User's Manual

MAGNETORESISTANCE SET-UP

Model: DMR-01

Manufactured by:

SCIENTIFIC EQUIPMENT & SERVICES

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Measurement of Magnetoresistance of Semiconductors

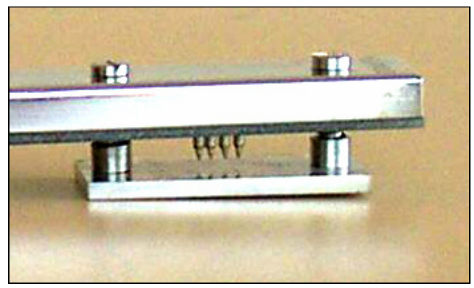
It is noticed that the resistance of the sample changes when the magnetic field is turned on. The phenomenon, called magnetoresistance, is due to the fact that the drift velocity of all carriers is not same. With the magnetic field on; the Hall voltage $V = E_y t = |\mathbf{v} \times \mathbf{H}|$ compensates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

Experimented 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 for 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.

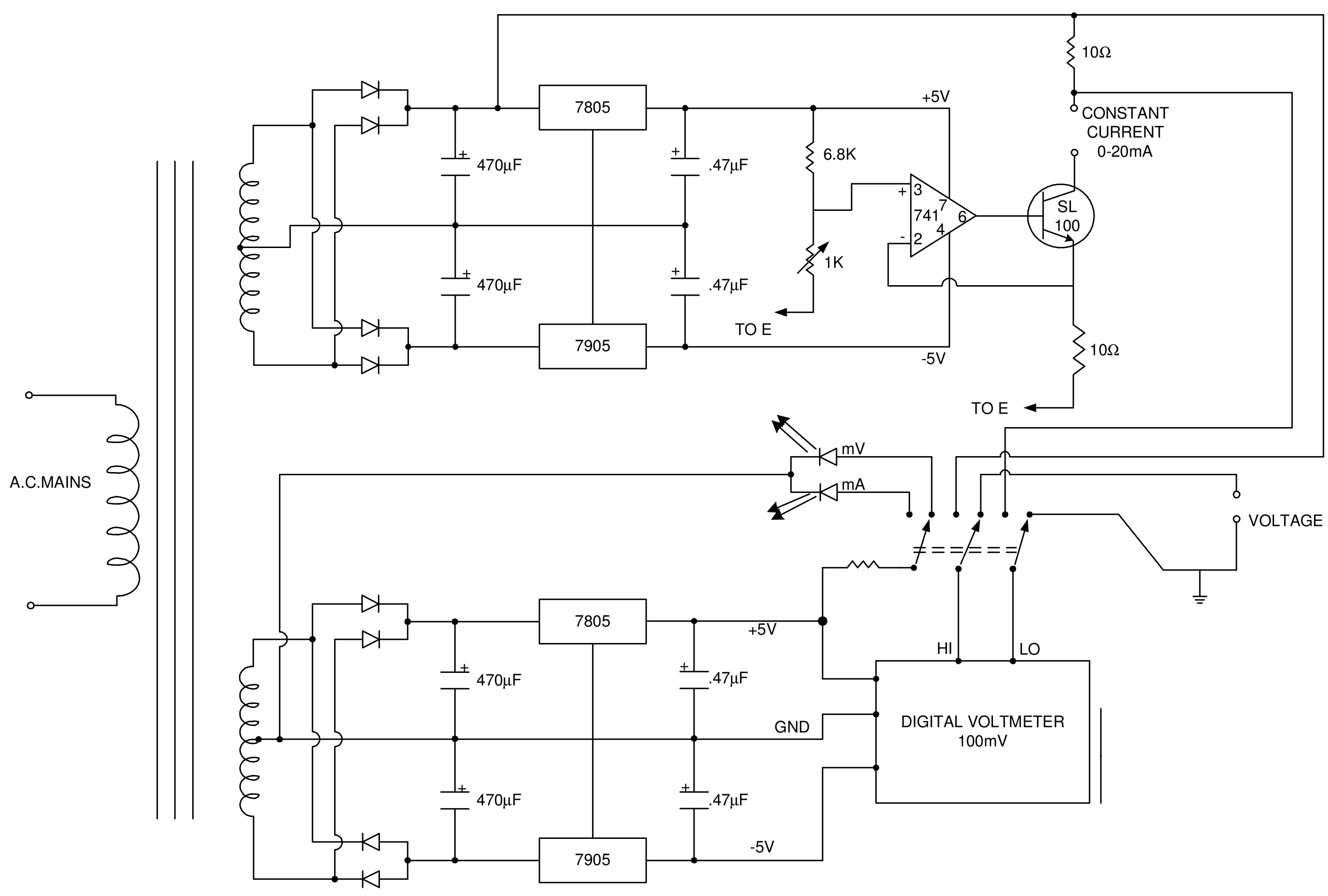
Specifications

Current : 0-20mA   Resolution : 10µA

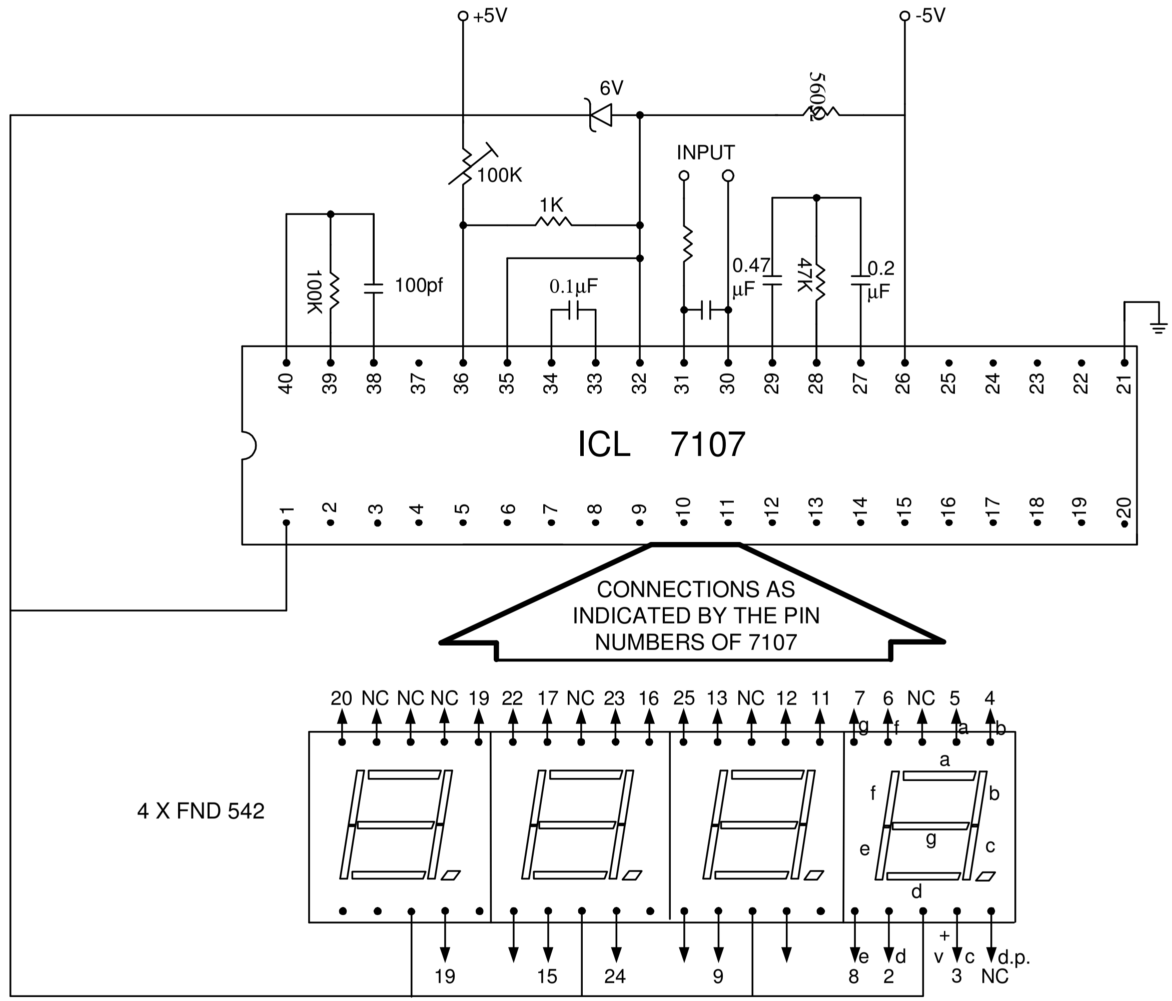
Accuracy : ±0.2% of the reading ±1 digit

Load regulated : 0.03% for 0 to full load

Line regulation : 0.05% for 10% variation



CIRCUIT DIAGRAM OF THE MAGNETORESISTANCE SET-UP, DMR-01



SCHEMATIC DIAGRAM OF DIGITAL PANEL METER

TEST RESULT OF MAGNETORESISTANCE PROBE S.No. 151

Observation and Calculations

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

S.No.	Current (A)	Magnetic Field (KG)
1	Min	0.087
2	0.25	0.310
3	0.50	0.537
4	0.75	0.793
5	1.00	1.035
6	1.25	1.290
7	1.50	1.544
8	2.00	2.050
9	2.50	2.550
10	3.00	3.050
11	3.50	3.530
12	4.00	4.000

(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 = 43.92

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)	$\text{Log}\left(\frac{\Delta R}{R} \times 10^{-3}\right)$
1	Min	0.087	175.7	43.925	0.00	0.94	∞
2	0.25	0.310	175.7	43.925	0.00	1.49	∞
3	0.50	0.537	175.8	43.950	0.57	1.73	-0.24
4	0.75	0.793	175.9	43.975	1.14	1.90	0.06
5	1.00	1.035	176.1	44.025	2.28	2.01	0.36
6	1.25	1.290	176.3	44.075	3.41	2.11	0.53
7	1.50	1.544	176.6	44.150	5.12	2.19	0.71
8	2.00	2.050	177.2	44.300	8.54	2.31	0.93
9	2.50	2.550	178.0	44.500	13.09	2.41	1.12
10	3.00	3.050	178.9	44.725	18.21	2.48	1.26
11	3.50	3.530	179.9	44.975	23.90	2.55	1.38
12	4.00	4.000	180.9	45.225	29.60	2.60	1.47

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

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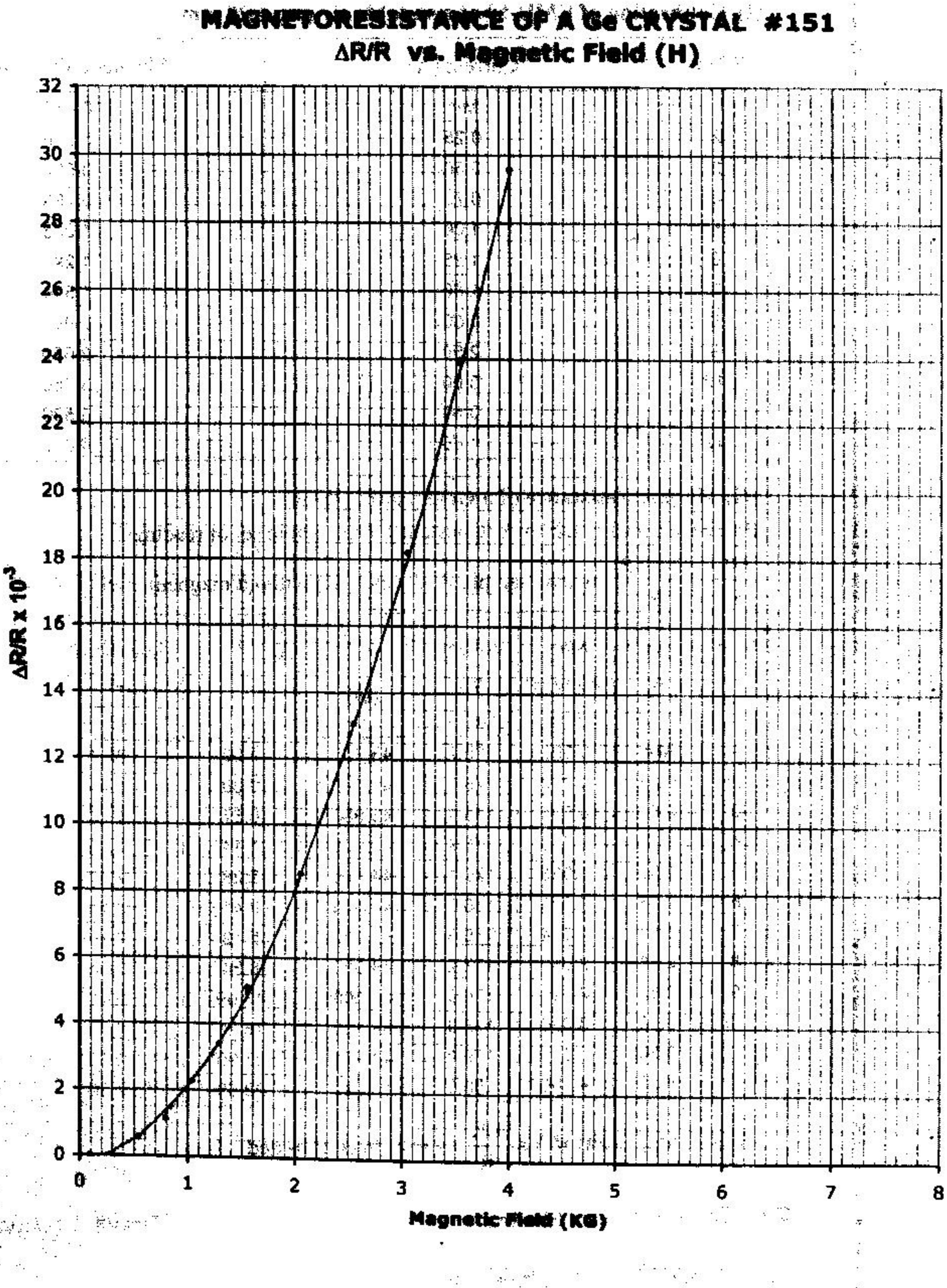
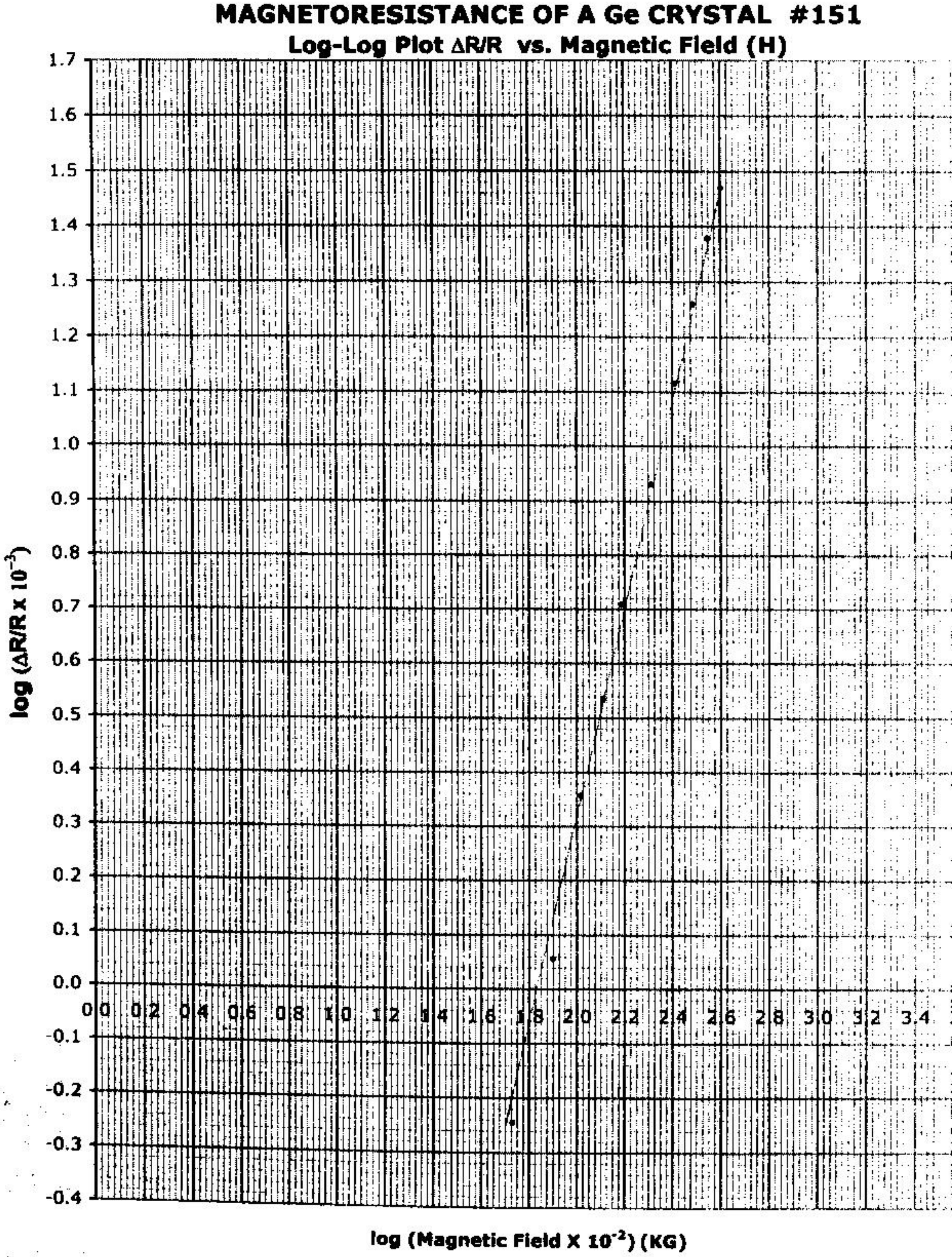

MAGNETORESISTANCE OF A Ge CRYSTAL #151
ΔR/R vs. Magnetic Field (H)
ΔR/R x 10^-3
Magnetic Field (KG)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
1
3
5
7


MAGNETORESISTANCE OF A Ge CRYSTAL #151
Log-Log Plot ΔR/R vs. Magnetic Field (H)
log (ΔR/R x 10^{-3})
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4
log (Magnetic Field X 10^{-2}) (KG)