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# IPC Irwin Search Coil

## Part Number IPC-4915-W

# User Instructions

## OPERATION.

The search coil comprises a 3,300 turn coil with an air core, connected to flying leads terminating in 4 mm plugs. It is used to measure varying magnetic fields.

When the axis of the coil is held perpendicular to the varying magnetic field, a voltage is induced in the coil, which can be measured using a sensitive voltmeter, or observed on an oscilloscope.

**Requirements**

- AC millivoltmeter, or
- Oscilloscope, or
- DC voltmeter with rectifying diode (see notes on following pages)

**Applications**

- Measuring varying magnetic fields
- Transformer investigation

## OPERATION.

**Never connect the Search Coil to a power supply; this will cause irreparable damage.**

Connect the coil to a suitable meter or oscilloscope using the 4 mm leads. A BNC-to-4 mm adaptor may be required for an oscilloscope.

If the sensitivity of the meter or oscilloscope is adjustable, set it to a high sensitivity. The signal from the coil is typically no higher than in tens of millivolts in most circumstances.

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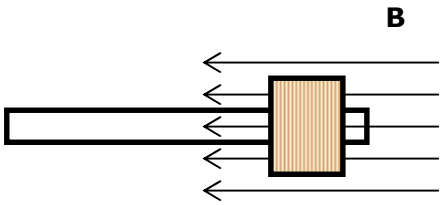
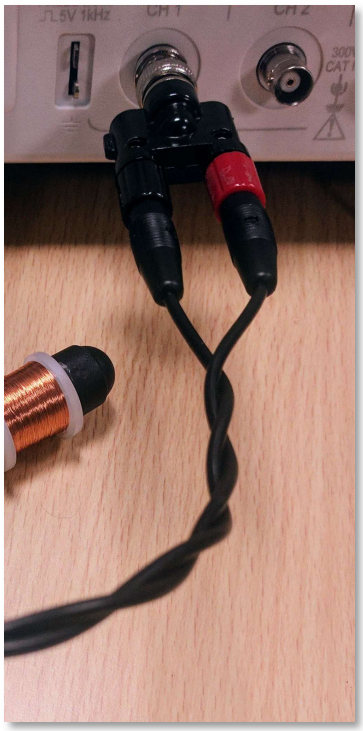
If using a meter, a sensitive AC meter is best. If using a DC voltmeter, a rectifying diode will be required - please see the note on the next page.

The axis of the coil is parallel to that of the handle. Therefore, to measure a magnetic field, hold the rod parallel to the lines of the field you wish to measure.



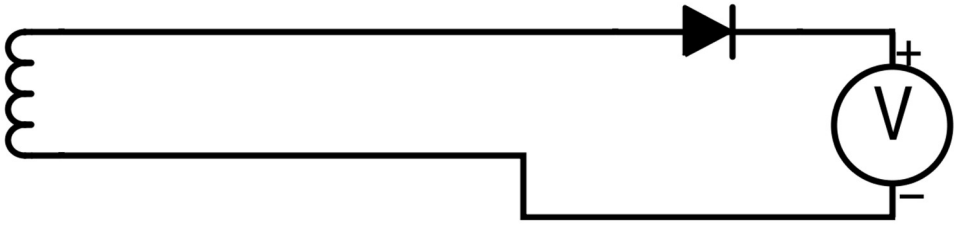



In the event that there is electromagnetic interference (i.e. an undesired signal) then this can be reduced significantly by forming the flying leads into a twisted pair, as illustrated.

## USING A DC VOLTMETER.

In most applications, the search coil measures an oscillating magnetic field and so produces an AC signal, if measured with a DC voltmeter this will average out to zero.

If no AC voltmeter is available, it is possible to rectify the signal with a diode so that it can be measured with a DC voltmeter.

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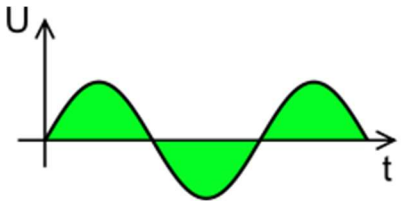
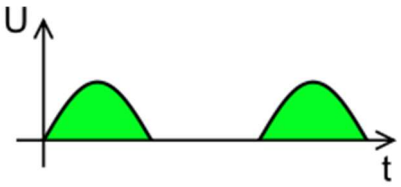
The diode only allows current to flow one way, and so half of the AC signal will be blocked, this is called **half wave rectification**.




Signal from coil




Half-wave rectified signal

The average voltage is no longer zero, so the DC voltmeter will show a reading. However, it can only be used to indicate the presence and relative magnitude of an AC magnetic field.

## THEORY.

The search coil works on the principle of magnetic induction (Faraday's Law).

When a magnetic field through a closed conducting loop changes, an electromotive force (EMF) is induced in that loop that opposes the varying field that induced it.

The size of that EMF depends on the rate of change of the flux of the magnetic field, and the cross-section of the closed loop through which the flux goes, which depends on the size of the loop, and the number of turns.

$$\varepsilon = -N \times S \frac{dB}{dt}$$

$\varepsilon$: induced EMF
$N$: number of turns
$S$: cross-sectional of coil
$B$: magnetic flux

$\frac{dB}{dt}$ is a mathematical expression of the change of flux with respect to time, i.e. "rate of change of magnetic flux".

If the magnetic field were changing at a constant rate, then a constant DC voltage would be induced which could be measured with a voltmeter.

However, in most applications, the magnetic field oscillates, and so an AC voltage is induced in the coil.

The search coil will not detect a static magnetic field, such as that of the Earth, or a stationary bar magnet, because the rate of change of flux would be zero.

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# AC FIELD FROM A COIL.

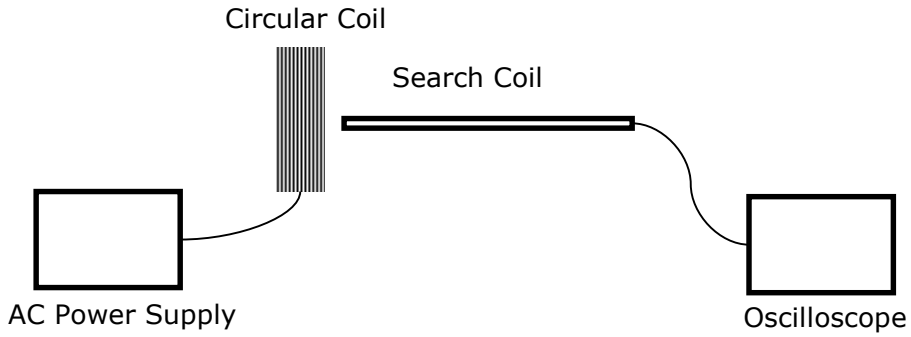
Construct a Circular Coil of wire of the following specifications below or simply purchase the IPC Irwin 'AC Magnetic Field Coil' (IPC-4924-W).

- Insulated wire
- 10 turns
- 15-20 cm diameter
- Current capacity of at least 5 Amps

Connect the Circular Coil to the AC output of a low voltage power supply that can deliver high current and tolerate a short circuit, such as the type typically used in electromagnetics investigations.

Connect the Search Coil to the input of an oscilloscope or meter.

Using a retort rod, boss and clamp, position the search coil such that it is in the middle of the larger coil, with the axes of the two coils aligned.




Set the oscilloscope such that the signal from the search coil can be seen clearly. Measure the peak-to-peak voltage.

Adjust the angle between the axes of the Search Coil and Circular Coil by 10° and record the peak-to-peak voltage against the angle. Repeat this for angles between 0° and 90°.

Plot the results on a graph to show the flux linkage as a function of angle. The value should be zero at an angle of 90° between axes of the two coils, and peak at 0°.

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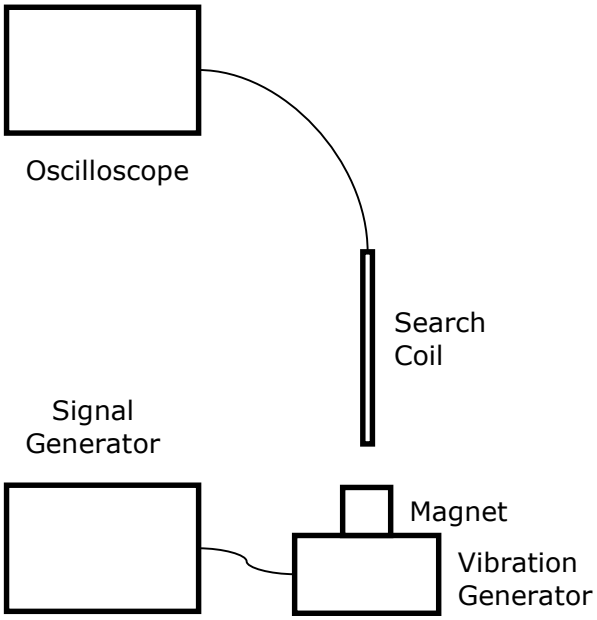
# CHANGING FIELD FROM A MOVING MAGNET.

A mechanical way to create a varying magnetic field at a fixed point in space is to move a permanent magnet nearby that point.

This can be achieved easily using a strong neodymium magnet attached to a vibration generator, driven by a signal generator and amplifier.

Use a retort clamp, stand and base to point the search coil "down" at the magnet, giving 1-2 cm clearance from the magnet.

When the magnet is moved by the vibration generator, the magnetic field in the search coil, which is stationery relative to the magnet, will change.




The rate of change of the magnetic field, $\frac{dB}{dt}$, is the waveform of the signal driving the vibration generator and thus moving the magnet.
Therefore, the signal seen on the oscilloscope will be the signal from the signal generator, differentiated with respect to time.
Note that increasing the frequency of the driving signal will increase the rate of change of the magnetic field, and thus the size of the signal seen on the oscilloscope.
Similarly, increasing the amplitude of the driving signal will increase that of the signal on the oscilloscope.
Finally, if your signal generator is capable of outputting different waveforms, you should be able to see the differential form of that waveform on the oscilloscope.

Thank you for choosing this IPC Irwin product, which has specifically been designed for education and we know it will bring you good service long into the future. This is just one product of a wide range of UK designed and manufactured products to enhance a STEM education, please see www.ipcirwin.com website for more details on the products and service we provide to support teaching and learning in science and technology.

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