Renewable Energy

Faraday's Law, Motors, and Generators

Introduction/Purpose:

The purpose of this experiment is to measure the electromotive force (emf) induced in a search coil and analyze the effect of permeable material on coupled coils.

Apparatus:

Field Coil, Search Coil, Voltmeter, Ammeter, Oscilloscope, Cables and connectors, Signal Generator, Battery, Banana plug leads, Hand generators, Small motors, Power supply, Metal rods, Protractor, Dismantled motor

Experimental Methods/Theory:

In this experiment, sinusoidal alternating currents will be passed through "field" coil assemblies, which will produce sinusoidal varying magnetic fields in the surrounding space. A small "search" coil nearby will intercept some of the sinusoidal-varying magnetic flux. When moving the search coil in or out of the field coil, the magnetic flux through the large coil changes, creating an electric field and inducing an emf. The search coil can probe the region around the field coil and oriented so as to maximize the amplitude of the induced voltage. This induced emf is measured with a voltmeter and may also be observed on the oscilloscope.

The presence of magnetic materials in regions shared by the field and search coils can also be investigated with these techniques. In a vacuum, the magnetic intensity $\vec{H}$ is related to the magnetic field $\vec{B}$ by the permeability of free space μ_o.

$$\vec{B} = \mu_o \vec{H} \qquad (1)$$

while inside any material the relation is

$$\vec{B} = \mu \vec{H}, \qquad (2)$$

where

$$\mu = \mu_o(1 + \chi) \qquad (3)$$

and χ is the magnetic susceptibility of the material. For paramagnetic and ferromagnetic materials, both μ and χ are positive quantities. The basic apparatus used in this experiment will permit a crude measurement of μ and χ.

Procedure:

A. Field Coil Characteristics

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1. A field coil has been supplied at each station, and you will be determining its characteristics with your search coil and associated test equipment. Set up the circuit in Figure 3

    a. You may omit the oscilloscope connections to the search coil's DMM, unless you need it for troubleshooting.

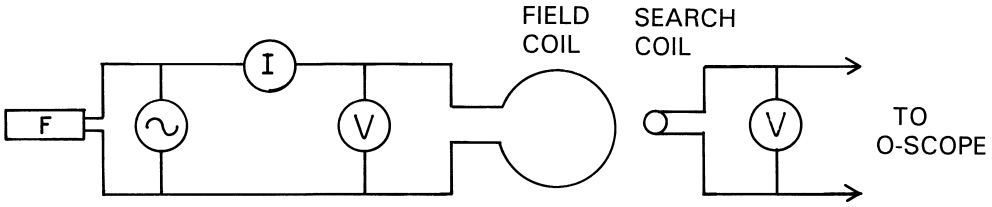

Figure 3. Field Coil Test Circuit Schematic

2. Sketch the signal as seen on the oscilloscope.

3. What happens when you change the frequency and/or voltage on the signal generator?

4. Investigate the field coil's magnetic field by holding the voltage and frequency constant and moving the search coil around. How does the field change with position?

5. Investigate the relationship between the induced emf in the search coil and the angle between the coil axes. Use the protractor to measure the angle for every 15^{o} step between 0^{o} and the maximum acute angle allowed by the apparatus. Describe how the field changes with angle.

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B. Magnetic Material Permeability and Susceptibility Measurement

1. Hold the search coil still inside the field coil and insert one of the rods into the search coil. Describe what happens. Does inserting the rod into the field coil but not the search coil have the same effect? Do both rods have the same effect? Discuss.

C. Motors as generators:

1. Attach the oscilloscope to one of the small motors or hand generators and spin it. Sketch the output as shown on the oscilloscope.

2. Describe what you observe when you spin the motor faster or slower. If you can spin it backward, try that too.

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D. Motors:

1. Hook the motor up to a single battery and describe what happens. Try hooking up the wires backward.

2. Replace the battery with a power supply. Begin with the voltage low and slowly turn it up. Use the voltmeter to determine what minimum voltage is needed to start the motor turning. Is it the same with the opposite polarity?

3. Sketch the inside of the dismantled motor and use words to describe how it works.