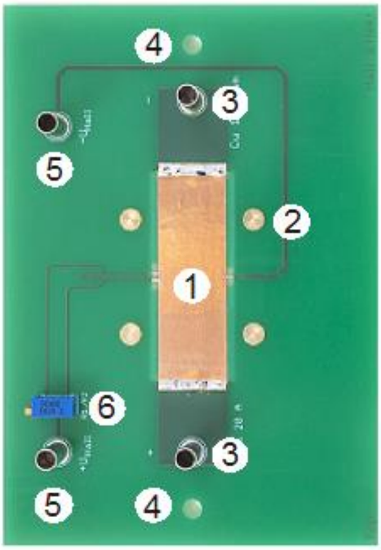
3B SCIENTIFIC® PHYSICS

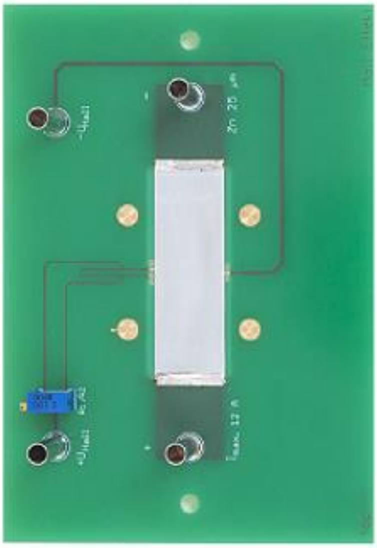
...going one step further

Copper Sample for Hall Effect 1018751
Zinc Sample for Hall Effect 1018752

Instruction manual

08/16 MH/JS





1 Sample
2 Spacers
3 Current terminals
4 Holes for holder
5 Terminals for Hall voltage
6 Offset calibration knob

1. Safety instructions

In these experiments investigating the Hall effect in metals, high currents of up to 20 A can flow across the copper sample and up to 12 A can flow across the zinc sample. Safe operation of the boards containing the samples can be guaranteed as long as they are used as stipulated in these instructions. Safety cannot, however, be guaranteed if the sample boards are used inappropriately or carelessly.

- If it can be surmised that it is no longer possible to operate the equipment safely (e.g. if there is visible damage), the sample boards must immediately be taken out of use.
- Use the sample boards in dry rooms only.
- Only allow the maximum permitted sample currents to flow briefly and never exceed them.

2. Description

The copper and zinc samples are for demonstrating the Hall effect and measuring the Hall voltage U_H across metal samples across which a current I is flowing while they are within a perpendicularly aligned magnetic field of flux density B.

The sample strips have a thickness of 17.5 µm (copper) and 25 µm (zinc). They are both soldered to a circuit board along with one pair of 4-mm sockets by which the Hall voltage can be tapped, another pair by means of which a current can be applied across the samples and an offset calibration knob.

Two holes in the boards allow them to be set up inside the combined holder for Hall effect (1019388). Four spacers maintain suitable spacing from the pole pieces of the electromagnet, which allows a magnetic field sensor to be set up in the vicinity of the samples.

3. Technical data

Copper sample:

Thickness:	17.5 µm ±25%
Max. current across sample:	20 A DC
Purity:	99.9%

Thickness **sample:**

Thickness:	25 µm ±25%
Max. current across sample:	12 A DC
Purity:	99.95%

Common specifications:

Surface area of samples:	16 x 50 mm
Dimensions including sockets: approx.	130x90x25 mm
Weight:	45 g approx.

4. Equipment for experiments

Sample circuit and voltage measurement:

1 Combined holder for Hall effect	1019388
1 Measurement Amplifier U @230V or	1020742
1 Measurement Amplifier U @115V	1020744
1 Digital Multimeter P1035	1002781
1 Set 15 Safety Experiment Leads	1002843
1 DC-Power Supply 0 – 16 V, 0 – 20 A	1002771
1 Pair of Experiment Leads	1002850

Electromagnet circuit:

1 U Core D	1000979
2 Coils D with 600 Turns	1000988
1 Pair of Pole Shoes and Clamping Brackets D	1009935
1 DC-Power Supply 20 V, 5 A, @230 V or	1003312
1 DC-Power Supply 20 V, 5 A, @115 V	1003311
1 Two-Pole Switch	1018439

Magnetic field measurement:

1 Flexible Magnetic Field Sensor	1012892
1 Teslameter E	1008537

5. Set-up

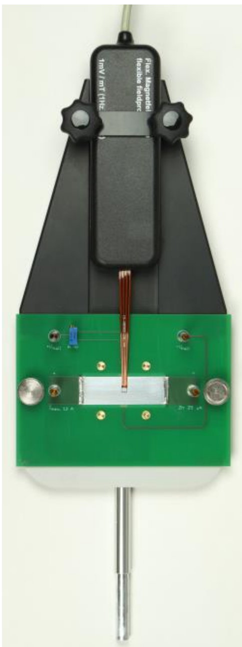


Fig. 1:
Combined holder with sample board and magnetic field sensor

Fig. 2: Full set-up for experiment

Setting up samples in their holder:

- Set up the boards in the combined holder for Hall effect (1019388) (see Fig. 1).
- Making sure you do not damage the sample foil, carefully attach the magnetic field sensor to the combined holder in such a way that the active region of the sensor is centred above the sample (see Fig. 1).
- Clamp the combined holder into the hole in the U-shaped core D.

Electromagnet:

Note:

Any induced voltages which arise may disrupt the sensitive measurement of the Hall voltage.

- *Always operate the electromagnet with a smoothed DC voltage*

- Slot coil D onto the U-shaped core. Put the pole pieces on top and clamp them in place just touching the spacers on the sample board.
- Connect coil D to the DC power supply (0 – 20 V, 0 – 5 A) in series. The second coil should be connected in such a way that it increases the flux density of the magnetic field rather than acting so as to cancel it out.

Measurement of Hall voltage:

- Use the measurement amplifier U with a gain of 10^5 and a time constant of 1 s.
- With the input terminals are shorted together, use the offset knob on the measurement amplifier to calibrate the zero point.
- Connect the measurement amplifier U to the terminal for tapping the Hall voltage, making sure that the polarity is correct.

Sample circuit and measurement of voltage:

Note:

Interference from the power supply for the current source or insufficient smoothing of the current can disrupt the sensitive measurement of the Hall voltage.

- *As the source of the current across the sample, use the second DC power supply (0 – 16 V, 0 – 20).*

- Make sure you get the polarity the right way round when connecting the current source to the sample boards.

Swapping sample boards:

- Turn off all power supplies and measuring instruments.
- Release the clamp for the pole pieces and pull the pole pieces slightly apart.
- Pull the combined holder up from the bottom section with the magnetic sensor attached and facing upwards.
- Swap over the sample boards.
- Carefully replace the top section, being careful not to damage the sample foil.
- Push the pole pieces together and clamp them in place.

6. Procedure

Magnetic field:

Notes:

The coils D used for the electromagnet are designed to withstand a maximum long-term current load of 2 A.

- *DO not exceed the maximum 2 A for any lengthy period.*

Swapping the polarity of the terminals at maximum current could overload the DC power supply.

- *DO not change the polarity of the current except when the current is very low.*

- Take the magnetic field sensor out of the set-up and put it somewhere where it will be safe from interfering magnetic fields (B > 1 mT).
- Set the offset of the teslameter in the 2000 mT range to zero.
- Check that the hysteresis curve of the electromagnet is symmetrical about zero.

Measurement of Hall effect:

Notes:

A sample can be considered in electrical terms as a resistance bridge presenting a resistance in horizontal and vertical directions. Asymmetries in the regularity of the solder joints will cause some error in the measurement of Hall voltages. All thermal distortions which are non-symmetrical about the centre line will distort the resistance bridge and will be superimposed on the Hall voltage being measured. Some of these distortions may be dependent on the current across the sample itself.

- *To calibrate the zero point for the measurement of the Hall voltage, run through the hysteresis curve in such a way that the magnetic field works out to be zero.*
- *Any time that the current across the sample changes, use the offset knob on the sample board to recalibrate the zero point. Use the supplied calibrating pin for this.*
- *Keep checking the zero calibration, especially when high currents are being used*.

- Set up the currents across the sample to match those of the desired magnitude and sign. Never exceed the maximum current value for the samples.
- Carefully adjust the magnetic field to its zero point by passing a suitable current through the electromagnet and calibrate the Hall

voltage displayed to zero using the offset knob on the sample board.

- Set up the desired magnetic field and read of the Hall voltage.

- Depending on the experiment being done, set up different magnetic field values for the same current across the sample and measure the corresponding Hall voltage.
- Keep checking the zero calibration for the Hall voltage.

- Depending on the experiment being done, set up different current values across the sample and set the magnetic field to zero.
- Recalibrate the zero point of the Hall voltage using the offset knob on the sample board.

7. Determination of Hall constant

The following equation applies: $U_H = A_H \cdot \frac{B}{d} \cdot I$

U_H: Hall voltage, A_H: Hall constant, B: Magnetic flux density through sample d: Thickness of sample, I: Current through sample

This means that the Hall constant can be determined from the gradients of the straight lines in the following graphs.

The following results are obtained:

$$A_H(\text{Cu}) = -47 \cdot 10^{-12} \, \frac{\text{m}^3}{\text{C}} .$$

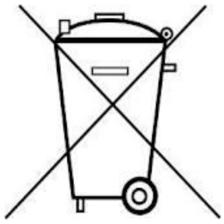
and

$$A_H(\text{Zn}) = +47 \cdot 10^{-12} \, \frac{\text{m}^3}{\text{C}} .$$

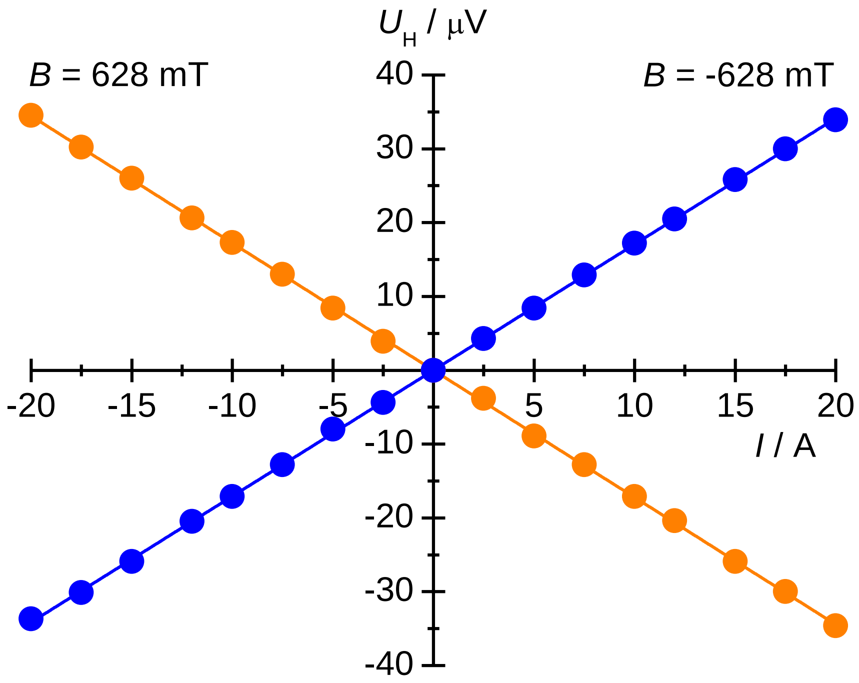
However, the manufacturer of the sample foils specifies that their thickness has a tolerance of ±25%. This means that the results for the Hall constants also have this degree of uncertainty.

8. Storage, cleaning and disposal

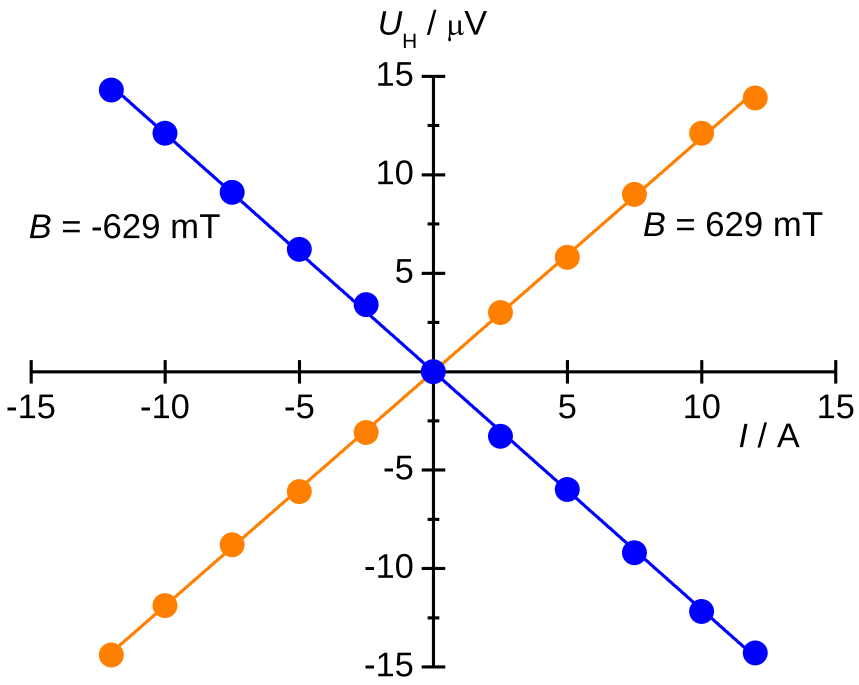
- Keep the equipment in a clean, dry and dust-free place.
- Do not use any aggressive cleaning agents or solvents to clean the equipment.
- The packaging should be disposed of at local recycling points.
- Should you need to dispose of the equipment itself, never throw it away in normal domestic waste. If being used in private households it can be disposed of at the local public waste disposal authority.



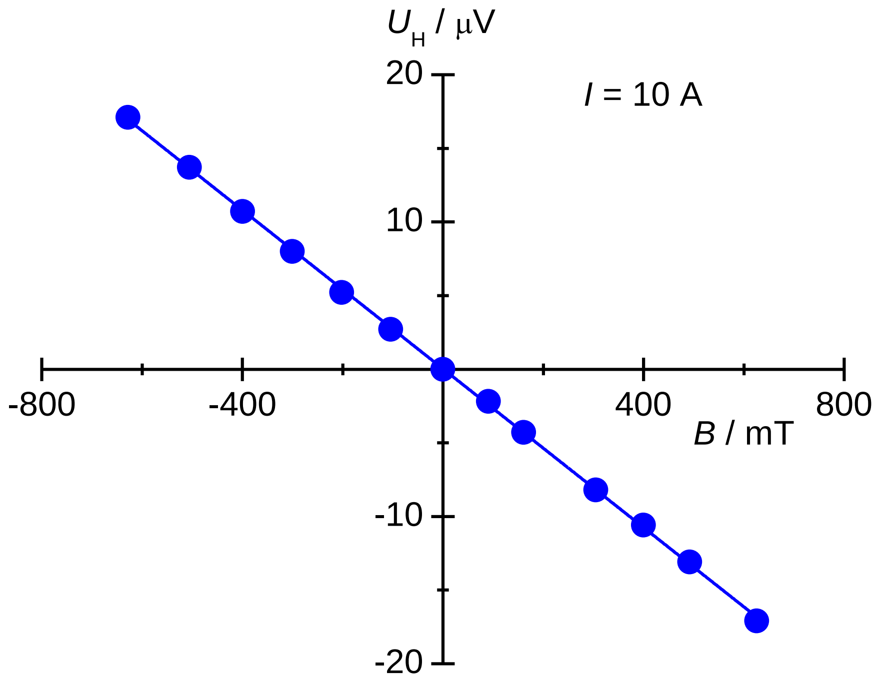
- Comply with the applicable regulations for the disposal of electrical equipment.



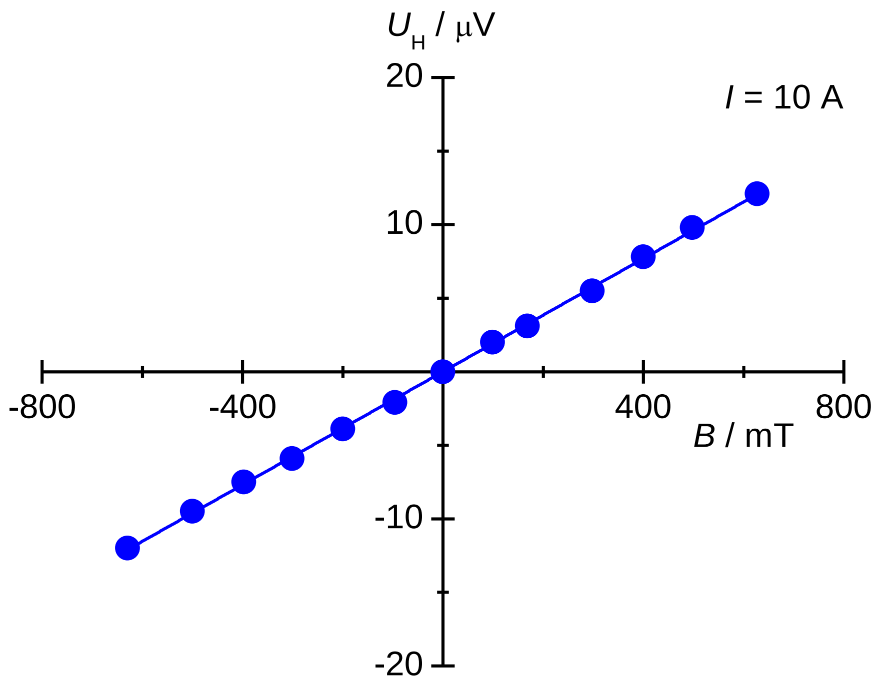
Hall effect in copper, U_H (I), B = -638 mT (blue), B = 638 mT (orange)



Hall effect in zinc, U_H (I), B = -638 mT (blue), B = 638 mT (orange)



Hall effect in copper, U_H (B), I = 10 A



Hall effect in zinc, U_H (B), I = 10 A