1. Experimental Contents

1) Acquire the relationship of Hall current vs Hall voltage under a DC magnetic field.
2) Measure the sensitivity of a GaAs Hall element.
3) Measure the magnetization curve of silicon steel material using a GaAs Hall element.
4) Measure a magnetic field distribution along horizontal direction using a Hall element.

2. Experimental Procedure

A. Measure the relationship between Hall Current I_H and Hall Voltage U_H

1) Place the Hall element at the center of the electromagnet.
2) Refer to Figures 7&8 to connect the circuit. Terminals 1&3 of the Hall element should be connected to the voltage stabilized supply while terminals 2&4 are used to measure Hall voltage.
3) Set the magnetizing current of the electromagnet I_M at 400 mA.
4) Adjust Hall current (i.e. the current applied to the Hall element) via knob "Hall Current Adj." to set Hall current at 0.5 mA, 1.0 mA, 1.5 mA, 2.0 mA, and 2.5 mA, respectively.
5) At each Hall current, measure the corresponding Hall voltage. To eliminate side effects, reverse the two toggle switches in sequence to obtain 4 U_H readings as described in sec. 2 C, and then take an average to get the final U_H value.
6) Plot U_H-I_H graph, and verify the linear relationship between I_H and U_H.

B. Measure the sensitivity K_H of GaAs Hall element

a) Learn how to use a Teslameter to measure magnetic field strength. **Warning**: the probe of the Teslameter is so fragile that it should be handled with great care.
b) Set and keep the Hall current I_H at 1.00 mA (input from terminals 1&3).
c) Adjust magnetizing current I_M via knob "Current Adj." at 50 mA, 100 mA, 150 mA, 200 mA, ..., 500 mA, respectively.
d) At each I_M, measure the corresponding magnetic field strength B using the Teslameter and Hall voltage U_H of the sample. **Note**, to eliminate side effects when measuring Hall voltage U_H, the two toggle switches should be reversed in sequence and the data should be averaged.
e) Calculate the sensitivity of the Hall element using Eq. (5). (It is a negative value for an n-type Hall element).

C. Measure the magnetization curve of a silicon steel material using Hall element

After acquiring sensitivity K_H of the GaAs Hall element, use this Hall element to measure magnetic field strength B in the gap of the electromagnet as follows:

a) Set Hall current I_H at 1 mA while changing excitation current I_M from 0 to 500 mA with step size of 100 mA.
b) At each I_M, measure the corresponding Hall voltage U_H. Note: remember to eliminate side effects by using the two toggle switches.
c) Calculate magnetic field strength B for each I_M using Eq. (5) based on the measured U_H and the known K_H.
d) Plot B-I_M curve.

D. Measure the magnetic field distribution of electromagnet along horizontal direction

a) Set the magnetizing current at 400 mA and the Hall current at 1 mA.
b) Adjust the support of the Hall element to allow Hall element to move from the left end to the right end of the electromagnet.
c) Read the horizontal position of the Hall element from the ruler on the support. At each position, measure the corresponding Hall voltage U_H, and calculate the magnetic field strength B at this location using Eq. (5). Note: no need to eliminate side effects here.
d) Plot the magnetic field distribution curve B-X along horizontal direction.

3. Examples of Data Recording and Processing

Note: Following data are for reference purposes only, not the criteria for apparatus performance:

Table 1 U_H—I_H relationship under: I_M=400 mA, R=300.0 Ω, B=0.2987 T

I_H (mA)	U_{H1} (mV)	U_{H2} (mV)	U_{H3} (mV)	U_{H4} (mV)	U_H (mV)
0.5000	-43.7	43.7	-43.0	43.0	-43.4
1.0000	-87.7	87.7	-86.1	86.0	-86.9
1.5000	-131.6	131.9	-129.4	129.3	-130.6
2.0000	-175.2	175.8	-172.4	172.4	-174.0
2.5000	-218.9	219.7	-215.5	215.6	-217.4
3.0000	-262.5	263.6	-258.6	258.8	-260.9

The plot of U_H—I_H for the data in Table 1 is shown in Figure 9. By means of curve-fitting, the correlation coefficient is r=0.999999 suggesting a good linear relationship between U_H and I_H.

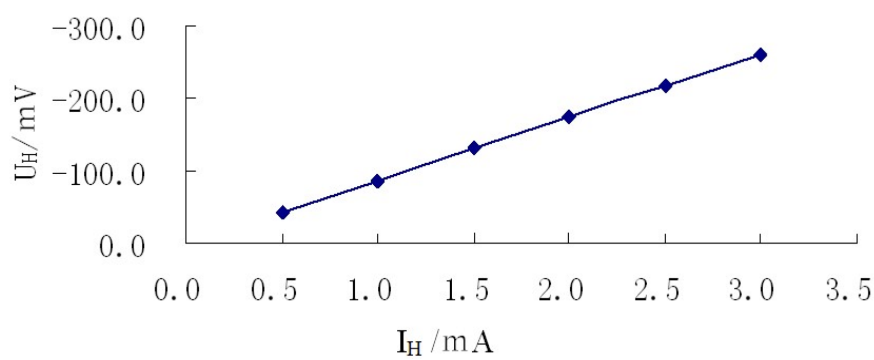

Figure 9 Relationship curve of U_H—I_H

Table 2 U_H—B relationship and B—I_M relationship under condition: I_H=1.000 mA.

I_M (mA)	U_{H1} (mV)	B_1 (mT)	U_{H2} (mV)	B_2 (mT)	U_{H3} (mV)	B_3 (mT)	U_{H4} (mV)	B_4 (mT)	U_H (mV)	B (mT)
50	-10.6	34.0	10.7	34.0	-9.3	-36.3	9.3	-36.3	-9.975	35.18
100	-20.8	69.6	21.0	69.7	-19.6	-72.0	19.5	-72.0	-20.225	70.83

150	-31.2	106.2	31.5	106.3	-30.1	-108.8	29.9	-108.8	-30.675	107.48
200	-42.2	144.8	42.6	144.7	-41.2	-147.4	40.9	-147.4	-41.725	146.8
250	-53.8	184.8	54.2	184.8	-52.7	-187.2	52.6	-187.2	-53.325	186.05
300	-64.8	222.0	65.1	222.0	-63.6	-224.5	63.4	-224.5	-64.225	223.25
350	-76.6	262.0	76.9	262.1	-75.3	264.0	75.1	-264.0	-75.975	263.05
400	-87.7	2988.0	87.8	298.8	-86.5	-301.2	86.2	-301.2	-87.025	300.05

* I_H＝1.000 mA was calculated by using voltmeter reading 300.0 mV and resistor R＝300.0 Ω, and the sample was placed in the uniform region of the magnetic field.

In Table 2, magnetic field strength *B* is averaged by using $B = (|B_1| + |B_2| + |B_3| + |B_4|)/4$.

By linear curve fitting to the data of U_H and *B* shown in Table 2, the correlation coefficient is r=-0.99996 and the slope is -0.2903 mV/mT. Using Eq. (5), we got K_H= -290.3 mV/mA• T.

The plot of I_M–B is shown in Figure 10 showing there is a good linear relationship between I_M and *B* for the silicon steel material under a certain magnetizing current.

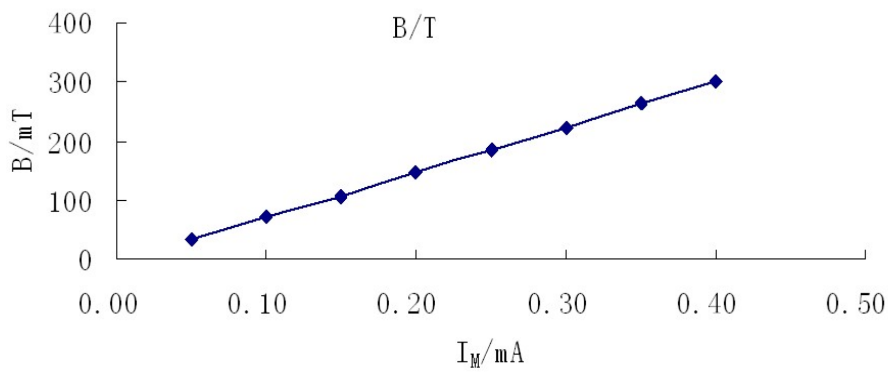

Figure 10 Relationship curve of I_M and *B*

Table 3 Magnetic field distribution along horizontal direction

X (mm)	-20.0	-18.0	-16.0	-14.0	-12.0	-10.0
B (T)	0.0659	0.1211	0.2683	0.2993	0.2993	0.2993
X (mm)	-8.0	-6.0	-4.0	-2.0	0.0	2.0
B (T)	0.2989	0.2984	0.2980	0.2976	0.2972	0.2964
X (mm)	4.0	6.0	8.0	10.0	12.0	14.0
B (T)	0.2960	0.2960	0.2960	0.2964	0.2964	0.2964

The data in Table 3 shows a uniform magnetic field range from X=-2.0 mm to X=14.0 mm.