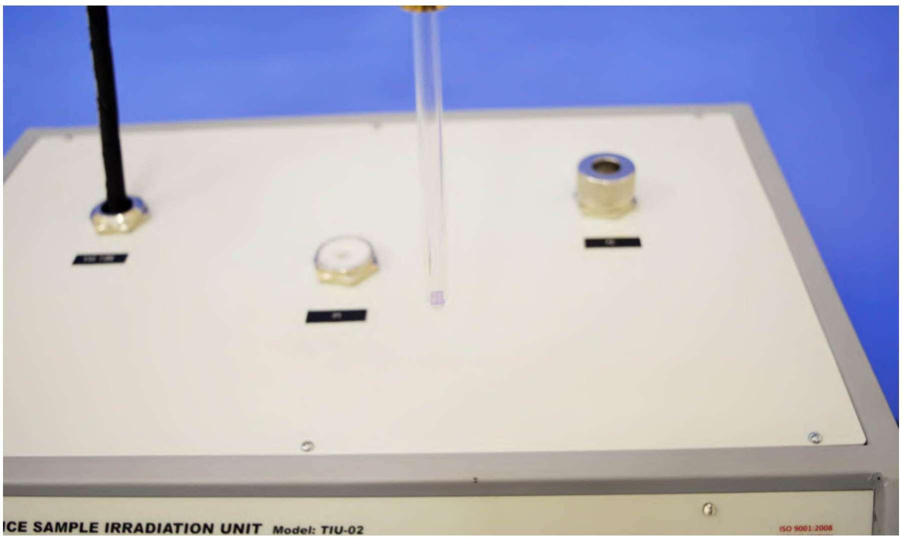
Study of Thermoluminescence in alkali halide crystals need creation of F-centres (colour centres) in alkali halide crystals. To produce the F-centres, the crystals are exposed to ionizing radiation which in turn causes the loss of electron from halide ions. An electron then becomes trapped in the halide ion vacancy. The color is the result of the absorption of a photon by the trapped electron and excitation from the ground state to an excited state for the F-center. This is a classic case of particle in a box.

The source of ionizing radiation could be X-rays, electrons, gamma rays etc. These techniques are too Expensive and unaffordable for normal laboratories. Another method, although little less efficient, is by keeping Alkali halide crystals under low pressure, in the proximity of high Voltage. This in turn produces F-centres in the crystals.

This later technique has been adopted in this set up to make it economical and affordable for all laboratories. The setup is complete in itself and can be used straight away.

Specifications

Vaccum	:	~15 micron
Extra High Voltage	:	~30,000VAC pulsating
Sample Size	:	Upto 6mmx6mmx1mm
Input Mains	:	220VAC, 50Hz



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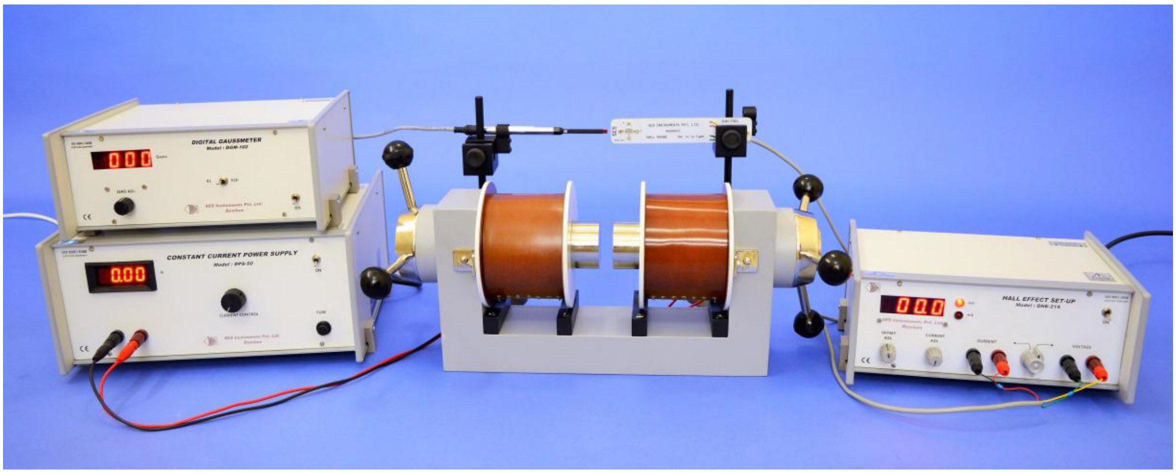
HEX-21

Hall Effect Experiment



Introduction

The resistivity measurements of semiconductors can not reveal whether one or two types of carriers are present; nor distinguish between them. However, this information can be obtained from Hall Coefficient measurements, which are also basic tools for the determination of carrier density and mobilities in conjuction with resistivity measurement.

Theory

As you are undoubtedly aware, a static magnetic field has no effect on charges unless they are in motion. When the charges flow, a magnetic field directed perpendicular to the direction of flow produces a mutually perpendicular force on the charges. When this happens, electrons and holes will be separated by opposite forces. They will in turn produce an electric field ($\bar{E}_h$) which depends on the cross product of the magnetic intensity, $\bar{H}$, and the current density, $\bar{J}$.

$$\bar{E}_h = R\bar{J} \times \bar{H}$$

Where R is called the Hall Coefficient

Now, let us consider a bar of semiconductor, having dimension, x, y and z. Let $\bar{J}$ is directed along X and $\bar{H}$ along Z then $\bar{E}_h$ will be along Y.

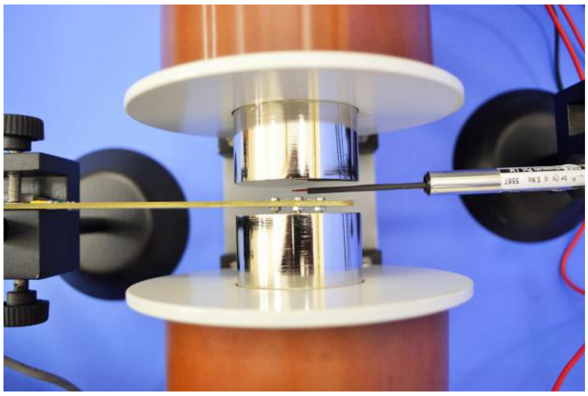
Then we could write

$$R = \frac{V_h/y}{JH} = \frac{V_h.z}{IH}$$

Where V_h is the Hall voltage appearing between the two surfaces perpendicular to y and I=Jyz

Hall Effect experiment consists of the following:

1. Hall Probe (Ge Crystal) n & p-type
2. Hall Effect Set-up, DHE-21C
3. Electromagnet, EMU-50V
4. Constant Current Power Supply, DPS-50C
5. Digital Gaussmeter, DGM-202C



Hall Probe (Ge Crystal)

Ge single crystal with four spring-type pressure contacts is mounted on a sunmica-decorated bakelite strip. Four leads are provided for connections with measuring devices.

Technical details		
Material	:	Ge single crystal n or p-type as desired
Resistivity	:	8-10Ω.cm
Contacts	:	Spring type (solid silver)
Zero-field potential	:	<1mV (adjustable)
Hall Voltage	:	25-35mV/10mA/KG

It is designed to give a clear idea to the students about Hall Probe and is recommended for class room experiment. A minor drawback of this probe is that it may require zero adjustment.

(b) Hall Probe (InAs)

Indium Arsenide crystal with 4 soldered contacts is mounted on a PCB strip and covered with a protective layer. The Hall Element is mounted in a pen-type case and a 4-core cable is provided for connections with the measuring device and current source.

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HEX-21

Hall Effect Experiment

Technical Details		
Contacts	:	Soldered
Rated Control Current	:	4mA
Zero Field Potential	:	<4mV
Linearity (0-20KG)	:	±0.5% or better
Hall Voltage	:	60-70mV/4mA/KG

The crystal alongwith its four contacts is visible through the protective layer. This is mainly used as a transducer for the measurement of magnetic field.

Hall Effect Set-up, DHE-21C

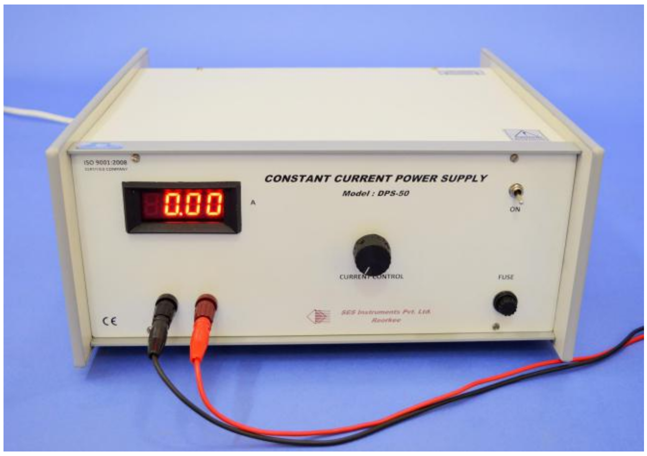
DHE-21C is a high performance instrument of outstanding flexibility. The set-up consists of a digital millivoltmeter and a constant current power supply. The Hall voltage and probe current can be read on the same digital panel meter through a selector switch. The unit is made compatible with SES-CAMM interface unit, for computer control option.

(i) Digital Millivoltmeter

Intersil 3½ digit single chip A/D Converter ICL 7107 have been used. It has high accuracy like, auto zero to less than 10μV, zero drift of less than 1μV/°C, input bias current of 10pA max. and roll over error of less than one count. Since the use of internal reference causes the degradation in performance due to internal heating, an external reference has been used. Digital voltmeter is much more convenient to use in Hall experiment, because the input voltage of either polarity can be measured.

Specifications		
Range	:	0-200mV (100mV minimum)
Accuracy	:	±0.1% of reading ±1 digit

(ii) Constant Current Power Supply



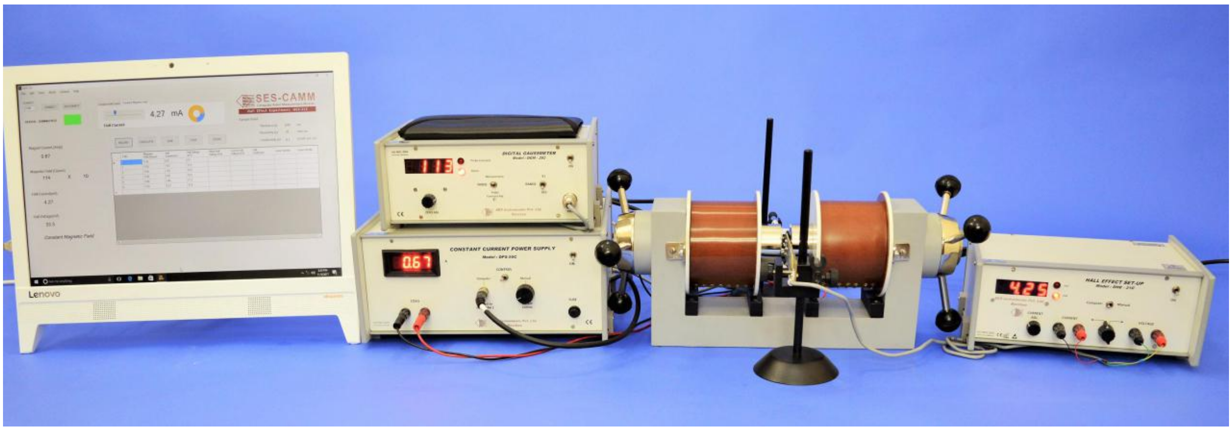
This power supply, specially designed for Hall Probe, provides 100% protection against crystal burn-out due to excessive current. The supply is a highly regulated and practically ripple free dc source.

Specifications		
Current	:	0-20mA
Resolution	:	10μA
Accuracy	:	±0.2% of the reading ±1 digit
Load regulation	:	0.03% for 0 to full load
Line regulation	:	0.05% for 10% variation

Datasheets of other sub units is available separately.
The experiment in complete in all respect.

HEX-21C

Hall Effect Experiment (with computer interface)



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Where V_h is the Hall voltage appearing between the two surfaces perpendicular to y and $I=\bar{J}yz$

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2. Hall Effect Set-up, DHE-21C
3. Electromagnet, EMU-50V
4. Constant Current Power Supply, DPS-50C
5. Digital Gaussmeter, DGM-202C
6. Computer Interface, SES-CAMM2

Hall Probe (Ge Crystal)

Ge single crystal with four spring-type pressure contacts is mounted on a sunmica-decorated bakelite strip. Four leads are provided for connections with measuring devices.

Technical details

Material	:	Ge single crystal n or p-type as desired
Resistivity	:	8-10Ω.cm
Contacts	:	Spring type (solid silver)
Zero-field potential	:	<1mV (adjustable)
Hall Voltage	:	25-35mV/10mA/KG

It is designed to give a clear idea to the students about Hall Probe and is recommended for class room experiment. A minor drawback of this probe is that it may require zero adjustment.

Hall Effect Set-up, DHE-21C

DHE-21C is a high performance instrument of outstanding flexibility. The set-up consists of a digital millivoltmeter and a constant current power supply. The Hall voltage and probe current can be read on the same digital panel meter through a selector switch.The unit is made compataible with SES-CAMM

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interface unit, for computer control option.

(i) Digital Millivoltmeter

Intersil 3½ digit single chip A/D Converter ICL 7107 have been used. It has high accuracy like, auto zero to less than 10μV, zero drift of less than 1μV/°C, input bias current of 10pA max. and roll over error of less than one count. Since the use of internal reference causes the degradation in performance due to internal heating, an external reference has been used. Digital voltmeter is much more convenient to use in Hall experiment, because the input voltage of either polarity can be measured.

Specifications

Range	:	0-200mV (100mV minimum)
Accuracy	:	±0.1% of reading ±1 digit

(ii) Constant Current Power Supply

This power supply, specially designed for Hall Probe, provides 100% protection against crystal burn-out due to excessive current. The supply is a highly regulated and practically ripple free dc source.

Specifications

Current	:	0-20mA
Resolution	:	10μA
Accuracy	:	±0.2% of the reading ±1 digit
Load regulation	:	0.03% for 0 to full load
Line regulation	:	0.05% for 10% variation

Computer Interface, SES-CAMM

An interface (SES-CAMM) enables the userto operate the hall effect setup through a computer. the interface is attached to any USB port and on activation a GUI shows the computer control, data storage and graph plotting of the experiment. Also included is the option for automatic computation of hall coefficient, carrier mobility and carrier density.

Datasheets of other sub units is available separately.

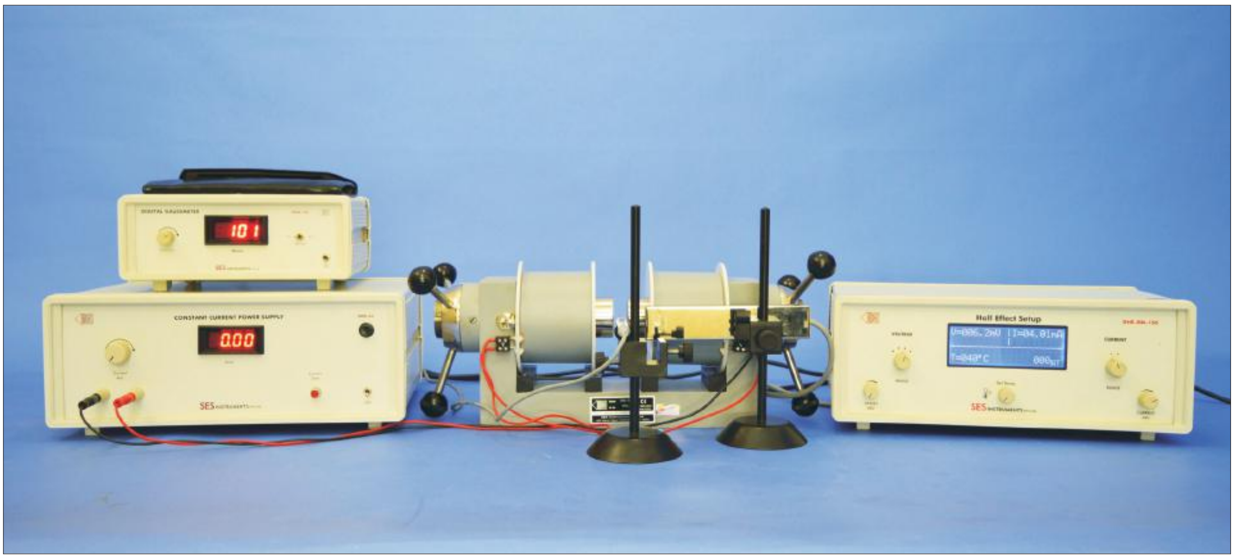
The experiment in complete in all respect.

Hall Effect Experiment

HEX-RM-150

SES Instruments Pvt Ltd.

Hall Effect Experiment (Research Model)



Introduction

When a current-carrying conductor is placed in a magnetic field perpendicular to the current direction, a voltage develops transverse to the cuurent. This voltage was first observed in 1879 by Edwin Hall and the effect is called Hall Effect.

The Hall effect has since led to a deeper understanding of the details of the conduction process. It can yield the density of the charge carriers as well as their sign. The hall voltage for p-carriers has opposite sign from that for n-carriers. Therefore if a semiconductor with p-type doping is gradually heated up, more and more electrons from its valence band will go to conduction band. As a result hall voltage would fall rapidly with temperature and even become zero or change sign. At the point of zero Hall Coefficient, it is possible to determine the ratio of mobilities $b=m_e/m_h$. The Hall coefficient inversion is a characteristic of only p-type semiconductors.

Theory

As you are aware, a static magnetic field has no effect on charges unless they are in motion. When the charges flow, a magnetic field directed perpendicular to the direction of flow produces a mutually perpendicular force on the charges. When this happens, electrons and holes will be separated by opposite forces. They will in turn produce an electric field (E_h) which depends on the cross product of the magnetic intensity, H, and the current density, J.

$E_h = RJ \times H$ where R is called the Hall Coefficient

Now, let us consider a bar of semiconductor, having dimension, x, y and z. Let J be directed along X and H along Z then E_h will be along Y.

Then we could write

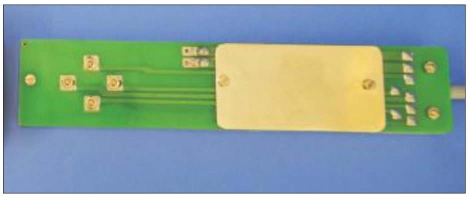
$$R = \frac{V_h/y}{JH} = \frac{V_h.z}{IH}$$

Where V_h is the Hall voltage appearing between the two surfaces perpendicular to y and I=Jyz

Hall Effect experiment consists of the following

The set-up consists of the following.

1. **Hall Probe (Ge: p-type), HPP-RM-33**



Ge single crystal with four spring type pressure contacts is mounted on a glass-epoxy strip. Leads are provided for connections with the current source and Hall voltage measuring devices.

Oven

It is a small oven which could be easily mounted over the crystal or removed if required.

Temperature Sensor

Cromel-Alumel thermocouple with its junction at a distance of 1mm from the crystal.

2. **Hall Probe (without sample), HPP-RM-33**NS

Same Hall Probe at HPP-33, except that it comes without sample, to enable the user to mount their own sample.

3. **Hall Probe (Ge Crystal), HPN-RM**

Ge single crystal with four spring-type pressure contacts is mounted on a sunmica-decorated bakelite strip. Four leads are provided for connections with measuring devices.

Technical details

Material : Ge single crystal n-type

Resistivity : 8-10Ω.cm

Contacts : Spring type (solid silver)

Zero- Field potential : <1mV (adjustable)

Hall Voltage : 25-35mV/10mA/KG

4. **Hall Probe (Si Crystal), HPSi-RM**

Si single crystal with four spring-type pressure contacts is mounted on a sunmica-decorated bakelite strip. Four leads are provided for connections with measuring devices.

Technical details

Material : Si single crystal n-type

Resistivity : 14-15Ω.cm

Contacts : Spring type (solid silver)

Zero- Field potential : <1mV (adjustable)

Hall Voltage : 25-35mV/10mA/KG

This probe is very similar to HPN-RM.

5.Hall Probe (without sample), HP10-RM

Same Hall Probe at HPN-RM, except that it comes without sample, to enable the user to mount their own sample of 10x10mm size.

6.Hall Probe (without sample), HP05-RM

Same Hall Probe at HPN-RM, except that it comes without sample, to enable the user to mount their own sample of 5x5mm size.

7.Hall Effect Set, DHE-RM-150

(a) Digital Millivoltmeter

Specifications
Range : 1mV, 10mV, 100mV, 1V & 10V with 100% over-ranging.
Resolution : 1μV
Accuracy : ±0.2% ±1 digit
Stability : Within ±1 digit
Input Impedance : >1000MΩ (10MΩ on 10V range)
Display : 3½ digit, 7 segment LED with autopolarity and decimal indication

(b) Constant Current Power Supply

Specifications
Range : 0-20mA, 0-200mA
Resolution : 10μA
Accuracy : ±0.25% of reading ±1 digit
Display : 3½ digit, 7 segment LED with autopolarity and decimal indication

5. Electromagnet, EMU-75T *(Refer datasheet for specifications)*

6. Constant Current Power Supply, DPS-175-C2 *(Refer datasheet for specifications)*

7. Digital Gaussmeter, DGM-202-C1 *(Refer datasheet for specifications)*

Optional Attachments

This model of Hall Effect Experiment may be connected to a computer for data logging purposes. Necessary hardware and software can be ordered with the system.

The setup is complete in all respect

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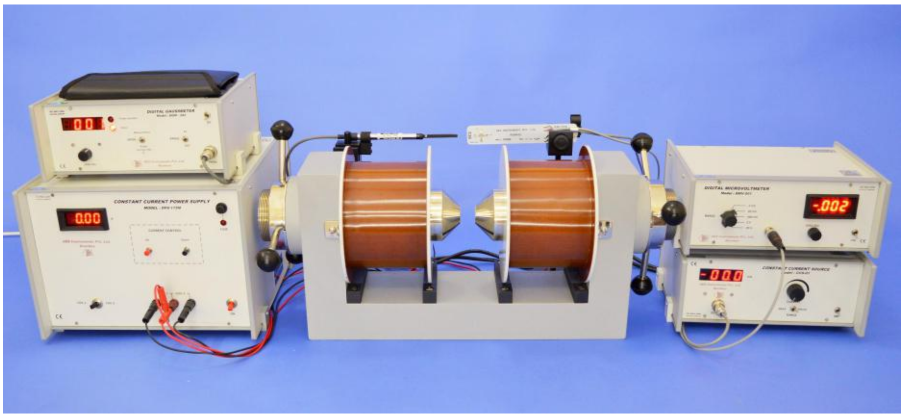
HEX-Bi

Hall Effect in Bismuth



Introduction

When a current-carrying conductor is placed in a magnetic field perpendicular to the current direction, a voltage develops transverse to the current. This voltage was first observed in 1879 by Edwin Hall and the effect is called Hall Effect.

The Hall effect has since led to a deeper understanding of the details of the conduction process. It can yield the density of the charge carriers as well as their sign.

Theory

As you are undoubtedly aware, a static magnetic field has no effect on charges unless they are in motion. When the charges flow, a magnetic field directed perpendicular to the direction of flow produces a mutually perpendicular force on the charges. When this happens, electrons and holes will be separated by opposite forces. They will in turn produce an electric field ($\bar{E}_h$) which depends on the cross product of the magnetic intensity, $\bar{H}$, and the current density, $\bar{J}$.

$$\bar{E}_h = R\bar{J} \times \bar{H}$$

Where R is called the Hall Coefficient

Now, let us consider a bar of semiconductor, having dimension, x, y and z. Let $\bar{J}$ is directed along X and $\bar{H}$ along Z then $\bar{E}_h$ will be along Y.

Then we could write

$$R = \frac{V_h/y}{JH} = \frac{V_h.z}{IH}$$

Where V_h is the Hall voltage appearing between the two surfaces perpendicular to y and I=Jyz

Hall Effect experiment consists of the following:

1. Hall Probe : Bismuth
2. Constant Current Source, CCS-01
3. Digital Microvoltmeter, DMV-01
4. Electromagnet, EMU-75 (Specifications as per datasheet attached)
5. Constant Current Power Supply, DPS-175 (Specifications as per datasheet attached)
6. Digital Gaussmeter, DGM-102 (Specifications as per datasheet attached)

Hall Probes

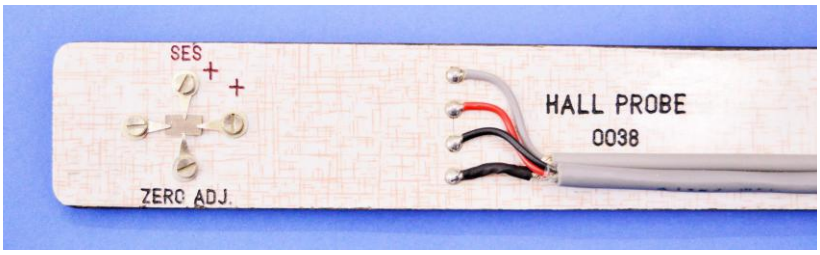
Bismuth Hall Probe

Bismuth strip with four spring-type pressure contacts is mounted on a sunmica-decorated bakelite strip. Seperate leads are provided for connections with measuring devices.

Technical details

Material	:	Bismuth
Resistivity	:	$1.29 \times 10^{-4}\Omega$.cm
Contacts	:	Spring type (solid silver)
Zero-field potential	:	<1mV (adjustable)
Hall Voltage	:	25-35mV/10mA/KG

It is designed to give a clear idea to the students about Hall Probe and is recommended for class room experiment. A minor drawback of this probe is that it may require zero adjustment.



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HEX-Bi

Hall Effect in Bismuth

Current Source
Constant Current Source, CCS-01

It is an IC regulated current generator to provide a constant current to the outer probes irrespective of the changing resistance of the sample due to change in temperatures. The basic scheme is to use the feedback principal to limit the load current of the supply to preset maximum value. Variations in the current are achieved by a potentiometer included for that purpose. The supply is a highly regulated and practically ripples free d.c source. The constant current source is suitable for the resistivity measurement of this films of metals/alloys and semiconductors like germanium.

Specifications

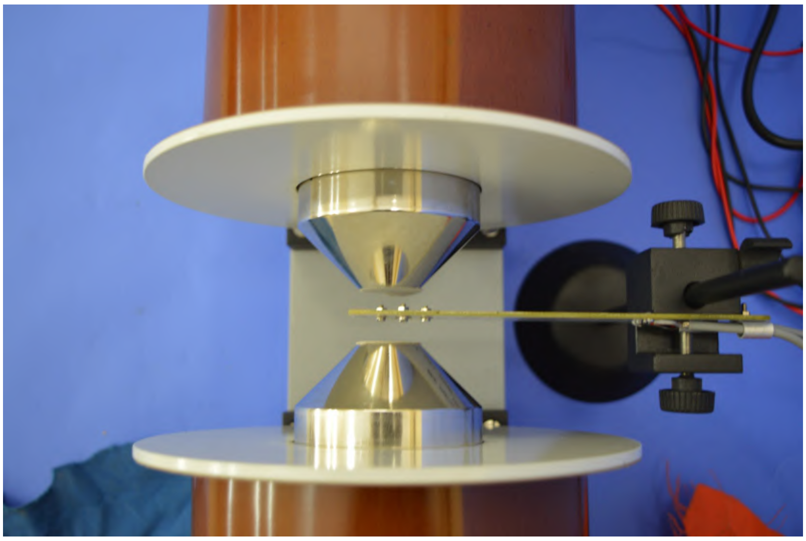
Range	:	0-20mA, 0-200mA
Resolution	:	10μA
Accuracy	:	±0.25% of reading ±1 digit
Display	:	3½ digit, 7 segment LED with autopolarity and decimal indication

Voltage Meter
Digital Microvoltmeter, DMV-001

It is a very versatile multipurpose instrument for the measurement of low dc voltage. It has 5 decade ranges from 1mV to 10mv with 100% over-ranging. For better accuracy and convenience, readings are directly obtained on 3½ digit DPM (Digital Panel Meter).

Specifications

Range	:	1mV, 10mV, 100mV, 1V & 10V with 100% over-ranging.
Resolution	:	1μV
Accuracy	:	±0.2% ±1 digit
Stability	:	Within ±1 digit
Input Impedance	:	>1000MΩ (10MΩ on 10V range)
Display	:	3½ digit, 7 segment LED with autopolarity and decimal indication



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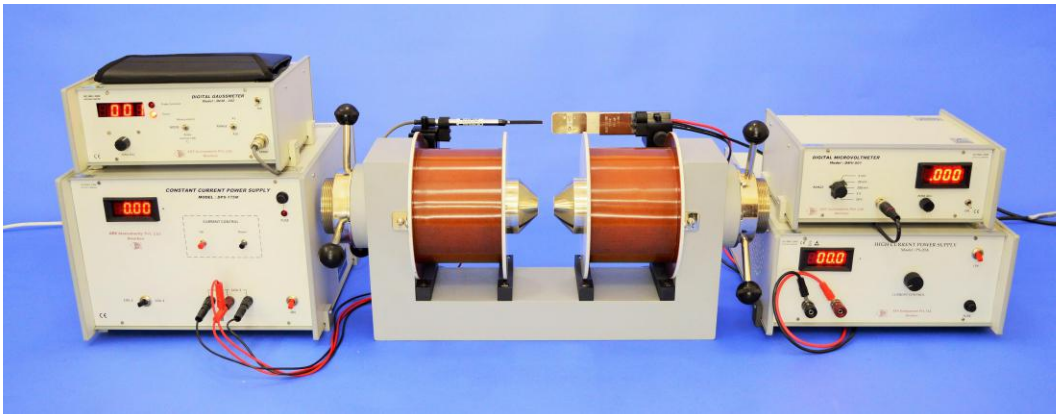
ISO 9001:2015

HEM-01

Hall Effect in Metal



Hall Effect enables the charge carrier concentration and mobility to be determined by experiment. Direction of the Hall Voltage in silver indicates negative charge carriers, which is in agreement with concepts of the model of the 'free electron gas'. Limitations of this model are shown by the so called ' abnormal Hall Effect' of tungsten. The experiment carried out under identical conditions for tungsten show the Hall Voltage to have about same magnitude but opposite direction as in silver.

This can be explained by the 'Energy Band diagram'. The tungsten atom has ....$5s^2$ $5p^6$ $5d^4$ $6s^2$ electronic structure. When the atoms come close together to form the solid, the close lying states 5d and 6s broaden into bands, with s band broadening considerably more than the d band. This is because of the larger size of the s orbital. The figure schematically shows the allowed energies as a function of the interatomic distance. The number of allowed states is ten per atom in the d band and two in the s band. In tungsten there are six electrons to be shared between these two bands. The result is that at the interatomic distance in tungsten there are holes in the d band and electrons in the s band, making tungsten predominantly a hole conductor.

This sort of mixed (electrons and holes) conduction is a general characteristic of transition metals. The apparatus consists of the following:

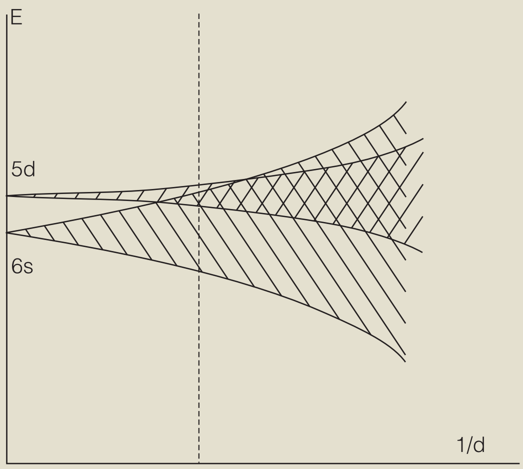
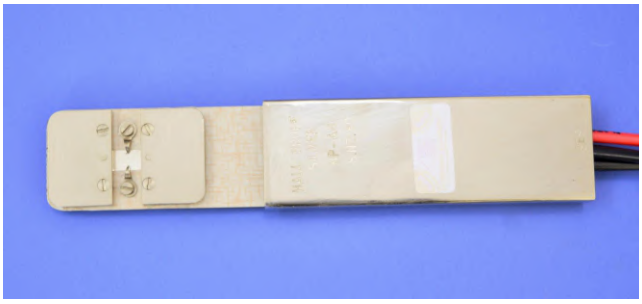


Fig.: Allowed energies as a function of interatomic distance (d)

a) **Hall Probes-Silver(HP-Ag)**

Technical Details

Material	:	Silver(8X6X0.05 mm)
Contacts	:	Press Type for current
		Spring type for Voltage
Hall Voltage	:	~17 mV/10A/10KG



b) **Hall Probe-Tungsten (HP-W)**

Technical Details

Material	:	Tungten Strip (8 x 6 x 0.05 mm)
Contacts	:	Press type for current
		Spring Type for Voltage
Hall Voltage	:	~15 mV/10A/10KG

HEM-01

Hall Effect in Metal

c) **High Current Power Supply, Model PS-20A**

Specification

Range	:	0-20A continuosly variable
Accuracy	:	±0.5%
Regulation	:	±0.5% for ±10% variation of mains
Display	:	3½ digit, 7 Segment LED

d) **Digital Microvoltmeter, DMV-001**

It is a very versatile multipurpose instrument for the measurement of low dc voltage. It has 5 decade ranges from 1mV to 10mv with 100% over-ranging. For better accuracy and convenience, readings are directly obtained on 31/2 digit DPM (Digital Panel Meter).

Specifications

Range	:	1mV, 10mV, 100mV, 1V & 10V with 100% over-ranging.
Resolution	:	1μV
Accuracy	:	±0.2% ±1 digit
Stability	:	Within ±1 digit
Input Impedance	:	>1000MΩ (10MΩ on 10V range)
Display	:	3½ digit, 7 segment LED with autopolarity and decimal indication

e) **Electromagnet, Model EMU-75T**

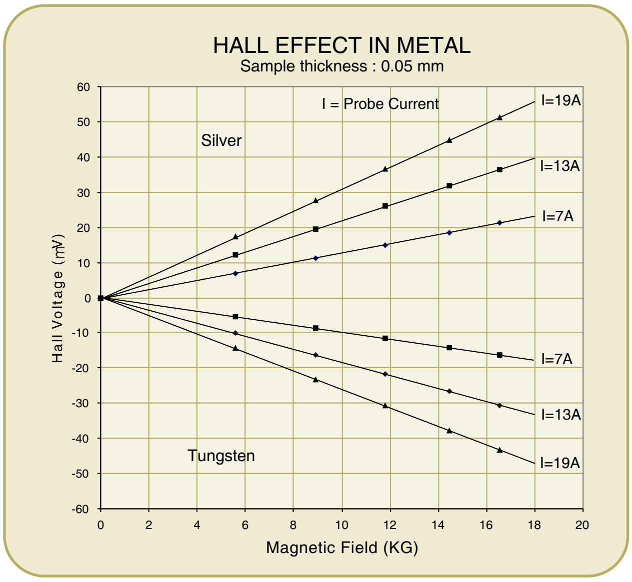
Specification

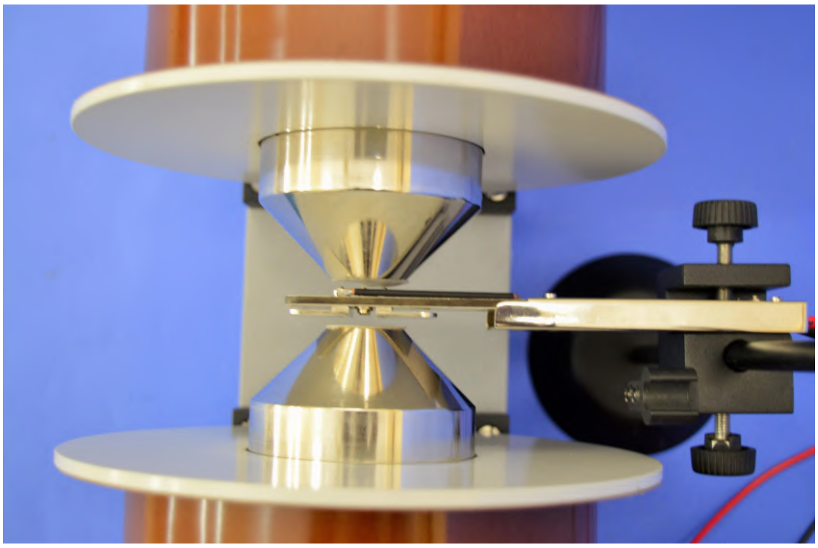
Pole Pieces	:	75mm tappered to 25mm
Mag. Field	:	17KG ±5% at 10mm airgap
Energising Coils	:	Two of approx. 13 each
Power	:	0-90Vdc, 3A, for coils in series 0-45Vdc, 6A, for coils in parallel

f) **Constant Current Power Supply, DPS-175M**

g) **Gaussmeter, DGM-202**

The experiment is complete in all respect.





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Hall Effect Setup

HEX-33

SES Instruments Pvt Ltd.

Dependence of Hall Coefficient on Temperature

Description

The Hall voltage for p-carriers has opposite sign from that for n-carriers. Therefore if a semiconductor with p-type doping is gradually heated up, more and more electrons from its valence band will go to conduction band. As a result hall voltage would fall rapidly with temperature and even become zero or change sign. At the point of zero Hall Coefficient, it is possible to determine the ratio of mobilities $b=m_e/m_h$. The Hall coefficient inversion is a characteristic of only p-type semiconductors.

The set-up consists of the following. The Hall Probe comes complete with

1. Hall Probe (Ge: p-type), HPP-33

   Ge single crystal with four spring type pressure contacts is mounted on a glass-epoxy strip. Leads are provided for connections with the current source and Hall voltage measuring devices.

   Oven

   It is a small 12W oven mounted over the crystal for heating from ambient to 100 C.

   Temperature Sensor

   Cromel-Alumel thermocouple with its junction at a distance of 1mm from the crystal.

2. Hall Effect Set-up :DHE-33

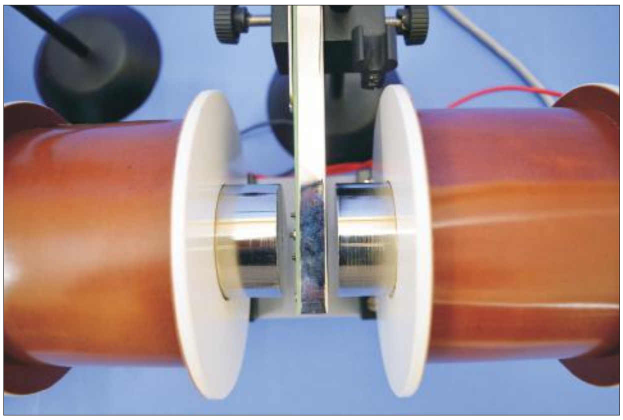
   The set-up, DHE-33 consists of two sub units to handle the probe parameters (probe current and hall voltage) and measurement of temperature. While the probe current is generated and measured by

A constant current source (0-20mA) having a resolution of 10μA, the hall voltage is measured by a high input resistance millivoltmeter in the range 0-200mV having a resolution of 100mV. The Probe. Current and hall voltage are both displayed on a 16 x 4 line LCD display. The sample temperature is controlled by a microcontroller based PWM heater current source. Thermo emf of the thermocouple is converted into temperature and is displayed on the same 16 x 4 line LCD display on the panel. Temperature range is ambient to 100 C and resolution is 1 C.

3. **Electromagnet, EMU-50V**
   (Refer datasheet for specifications)

4. **Constant Current Power Supply, DPS-50/ DPS-50-C1** *(Refer datasheet for specifications)*

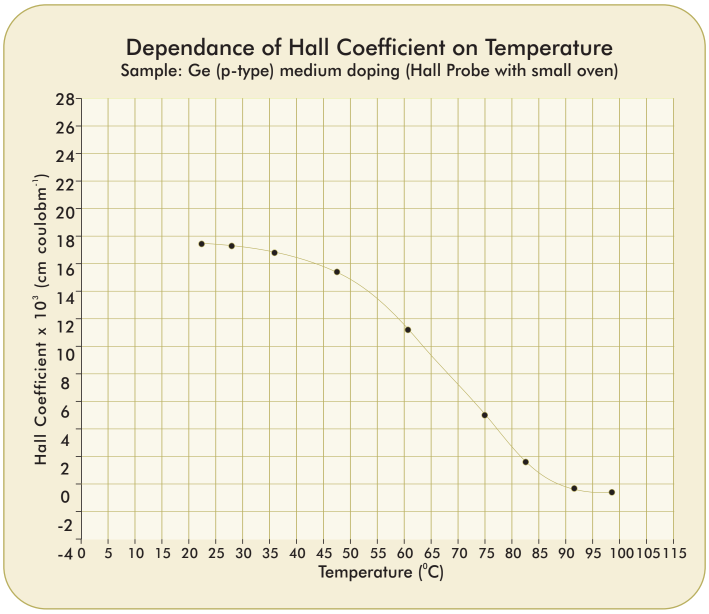
5. **Digital Gaussmeter, DGM-202/ DGM-202-C1/ DGM-102** *(Refer datasheet for specifications)*



Optional

Computer connectivity along with required hardware and software are optional and can be ordered as required.

The experiment is complete in all respect.



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Hall Effect Setup

HEX-33C

SES Instruments Pvt Ltd.

Dependence of Hall Coefficient on Temperature

Description

The Hall voltage for p-carriers has opposite sign from that for n-carriers. Therefore if a semiconductor with p-type doping is gradually heated up, more and more electrons from its valence band will go to conduction band. As a result hall voltage would fall rapidly with temperature and even become zero or change sign. At the point of zero Hall Coefficient, it is possible to determine the ratio of mobilities $b=m_e/m_h$. The Hall coefficient inversion is a characteristic of only p-type semiconductors.

The set-up consists of the following. The Hall Probe comes complete with

1. Hall Probe (Ge: p-type), HPP-33

   Ge single crystal with four spring type pressure contacts is mounted on a glass-epoxy strip. Leads are provided for connections with the current source and Hall voltage measuring devices.

   Oven

   It is a small 12W oven mounted over the crystal for heating from ambient to 100 C.

   Temperature Sensor

   Cromel-Alumel thermocouple with its junction at a distance of 1mm from the crystal.

2. Hall Effect Set-up :DHE-33

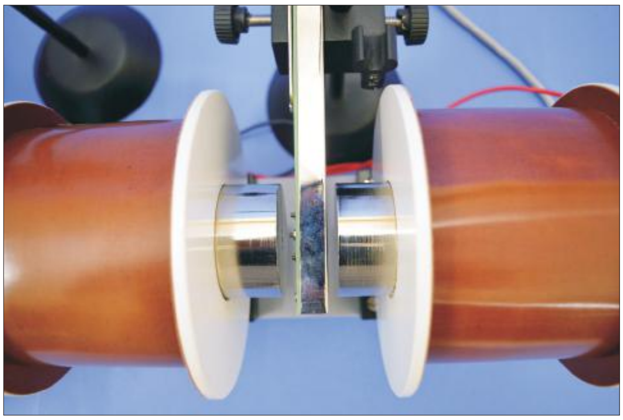
   The set-up, DHE-33 consists of two sub units to handle the probe parameters (probe current and hall voltage) and measurement of temperature. While the probe current is generated and measured by

A constant current source (0-20mA) having a resolution of 10μA, the hall voltage is measured by a high input resistance millivoltmeter in the range 0-200mV having a resolution of 100mV. The Probe. Current and hall voltage are both displayed on a 16 x 4 line LCD display. The sample temperature is controlled by a microcontroller based PWM heater current source. Thermo emf of the thermocouple is converted into temperature and is displayed on the same 16 x 4 line LCD display on the panel. Temperature range is ambient to 100 C and resolution is 1 C.

3. Electromagnet, EMU-50V
   (Refer datasheet for specifications)

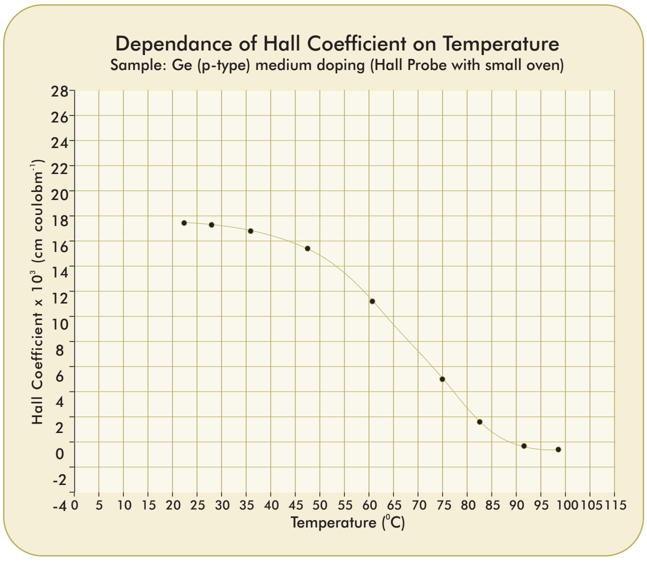
4. Constant Current Power Supply, DPS-50-C1
   (Refer datasheet for specifications)

5. Digital Gaussmeter, DGM-202-C1
   (Refer datasheet for specifications)



In addition to the above, this Hall Effect Experiment may be connected to a computer for data logging purposes. Necessary hardware and software are included in the system.

The experiment is complete in all respect.



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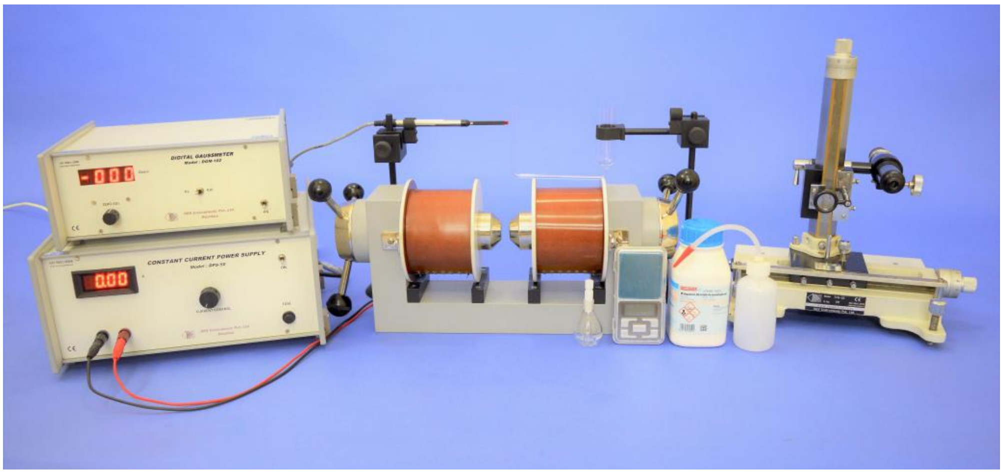
QTX-01

Quinck's Tube Method

Apparatus For The Measurement of Susceptibility of Paramagnetic Solution by Quinck's Tube Method



Introduction

It was established by Faraday in 1845 that magnetism is universal property of every substance. He classified all magnetic substances into two classes, viz., paramagnetic and diamagnetic. Weber, later on, tried to explain para and diamagnetic properties on the basis of molecular currents. The molecular current gives rise to the intrinsic magnetic moment to the molecule, and such substances are attracted in a magnetic field, and called paramagnetics. The repulsion of diamagnetics is assigned to the induced molecular current and its respective reverse magnetic moment. The force acting on a substance, either of repulsion or attraction, can be measured with the help of an accurate balance in case of solids or with the measurement of rise in level in narrow capillary in case of liquids. The force depends on the susceptibility K, of the material, i.e., on ratio of intensity of magnetisation to magnetising field (I/H). Evidently it refers to that quantity of substance by virtue of which bodies get magnetised. Quantitatively it refers to the extent of induced magnetisation in unit field. If the force on the substance and field are measured, the value of susceptibility can be calculated.

The value of the susceptibility K of liquid aqueous solution of a paramagnetic substance in air is given by a well know expression:

$$K = \frac{2(\rho - \sigma)gh}{H^2}$$

where ρ is the density of the liquid or solution

σ is the density of air

g is the acceleration due to gravity

h is the height through which column rises on switching on the field

H is the magnetic field at the centre of pole pieces

Procedure

The apparatus consists of U-shaped tube known as Quinck's tube. One of the limb of the tube is wide and the other one narrow. The experimental liquid or solution is filled in the tube and is placed in such a way that the meniscus of the liquid in narrow limb is at the centre of the magnetic field. The level of the liquid in the narrow tube is read by a travelling microscope when magnetic field is off. The magnetic field is switched on and the new raised level of the column is again read with the travelling microscope.

The apparatus consists of the following:

- Quinck's tube with stand
- Sample: $MnSO_4 2H_2O$
- Digital Balance 500gms (LC:0.1gm)
- RD Bottle
- Mixing Bottle
- Electromagnet, Model: EMU-50T
- Constant Current Power Supply, Model: DPS-50
- Digital Gaussmeter, Model: DGM-102
- Travelling Microscope

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ISO 9001:2015

Travelling Microscope
(Horizontal and Vertical)

The bed is of heavy casting, thoroughly aged, machined and is fitted with levelling screws. On the dovetail guide ways slides the horizontal carriage which can be clamped at any position by means of a thumb screw. A second sliding carriage slides along a gun metal vertical pillar fitted on the horizontal carriage. The slow motion guide bars are made of sturdy material and the motion is very smooth.

Optics

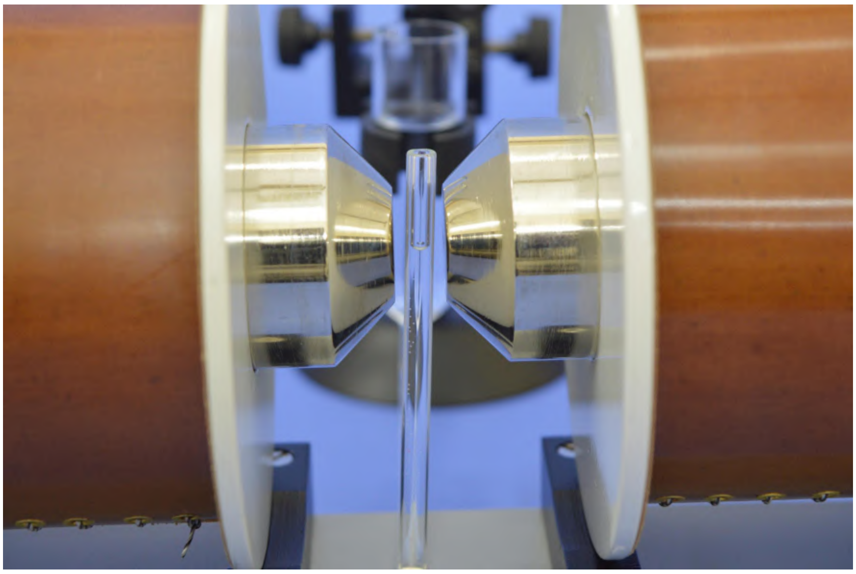
(i) True achromatic objective with 7.5cm focussing distance
(ii) 10X Ramsden eyepiece with fine cross wire

Scale and Vernier

(i) Horizontal scale: 20cm divided at 0.5mm interval
(ii) Vertical scale: 15cm divided at 0.5mm interval
(iii) Venier scales: 50 divisions with a least count of 0.01mm

The setup is complete in all respect

For details of other subunits, kindly refer to their respective datasheets



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GMX-01

Gouy's Method

Apparatus for Measurement of Susceptibility of Paramagnetic Solids by Gouy's Method

In the Gouy's method of susceptibility measurement, the solid sample in the form of a long cylinder (area of cross section A) is hung from the pan of a balance and is placed such that one end of the sample is between the pole-pieces of the magnet (field H) and the other one is outside the field. The force exerted on the sample by the inhomogeneous magnetic field is obtained by measuring the apparent change (Δm) in the mass of the sample. The susceptibility χ is given by

$$\chi = 2\Delta mg/AH^2$$

If the sample is in the form of powder, it is filled in a long nonmagnetic tube which is then suspended from the pan of the balance.

The set up consists of the following:

(a) **Scientific Balance, KSB-07**

Capacity	:	200 gms
Sensitivity	:	1/10 mg. by vernier
Beam	:	Hard Bronze/ Brass
Arrestment	:	Circular, falling away type
Air Damping	:	Very quick and positive, beam coming to rest in 2-3 sec
Chainomatic Device	:	A gold plated chain is suspended from the beam with its other end screwed on the Device rotating drum on which a scale graduated from 0 to 10 div each division representing 1mg is installed. By the movement of this scale before a vernier, reading upto 1/10th mg is taken

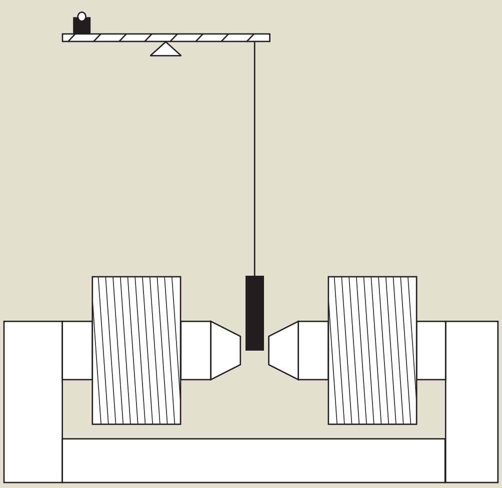
(b) **Sample in the form of a long rod:** Set of samples

(c) **Electromagnet, Model EMU-75T**

Pole Pieces	:	75mm tappered to 25mm
Mag. Field	:	20KG mm airgap
Energising Coils	:	Two of approx. 13Ω each
Power	:	0-90Vdc, 3A, for coils in series 0-45Vdc, 6A, for coils in parallel

(d) **Constant Current Power Supply,** Model DPS-175 (specifications as per datasheet)

(e) **Gaussmeter,** Model DGM-202 or DGM-102 (specifications as per datasheet)



Schematic Diagram
Gouy's Balance Experiment

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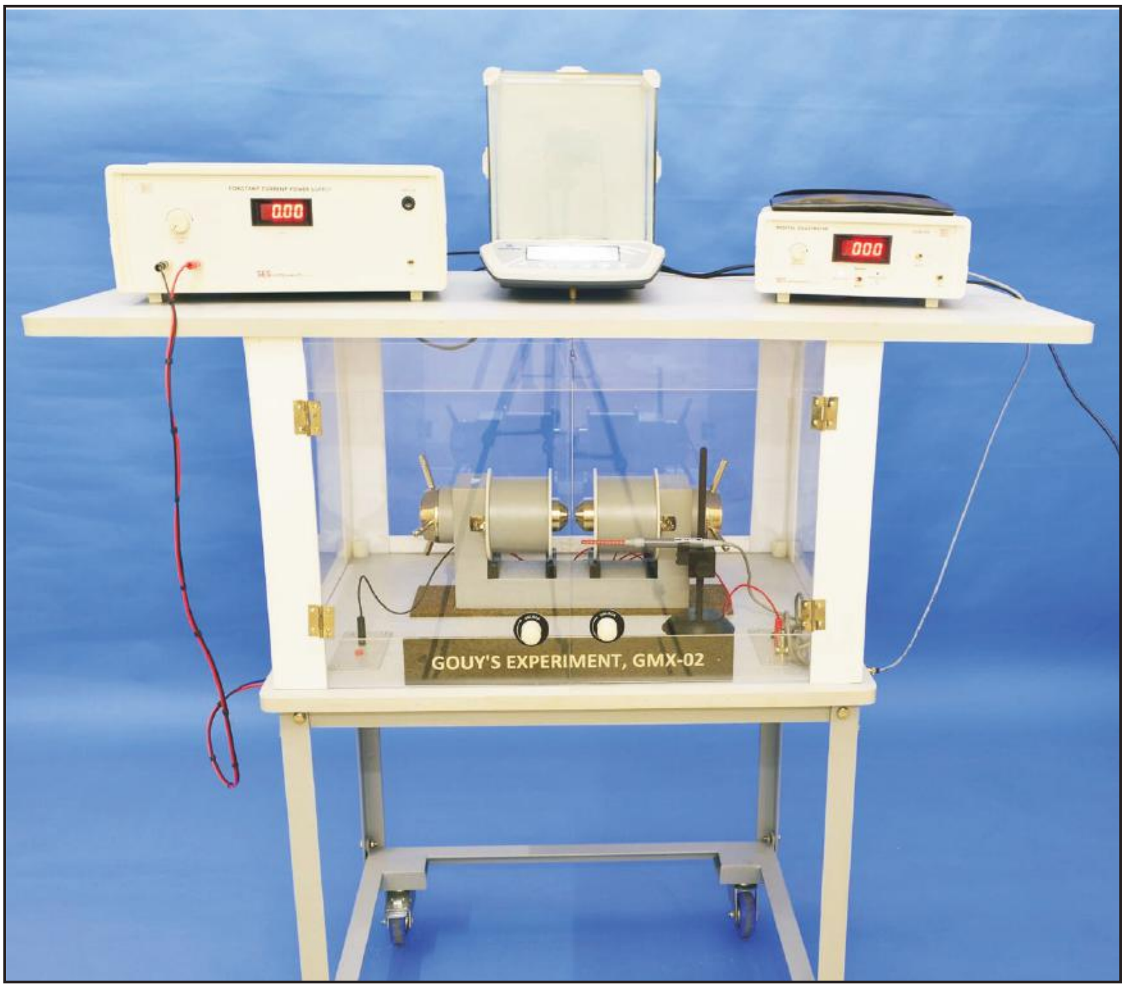
Gouy's Experiment

GMX-02 (50)

SES Instruments Pvt Ltd.

Apparatus for Measurement of Susceptibility of Paramagnetic Solids by Gouy's Method



Description

In the Gouy's method of susceptibility measurement, the solid sample in the form of a long cylinder (area of cross section A) is hung from the pan of a balance and is placed such that one end of the sample is between the pole-pieces of the magnet (field H) and the other one is outside the field. The force exerted on the sample by the inhomogeneous magnetic field is obtained by measuring the apparent change (Dm) in the mass of the sample. The susceptibility c is given By 2 c= 2Dmg/AH If the sample is in the form of powder, it is filled in a long nonmagnetic tube which is then suspended from the pan of the balance.

Description of Experimental Set-up

1. Digital Balance, CA-44

Capacity : 40gms

Readability : 0.0001gms

Repeatability : (+/-) 0.1mg

Linearity : (+/-) 0.2mg

Pan Size : 80mm

Standard bidirectional RS-232 interface

Complete with weigh below hook feature suitable for Gouy's measurements

2. Samples

Sample is provided iwth the steup in the form of a long rod: Aluminium sample and Glass Tube.

3. Electromagnet, Model EMU-50T

Field Intensity : 9.0KG at 10mm air-gap with tapered pole pieces

Pole Pieces : 50mm diameter

Energising Coils : Two, each with a resistance of about 3.0W

Power Requirement : 0-30Vdc, 4A, if coils are connected in series

Weight : 33Kg

4. Constant Current Power Supply, Model DPS-50

Current Range : Smoothly adjustable from 0-4A

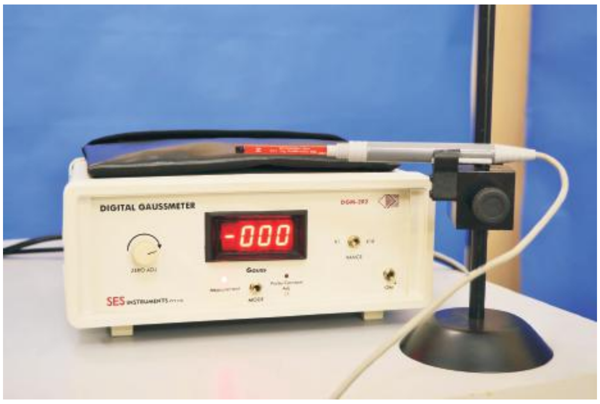
Load Regulation : 0.1% for load variation from 0 to max.

Line Regulation : 0.1% for ±110% mains variation

Display : 3½ digit, 7 segment LED DPM

Power : 220V ±10%, 50Hz

5. Gaussmeter, Model DGM-202



Resolution : 1 gauss at 2 kilogauss range

Range : 2KG and 20KG

Accuracy : ±0.5%

Temperature : Upto 40°C

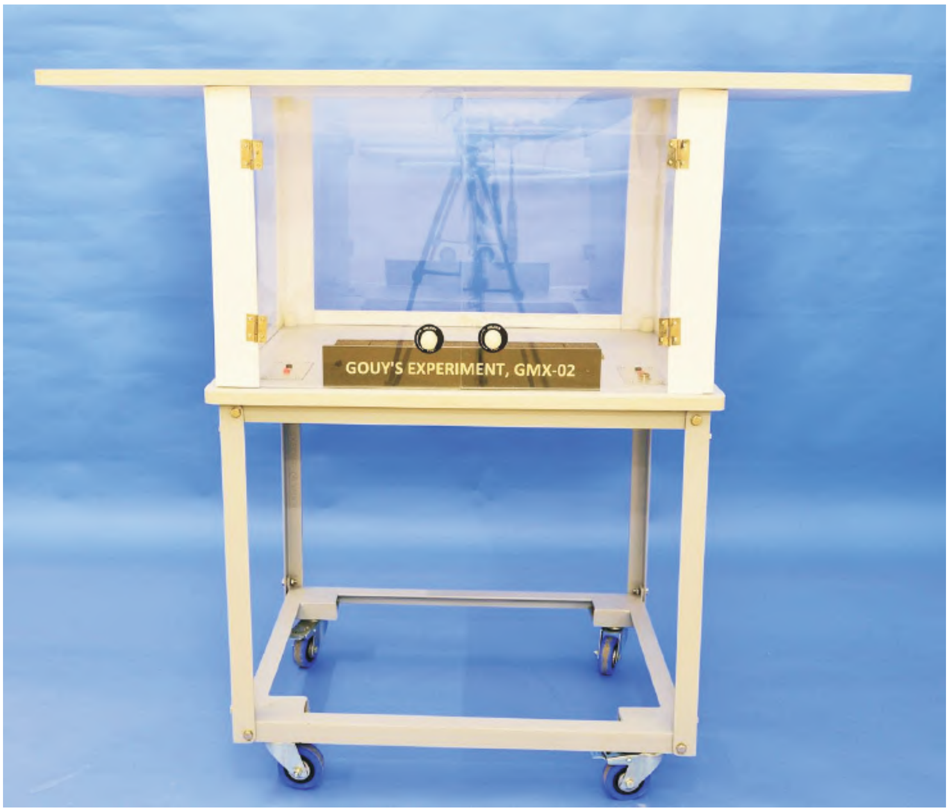
Display : 3½ digit, 7 segment LED DPM with auto polarity and overfow indication

Power : 220V ±10%, 50Hz

Transducer : Hall Probe-GaAs

Special Feature : Indicates the direction of the magnetic field

6. GMX-02 Trolley, Model GMX-TR2



The setup is complete in itself

GMX-02

Gouy's Method

Apparatus for Measurement of Susceptibility of Paramagnetic Solids by Gouy's Method

In the Gouy's method of susceptibility measurement, the solid sample in the form of a long cylinder (area of cross section A) is hung from the pan of a balance and is placed such that one end of the sample is between the pole-pieces of the magnet (field H) and the other one is outside the field. The force exerted on the sample by the inhomogeneous magnetic field is obtained by measuring the apparent change (Δm) in the mass of the sample. The susceptibility χ is given by

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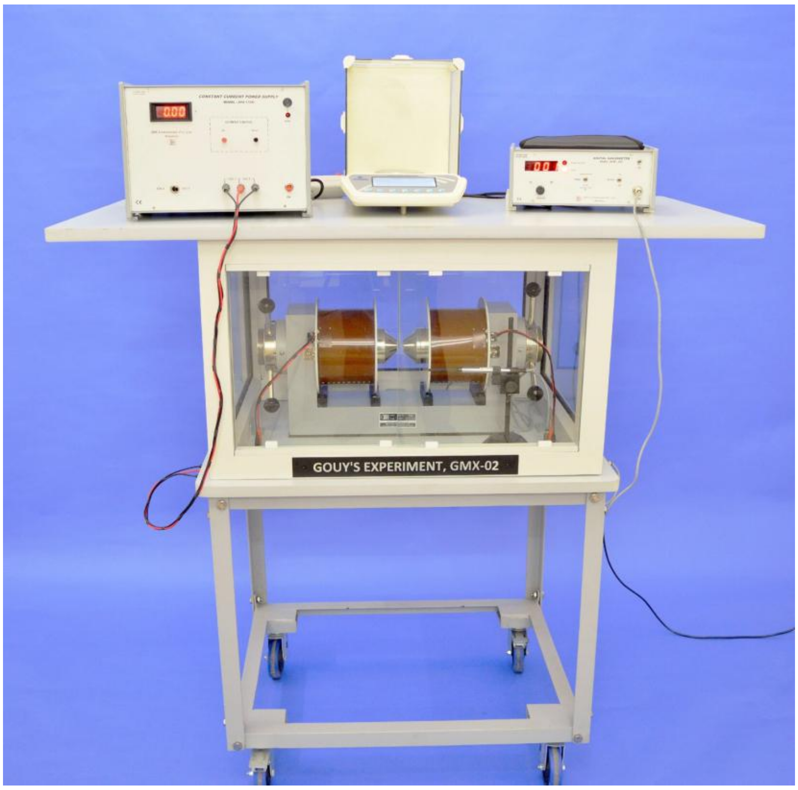
If the sample is in the form of powder, it is filled in a long nonmagnetic tube which is then suspended from the pan of the balance.

The set up consists of the following:



(a) **Digital Balance, CA-44**

Capacity	:	40gms
Readability	:	0.0001gms
Repeatability	:	(+/-) 0.1mg
Linearity	:	(+/-) 0.2mg
Pan Size	:	80mm

Standard bidirectional RS-232 interface
Complete with weigh below hook
feature suitable for GMX-01measurement

(b) **Sample in the form of a long rod**: Aluminium sample and Glass Tube

(c) **Electromagnet, Model EMU-75T**

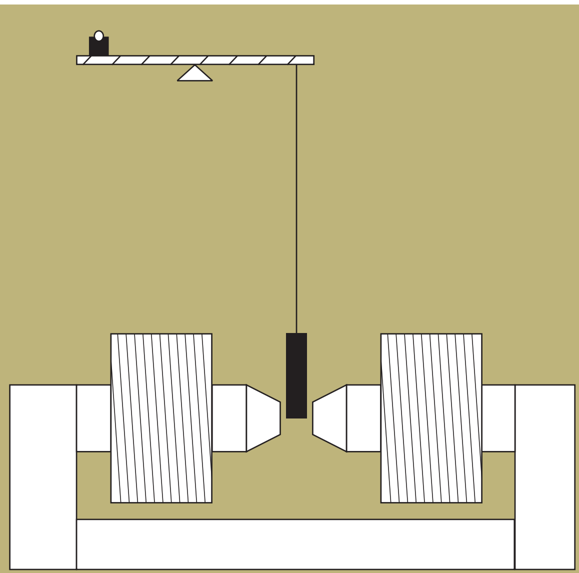
Pole Pieces	:	75mm tappered to 25mm
Mag. Field	:	20KG mm airgap
Energising Coils	:	Two of approx. 13Ω each
Power	:	0-90Vdc, 3A, for coils in series 0-45Vdc, 6A, for coils in parallel

(d) **Constant Current Power Supply,** Model DPS-175 (specifications as per datasheet)

(e) **Gaussmeter,** Model DGM-202 (specifications as per datasheet)

(f) **GMX-02 Trolley, Model GMX-TR2**

The experiment is complete in all respect.



Schematic Diagram
Gouy's Balance Experiment

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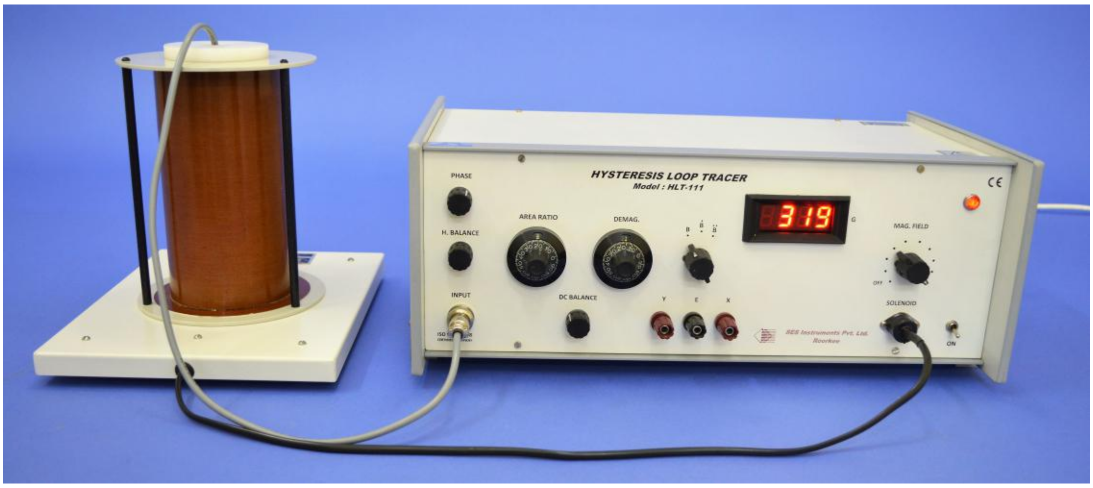
HLT-111

Hysteresis Loop Tracer



- Measures magnetic parameters accurately
- Demagnetisation, eddy currents and sample cross-sectional area have been accounted for
- Capable of detecting the number of magnetic phase present in a sample

Introduction

A precise knowledge of various magnetic parameters of ferromagnetic substances, viz. coercivity, retentivity, saturation magnetisation and hysteresis loss, and ability to determine them accurately are important aspects of magnetic studies.

The information about the aforementioned properties can be obtained from a magnetic hysteresis loop which can be traced by a number of methods in addition to the slow and laborious ballistic galvanometer method. Among the typical representatives of AC hysteresis loop tracers, some require the ring form of samples while others can be used with thin films, wires or even rock samples. Ring form samples are not always practically convenient to make while in others demagnetisation effects sometime become quite important.

The present set-up can accept the samples of thin wires of different diameters. The demagnetisation effects, different diameters of samples and eddy currents (due to the conducting property of the material) has been taken into account within the design or graphically.

Design Principle

When a cylindrical sample is placed coaxially in a periodically varying magnetic field the magnetisation in the sample also undergoes periodic variation. This variation is picked up by a coil, placed coaxially with the sample. For the uniform field H_a produced, the effective field H acting in the cylindrical sample will be

$$H = H_a - NM$$

or
$$H = H_a - \frac{NJ}{\mu_0} \qquad (1)$$

where M is magnetisation, N is normalised demagnetisation factor including 4π and J is the magnetic polarisation defined by

$$B = \mu_0 H + J$$

with $B = \mu H$ or $\mu_0(H+M)$ as magnetic induction. The signal corresponding to the applied field, H_a can be written as

$$e_1 = C_1 H_a \qquad (2)$$

where C_1 is a constant

Further the flux linking with the pick-up coil of area A_c due to sample of area A_s will be

$$\phi = \mu_0(A_c - A_s)H' + A_s B$$

where H' is the field in the excess area of the pick-up coil.

Under certain conditions this equation reduces to

$$\phi = \mu_0 A_c H + A_s J$$

The signal induced in the pick-up coil (e_2) will be proportional to df/dt which after integration yields

$$e_3 = C_3\phi = C_3\mu_0 A_c H + C_3 A_s J \qquad (3)$$

Solving (1), (2) and (3) gives

$$C_1C_3A_c\left(\frac{A_s}{A_c} - N\right) J = C_1e_3 - \mu_0 C_3 A_c e_1$$

$$C_1C_3A_c\left(\frac{A_s}{A_c} - N\right) J = C_3A_se_1 - \frac{N\,C_1e_3}{\mu_0}$$

Based on these equations the electronic circuit has been designed to give values of J and H and hence the hysteresis loop. Further different magnetic phases present in the sample may also be identified by electronically manipulating the pick-up signal.

Description of the set-up

The block diagram of the set-up is given next and a brief description now follows:

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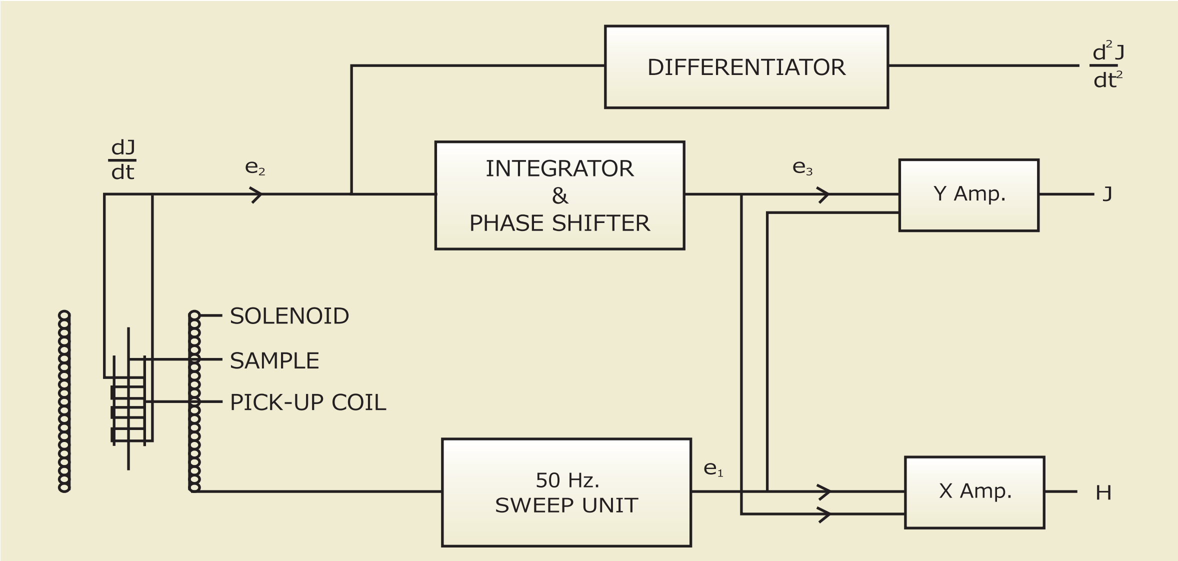
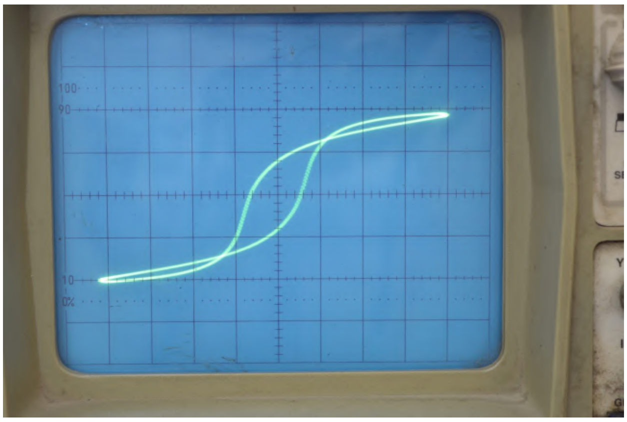


Fig. 1 Block diagram of Hysteresis Loop Tracer

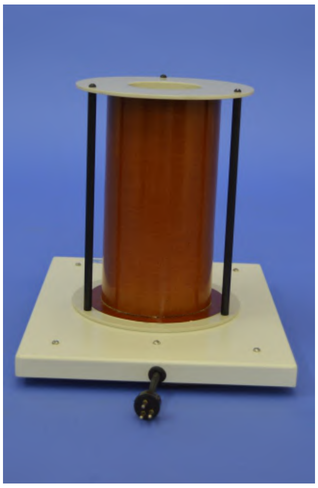


Basic Circuit

The magnetic field has been obtained with an ac mains driven multilayered solenoid. This magnetic field has been calibrated with a Hall Probe for uniformity and correspondence with the magnetic field calculated through ac current passing in the solonoid. A small resistance in series with the solenoid serves the purpose of taking a signal e_1 corresponding to H.

The signal e_2 (corresponding to dJ/dt) is taken from the pick-up coil placed at the centre of the solenoid and contains the sample. It is integrated and corrected for phase. This signal is then subtracted from the reference signal e_1 and amplified to give the signal corresponding to J. The e_1 signal is also subtracted from $3e_3$ in correct ratio (to account for demagnetisation and area ratio) and amplified to give signal corresponding to H.

e_2 is also passed through the differentiator for getting signal corresponding to d^2J/dt_2 which is used for phase identification.



Applications

The following magnetic parameters can be measured by this set-up:

- Coercivity
- Retentivity
- Saturation magnetisation
- Various magnetic phase identification
- Hysteresis loss

The equipment is complete in all respect, including a set of samples (wires of Nickel, and different grades of iron etc.). A Cathode Ray Oscilloscope will however be required.

HLT-111C

Hysteresis Loop Tracer

- Measures magnetic parameters accurately
- Demagnetisation, eddy currents and sample cross-sectional area have been accounted for
- Capable of detecting the number of magnetic phase present in a sample
- Computer Interface provided

Introduction

A precise knowledge of various magnetic parameters of ferromagnetic substances, viz. coercivity, retentivity, saturation magnetisation and hysteresis loss, and ability to determine them accurately are important aspects of magnetic studies.

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Based on these equations the electronic circuit has been designed to give values of J and H and hence the hysteresis loop. Further different magnetic phases present in the sample may also be identified by electronically manipulating the pick-up signal.

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HLT-111C

Hysteresis Loop Tracer

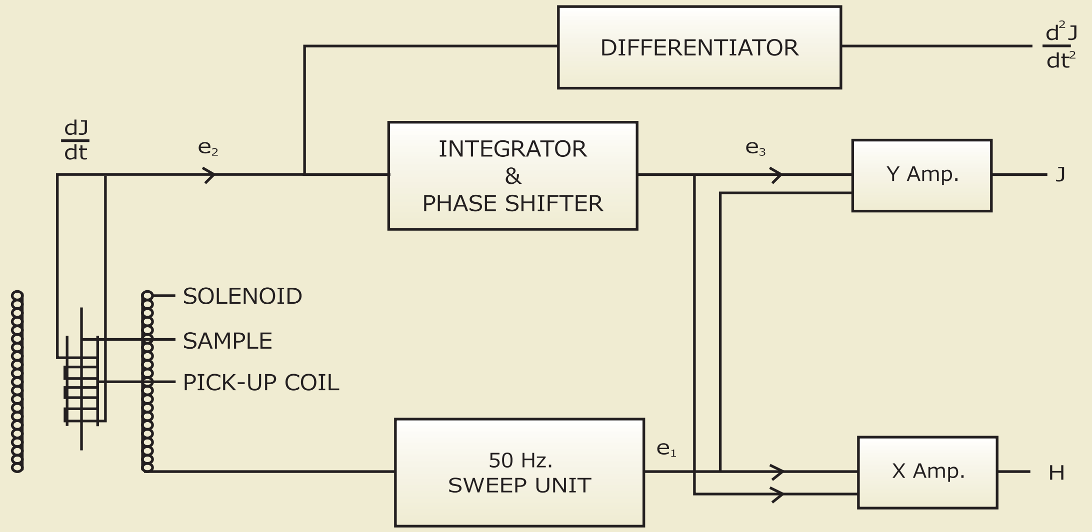

Fig. 1 Block diagram of Hysteresis Loop Tracer

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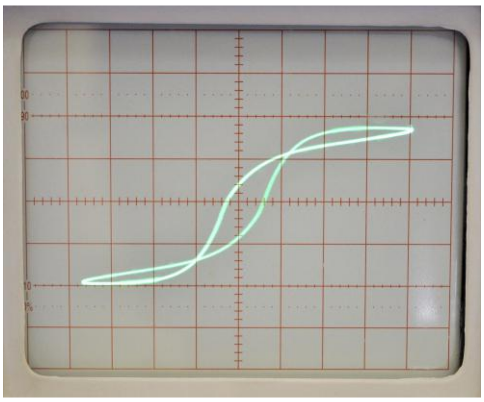
e_2 is also passed through the differentiator for getting signal corresponding to d^2J/dt_2 which is used for phase identification.



Computer Interface, SES-CAMM

This interface enables the user to get a plot of the B-H Loop on the computer screen as soon as a magnetic field is set soon the hardware. Procedure for initial setting and conduction of experiment are available through the software provided with the unit. In the end, data would be stored in the excel format.

Applications

The following magnetic parameters can be measured by this set-up:

- Coercivity
- Retentivity
- Saturation magnetisation
- Various magnetic phase identification
- Hysteresis loss

The equipment is complete in all respect, including a set of samples (wires of Nickel, and different grades of iron etc.). A Cathode Ray Oscilloscope and a computer will however be required.

Computer is not included with the setup..

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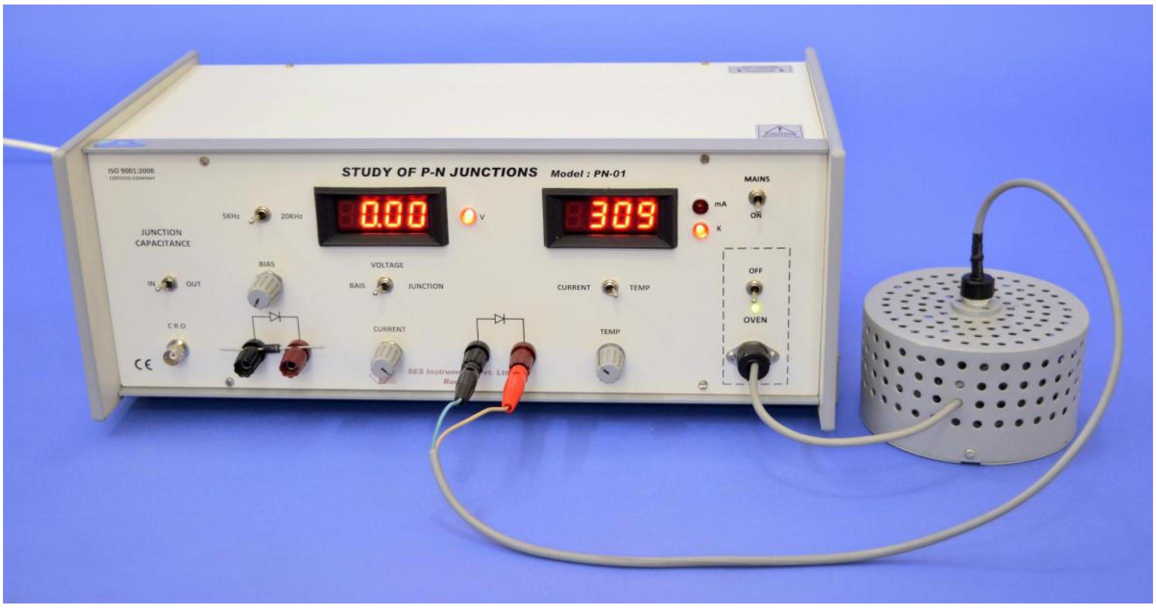
PN-01

P-N Junctions

Study of the energy band-gap and diffusion potential of P-N Junctions



Experimental Determination of :

- Reverse saturation current I_0 and material constant η
- Temperature coefficient of junction voltage dV/dt
- Energy band-gap VG_0
- Junction capacitance

Introduction

This is an advanced level experiment to be performed on commercially available diodes viz. germanium or silicon diodes, various types of LED's and also on the base-emitter/collector-base junctions of a transistor. The results of the experiments not only give the device characteristics but also provide an insight into the properties of the materials used in the fabrication of the junction. In the set-up, all the necessary instrumentation is integrated as a result of which a minimum of external connections need to be made by the user. A CRO is the only accessory that is required.

Experiments

Given below is a brief description of the experiments that may be performed.

(a) Reverse saturation current I_0 and material constant η

The magnitude of I_0 is too small to be measured conveniently and further, it is a function of the applied voltage. The direct measurement of this current is therefore both difficult and erroneous. In the present set-up, readings for the forward V-I characteristics are obtained by 3½ digit DPM for a wide range of currents.

If, V and lnI are plotted on a graph paper a straight line is obtained. This line intersects the current (lnI) axis at $\ln I_0$ and its slope $\Delta V/\Delta \ln I$ may be solved to compute η. (fig.1)

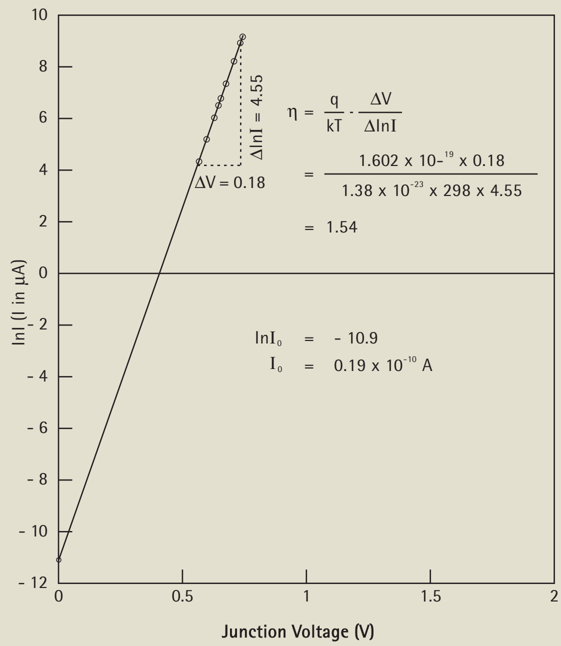


Fig. 1 Reverse Saturation Current

(b) Energy band-gap and temperature coefficient of the junction voltage

The P-N junction under test is kept in a small, fast temperature controlled oven. The temperature is

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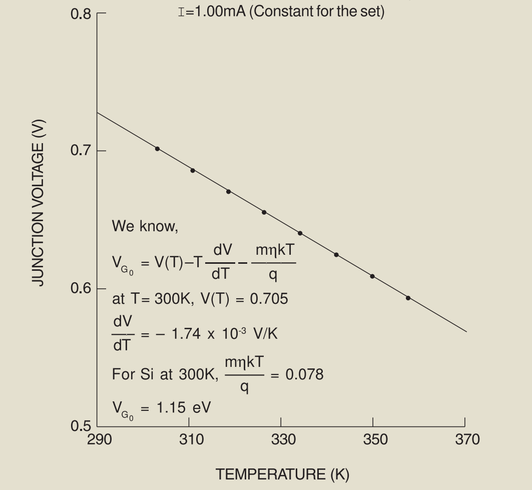
adjustable in the range from room temperature to about 80°C. From the readings of the temperature and junction voltage on digital instruments provided on the panel, the temperature coefficient and energy band-gap are computed. (fig.2)

Fig. 2 Temperature Dependence of Junction Voltage

SAMPLE: BC109 (BASE-EMITER JUNCTION)

I=1.00mA (Constant for the set)

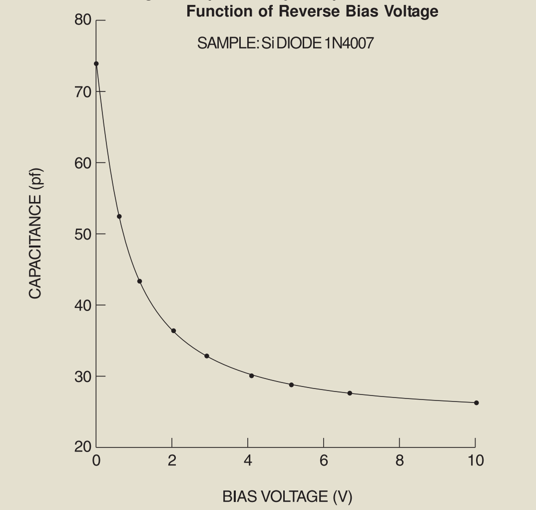


(c) The Junction Capacitance

The junction capacitance of a typical diode varies in the range 10pf-100pf approximately, as a non-linear function of the reverse voltage. This parameter though important in high frequency circuits, is difficult to measure because of its small value. In the present set-up, the output V_1 and V_2 at two frequencies f_1 & f_2, where $f_2>f_1$, are obtained at different values of bias voltage to compute the junction capacitance. A typical graph between bias voltage and junction capacitance is shown in fig.3.

Fig. 3 Depletion Layer Capacitance as a Function of Reverse Bias Voltage

SAMPLE: Si DIODE 1N4007



The experimental set-up consists of the following

(1) Study of P-N Junction, Model PN-1

(a) 3½ digit DPM for current/temperature measurements.

(b) 3½ digit DPM for bias voltage/junction voltage measurements.

(c) Two parts to connect the diode - one for experiment 1 & 2 and other for experiment 3.

(d) Two fixed frequency oscillators (5KHz & 20KHz) with the same output (200 mV).

(2) Fast temperature controlled oven with sensor

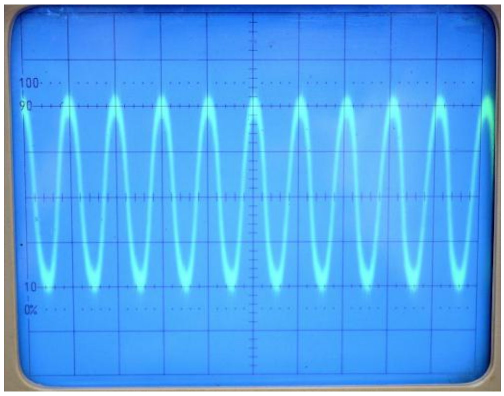
(3) Set of samples

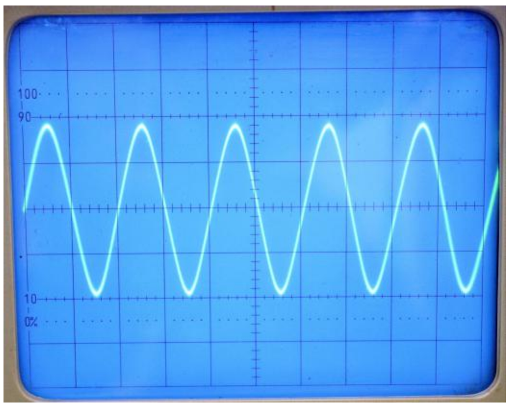
(a) Transistor BC109 (base-emitter)-Si

(b) Transistor AC126 (base-emitter)-Ge

(c) Diode 1N 5408/1N 4007-Si

The unit is supplied complete with a detailed instruction manual. Sufficient theoretical description is included for a proper understanding. This is followed by a step-by-step procedure and a typical set of readings and results.





Complete in all respect, except a CRO for capacitance measurement. Typical results obtained are shown in fig. no. 1, 2 & 3.

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DCBC-01

Diodes Characteristics & Boltzman Constant

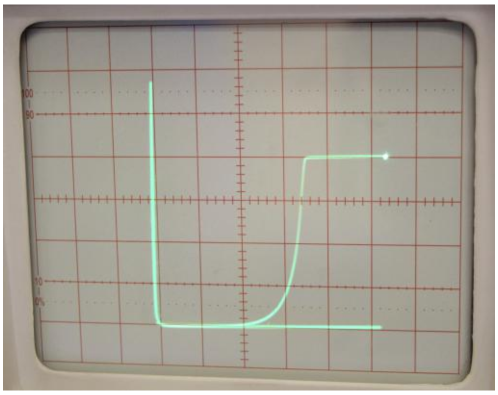
- Forward and reverse characteristics of Ge, Si diodes and LEDs
- Study of Zener diode characteristics
- CRO display of forward and reverse characteristics
- Determination of Boltzman Constant

The set-up is provided with a booklet which contains its theory of operation, description, suggestions and discussion of the experiments that may be performed with it.

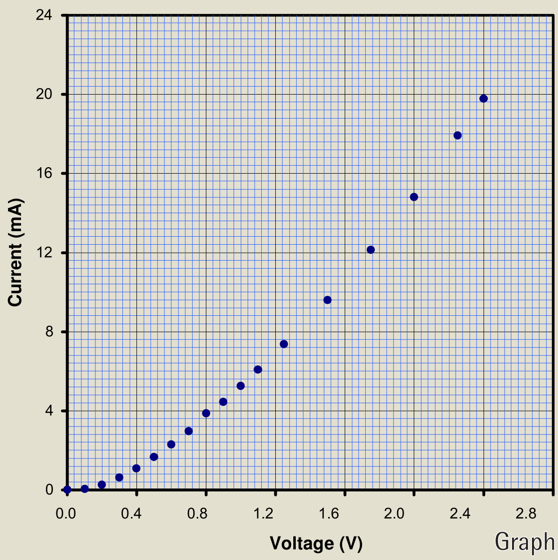
The experimental set-up consists of the following:

1. Diodes: Rectifier-4007 (Si), Signal diode-1N34 (Ge), Zener 4.7V, LED and transistor BC-109
2. 3½ digit DPM which can measure diode voltage and current through op-amp circuit. This provides near ideal measurements.
3. Circuit to display forward/reverse characteristics of the diodes on a double trace CRO.
4. IC regulated internal power supplies

The experimental set-up is complete in all respect, except a measuring CRO.



CRO Display



Graph

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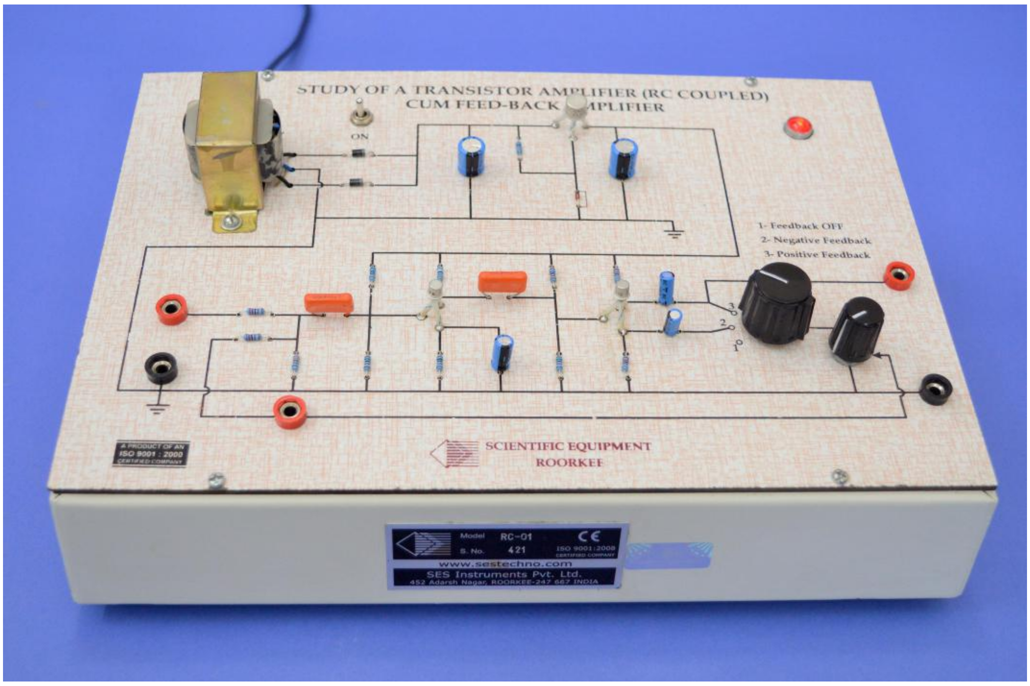
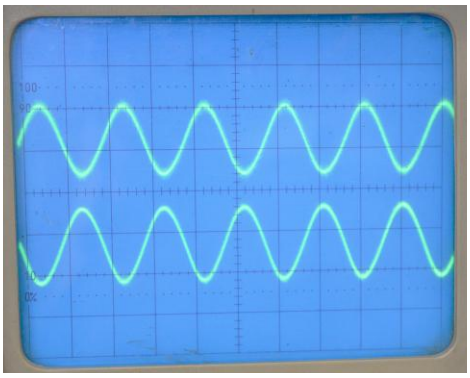
RC-01

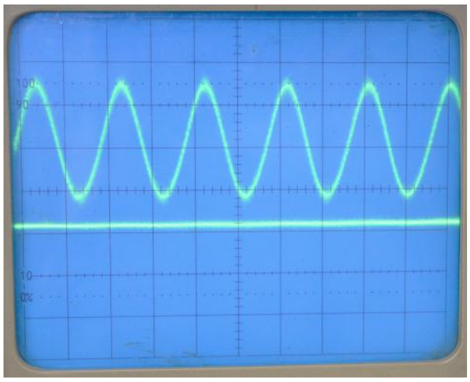
Study of a Transistor Amplifier (RC Coupled)



Features

1. Study of the basic circuit of a RC coupled Amplifier
2. Frequency response of RC coupled Amplifier
3. Effect of negative feedback on the gain and frequency response of the amplifier
4. Effect of positive feedback on the gain and frequency response of the amplifier
5. Verification of the condition of oscillation
6. Study of different classes of amplifier





Introduction

This is a two stage transistor amplifier with a provision for positive and negative feedback. The amount of feedback is adjustable and with the help of this it is even possible to make the amplifier oscillate. A 9V stabilized power is provided on the same board.

The experimental set-up has been laid down on a decorated bakelite board with an aim of providing an easy understanding to the students. All components are well spread out for clarity and easy repairs and replacement. The set-up is provided with a booklet, which contains its detailed theory of operation, description, specifications, suggestions and discussion on the various experiments that may be performed with it.

Measuring/testing instruments required

1. A.C. Millivoltmeter (True R.M.S. A.C. Millivoltmeter, Model: ACM-102)
2. A.F. Oscillator
3. CRO

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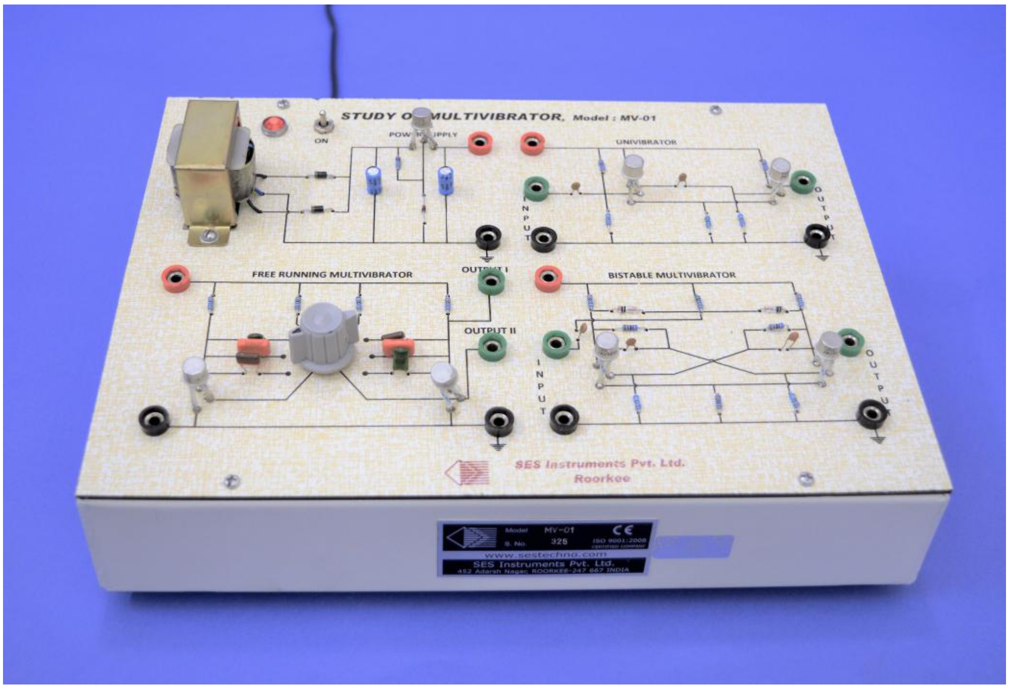
MV-01

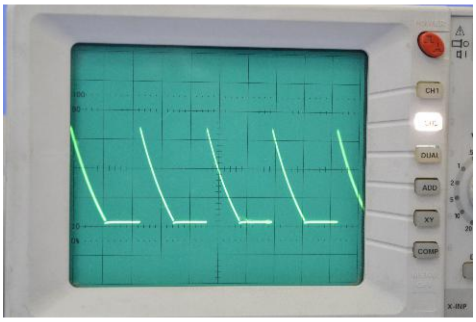
Study of Multivibrators

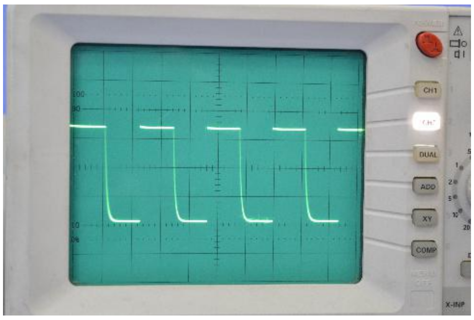


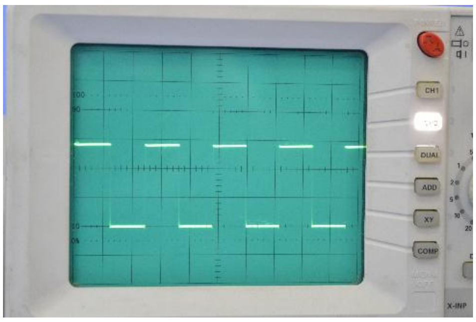
Features

- Study of a Bistable Multivibrator.
- Study of a Free Running Multivibrator.
- Study of a Univibrator.

The free running multivibrator also serve as a pulse generator for the study of bistable multivibrator and univibrator.







Introduction

The set-up consists of circuits of three type of multivibrators : (1) Free running multivibrator (2) Bistable multivibrator (3) Univibrator and their stabilized power supply, all mounted on a decorated bakelite board. Usual provisions for convenient inputs and outputs are provided on binding terminals.

The experimental set-up have been laid down on a decorated bakelite board with an aim of providing an easy understanding to the students. All components are well spread out for clarity and easy repairs and replacement. The set-up is provided with a booklet, which contains its detailed theory of operation, description, specifications, suggestions and discussion on the various experiments that may be performed with it.

The unit is self contained and need no additional accessory, except an Oscilloscope.

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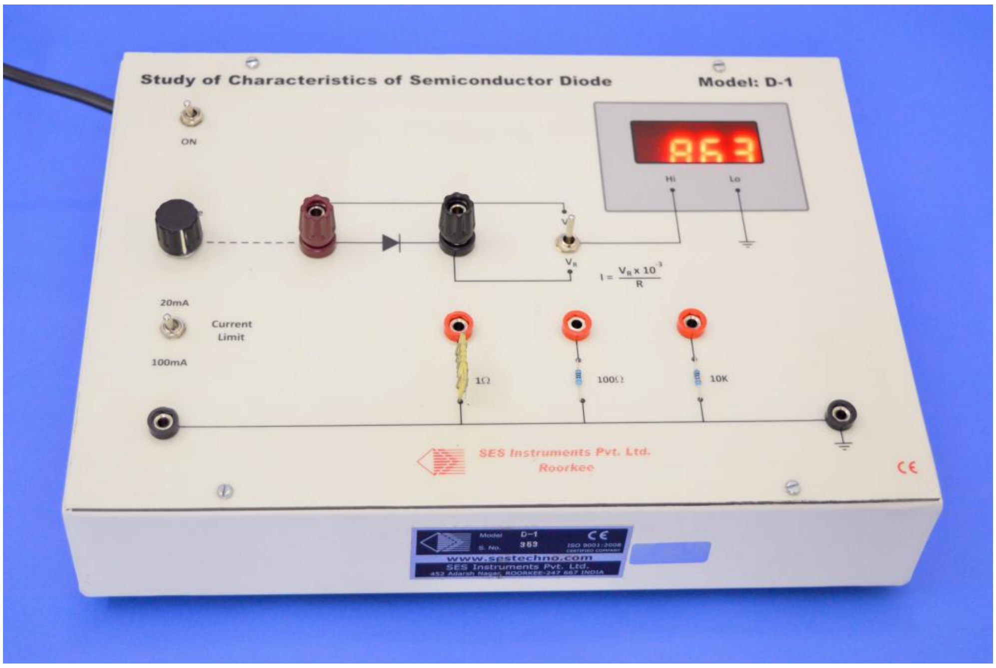
D-1

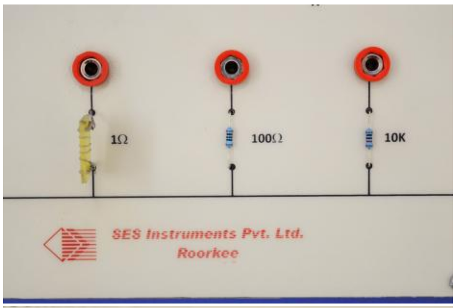
Characteristics of Semiconductors Diodes



Features

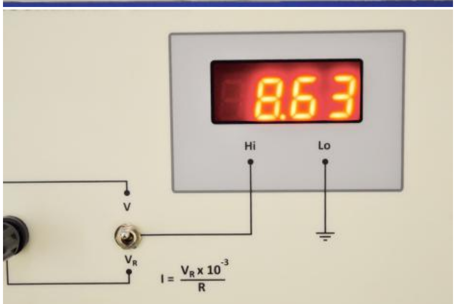
- Forward and reverse characteristics of Ge, Si diodes and LED's
- Study of Zener diode characteristics

The set-up is provided with a booklet which contains its theory of operation, description, suggestions and discussion of the experiments that may be performed with it.

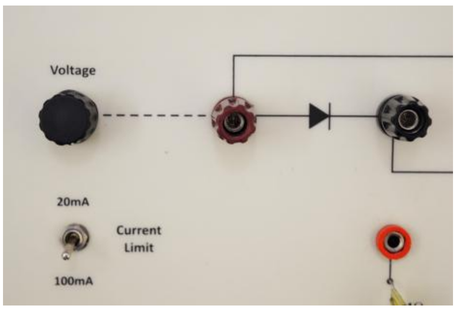


The experimental set-up consists of the following

1. Diodes: Rectifier-4007 (Si), Signal diode-1N34 (Ge), Zener 5.1V and LED
2. 3½ digit DPM which can measure voltage (0-20V)
3. Suitable precision resistances are provided for the measurement of forward current, Reverse current, in the range of 10nA to 200mA
4. IC regulated variable power supply (0-12V)



The experimental set-up is complete in all respect.



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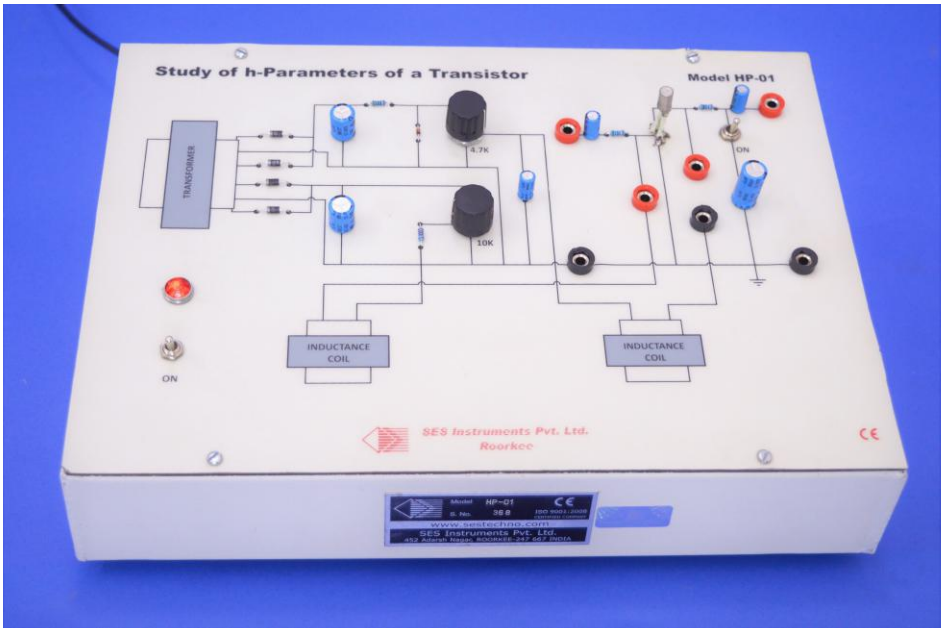
HP-01

Study of Hybrid Parameters of a Transistor



Features

- Study of h_{11} parameter (input impedance parameter)
- Study of h_{22} parameter (output admittance parameter)
- Study of h_{21} parameter (forward current transfer ratio)
- Study of h_{12} parameter (reverse voltage feedback ratio)
- Built-in power supply

Measuring/testing instruments required

- True R.M.S A.C. Millivoltmeter, Model ACM-103 or
- True R.M.S A.C. Millivoltmeter, Model ACM-102 & Oscillator

Introduction

A transistor has low input impedance and high output impedance and hence the use of Z and Y parameters becomes awkward specially at high frequencies. As a result the hybrid of 'h' parameters are found to be most useful for transistor circuit analysis, because the hybrid parameters form a and high impedance of the transistor. Another advantage is that the parameters h_{11} , h_{21} and h_{22} almost correspond to the actual operating conditions.

The experimental set-up have been laid down on a decorated bakelite board with an aim of providing an easy understanding to the students. All components are well spread out for clarity and easy repairs and replacement. The set-up is provided with a booklet, which contains its detailed theory of operation, description, specifications, suggestions and discussions on the various experiments that may be performed with it.

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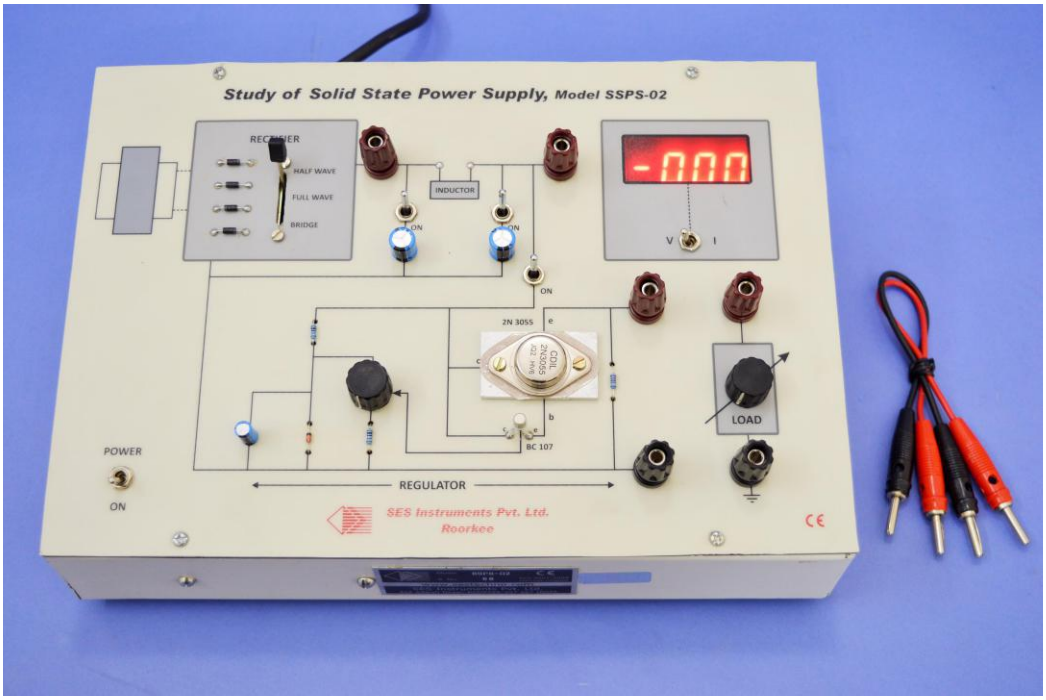
SSPS-02

Study of a Power Supply (Solid State)



Features

1. Study of rectification
   - (a) Full wave rectification
   - (b) Half wave rectification
   - (c) Bridge rectification
2. Study of ac component (Ripples)
   - (a) Efficiency of various type of filters L, π, T type etc.
   - (b) The effect of load
   - (c) The effect of regulation
3. Regulation characteristics
   - (a) The effect of load on regulation
   - (b) The effect of change in main's voltage
4. Electronic Load
   To draw the load current smoothly

Introduction

The Set-up consists of a step-down transformer, a rectifier circuit (can be used as a half-wave or a full-wave rectifier), a filter circuit (an inductance and two capacitors) - the arrangement can be used for the study of various configuration of filters and a regulator circuit. A built-in electronic load is used to smoothly vary the load current while a digital panel meter on the board measures the load current and load voltage.

Specifications

Output	:	0-12 volts
Max. Current	:	200 mA
Regulation	:	1%
Metering	:	Output Voltage/ Current on the switchable DPM

The experimental set-up is complete in all respect, except a Multimeter and a CRO

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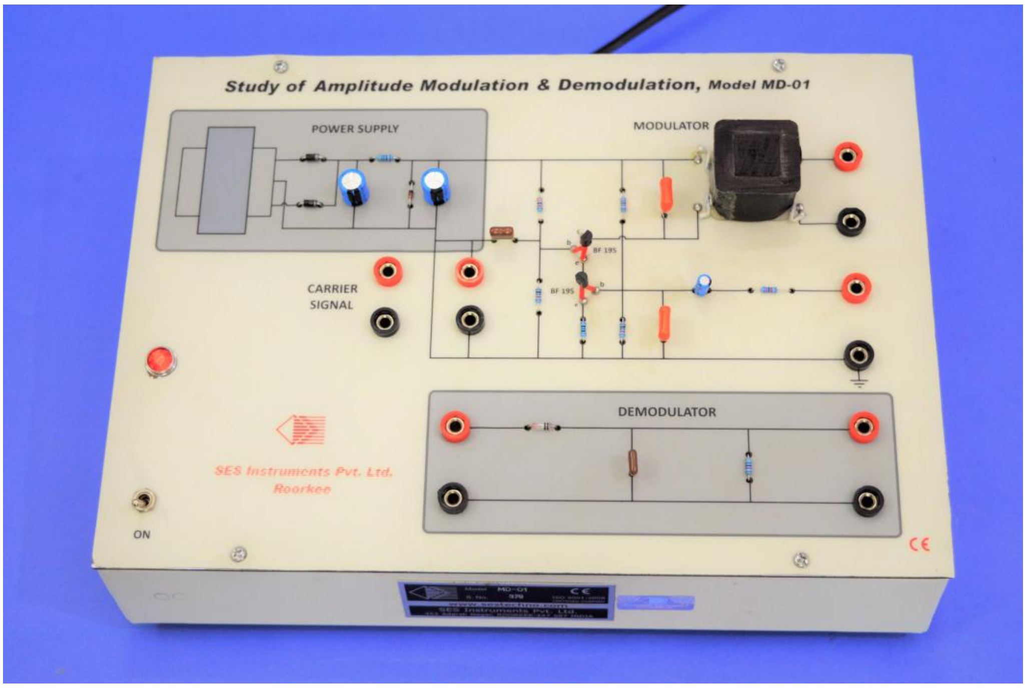
MD-01

Study of Modulation and Demodulation



Features

- Study of carrier signal testing.
- Study of variation of modulated wave with the modulation signal.
- Study of detector circuit.
- Built-in power supply

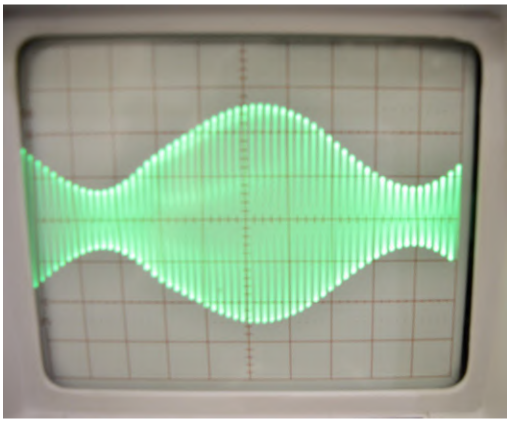
Introduction

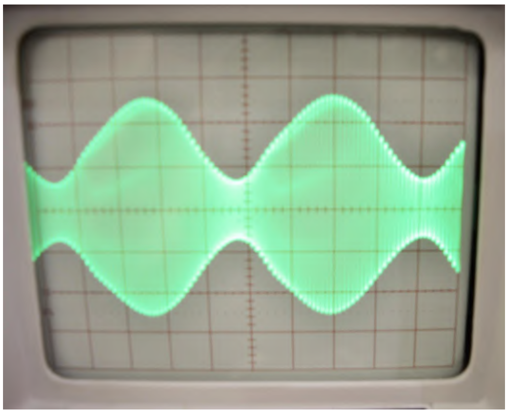
The set-up consists of modulating and demodulating circuits. It is provided with a fixed frequency (70 KHz) oscillator, which may be used for carrier frequency. This eliminate the need of a R.F. Oscillator. The carrier signal may be given from any other oscillator also if the change in carrier frequency is desired. Since the circuit is designed for comparatively low frequency (70 KHz to 150 KHz) carrier signal, the usual A.F. Frequency Oscilloscope is good enough.

The experimental set-up have been laid-down on a decorated bakelite board with an aim of providing an easy understanding to the students. All components are well spread out for clarity and easy repairs / replacement. The set-up is provided with a booklet, which contains its detailed theory of operation, description, specifications, suggestions and discussion on the various experiments that may be performed with it.

Measuring/testing instruments required

1. A.F. Oscillator
2. CRO





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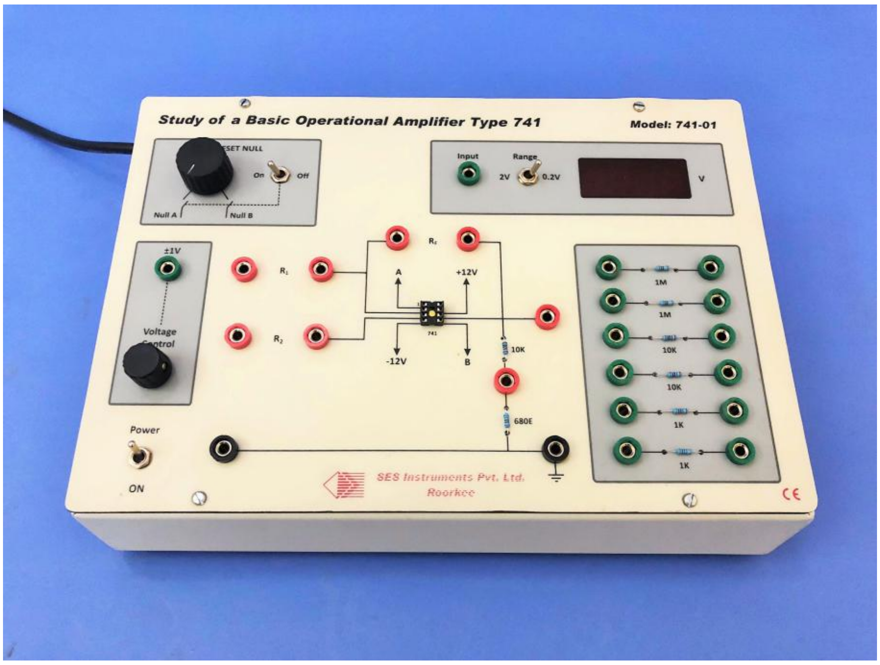
741-01

Study of Basic Operational Amplifier



Features

- Working of the basic circuit
- Measurement of bias currents, offset currents and offset voltage
- Study of inverting and non-inverting amplifier configurations
- Introduction to amplifier drift
- Measurement of CMRR and slew rate
- Study of frequency response (band width)
- Built-in power supply

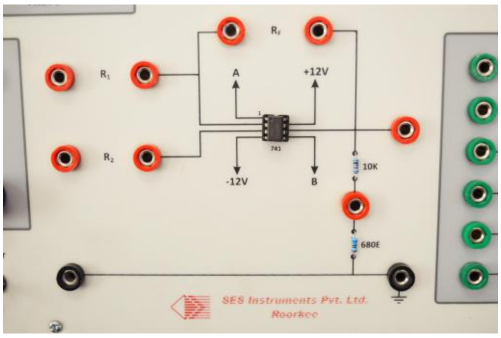
Introduction

The term operational amplifier (Op. Amp.) refers to high gain dc amplifier that has a differential input (two input leads) and a single ended output (one output lead). Op. Amps. have characteristics such as high input resistance, low output resistance, high gain, low drift etc., that make them highly suitable for many applications and therefore, wide spread use in electronic circuits.

The experimental set-up on the study of Op. Amp. consists of a 741 IC with facilities for convenient connections, two regulated power supplies (±12V), a variable voltage source and a multirange digital voltmeter with 3½ digit LED display.

The resistances (0.1% metal film) required are mounted on the board separately, which may be connected as required through patch chords. The student can also connect external components, if required.

The set-up is complete in all respect, but a A.F. oscillator would be required for frequency response.



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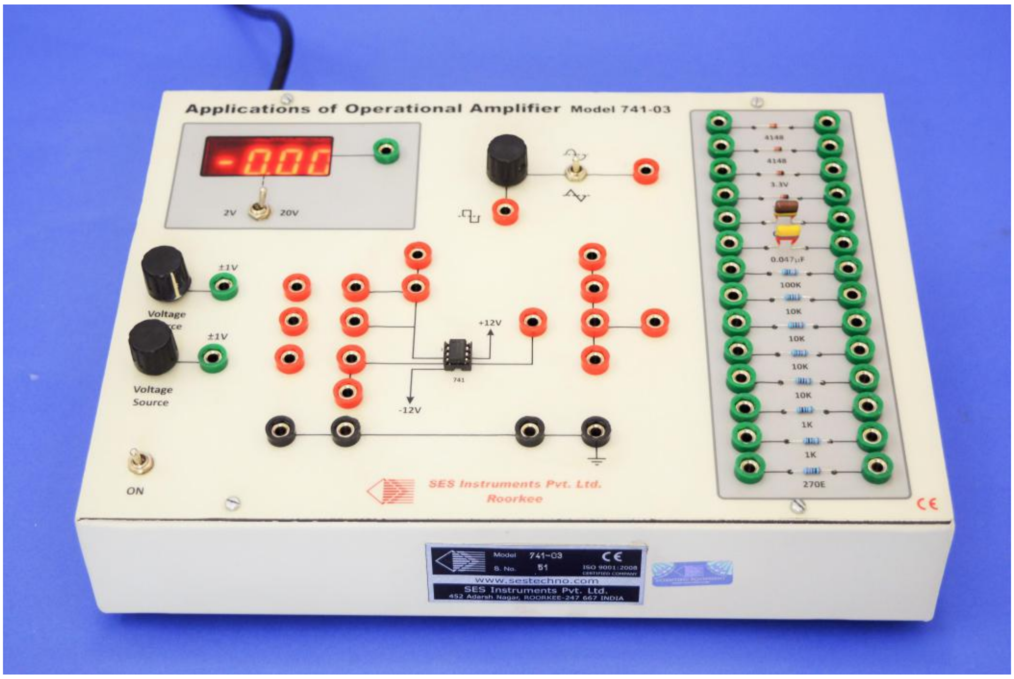
741-03

Study of Operational Amplifier Application



Features

- Study of linear and non linear applications as
  - Integrator
  - V - I converter
  - Clipper
  - Differentiator
  - I - V converter
  - Clamper
  - Summer
  - Astable Multivibrator
  - Peak Detector
  - Subtractor
  - Precision rectifier
  - Schmitt Trigger
- Built-in power supply
- Built-in square wave and triangular wave Generator
- Built-in current source
- All components for the experiments suggested are available on panel

Introduction

The operational amplifier (Op. Amp.) is a versatile device that can be used to amplify dc as well as ac input signals and was originally designed for such mathematical functions as addition, subtraction, multiplication, and integration. Thus the name operational amplifier stemps from its original use for these mathematical operations. With the addition of suitable external feedback components, the modern day op-amp can be used for a variety of applications such as Voltage to current converter, oscillator, comparators, clippers, clampers, peak detector, Schmitt trigger and others.

The experimental set-up on the study of Op. Amp. consists of a 741 IC with facilities for convenient connections, two regulated power supplies (±12V), two variable voltage source and a multirange digital voltmeter with 3½ digit LED display. The resistances (0.1% metal film), capacitances, diodes etc. as required are mounted on the board separately, which may be connected through patch chords. The student can also connect external components also, if required.

The set-up is complete in all respect. An extra CRO would however be necessary for waveform studies.

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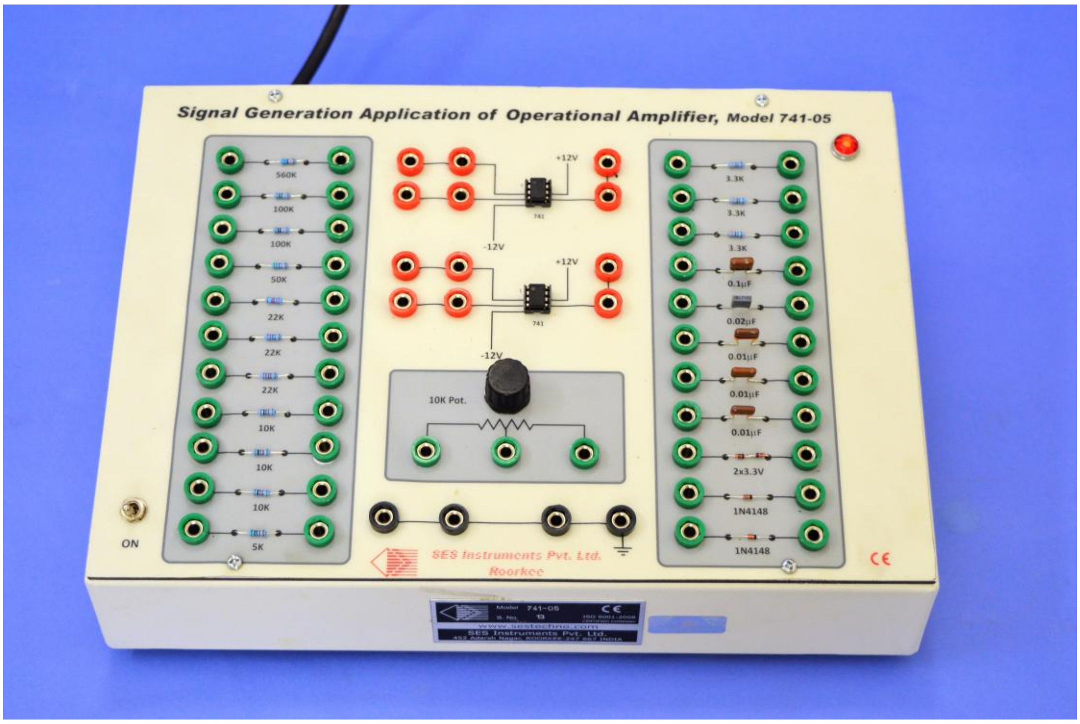
741-05

Signal Generation Applications of Operational Amplifiers



Features

- Study of different LC oscillator cirucuits using operational amplifiers type-741
  - Wien-Bridge Oscillator
  - Phase Shift Oscillator
  - Twin-T Oscillator
  - Quadrature Oscillator
  - Squre and Triangular Wave Oscillator
  - Sawtooth and Pulse Generator
- All necessary components are available on the panel
- Built-in power supply
- Patch cords and user manual included
- Accessory require – a dual trace oscilloscope

Introduction

Continuous signals of various kinds form an essential block in the testing of electronic circuits. Signal generation is therefore an important task that needs to be introduced to a student of electronics at an early stage. Particularly important are the medium to low frequency signals that are used so commonly. The present unit is designed to explore the operational amplifier based resistance-capacitor type signal generation circuits of various kinds in the lower kHz region. Besides sinusoidal signals, the study covers square wave, triangular wave, sawtooth and sharp pulse generation. The description begins with the basic theory of oscillations, viz., the Barkhausen criterion, and discusses various oscillator circuits and their mode of working. Apart from the configurations suggested, additional circuits too may be attempted by the user.

The experimental board comprises of two operational amplifiers and some 24 passive components carefully arranged on it. While the amplifiers are pre-wired with internal power supply, the other components need to be suitably connected using the patch cords provided. Only a dual trace oscilloscope would be required as an accessory. The user manual supplied with the unit covers all technical details for conducting the experiments. References are cited for additional information.

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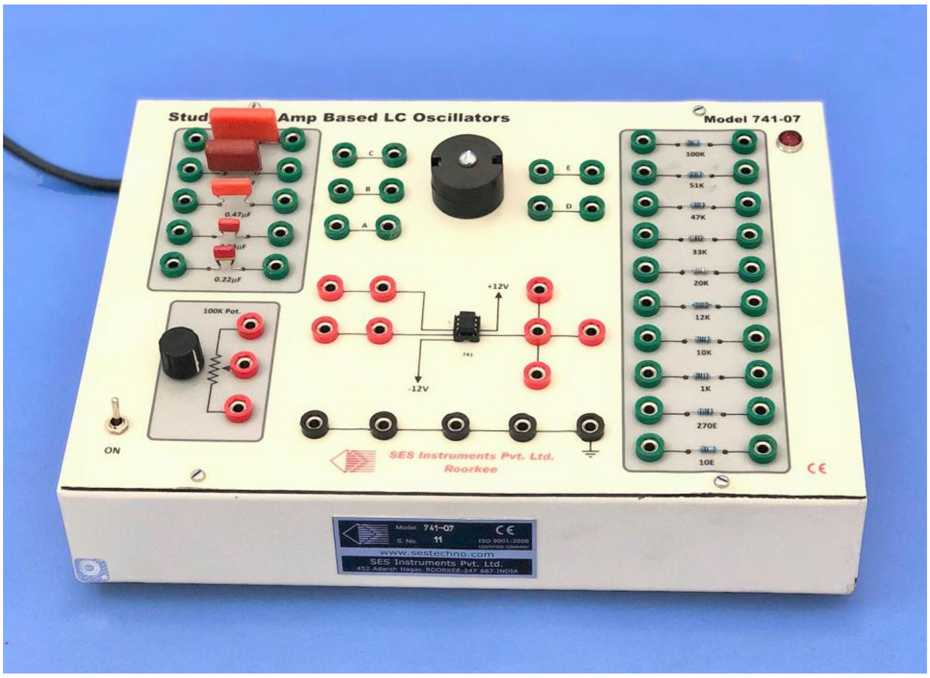
741-07

Study of OP AMP based LC Oscillators



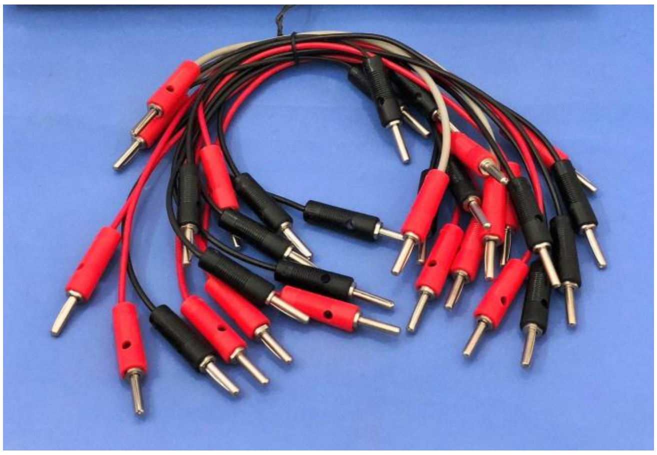
Features

- Study of different LC oscillator cirucuits using operational amplifiers type-741
  - Hartley Oscillator
  - Tuned Output Oscillator
  - Colpitts Oscillator
  - Clapps Oscillator
- All necessary components are available on the panel
- Built-in power supply
- Patch cords and user manual included
- Accessory require – a dual trace oscilloscope

Introduction

Sine wave signals at different frequencies find application in the frequency response studies of various electronic circuits and systems. Historically these sine wave signals have been generated using LC tuned circuits and RC circuits, although digitally synthesized signals are now becoming more common. Basic signal generation is therefore an important task that needs to be introduced to a student of electronics at an early stage. Particularly important are the medium to low frequency signals in the audio ranges. Our experimental unit type 741-05 covers RC oscillators while the present unit is designed to explore the operational amplifier based inductance-capacitor type circuits of various kinds in the lower kHz region. The unit has the possibility of a range of component variation by the user and study their effects. The user manual coversa description of the basic theory of oscillations, viz., the Barkhausen criterion, and discusses various oscillator circuits and their mode of working. Of special interest are the mechanism of amplitude stabilization and the loop phase.

The experimental board comprises of an operational amplifiers and some 17 passive components carefully arranged on it to be suitably connected with patchcords. Only a dual trace oscilloscope would be required as an accessory. The user manual supplied with the unit covers all technical details for conducting the experiments.



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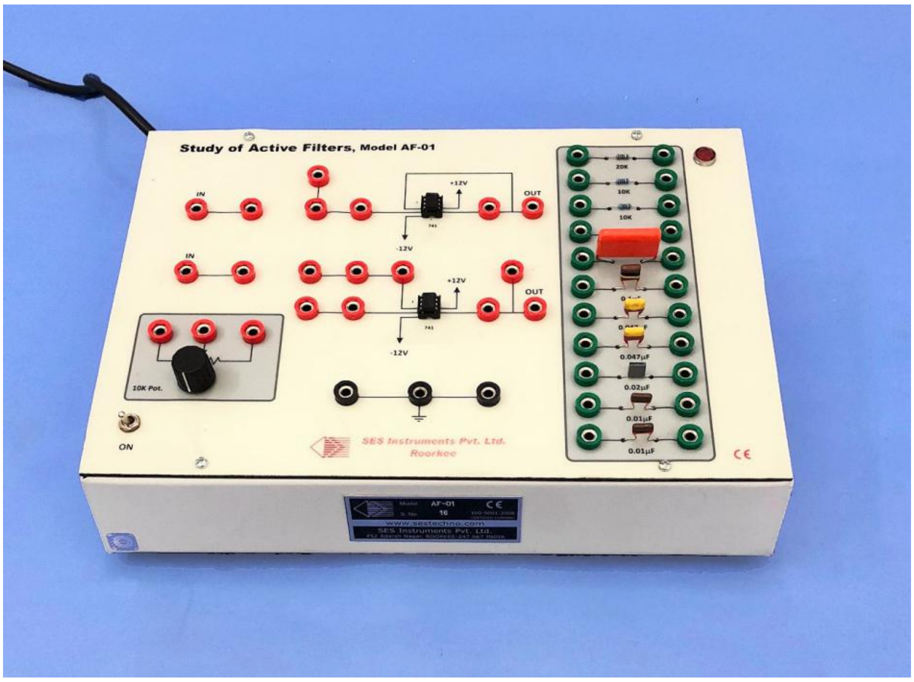
AF-01

Study of Active Filters



Features

- Frequency response studies of various active filter circuits using operational amplifiers type-741
  - Lead/Lag compensator
  - Low/High pass filter
  - Band Pass/Band Reject filters
  - All pass filte
  - Twin-T (Notch) filter
  - Adjustable Q Notch filter
- All necessary components are available on the panel
- Built-in power supply
- Patch cords and detailed user manual included
- Accessory required– (i) Function Generator (ii) Dual trace oscilloscope

Introduction

Filters are circuits which have a varied response to different frequencies and are primarily used in applications where one intends to boost or suppress some frequencies. There is naturally a very large number of filter circuits that are in use. The aim here is to suggest a few basic filters that may be constructed using the components available on the experimental board and then determine their frequency response (Bode diagram). The experimental board comprises of two operational amplifiers and some 17 passive components carefully arranged on it to be suitably connected with patchcords. A function generator and a dual trace oscilloscope would be required as an accessory for determination of the magnitude and the phase responses. The user manual supplied with the unit covers all technical details for conducting the experiments howeverit is recommended that the reader goes through a theoretical analysis of the circuits from available literature and note the significant performance characteristics of each filter that may then be verified.

Although any sine wave source may be used for the experiment, we recommend a DDS dual channel function generator Type JDS 6600 which greatly simplifies the measurements.

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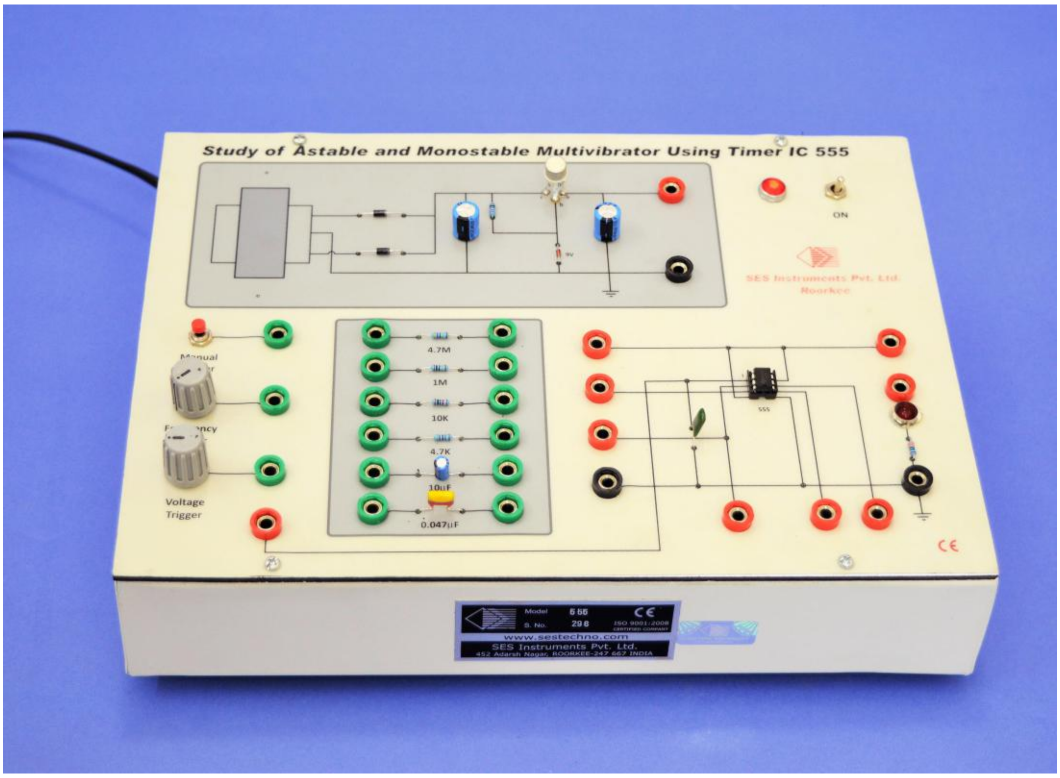
555

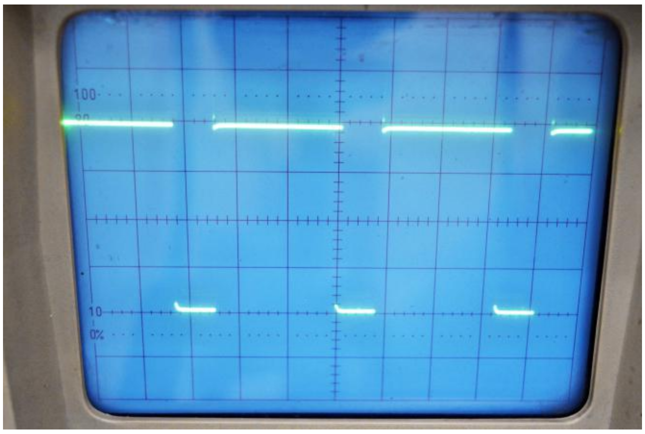
Study of Astable & Monostable Multivibrators

Study Of Astable & Monostable Multivibrators Using Timer Ic: 555



Features

- Operation as a free running/ astable multivibrator
- Operation as a monostable multivibrator
- Operation as a preset time delay



Introduction

555 timer is a highly stable integrated circuit capable of functioning as an accurate time-delay generator and as an astable multivibrator or free running multivibrator. When used as an oscillator the frequency and duty cycle are accurately controlled by only two external resistors and a capacitor. Some of its important features are timing from micro-seconds through hours, monostable and astable operation, trigger and reset inputs are logic compatible, and output compatible with CMOS, DTL and TTL (when used with 5V supply).

The set-up consists of 555 IC with facilities for convenient connection at the board, a power supply, built-in facilities for various type of triggers-variable frequency, variable voltage, and manual. The resistors and capacitors required are mounted on the board.

The set-up is complete in all respect, including patch chords

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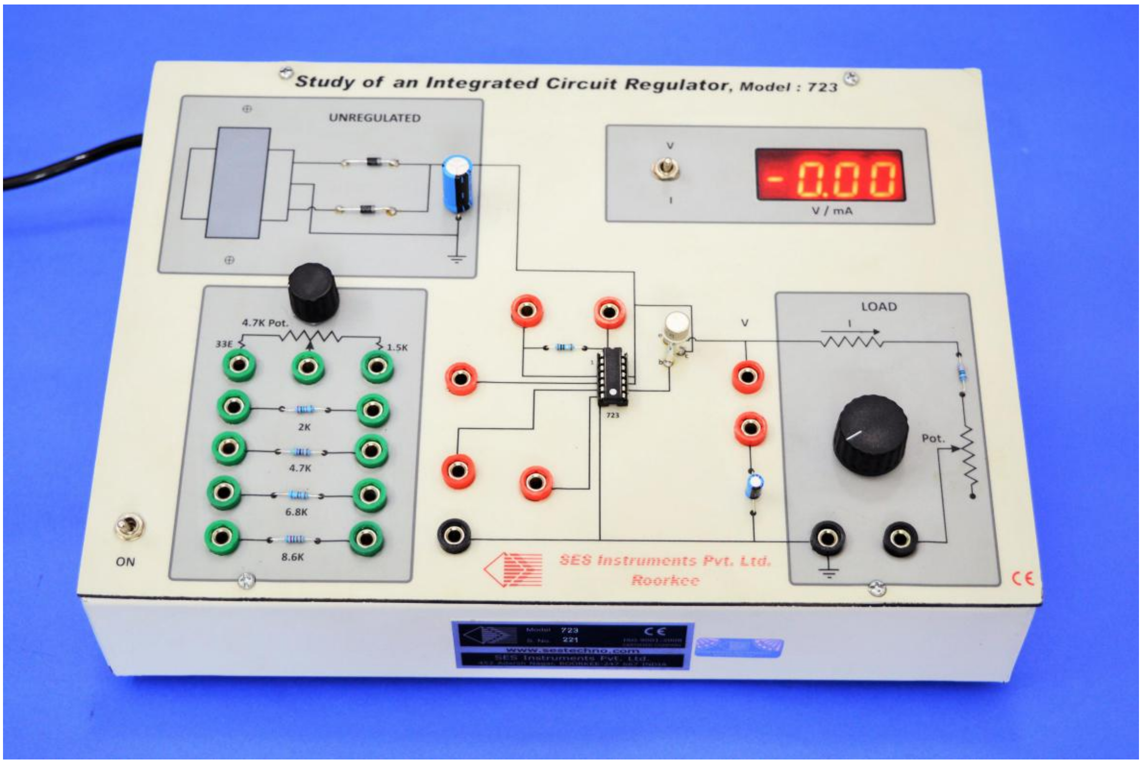
723

Study of An Integrated Circuit Regulator



Features

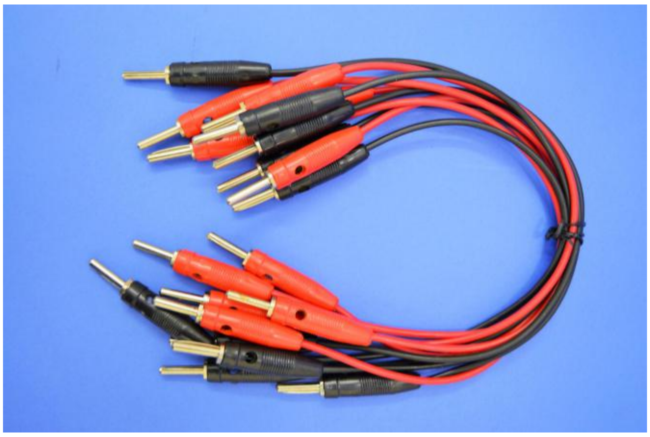
- Study of 723, working as a voltage regulator
- Study of 723, working as a current regulator

Introduction

The 723 is a monolithic precision voltage regulator constructed on a single silicon chip. The device consists of a temperature compensated reference, error amplifier, power series pass transistor and current limit circuitry. Some of its important features - adjustable output voltage from 2 to 37V, of either polarity, 0.01% line and 0.03% load regulation, output current upto 150mA without external pass transistor make it a general purpose IC for voltage or current regulation.

The experimental set-up consists of an IC 723 with facilities for convenient connections, an unregulated power supply, voltmeter, an ammeter and all the other components - resistances, potentiometers, variable load etc. required to perform the experiments.

The set-up is complete in all respect including patch cords.



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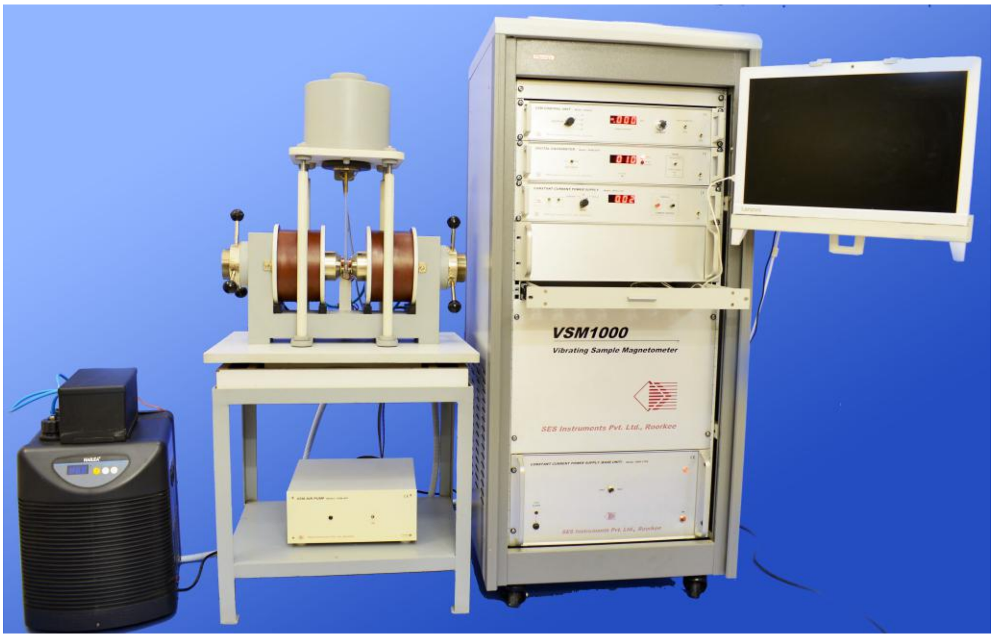
VSM-1000

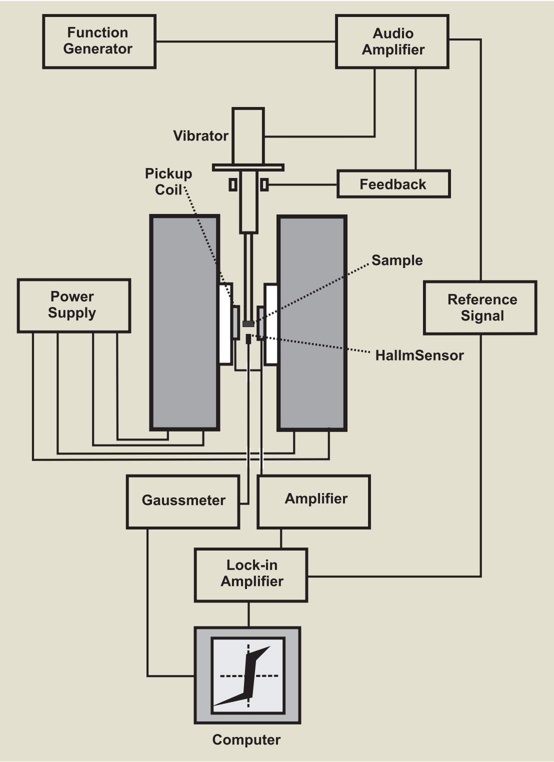
Vibrating Sample Magnetometer



VSM Measurement System/ Magnetic Measurement Instrumentation

- High sensitivity (Resolution better than 10^{-4}emu)
- Four Measuring Ranges (10^{2}, 10, 1, 10^{-1})
- Low noise and highly stable system
- High speed measurements with precision
- Menu driven easy to use software
- Easy change of sample
- Water cooled electromagnet for increased stability

The SES Vibrating Sample Magnetometer (VSM) measures the magnetization of a sample of magnetic material under an external magnetic field by converting the dipole field of the sample into an ac electrical signal. A vibrator along with its electronics vibrates the sample with a fixed frequency and stabilized amplitude. The sample is driven to vibrate. Due to changes in flux, voltage proportional to the sample's magnetic moment is induced in the pickup coils. By calibrating this voltage to magnetic moment using calibration standards and measuring the magnetic field, the magnetic moment of the sample can be obtained. The software controls the instrument and measures the magnetic moment. Hysteresis Loop can also be drawn through this software and its parameters calculated.



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ISO 9001:2015

VSM-1000

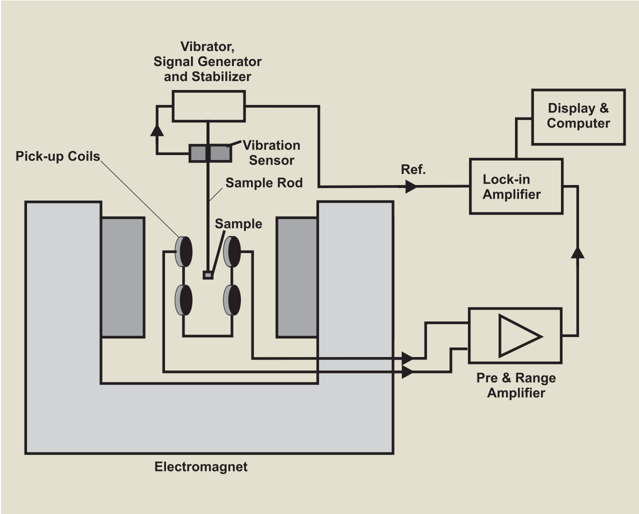
Vibrating Sample Magnetometer

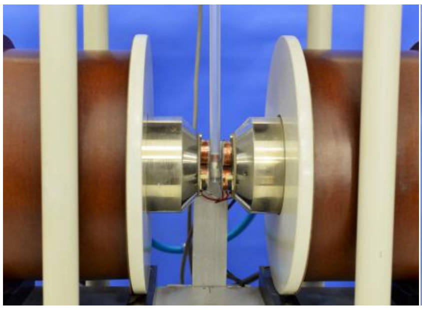
System Description

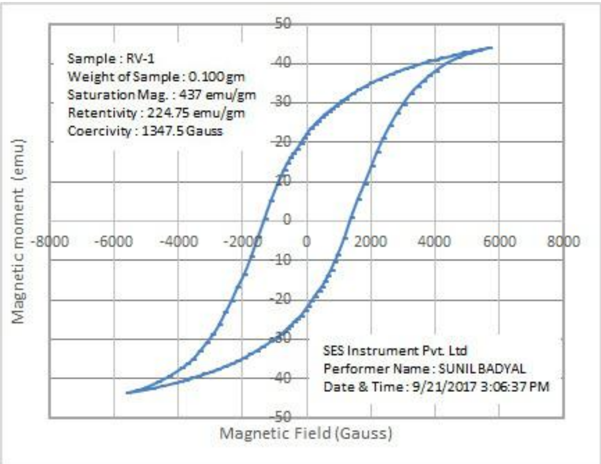
1. Magnetic Field System
   a. Electromagnet (Magnetic field is higher than 0.5T at gap of 25mm in iron cores)
   b. Power Supply
   c. Gauss Meter (Range: 20kGauss to 1Gauss)
   d. Embedded Magnetic Flux Detector
2. Control System
   a. Built-in computer systems (with Microsoft Windows)
   b. Built-in Software Interface for Collecting and Analyzing Data "

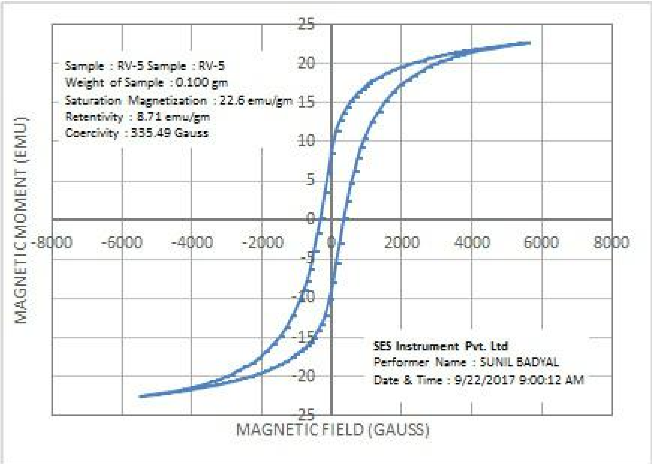
      (Hysteresis loops can be measured automatically to find the saturation, magnetization, coercivity and remanence of magnetic samples.)
   c. Built-in Data Acquisition System
3. Others
   a. Standard Computer with i-core 3 processor and original Windows10 loaded.
   b. Keyboard and Mouse
   c. Calibrations standard samples (99.9% Nickel and HgCo (SCN_4)
4. Test Results

   The different test samples









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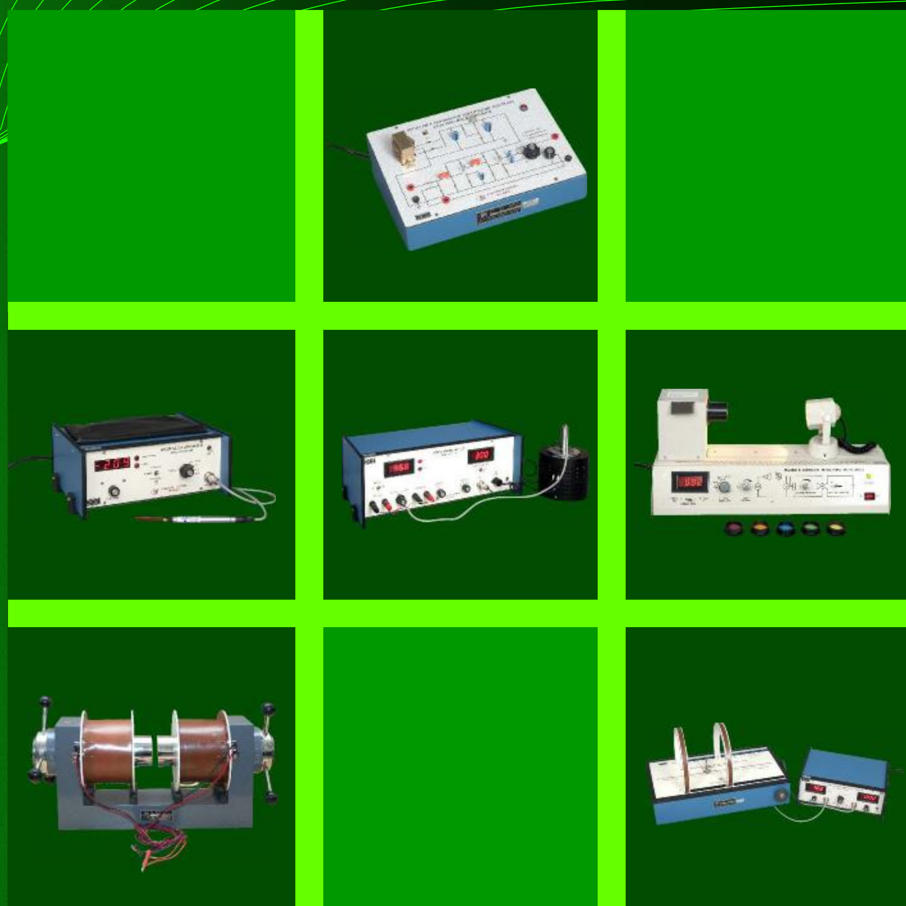

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