

## Abstract

Electromagnetics, loosely defined as the study of fields generated by charged particles, is widely considered as one of the least understood yet most essential components of engineering training and application. Magnetic flux density sensor analysis provides a means of introducing students to the complex behaviors of electromagnetic fields while engaging individual creativity and stimulating a thorough understanding of the engineering design process. This research seeks to demonstrate a procedure for collecting and analyzing field data for a variety of physical configurations. The original experiment described below defines a combination of hardware, firmware, and software techniques that offer a repeatable, intuitive, and effective analysis of observed electromagnetic fields.

This research proposes an experiment that allows researchers to observe and analyze electromagnetic phenomena through a combination of hardware and software components. The hardware setup features jointed PVC piping that can be arranged to accommodate cartesian, spherical, or cylindrical coordinate systems. These PVC stands hold the magnetic field sensors at locations surrounding the selected experimental artifact (e.g. a magnet, an electric circuit, an antenna, etc.), allowing comprehensive data collection. Microcontrollers collect the sensors' data and pass the information through a USB to the user's computer. An Arduino microcontroller selected for this experiment provides analog pinouts for multiple sensors, allowing efficient data collection from multiple angles simultaneously. After the microcontroller sends the data to the computer serial ports, an original MATLAB program processes and visualizes the data while providing feedback to the researcher using a graphical user interface (GUI). As the program calculates a variety of field characteristics, including curl and divergence, this GUI allows users to view the real-time magnitude and direction of the magnetic field at selected points within the geometry, offering an intuitive, accessible, and repeatable approach for a variety of

electromagnetics-related experiments. The raw data from each sensor can be saved for further reference and analysis.