Magnetic Field sensor

(Product No. 3170)

Range 1: **±10 mT** radial
Range 2: **±10 mT** axial
Resolution: 0.01 mT

Magnetic Field sensor

(Product No. 3172)

Range 1: **±100 mT** radial
Range 2: **±100 mT** axial
Resolution: 0.1 mT

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DS 032 No 5

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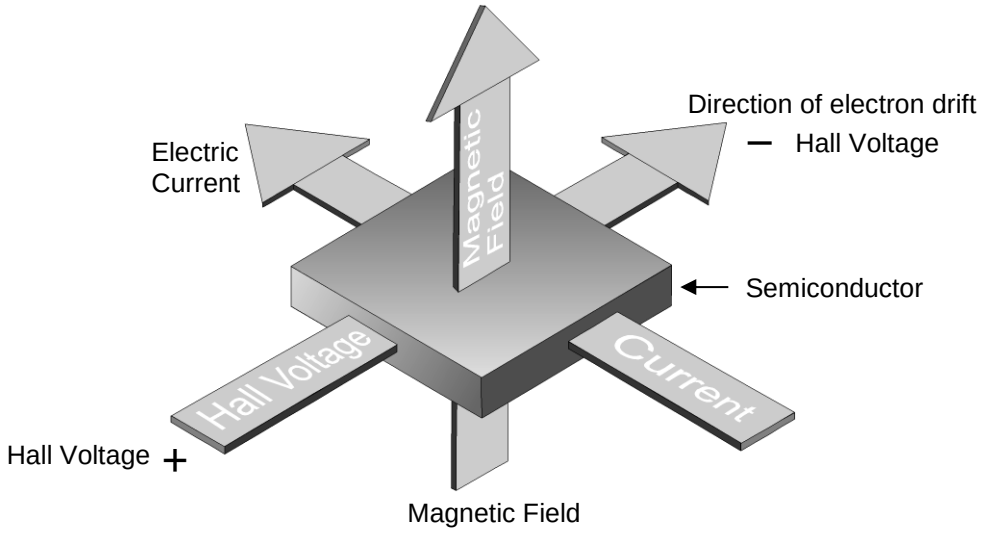
Introduction

The *Smart Q* Magnetic Field sensor is a Hall Effect device. The sensing area consists of a small piece of semiconductor material. A current is supplied (by the **EASY**SENSE unit) to the semiconductor. When a magnetic field passes through the semiconductor a potential difference is generated at right angles to the magnetic field. The magnitude of this potential difference (called the Hall Voltage) is used to calculate the strength of the field.



There are two Hall Effect devices in the Sensor, placed at right angles to each other. This enables fields along the axis of the Magnetic Field sensor (the axial field) or at right angles to it (the radial field) to be measured.

Connecting

- Push one end of the sensor cable (supplied with the **EASY**SENSE unit) into the hooded socket on the Sensor with the locating arrow on the cable facing upwards.
- Connect the other end of the sensor cable to an input socket on the **EASY**SENSE unit.

- The **EASY**SENSE unit will detect that the Magnetic Field sensor is connected and display values using the currently selected range. If the range is not suitable for your investigation, set to the correct range.

To set the range

The Magnetic Field sensor can record using two ranges.

With some **EASY**SENSE units it is possible to set the range from the unit. Please refer to the **EASY**SENSE unit's user manual.

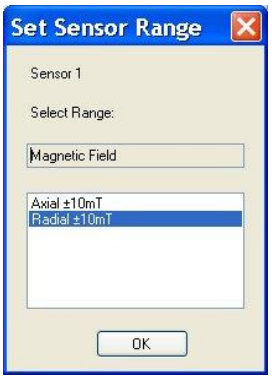
To alter the range in the EasySense software:

1. Select **EasyLog** from the Home screen.
2. Select the **New** recording wizard icon. 

3. Click on the sensor's name.
4. A set sensor range window will open. Select the required range, then OK.
5. Select Finish to exit the wizard.

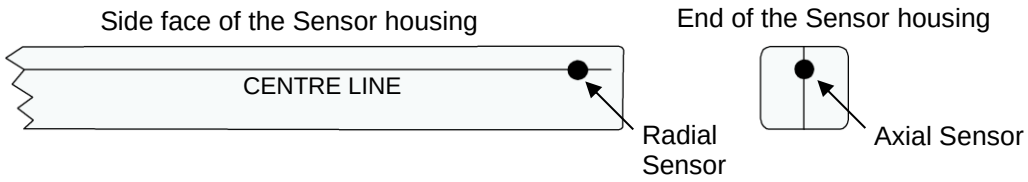
Or

1. From the Home screen select **Sensor Config** from the Settings menu.
2. Select the Magnetic Field sensor from the list (it will be listed using its current range) and click on the **Change Range** button.
3. The current range will be highlighted. Select the required range and click on OK.
4. Close Sensor Config.



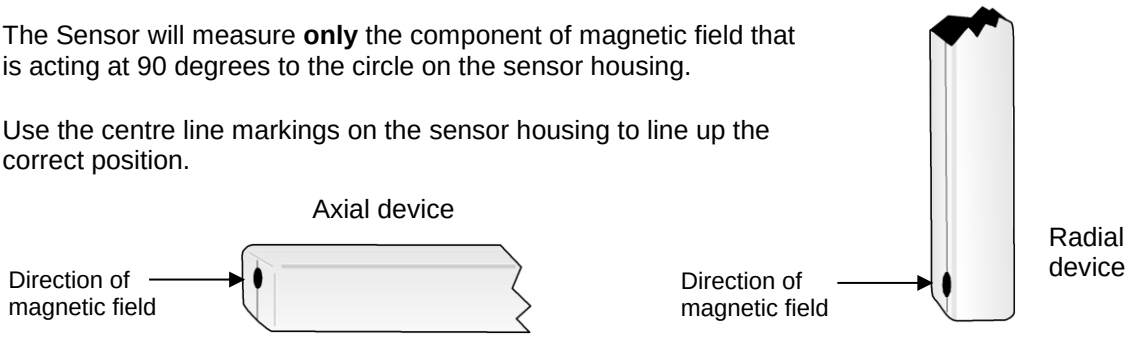
The range setting will be retained until changed by the user.

Practical information



The two Hall Effect devices are located immediately behind the moulded circles on the sensor housing. The axial device is 2.35 mm behind the circle on the end face, and the radial device is 2.85 mm behind the circle on the side face. Each device is approximately the same size as the circle.

- The Sensor will measure **only** the component of magnetic field that is acting at 90 degrees to the circle on the sensor housing.
- Use the centre line markings on the sensor housing to line up the correct position.



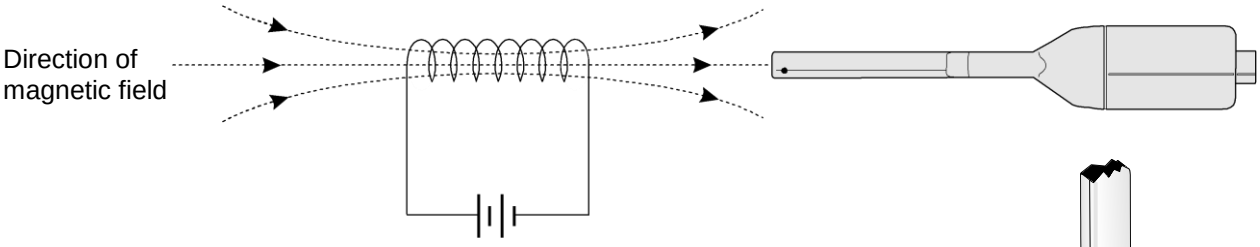
TIP: As the values obtained will be sensitive to the position in the field, and the orientation of the Sensor to the field direction, it can be useful to: -

a. Fix either or both the source and the Sensor in one position.
b. Use a non-magnetic ruler or metre rule as a guide to move the Sensor.
c. Use a non-magnetic clamp and stand to secure the Sensor so it is kept facing at the same angle and in the same direction during the investigation.

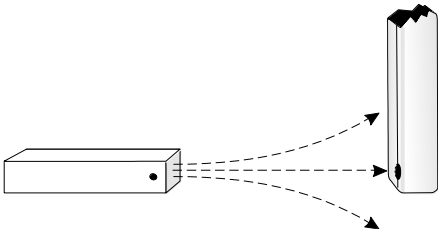
***Note**: A false low value could be achieved if the direction of magnetic field is not at 90° to the plane of the Sensor i.e. perpendicular to the relevant circle.*

- Select the range most suitable for the direction of the magnetic field or the position of the Magnetic Field sensor during an investigation.

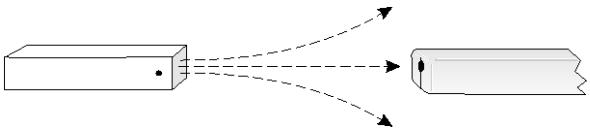
  Examples: -
  Select the **Axial** range when the magnetic field direction is parallel to the axis of the circle on the end face of the Sensor e.g. inside coils or solenoids.



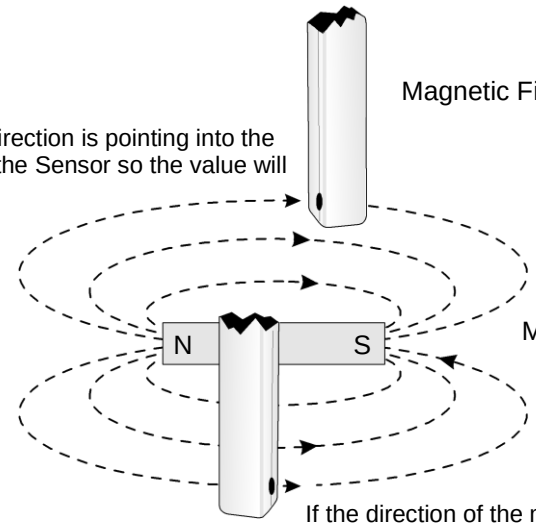
The Sensor can be positioned in either a horizontal or vertical position when using the **Radial** range to detect the field from a magnet.

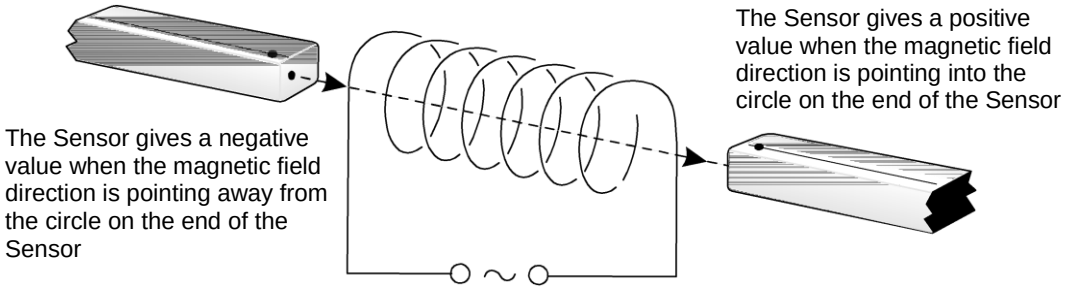


The Sensor can be positioned end-facing when the **Axial** range is used to detect the field from a magnet.

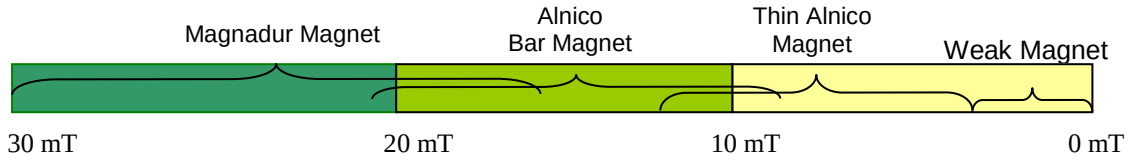


- Using the conventional direction of magnetic fields i.e. from North to South, the value from the Sensor will positive when the direction of the magnetic field is travelling into the circle on the sensor housing.





- The Hall voltage and internal resistance have low temperature coefficients. The effect of temperature can therefore be ignored in the normal school laboratory situation.
- This Sensor is not suitable for investigating very small field strengths e.g. the effect of the Earth's magnetic field.
- Check how smooth low voltage units are before using them for electro magnetic field experiments. Many DC low voltage supplies are not very smooth and will therefore vary the field with the ripple voltage.
- There should be no ferrous metals or magnetic alloys in the vicinity of magnetic field experiments. Such materials will become magnetised and distort the magnetic field. Benches and equipment should be made from non-magnetic materials e.g. wood, plastic or aluminium. Please note that many clamp stands have aluminium rods and clamps, but their bases are made of iron.
- The safest coils to use for solenoid experiments are commercially wound coils, that are marked with a rating e.g. the coils from a demountable transformer kit.
- If homemade coils are used take care to avoid overheating. Do not switch on except when taking measurements. It may be useful to add a contact switch (which is normally open) to the circuit. Insert an ammeter or Current sensor in the circuit to monitor the current, to ensure that it is at a safe level. Too high a current may cause damage through overheating, and will probably cause the resistance to rise.
- Fields in excess of the Magnetic Field sensors range (i.e. ±10 mT for Product No. 3170 or ±100 mT for Product No. 3172) will not cause any damage.
- Typical strengths of magnets are: -



- This Sensor is not waterproof.

Units

Magnetic field strength (also known as the *magnetic flux density*) is a measure of the force the magnetic field will exert on an electric current or another magnet.

S.I. units

The strength of a magnetic field is expressed in **teslas (T).**

A field of strength 1 tesla containing a wire of length 1 m carrying 1 A at right angles to the field will produce a force of 1 N on the wire. The tesla is a very large unit. The Earth's magnetic field strength is, typically, only 50 μT (micro Teslas). The Sensor values are expressed in mT (milli Teslas).

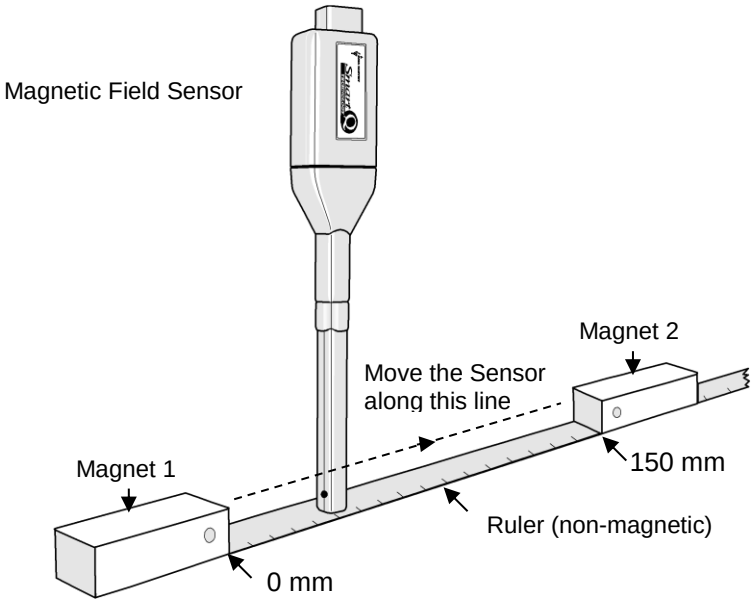
In **cgs units** *magnetic field strength* is expressed in **Gauss (G).**

1 G = 1 x 10^{-4} T, 1 G = 0.1 mT, 1 mT = 10.0 G

Investigations

- *Comparison of the field strength of different types of magnet*
- *Investigating materials that a magnetic field will pass through*
- *Change of magnetic field strength with distance*
- *Change in magnetic field strength between magnets*
- *Directly measuring the field due to a magnet or coil*
- *Investigating magnetic field patterns around magnets and coils*
- *Relationship between the field due to a coil and the current in the coil*
- *Relationship between the field due to a coil and the number of turns in the coil*
- *The variation of the field due to Helmholtz coils*
- *Variation of the field of a solenoid along its axis*
- *Variation of the field of an AC current*

Change in magnetic field strength between magnets

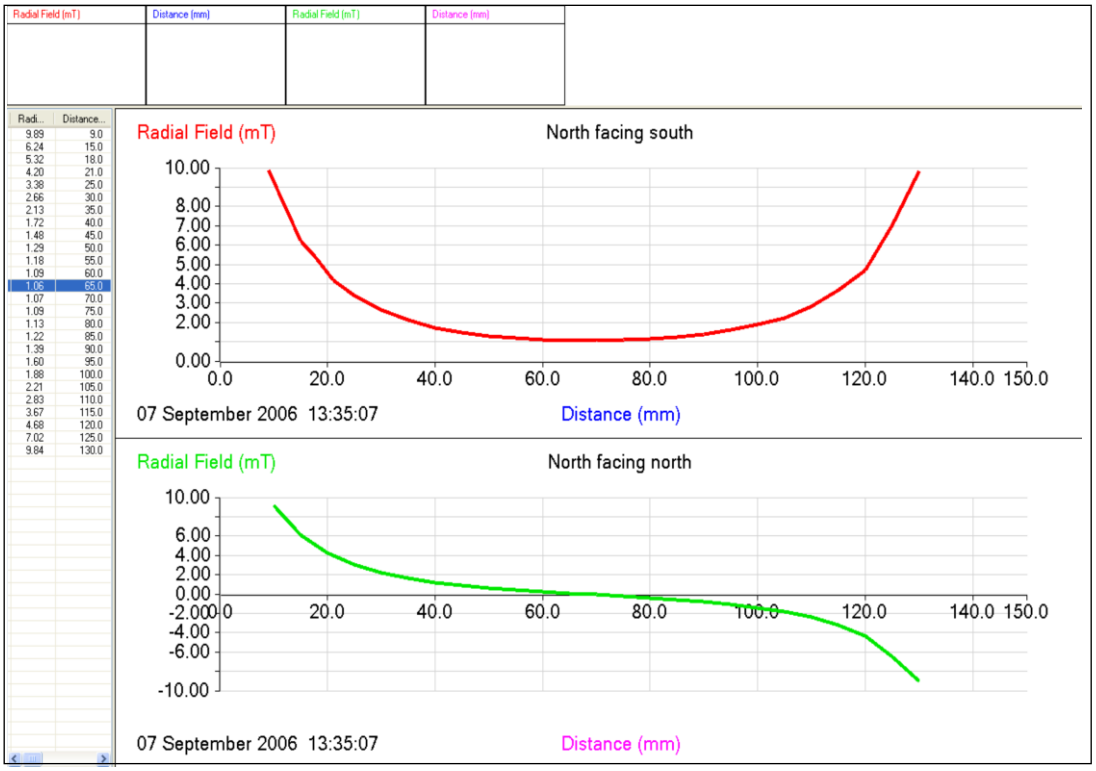


- Use two magnets positioned on top of a ruler with **North** Pole facing **South** Pole. Place magnet 1 at the 0 mm mark and magnet 2 at the 150 mm mark and secure in position.
- Attach the Magnetic Field sensor to the **EASY**SENSE unit and clamp vertically in a non-magnetic clamp and stand (it needs to be moved into different positions along the ruler without disturbing the magnets). Ensure the Radial circle on the Sensor faces magnet 1 at all times during the experiment.
- Place the Sensor so the centre line from the radial circle is close to the zero position on the ruler.
- Open the **EASY**SENSE program and select **Snapshot** from the Home screen. The Y-axis should show Radial Field (mT), if not change the range.
- Select **Pre-log Function** from the Tools menu. Select **Preset function**, **General**, **Asks for Value**, Next. Enter a name e.g. Distance, units as mm, and 150 as the maximum value, Finish.
- From the **Options** icon select X-axis and select **Channel**, OK. If necessary click below the X-axis so that Distance is displayed.

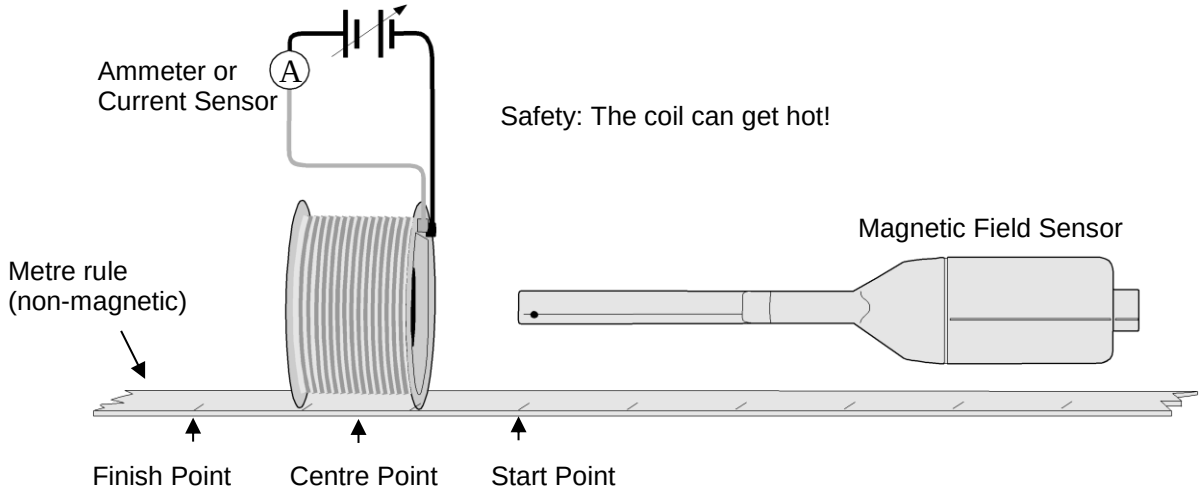
- Click on the **Start** icon to begin. Move the Sensor away from the magnet until the value is less than the maximum of its range. Click in the graph area to record the first value. Type the distance into the 'enter value box', OK.
- Move the Sensor to the next position and repeat. Continue along the ruler until either the 140 mm mark is reached or the values reach maximum of range. Click on Stop to finish recording.
- Save the data.

Turn one of the magnets round so **North** Pole faces **North** Pole.

- Select **Overlay**. Click on the **Start** icon to begin.
- From the **Options** icon select the 'Number of graphs' as 2. Right click in the graph area of the top graph, select **Show or Hide Channel**, hide the 3rd and 4th set of data. Repeat in the bottom graph but hide the 1st and 2nd set of data. If necessary click below the X-axis so Distance is displayed.
- Move the Sensor away from the magnet until the value is less than the maximum of its range. Click in the graph area to record the first value. Type the distance into the 'enter value box', OK.
- Move the Sensor to the next position and repeat. Continue along the ruler until either the 140mm mark is reached or the values reach maximum of range. Click on Stop to finish recording.
- Save the data.

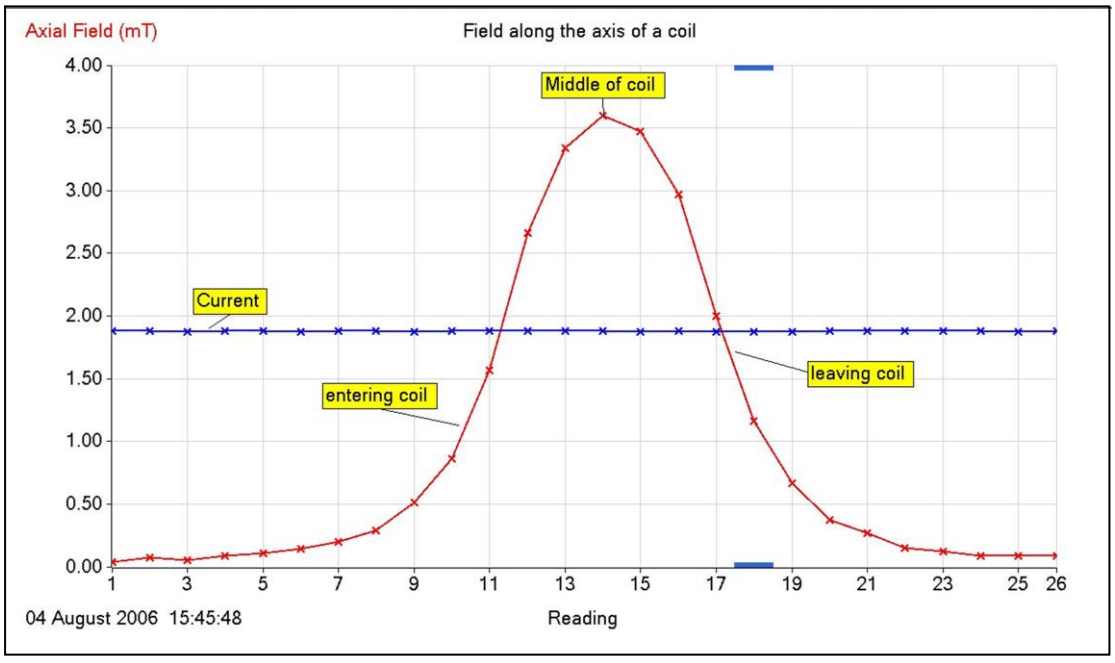


The variation of magnetic field along the axis of a coil



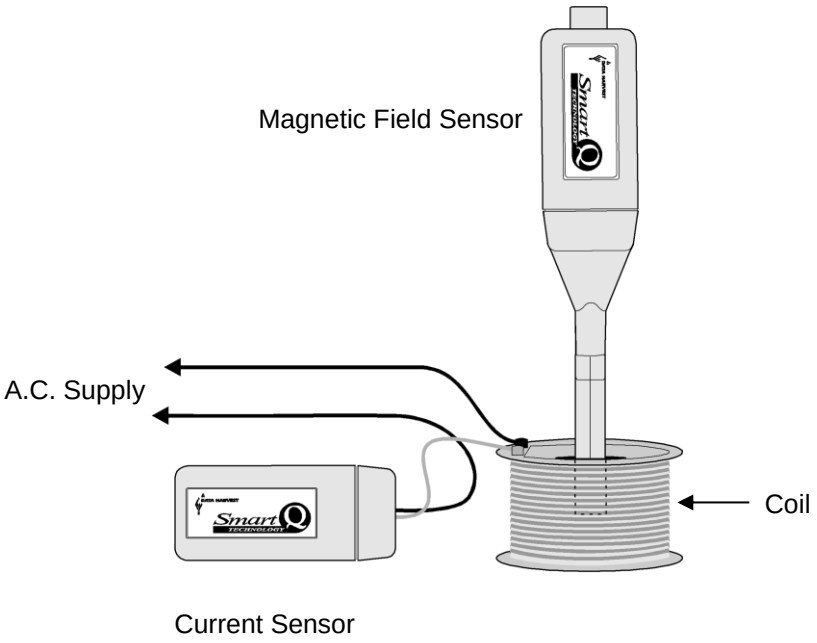
- Arrange the apparatus as shown in the diagram (don't connect power until you are ready to start recording). Attach the Current and Magnetic Field sensor to the **EASY**SENSE unit.
- Open the **EASY**SENSE program and select **Snapshot** from the Home screen. The Y-axis should show Axial Field (mT), if not change the range.
- Position the end of the Magnetic Field sensor at the start point.
- Connect electrical power to the coil. The Current sensor is used to monitor the current, which should be constant.

  ***Note**: Make sure the current doesn't change during the experiment; this may occur if the temperature of the coil rises.*
- Click on **Start** and then click in the graph area to record the first value.
- Move the Magnetic Field sensor towards the coil e.g. in 10 mm steps, and click in the graph area at each point to record the value of the field. Right click in the graph area and use Add Text to label any specific points on the graph.
- Continue this process until the Sensor has moved through the coil and out the other side to an equal distance.

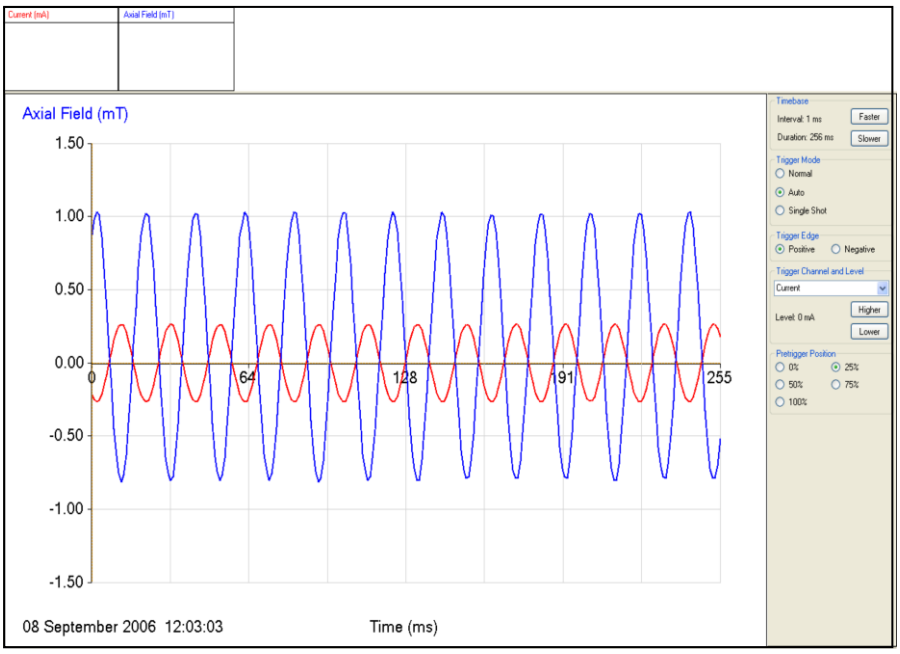


Result using a 200 turn 'home made' coil and 4.5 V d.c. from a power supply. Axis limits reduced to display from 0 to 4 mT.

How does the field vary when an alternating current flows through a coil?



- Arrange the apparatus as shown in the diagram (don't connect power until you are ready to start recording). Place the Magnetic Field sensor in the middle of the coil. Attach the Current and Magnetic Field sensor to the **EASY**SENSE unit.
- Open the **EASY**SENSE program and select **Scope** from the Home screen. The Y-axis should show Axial Field (mT), if not change the range.
- Select Auto trigger with a **1 millisecond** interval.
- Click on **Start**. Switch the power on and adjust the alternating current to the desired level.



These results were obtained using a 350-turn coil and the 10 mT sensor

Limited warranty

For information about the terms of the product warranty, see the Data Harvest website at: https://data-harvest.co.uk/warranty.

Note: Data Harvest products are designed for **educational** use and are not intended for use in industrial, medical or commercial applications.

WEEE (**W**aste **E**lectrical and **E**lectronic **E**quipment) Legislation

Data Harvest Group Ltd is fully compliant with WEEE legislation and is pleased to provide a disposal service for any of our products when their life expires. Simply return them to us clearly identified as 'life expired' and we will dispose of them for you.