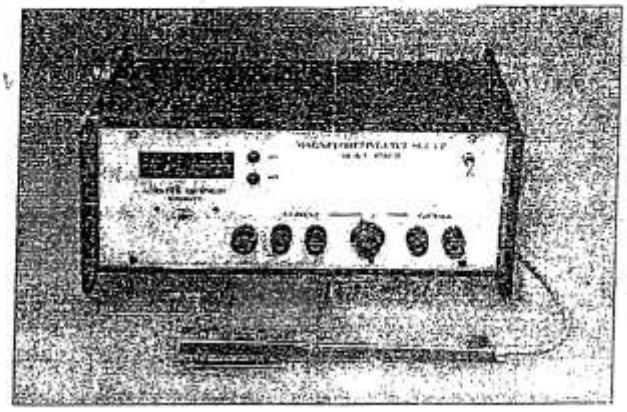
MEASUREMENT OF MAGNETORESISTANCE OF SEMICONDUCTORS

Measurement of Magnetoresistance of Semiconductors



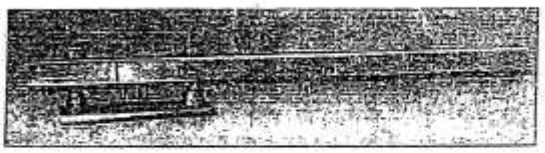
It is noticed that the resistance of the sample changes when the magnetic field is turned on. The phenomenon, called magnetoresistance, is due to the fact that the drift velocity of all carriers is not same. With the magnetic field on; the Hall voltage $V = E_y t = |\mathbf{v} \times \mathbf{H}|$ compensates 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 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-11
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 fo measuring the voltage developed across these probes. This eliminate 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-11

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.

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

TEST RESULT OF MAGNETORESISTANCE PROBE S.No. 84

Observation and Calculations

(I) Calibration of EMU-50 at a suitable air-gap = 20 mm

S No	Current (A)	Magnetic Field (KG)

(II) Magnetoresistance of a Ge-crystal (n-type)

Probe Current I = 4.00 mA (Constant for the whole set of readings)

$\frac{\Delta R}{R} = \frac{R_m - R}{R}$, where Sample Resistance (R) without magnetic Field = 43.3

SNo	Current (A)	Mag. Field H (KG)	Voltage V_m (mV)	$R_m = \frac{V_m}{I}$ (Ω)	$\frac{\Delta R}{R} \times 10^{-3}$	Log (H$\times 10^{-2}$) (KG)	$\text{Log}\left(\frac{\Delta R}{R} \times 10^{-3}\right)$

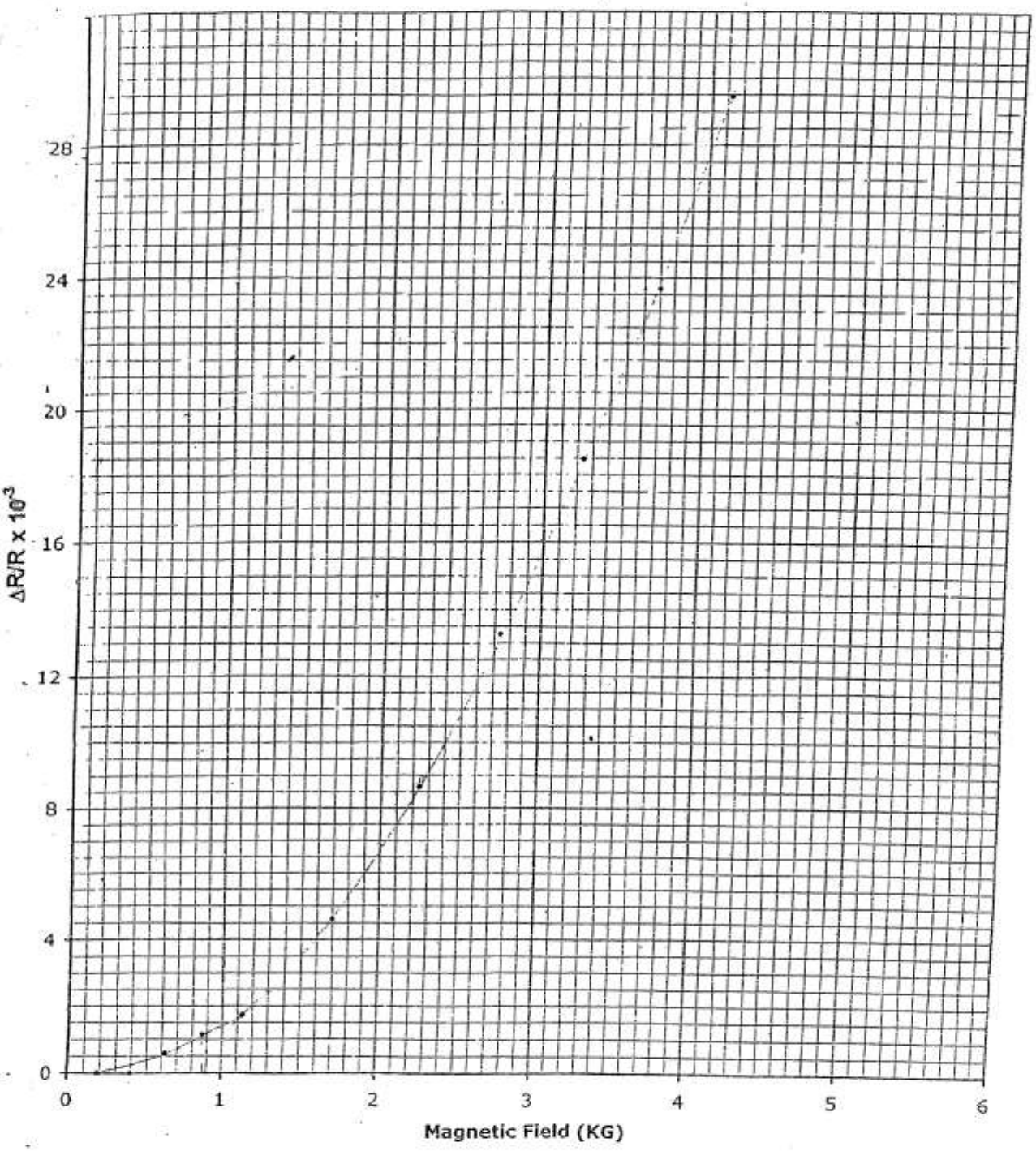
Nature of Graph: H Vs. $\frac{\Delta R}{R}$ as per sheet attached

Q.C. Engineer: U.S. Chauhan

Dated : 28/04/2006

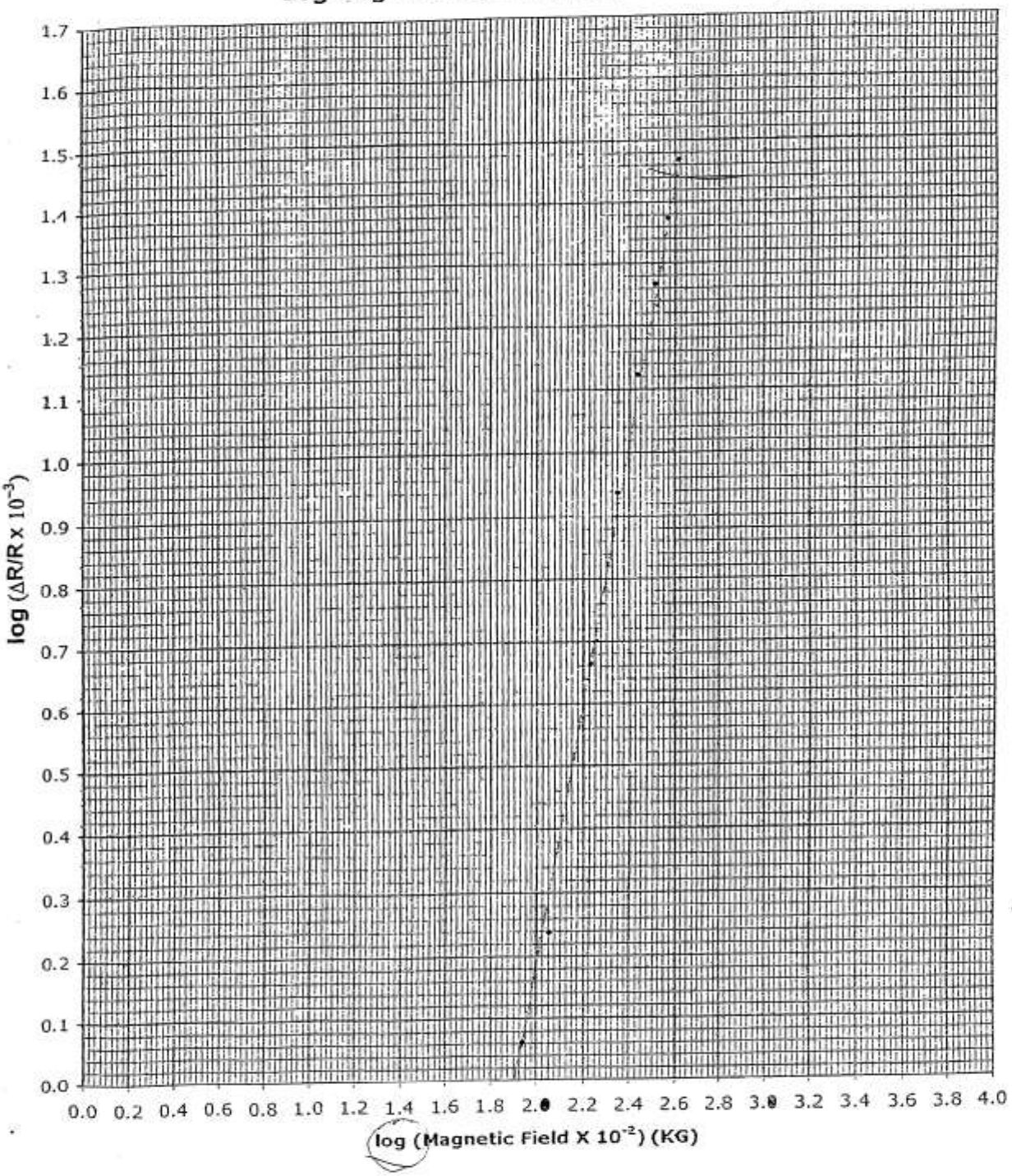
MAGNETORESISTANCE OF A Ge CRYSTAL #84

ΔR/R vs. Magnetic Field (H)



MAGNETORESISTANCE OF A Ge CRYSTAL #84

Log-Log Plot ΔR/R vs. Magnetic Field (H)



User's Manual

DIGITAL GAUSSMETER

Model : DGM-102

Manufactured by:

SCIENTIFIC EQUIPMENT & SERVICES

16, Civil Lines, Roorkee-247 667

Ph.: 01332-272852, Fax: 274831

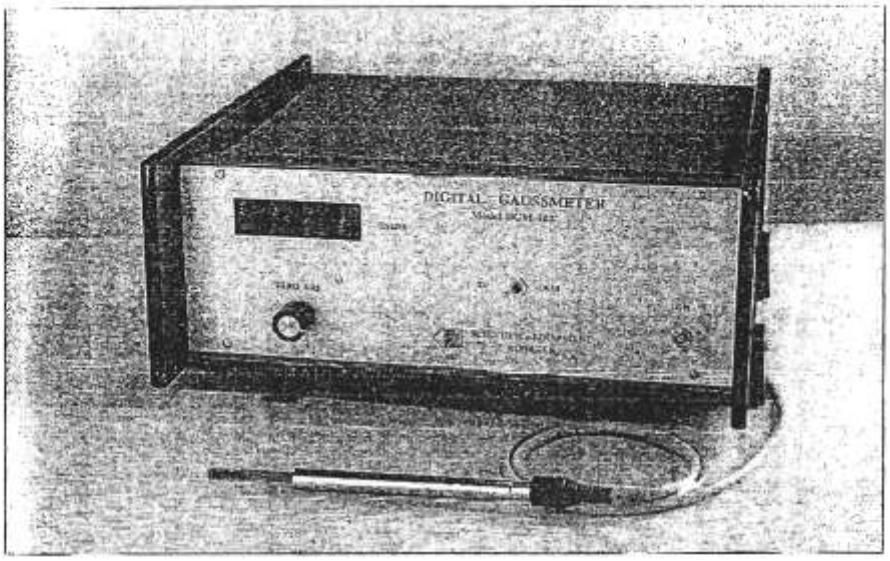
Email: ses@sestechno.com

Website: www.sestechno.com

IAS - ANZ

ISO 9001 : 2000
Certified Company

Digital Gaussmeter DGM-102



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

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 over flow indication
Power	220V ±10%, 50Hz
Transducer	Hall Probe – InAs (Axial Type)
Special Feature	Indicate the direction of the magnetic field
Weight	3Kg
Dimensions	280mm X 255mm X 120mm

SCIENTIFIC EQUIPMENT & SERVICES

16 Civil Lines, Roorkee - 247 667, india. Phone: 91-1332-272852 Fax: 91-1332-274831
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OPERATING INSTRUCTIONS

PROBE

Take out the probe alongwith the cable through the *cutting provided on the rear side.*

The probe is encapsulated in a non-magnetic sheath. It is connected to the instrument by means of a four-core cable of suitable length and is normally kept inside the instrument. A transport cap is provided for protection of probe. It is advisable that the probe should not be used at temperature higher than 50 °C. The probe is very delicate and hence it is advised that its cap is inserted whenever the probe is not in use and kept inside the instrument alongwith the cable. Any kind of strain on the probe element is to be avoided.

ZERO ADJUSTMENT

Switch on the instrument. The readings is adjusted to zero with 'ZERO' control with the *probe away from any magnetic field.* The zero adjustment should be checked on X1 range.

MEASUREMENT

The range switch is now set to the appropriate range. The probe cap is removed and the probe is kept in the magnetic field to be measured. The flat face of the probe is kept perpendicular to the direction of the magnetic field. The reading of the meter multiplied by the range value gives the flux density of the magnetic field in gauss. *If the field strength is not known* it is advisable to start with X10 range.

DIRECTION OF MAGNETIC FIELD

If the magnetic field indicated by the gaussmeter is positive (without sign), the pole facing the side of the Hall Probe marked 'N' is 'North Pole'.

SERVICING INSTRUCTIONS

Normally the resistance between the Red & Black wires (Current input terminals) of the probe is about 1035 ± 50 ohms and that between Yellow & Blue wires (Hall Voltage terminal) is 625 ± 50 ohms. If any of these resistances is very high or short probe is taken to be defective.

After replacing the new Hall Probe it may be calibrated by adjusting the Hall Probe current to the value given for the new probe with the help of a preset (1K) provided for it in the circuit. Alternately it may be recalibrated with a standard magnet or gaussmeter.

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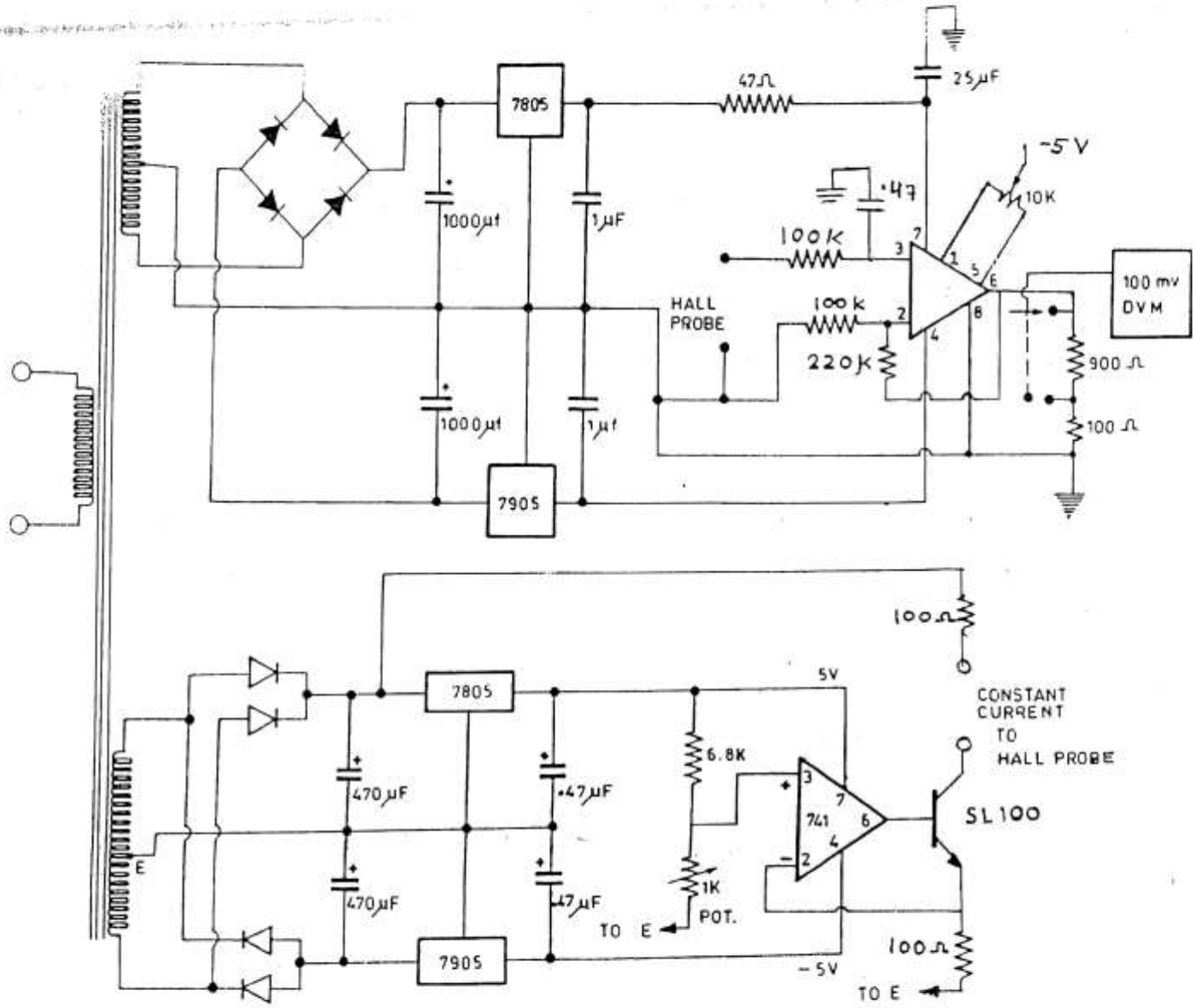

DIGITAL GAUSSMETER MODEL DGM-102

User's Manual

ELECTROMAGNET, Model EMU-50
&
CONSTANT CURRENT POWER SUPPLY, Model DPS-50

Manufactured by:

SCIENTIFIC EQUIPMENT & SERVICES
385/1 New Adarsh Nagar, Roorkee-247 667
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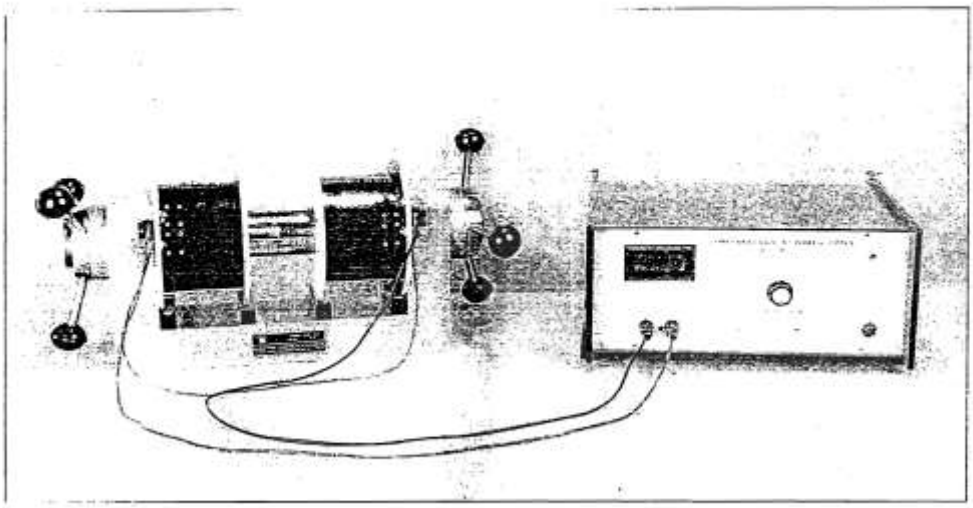
MOODY INTERNATIONAL

Electromagnet & Power Supply - EMU-50, DPS-50



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 tappered pole pieces.

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
7.5KG at 10mm air-gap with flat pole pieces

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

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 6Ω.

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 ±10% mains variation

Display
3½digit, 7 segment LED DPM

Power: 110V ±10%, 60Hz

Weight: 9Kg

Dimensions:
335mm X 305mm X 155mm

UNPACKING

1. Keep the case in upright position and remove all the nails from the top lid.
2. Remove the side panels also and unscrew the clamp holding the base of the magnet with the bottom of packing case.
3. Put the magnet on a table. The magnet is in a assembled state, including the coils connections. Fix the handles provided in a small box with the magnet.

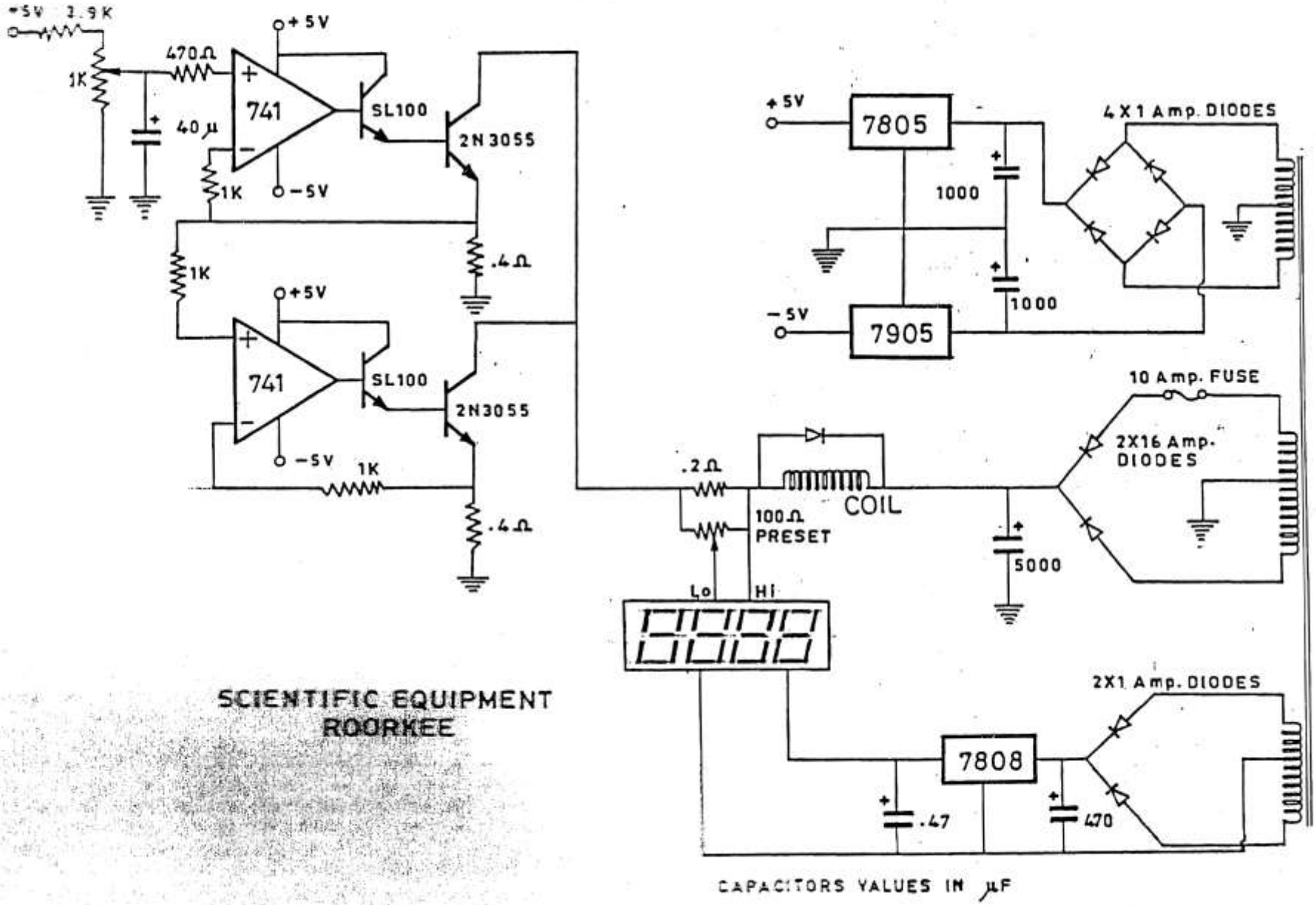
OPERATING INSTRUCTIONS

1. Connect the two coils in series i.e. the direction of current in both the coils should be same. Otherwise little or no magnetic field would result even at full current.
2. Connect the leads to the power supply and switch on the power supply. The electromagnet is now ready to use.

PRECAUTIONS

1. Power supply should be connected to a 3-pin main's socket having good earth connection.
2. Always increase or decrease the current gradually, switch 'ON' or 'OFF' the power supply at the zero current position.
3. Keep the pole pieces covered with small amount of grease to avoid rusting and the magnet as a whole may be covered with dust cover provided, when not in use.

CONSTANT CURRENT POWER SUPPLY
DPS-50



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