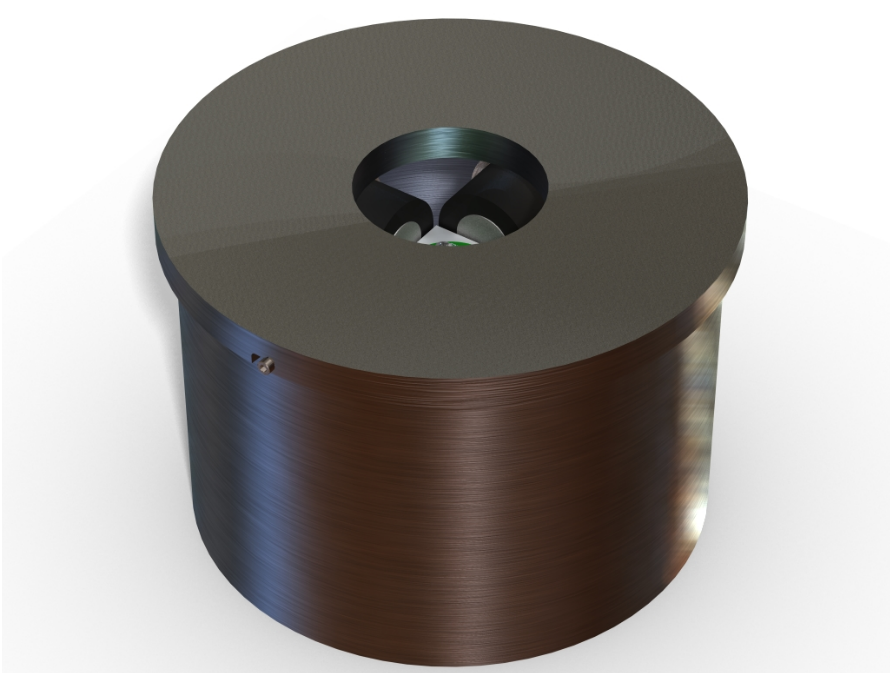
SpinField-2D: Two Dimensional Magnetic Field Platform

User Manual

www.directvacuum.com

www.micromagnetics.com



Overview

<u>SpinField-2D: Two-Dimensional Magnetic Field Platform</u>

The SpinField-2D Two Dimensional Magnetic Field Platform is used to generate a two-dimensional magnetic field of arbitrary direction and strength. The platform consists of a pair of orthogonal electromagnets capable of generating two magnetic fields along the X and Y-axis. Sample space is a square (approximately1.5 by 1.5 inch).

Magnetic field strength is measured by a pair of magnetic sensors located below the sample-mounting surface. There is one sensor each for the X and Y-axis magnetic fields. Each sensor outputs a voltage proportional to the magnetic field along its sensing axis.

Applications

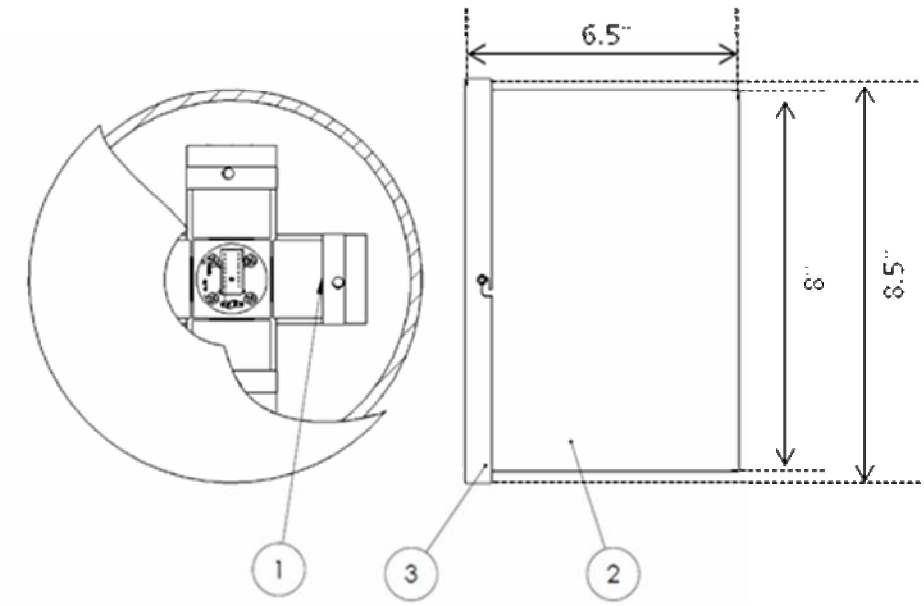
- Magnetic sensor characterization
- Research on magnetic properties of thin films, crystals, devices
- Research on spintronics
- Bio-magnetic applications in magnetic immunoassay, magnetic separation
- Magneto-optics
- Magnetic hysteresis loop measurement
- Ordinary and extraordinary Hall effect measurement
- Magnetic biasing for sensors and other devices
- Non-destructive evaluation based on eddy current sensing
- Using rotating field to remotely control magnetic particles
- Ferromagnetic resonance
- EPR/NMR spectroscopy

Electromagnet Specifications

Pole Diameter:	1.06 inches (27 mm)
Pole Gap:	1.8 inches
Dimensions:	Diameter: 8.5 inches (8" without cover); H: 6.5 inches
Weight:	21 lbs (9.5 kg)
Resistance of coils:	48 ohms (nominal)
Maximum current:	1 Amp (sustained)
Magnetic field per amp	
X-Axis:	343G
Y-Axis:	337G
Cooling:	ambient

X-Y Magnetic Field Sensors Specifications

Supply Voltage (Vcc):	3 VDC (2.5-3.5V)
Supply Current:	6 mA
Output Saturation:	Vcc-0.1V
Sensitivity:	10 mV/G
Quiescent Output:	0.50 x Vcc
Noise:	80 mV(peak-to-peak)



1 - Electromagnet Pole Fixture
2 - Housing
3 - Removable Cover

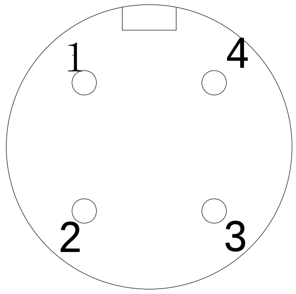
Use of the Two Dimensional Field Platform

The field platform comes with two cables, a power cable and a sensor cable, each having a unique connector. These cables plug into the matching sockets of the field platform.

1. Connect the field platform to the external current sources

The power cable's connector has four pins as shown below. Terminal 1 (brown wire) and 2 (yellow) are used for X-axis electromagnet. Terminal 3 (green) and 4 (white) are used for the Y-axis electromagnet. Connect these four colored electrical wires to two external power supplies that supply the currents to the X- and Y-axis electromagnets.

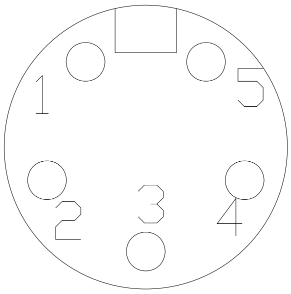
When applying currents to the electromagnets, do not exceed the maximum current as specified. The magnetic field strength is linearly proportional to the amplitude of the applied current. The magnetic field direction is controlled by the polarity of the applied current.



Terminal	Color	Function
P.1	Brown	+X coil
P.2	Yellow	-X coil
P.3	Green	-Y coil
P.4	White	+Y coil

2. Connect the sensor cable to the external voltmeters

The sensor cable's connector has five pins as shown below. However, only 4 pins are used. Pin 1(to red wire) is ground. Pin 2 (yellow) is to be connected to DC +3Volt power supply. Pin 3 (blue) is X-axis field sensor voltage output (V_X). Pin 4 (black) is Y-axis field sensor voltage output (V_Y)



Terminal	Color	Function
S.1	Red	Ground
S.2	Yellow	V supply
S.3	Blue	V_Y
S.4	Black	V_X

3. Magnetic Sensor Readings

The magnetic field sensor outputs are ratiometric. Zero magnetic field output corresponds to 50% of the voltage supplied to S.2 (V supply). A positive field increases the output voltage and a negative field reduces the output voltage from this 50% of S.2 value. To obtain best sensor performance DC +3V should be applied to S.2. Do not exceed 3.5VDC.

The sensitivity is 10mV/G but a calibrated correction factor needs to be used to determine actual field at the location of the device under test. Calibration parameters taken at the center of the test area and in the plane of the mounting PCB are given below.

With 3VDC supplied to S.2, zero magnetic field corresponds to V_X = +1.5 V and V_Y = +1.5V. Positive field corresponds to an output of >1.5 to +2.9 V, and negative field corresponds to an output of <1.5V to 0.1V. Therefore, the magnetic field strength can be computed using the following formula.

$$B_x(Gauss) = [(V_x - 0.5*V(supply)) *159]+[(V_Y - 0.5*V(supply)*233)*0.302)$$
$$B_Y(Gauss) = [(V_Y - 0.5*V(supply)) *233]+[(V_x - 0.5*V(supply)*159)*0.302)$$

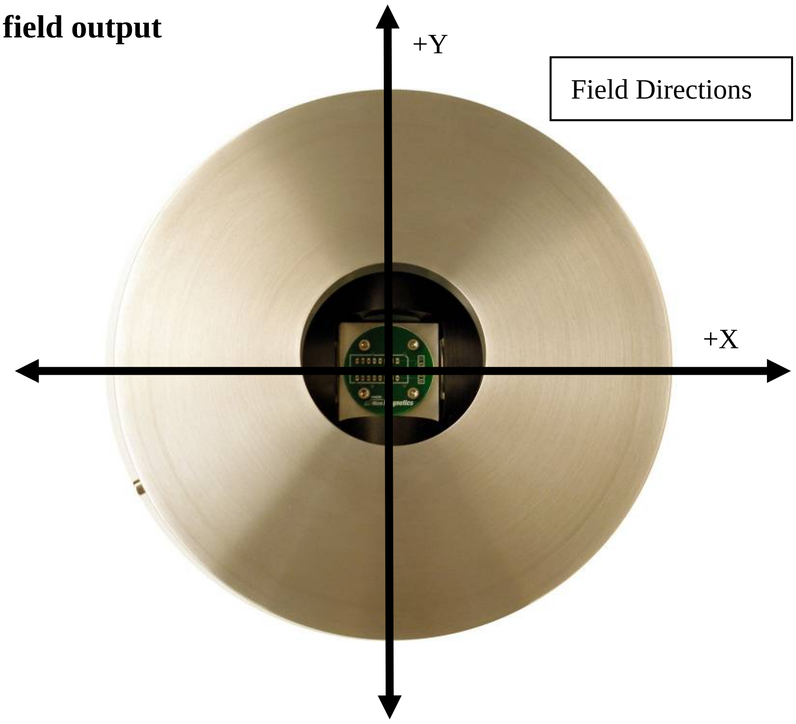
Calibration Parameters

Sensor output to field strength

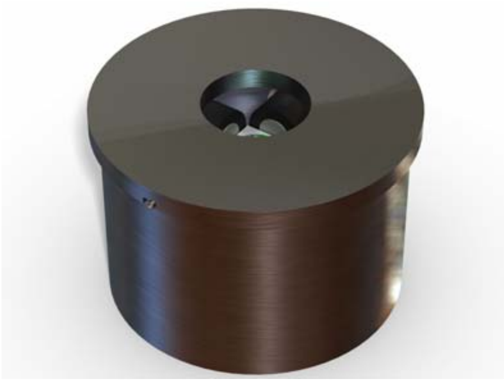
X-axis: 6.3 mV/G (off axis -1.9 mV/ B_x G)
Y-axis: 4.3 mV/G (off axis -1.3 mV/ B_Y G)

Applied current to magnetic field output

X-Axis: 343 G/Amp
Y-Axis: 337 G/Amp

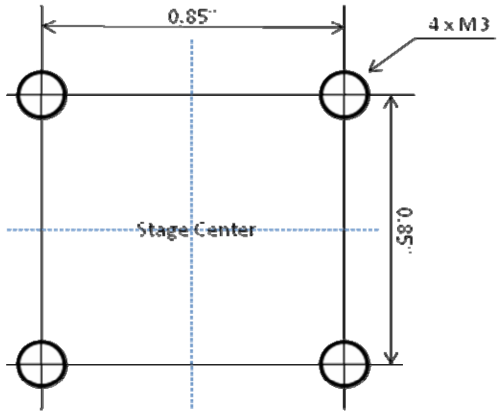


4. Mounting a Sample



The SpinField-2D Two Dimensional Magnetic Field Platform can be used with or without the aluminum cover. The cover is removed by loosening the hex head screw (located on the outer lip of the cover), rotating the cover counter clockwise, and lifting the cover up and off the housing.

Mount the device under test as close to the surface of the square aluminum stage and to the center of the stage as possible. The will ensure the fields sensed by the sensors are the same field applied to the sample. The device under test can be mounted onto the platform using the M3 hole pattern (see figure below) located on the fixture in the plane between the magnet poles.



5. Ventilation of the Magnetic Field Platform

The magnetic field platform is designed to handle 1 amp maximum sustained current. However, larger currents can be used for short durations if care is taken not to overheat the magnets. During higher current or long maximum current operation, make sure the region near the magnetic field platform is well ventilated. If needed, use an electric fan to remove heat generated by the platform. Keep the magnetic field platform in a dry environment.

SpinField-2D Application Note: Generating AC Magnetic Field -

Frequency Dependence of Maximum Magnetic Field Generated by

SpinField Magnetic Field Platform

Frequency Dependence of Maximum H-Field in RL Circuit

Micro Magnetics, Inc., Fall River, MA, USA

I. Introduction

In any scientific experiment, it is important to document the physical limits of the apparatus used. It would be counterproductive to attempt data collection in a regime where the equipment cannot function properly or at all. In our laboratory, constant use of magnetic fields produced by alternating currents running through magnetic coils is needed, and it is very valuable to know the extent to which these coils can produce various field strengths. We wish to find the maximum magnetic field strength a given set of coils can produce at a range of different frequencies.

The circuit used is essentially a RL circuit consisting of a resistor and an inductor in series. The AC source can be assumed to be a purely sinusoidally oscillating potential difference.

$$V(t) = V_0 sin(\omega t)$$

In a series circuit consisting of a resistor and an inductor, the potential difference across the entire circuit can be defined purely in terms of the resistance R, the inductance L, and the alternating current.

$$V(t) = RI(t) + L\frac{dI(t)}{dt}$$

After assuming the current flowing through the circuit is a superposition of sine and cosine functions, the differential equation can be solved, yielding an

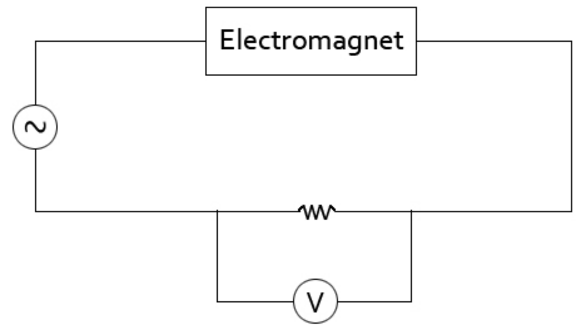


Figure 1: Experimental apparatus

expression for the current in the circuit, as well as its maximum.

$$I(t) = V_0 \frac{R\sin\omega t - L\omega\cos\omega t}{R^2 + L^2\omega^2}$$

$$I_{MAX} = \frac{V_0}{\sqrt{R^2 + L^2\omega^2}}$$

Since the current flowing through the inductor is directly proportional to the magnetic field produced by it, the

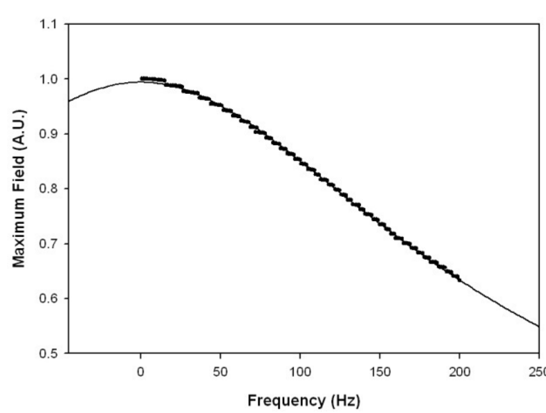


Figure 2: Maximum field as a function of AC frequency with fit curve

maximum field is related to the maximum current by a constant factor.

$$H_{MAX} = \frac{C}{\sqrt{R^2 + L^2\omega^2}}$$

II. Experimental Setup and Procedure

A function generator was set to output a sine wave with a peak-to-peak voltage of 1.000 V and an offset of 0.000 V. A resistor of known resistance was placed in series with the magnetic coils, and a voltmeter was placed in parallel to the resistor to measure the potential difference across the resistor (Figure 1).

Potential differences were measured across the resistor for a time equivalent to 10 periods of AC current at a given frequency. A range of frequencies from .0010 Hz to 200.0 Hz was tested. Using previous calibration, the calculated current flowing through the coils was converted to magnetic field strength. All parameters were controlled and set up with National Instruments' LabVIEW software.

III. Results

The maximum magnetic field as a function of AC frequency is shown in Figure 2. As can be seen, the highest maximum fields are seen with the lowest frequencies, decreasing rapidly until an inflection point. After this point, the maximum field approaches zero slowly as the frequency increases.

After fitting the predicted maximum field/frequency relationship to the data, it is apparent that the theory matches the experimental results quite well. The data shown in figure 2 differs from the value of the maximum magnetic field by just a constant. A simple calibration routine relating current flow in the circuit to the produced magnetic field would yield the correct values.