7. 2021,Irwandi,Ishafit Node.js_for_Development_RSTEM.pdf

WORD COUNT 3100

TIME SUBMITTED 26-JUL-2024 10:12AM

PAPER ID 110683428

Node.js for Development RSTEM to Support Remote Physics Practicum During COVID-19

I.Irwandi
STEM Research Center
Universitas Syiah Kuala
Banda Aceh, Indonesia
Irwandi@unsyiah.ac.id

Ishafit
Physics Education Department
Univeristas Ahmad Dahlan
Yogyakarta, Indonesia
ishafit@pfis.uad.ac.id

Nizamuddin
Informatics Department
Universitas Syiah Kuala
Banda Aceh, Indonesia
niz4muddin@unsyiah.ac.id

Khairul Umam
Mathematics Education Department
Universitas Syiah Kuala
Banda Aceh, Indonesia
khumam77@unsyiah.ac.id

Fashbir
Physics Department
Universitas Syiah Kuala
Banda Aceh, Indonesia
fashbir@unsyiah.ac.id

2021 2nd SEA-STEM International Conference (SEA-STEM) | 978-1-6654-1680-1/21/$31.00 ©2021 IEEE | DOI: 10.1109/SEA-STEM53614.2021.9668002

***Abstract*—Social distancing during the COVID-19 pandemic has changed many things in the way we teach. We are used to learning through video conferencing, e-learning, and virtual experiments such as PhET interactive simulation. However, the experience gained from an experiment in a real condition is still interesting to do and cannot be replaced by a virtual experiment. Therefore, we investigated several remote instrumentation models and technologies that were more effective and more efficient to develop. The results of our research show that the Node.js runtime environment is the most appropriate, effective choice because Node.js is based on open source, so that various microprocessors and various OS support it. We run Node.js on a low-cost device, Raspberry PI 4, with Ubuntu 20.10, a very familiar open-source OS. In addition, Node.js has a feature to communicate with the hardware, making it very easy to connect to experimental physics instrumentation. Because Node.js is based on javascript, it is indeed very suitable for developing web-based applications. We succeeded to carry out initial development through measurements on the magnetic field generated by a coil. Students can interactively control the movement of the sensor and see it in real-time during experiments of measuring the strength of the magnetic field generated by a coil. Experimental activities are part of STEM activities, so we call this remote experimental platform "Remote STEM", abbreviated as RSTEM.**

Keywords*—Remote Instrumentation, RSTEM, Node.js STEM Education

I. Introduction of RSTEM

The implementation of social distancing has significantly changed the way of learning, including the performance of conference meetings and lectures. One very efficient thing is that it can already do the theoretical physics learning process or face-to-face lectures through video conferencing applications such as zoom without spending energy and time to gather in one place[1]. The STEM Research Center experienced this efficiency during the implementation of the 1st SEA-STEM 2020 International Conference. It could invite nine keynote speakers without having to bring the speakers physically. In general, learning in lectures or theory can be carried out well, although there are still shortcomings due to technological adaptation in learning methods. However, practicum cannot be carried out at all, such as the Basic Physics practicum, which serves many students from various study programs. Even though, the implementation of the practicum is essential to provide real-world experience and compare with theory obtained from llectures.

Some teachers try to use simulation or animation, such as PhET simulation. These activities are often called virtual experiments or virtual laboratories[2]. Activities carried out virtually do not give a real impression and cannot wholly replace experiments carried out in real terms, so experiments still need to be carried out in real terms. Therefore, the practicum implementation while maintaining a distance is considered important to be developed with the concept of a remote experiment conducted in an IoT-based remote laboratory. Because experimental activities are part of STEM activities, this remote experiment can be called Remote STEM, abbreviated as RSTEM.

II. Physics of Magnetic Induction by Coil

Magnetic induction by an electric current can be explained by laws such as Biot Savart's law which describes the electric field produced by an electric current, as shown in Fig. 1, and expressed by equation (1). Biot Savart's law sees the current element Id*l* as a point element similar to Coulomb's law for electrostatics. The difference is that the electrostatic potential field is a scalar field, while the magnetostatic potential field is a vector field. Magnetic induction by an electric current can also be described by Ampere's law from the point of view of the integral magnetic field along a closed path surrounding the current.

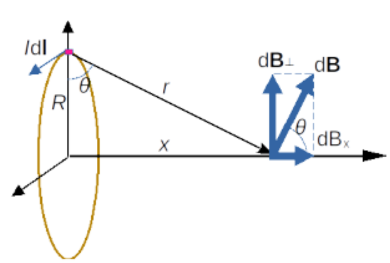

Fig. 1. Sketch for Biot Savart's law and the set of elements dl forming a circular coil

$$dB = \frac{\mu_0}{4\pi}\frac{Idl \times \hat{r}}{r^2} \qquad (1)$$

If the elements dl are always perpendicular to the vector r, then their angle is always 90 degrees so $dl \times r\text{^} = dl$. Due to the symmetry effect, the perpendicular components to the x-axis will cancel each other out and leave the x-component elements, as shown in equation (2).

$$dB_x = dB\cos\theta = \frac{\mu_0}{4\pi}\frac{Idl}{r^2}\cos\theta \quad (2)$$

Integrating the circumference of the path as long as $2\pi R$ avδ substituting the geometry for $\cos\theta = R / r$ dan $r = \sqrt{R^2 + X^2}$, we get the magnitude of the magnetic field on the x-component.

$$BB_x = \frac{\mu_0}{4\pi}\frac{I}{r^2}\cos\theta \oint_0^{2\pi R} dl = \frac{\mu_0 IR^2}{2(x^2+R^2)^{3/2}} \quad (3)$$

If there are more than one winding, the electric current needs to be multiplied by the number of turns. Equation (3) will be tested with the RSTEM platform.

To carry out experiments, of course, you need sensors to measure the magnetic field B. Magnetic field measurements can use the Hall effect, Proton Precision Magnetometer (PPM), and fluxgate. However, with the advancement of material science, magnetoresistance technology has been found and it can be implanted into a chip that can measure magnetic field vectors for three components. In this study, we use the QMC5883 anisotropic magnetoresistance chipset at a meager price combined with signal condition ASIC. The use of this sensor is extensive, e.g. as a compass in a smartphone. The sensor has a high-resolution 16-bit ADC and can achieve an accuracy of 2 milliGauss (0.2 uT), and it is very easy to be connected with controller devices via the I2C interface [3].

III. NODEJS SOLUTION FOR PROPS AND WEB INTERFACING

A. *Searching web-instrument interfacing*

At the beginning of the proposal, we were unfamiliar with NodeJS technology. Still, we have experience using Common Gateway Interface (CGI) technology where web servers (such as Apache) can run external programs when needed. The program is usually written in the Perl language. After exploring some technology[4][5], we found the Node.js technology is more advanced because it can be a web server and communicate with the hardware. Another advantage of Node.js is that it is open-source software and cross-platform. Node.js was developed by Ryan Dahl in 2009 by utilizing the V8 engine from the Google Chrome web browser. Node.js is not a programming language but a runtime environment that runs on the server side using the JavaScript language to generate dynamic web pages [6].

Node.js can run web server functions using JavaScript with many libraries called modules with various main facilities. These modules provide the functions of networking tools, file system I/O, data streaming, and what is needed in the RSTEM platform is access to hardware I/O via various protocols such as UART, I2C, SPI, and parallel GPIO. To facilitate application development, frameworks such as Express.js and Socket.IO were created. To install the module, the npm package manager was developed to make the installation process more manageable. The Node.js module uses application programming interfaces (APIs) to reduce the complexity of writing programs. For writing program code, including debugging facilities, you can use Visual Studio Code [7].

The Node.js server can be connected and accessed by multiple clients at once by utilizing web sockets and getting feedback for all clients instantly without refreshing the webpage.

B. *Node.js programming*

Node.js requires a relatively large power and processor and is somewhat incapable of running on a small microcontroller. Therefore, to run the JavaSciprt command, the host-client method is used. Where on the host, there is Node.js which will run JavaScript commands. For this host in this study, we use raspberry 4 running Node.js v14.17.2. Many advantages are obtained both in terms of hardware and software with the host-client method. The communication between the host-client uses the UART protocol with the help of the serial port module.

The data received by node.js is transferred to the user's web browser using the socket.io module. Socket.io is an open-source real-time engine built on top of Node.js. With Socket.io, we can communicate in real-time, two-way, and event-based communication. With event-based communication, we don't need a request to get the latest data, all we need to do is listen/subscribe to a topic. So as long as WebSocket remains active and listens to an issue, if there is new data in that topic, we will get the data automatically. Both server and web-client have main functions and APIs, namely Event emitter, Event listener, and Broadcast. To transfer from the web browser, GUI to the instrument socket.io is used using the emit () method shown in Listing 1, equipped with an updated web element. Meanwhile, the web browser detects the arrival of data from the instrument using the on () method, as shown in listing 2.

```
// from web to instrument
var socket = io();
function clickR(evt) {
var x = document.getElementById("slideServo").value;
document.getElementById("labelServo").innerHTML =+x ++1;
document.getElementById("slideServo").value=+x ++1;
socket.emit('pipe1', {status:"a+\n"});
}
```

Listing 1. javascript example to send data from web-browser to instrument

```
// from instrument to web
socket.on('data',function(data){
console.log(data);
data2=parseInt(data);
if(data.charAt(0)=='a') {
  data2=parseInt(data.substring(1,data.length));
  document.getElementById("labelServo").innerHTML=data2;
  document.getElementById("slideServo").value=data2;
}
}
```

Listing 2. javascript example to received data from instrument to web-browser

IV. RSTEM PLATFORM FOR COIL MAGNETIC INDUCTION

The RSTEM platform must be capable of remotely instrumenting and observing it in real-time. Therefore, the platform must have a GUI connected via the internet with instruments and cameras for remote observation. On this occasion, we experimented with measuring the magnetic induction generated by a coil that is energized with the block diagram shown in Figure 2. Due to limited space at the USK STEM Research Center, we installed the equipment on the wall, as shown in Figure 3. The node.js web server program runs on a low-cost SBC Raspberry PI 4 with Ubuntu 20.04 operating system. The RSTEM GUI display for the magnetic induction coil experiment using the Firefox web browser is shown in Figure 4.

There is an instrument initialization button for homing positioning at the very top, which will place the leftmost sensor position until it touches the homing switch. The GUI provides facilities for writing text to the LCD. This is followed by setting the direction of the Forward, Idle, and Backward currents. Next is the menu to select the sensor-shift interval when the Left and Right buttons are pressed. After that, there is a getData button for the data acquisition process. The process can be repeated, the position can be shifted, and the results are collected in the accumulation form.

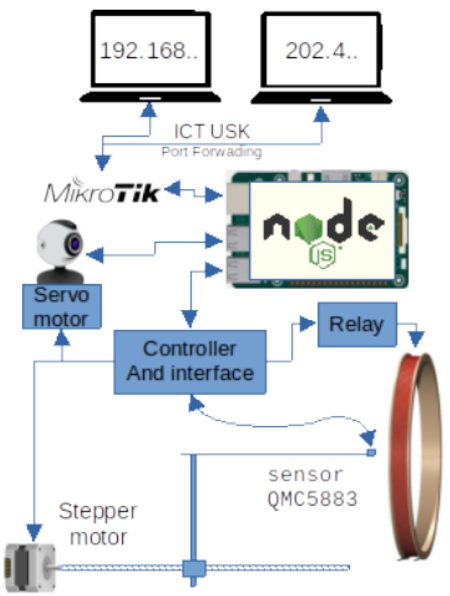

Fig. 2. Block diagram of RSTEM for magnetic induction by coil

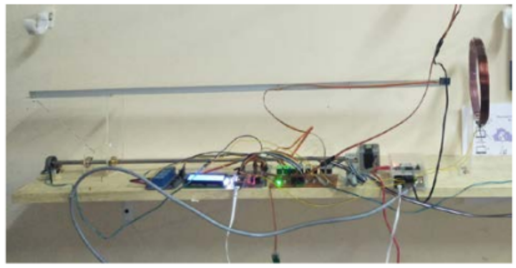

Fig. 3. Photo of RSTEM instrument for magnetic induction by coil

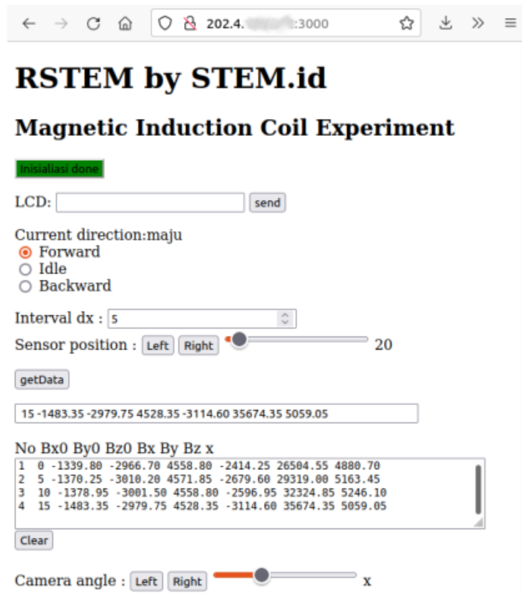

Fig. 4. GUI display running on the Firefox web-browser

Data from the accumulation form can be copied and pasted into the editor. The RSTEM platform is equipped with a webcam to show that the measurements are accurate, and the camera angle can also be adjusted by setting the last Left Right button. The results of the webcam capture are shown in Figure 5. The GUI web-browser page can be accessed locally and publicly, but the web-cam page cannot be accessed from the public network, which uses port 11000. It may need to be investigated further in collaboration with the USK ICT unit as the manager of the broadband internet network.

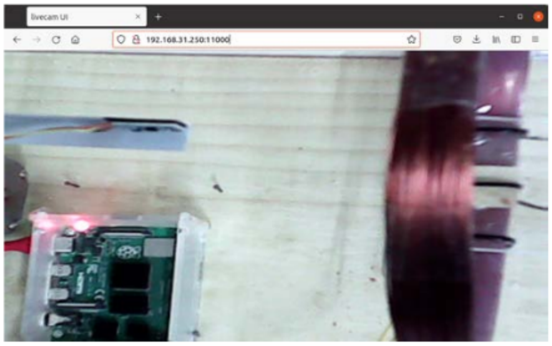

Fig. 5. Screen shot of camera view of the RSTEM

V. Result and Discussion

After completing the measurement from the leftmost position to the far right, the student can plot the results using Gnuplot, octave, or a spreadsheet. This paper is planned using the LibreOffice 7.2 spreadsheet for the reverse current. Once the data acquisition, the data obtained in the form of 8 columns in the form of: no, x, Bx0, By0, Bz0, Bx, By, Bz. The HMC5883L magnetic sensor can perform the acquisition of all three components simultaneously. Acquisition is done before the coil is electrified and when electrified. The purpose of the measurement before the coil is electrified and after is to be able to eliminate the background effect.

Figure 6 shows the measurement of the magnetic field when the components are Bx (red), By (blue), Bz (green) for the background effect where there is no electric current in the coil. The field of the Bz component is larger than the other components, which is consistent where the instrument is mounted on the wall of the research center, which is oriented from east to west. So the Bz position of the sensor points to the north and produces a value of about 40 uT, which is the range for the earth's magnetic field. However, the magnitude of the magnetic field is not constant along the x-axis due to the presence of a field generated by ferromagnetic materials from the bearing and stepper motor. However, this effect can be ignored when the coil generates the magnitude of the magnetic field energized by electrical current, as shown in Figure 7. In the figure, some data are far deviant, which may be due to data communication errors and need to be checked for the program. In order to eliminate the background effect, the value in Figure 7 is reduced by the value in Figure 6, and the results are shown in Figure 8.

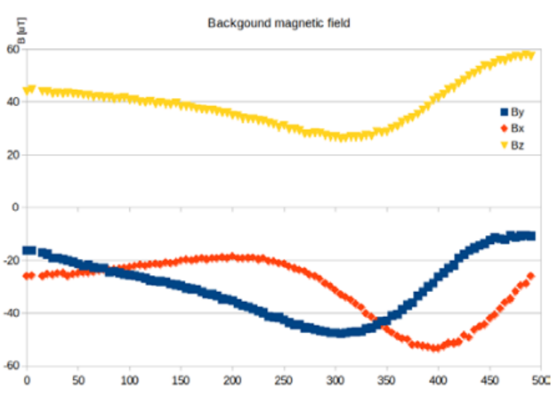

Fig. 6. Background magnetic field without electric current in the coil

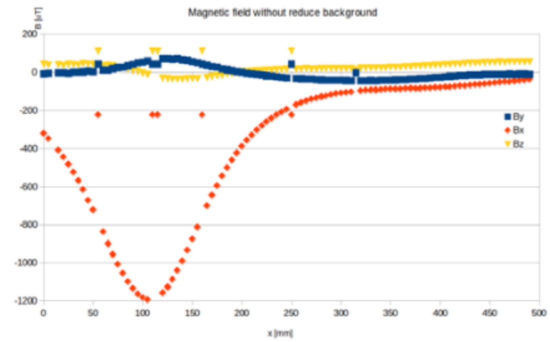

Fig. 7. The magnetic field when reverse current flows in the coil

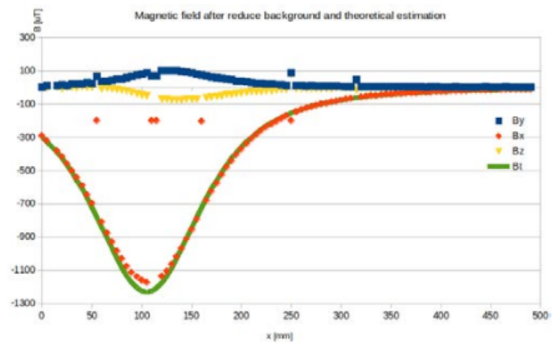

Fig. 8. The current-carrying magnetic field is reduced by the background magnetic field, compared with the theoretical obtained magnetic field based on equation 3.

Students can compare the results of magnetic induction measurements by direct remote coil experiments with the theoretical calculations of equation 3. In this equation, it is necessary to know the current value and the geometry of the coil radius. Equation 3 applies to one winding, and if the coil is more than one winding, then the current is multiplied by the number of turns where the instrument has 175 turns. The electric current flowing in the coil is measured using a multimeter, and the value is 0.94A. These values are entered into equation 3, then the value corresponding to the measurement results is obtained after setting the offset value to zero x. The experimental measurement value is suitable with theoretical predictions, as shown in the green line in Figure 8.

VI. Conclusion

The implementation of RSTEM has been successfully applied to the experiment of magnetic field induction by coils by utilizing Node.js technology with web server capabilities that can interact with instrument hardware. Apart from being influenced by the earth's magnetic field, the background field is also significantly affected by the ferromagnetic components of the RSTEM device. Therefore, the calculation of the induced field by the coil must be subtracted by the background magnetic field. The hardware and software from RSTEM still need to be updated, and for example, there are still some data acquisition errors. The appearance of the web-cam that can be adjusted for the angle view seems like an experiment is really happening. However, unfortunately, the web-cam can only be accessed from the USK local network and cannot be accessed from the public network by students. The RSTEM platform is expected to be an example to be widely applied to overcome social distancing problems during the COVID-19 pandemic and a future learning model.

ACKNOWLEDGMENT

This research was supported financially by research project *Penelitian Lektor* No 172/UN11/SPK/PNBP/2021 entitle "Development of an IoT (Internet of Thing)-Based Remote Instrumentation System as an Alternative for the Implementation of Physics Practicum in the Conditions of the Covid19 Pandemic". The tools and computer we used in the study came from NAS and USAID support under USAID Prime Award Number AID-OAA-A-11-00012.

REFERENCES

[1] A. Halim, E. Mahzum, M. Yacob, I. Irwandi, and L. Halim, "The impact of narrative feedback, e-learning modules and realistic video and the reduction of misconception," *Educ. Sci.*, vol. 11, no. 4, 2021, doi: 10.3390/educsci11040158.

[2] E. Stark, P. Bistak, S. Kozak, and E. Kucera, "Virtual laboratory based on Node.js technology," *in Proc. 2017 21st Int. Conf. Process Control. PC 2017*, 2017, pp. 386–391, doi: 10.1109/PC.2017.7976245.

[3] N. Systems, S. M. T. Sensors, L. Cost, R. Packaging, and P. Offset, "3-Axis Magnetic Sensor," *Sensors (Peterborough, NH)*, p. 1053.

[4] I. Ishafit, T. K. Indratno, and Y. D. Prabowo, "Physics Education Arduino and LabVIEW-based remote data acquisition system for magnetic field of coils experiments," pp. 0–7, 2019.

[5] I. Irwandi, R. Oktavia, Rajibussalim, and A. Halim, "Using the ELVIS II+ platform to create 'learning is fun' atmosphere with the ISLE-based STEM approach," *J. Phys. Conf. Ser.*, vol. 1470, no. 1, 2020, doi: 10.1088/1742-6596/1470/1/012003.

[6] S. Tilkov and S. Vinoski, "Node.js: Using JavaScript to build high-performance network programs," *IEEE Internet Comput.*, vol. 14, no. 6, pp. 80–83, 2010, doi: 10.1109/MIC.2010.145.

[7] C. Peters, "Building Rich Internet Applications with Node. js and Express. Js", in *Rich Internet Applications w/HTML and Javascript*, Oldenburg, Germany, Feb. 6, 2017, pp. 15-20.

7. 2021,Irwandi,Ishafit Node.js_for_Development_RSTEM.pdf

ORIGINALITY REPORT

7%
SIMILARITY INDEX

PRIMARY SOURCES

1	repository.lppm.unila.ac.id Internet	118 words — 4%
2	rp2u.unsyiah.ac.id Internet	19 words — 1%
3	Elin Yusibani, Yosuke Nagahama, Masamichi Kohno, Yasuyuki Takata, Peter L. Woodfield, Kanei Shinzato, Motoo Fujii. "A Capillary Tube Viscometer Designed for Measurements of Hydrogen Gas Viscosity at High Pressure and High Temperature", International Journal of Thermophysics, 2011 Crossref	15 words — 1%
4	www.proceedings.com Internet	13 words — < 1%
5	I Ishafit, T K Indratno, Y D Prabowo. "Arduino and LabVIEW-based remote data acquisition system for magnetic field of coils experiments", Physics Education, 2020 Crossref	12 words — < 1%
6	Xiling Luo. "The Logic of Homophily Dynamics in Heterogeneous Networks: Axiomatization, Model Checking and Validity Checking", Mathematics, 2023 Crossref	11 words — < 1%

7 I M Sari, E Yusibani, I Irwandi, H Sofyan, Suherman. "Analysis TPACK framework in ISLE-based STEM approach model: case study", Journal of Physics: Conference Series, 2021
Crossref

9 words — < 1%

EXCLUDE QUOTES	OFF	EXCLUDE SOURCES	OFF
EXCLUDE BIBLIOGRAPHY	ON	EXCLUDE MATCHES	OFF