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Development of an educational low-cost teslameter by using Arduino and Smartphone application

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Abstract
We present in this paper the construction of an educational low-cost teslameter and its use for the magnetic field measurement of a system containing two coils. Our framework is based on the Arduino program and Smartphone application in an educational context. As a finding, we have obtained good agreement between the experimental results and those found using the theoretical model. These results are validated by the new technology based on the integration of Arduino platform and Smartphone application.

Keywords: physics education, teslameter, Arduino, Smartphone, magnetic field, technology

1. Introduction

Recently, it is clearly shown that technology can play a dominant role in making teaching physics more relevant and more related to real-life [1,2]. The Arduino microcontroller board is a good example which can be employed to realize some experiments in different fields of science and technology [3]. The benefits of using Arduino boards as low-cost data systems for experiments are currently more interested in physics teachers. Learners are usually attracted by physics labs integrating new technologies [4].

In this paper, we have designed and constructed an innovative low-cost teslameter based on an Arduino and Smartphone application. This device is used to measure the magnetic field of a system containing two Helmholtz coils.

In order to facilitate the manipulation of the measurement, we have developed a new Smart-

Figure 1. Experimental dispositive realized in our laboratory.

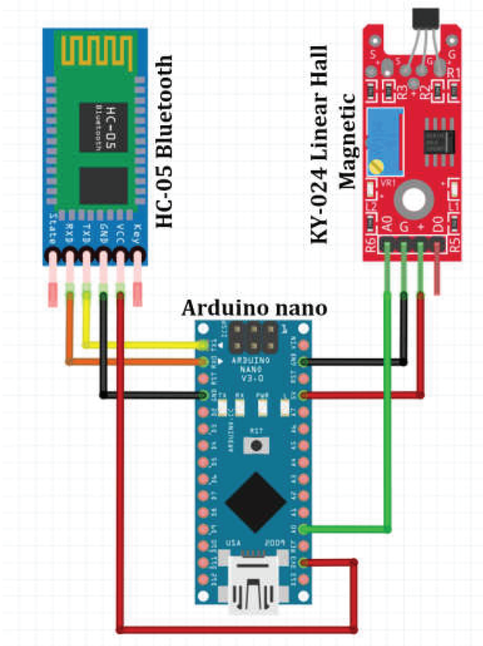

Figure 2. The integrated circuit.

phone application. Our results obtained by the experimental data collected through our low-cost teslameter are compared to the theoretical model.

2. Experiment and Arduino measurements

2.1. Materials and method

The experimental measurements carried out in this work require knowledge of the values of the magnetizing current I (A), the magnetic field B (mT) and the voltage U (mV). To do this, we have used a magnetic field probe of the proposed teslameter, which is based on a Hall effect sensor. According to the specifications, this sensor has an adjustment control that eliminates the residual magnetic field.

The Hall sensor was mounted inside the end of a short length of plastic tubing, as shown in figure 1. A HIT/23S multimeter displaying the voltage value in (mV) should be connected to the teslameter (figure 1), which allows us to select the meter available in the laboratory.

The value of the measured magnetic field is given by the following expression:

$$B = \frac{X(mV) * 10^{-1}(mT)}{10(mV)}. \qquad (1)$$

After performing a measurement series, i.e. for each value of the magnetizing current, we note the value of the voltage displayed at the multimeter and we use equation (1) to obtain the value of the magnetic field.

2.2. The magnetic sensor S49

The S49 is a small linear Hall-effect sensor. It can measure both the north and south polarity of a magnetic field and the relative strength of the field. This sensor has an operating temperature range of $-40°C$ to $85°C$ appropriate for commercial, consumer and industrial environments.

2.3. The integrated circuit

To plot a graph of the magnetic flux density B as a function of current I (A) by using this new coupled Smartphone–Arduino technology, we have developed a teslameter containing a KY-024 Hall effect sensor, microcontroller board (Arduino nano) and a Bluetooth module (figure 2).

Figure 3. Typical set-up using the Arduino.

The KY-024 linear magnetic Hall sensor reacts in the presence of a magnetic field. It has a potentiometer to adjust the sensitivity of the sensor and provides analog and digital outputs.

The digital output acts as a switch that will turn on/off when a magnet is near. However, the analog output can measure the polarity and relative strength of the magnetic field.

We then need to connect the Arduino programmable board to the Bluetooth module in order to obtain the values of the magnetic field B and display them into the Smartphone. It is important to note here that the Bluetooth base consumption modules are available at a reasonable cost. However, most of these modules are not in accordance with the current peripherials that support classic Bluetooth. The HC-05 module is compatible with a wide range of devices, including Smartphones, laptops and tablets. We have represented in figure 3 our teslameter based on the Arduino card programmable by using a code.

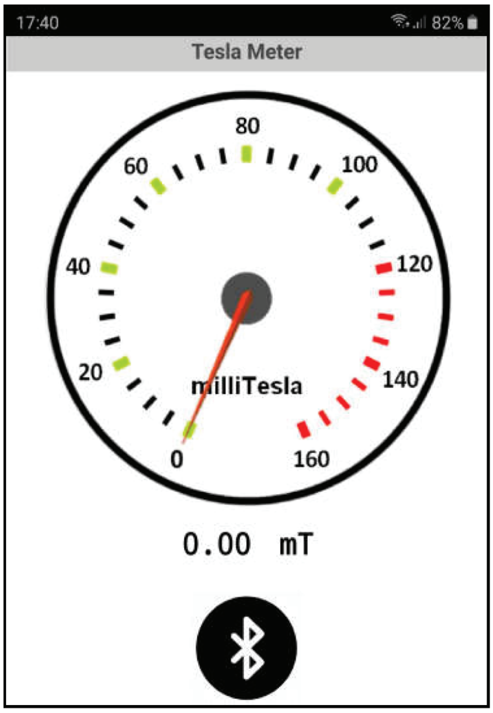

Figure 4. MIT application inventor.

After we have paired the devices, we need an application to display the information sent by Arduino. Indeed, we have made our own custom application for this tutorial using the MIT App Inventor online application (figure 4). Figure 5 shows the block code used to develop the Smartphone application.

3. Comparison results and discussion

After performing a series of measurements using our teslameter realized by an Arduino card programmable, we have posted in figure 6 the magnetic field as a function of magnetizing current obtained by the theoretical model, Arduino measurement and classic experiment. From this figure, we note a good agreement between the measurements made by Arduino, those found by the theoretical model and the classical experiment. This makes our circuit by Arduino more

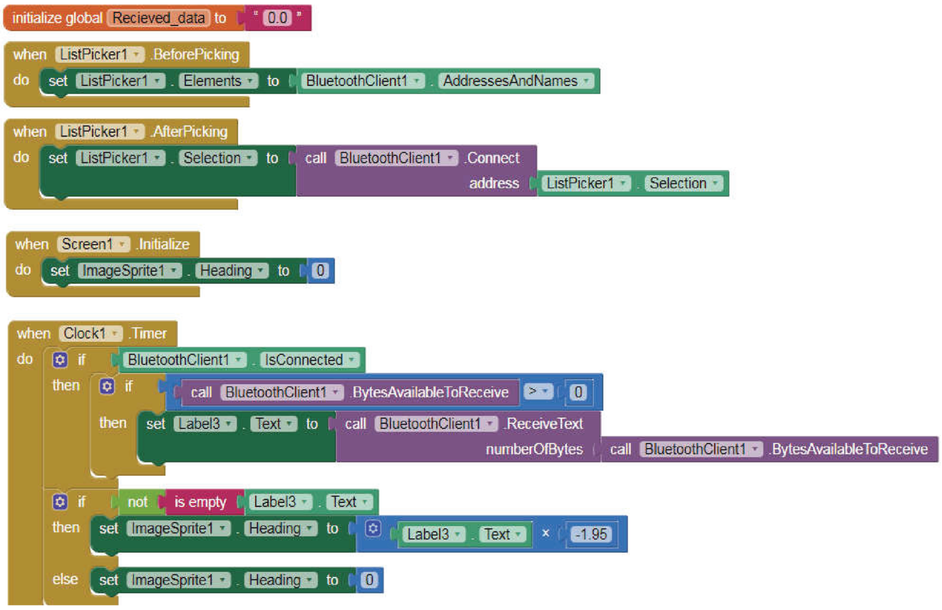

Figure 5. The Bloc code for Smartphone.

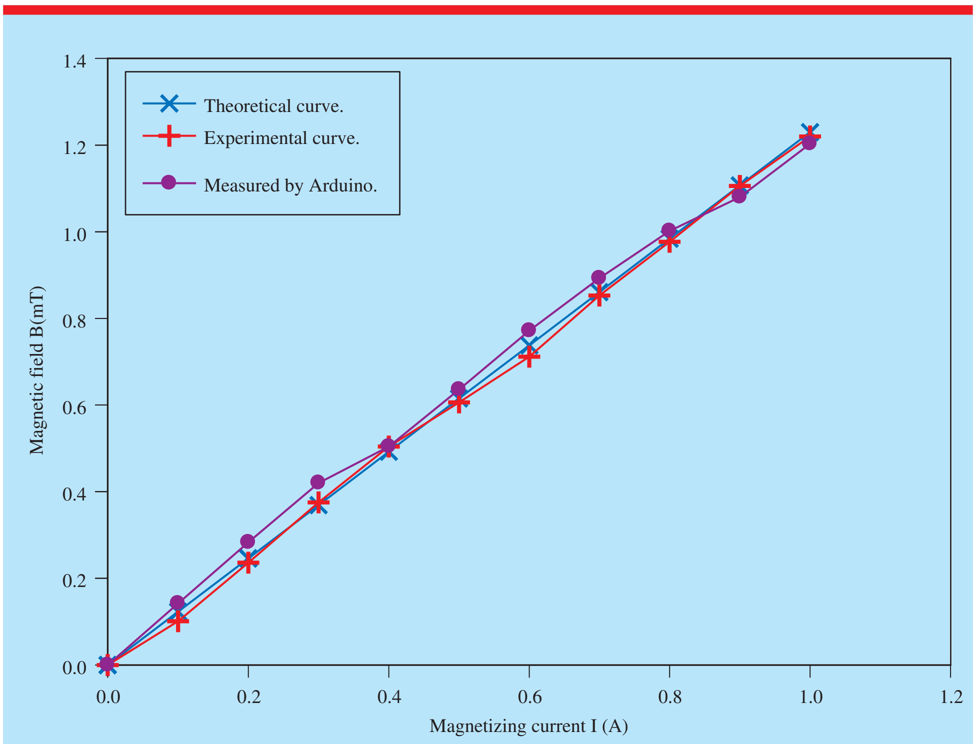

Figure 6. Magnetic field as a function of magnetizing current.

efficient and even close to using different didactic manipulation.

4. Conclusion

In this work, we have designed and realized a digital low-cost teslameter based on the S-49 Hall effect sensor by using an Arduino and Smartphone application. The magnetic field as a function of magnetizing current obtained by the theoretical model, Arduino measurement and classical experiment have been illustrated. We have found a good agreement between different models of measurement.

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