Development of data communication trainer with hands-on and remote laboratory hybrid system

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Abstract. Data communication is the process of sending data that involves two or more devices connected to the network. This is influenced by several factors, depends on the type of data and data conversion media. The data conversion component can be in the form of RS232, which uses max232 IC as a conversion from TTL to Serial data or vice versa. This tool is a development of a data communication trainer where can see the characteristics of data communication via graphic LCD. Input from the trainer can be in the form of logic sent through the LCD touchscreen and received by the microcontroller. The data input will enter an Arduino, as a control component. The Arduino will process the input data and send it out as signal corresponding to the input data along with the signal characteristics. This tool is also equipped with an IoT system where input data can be put in from the internet network, and the output signal will appear on the page provided. The application of IoT to this tool makes it a hybrid system where can be accessed either directly in the lab, or via the internet.

1. Introduction
The rapid development of technology currently affects almost all areas of life, with no exception in the field of education. The development of Internet of Things (IoT) technology has become a frequent topic of discussion in recent years [1], where the use of the internet as a significant component in running a piece of equipment is inseparable from the process of data communication. This underlines the importance of the topic of data communication given in the learning process at the tertiary level.

To provide a more contextual experience about data communication, it requires direct practice with the support of training modules that can describe the flow and characteristics of data communication appropriately [2]. In addition, the era of the industrial revolution 4.0 with its IoT technology also encouraged the creation of hybrid training modules that allow access both directly and remotely via the internet.

Data communication practices usually do not use a trainer. This causes students to not understand the data communication process. Therefore a training module is needed that is able to describe the process of data communication and can train hands-on skills in sending data.

2. Methods
This trainer is made through two stages, the first is the design stage, both for direct use in the laboratory and for long-distance via the internet network. In the second stage, a training module is fabricated for
serial and parallel data communication using the main components of the MAX232 IC and Arduino mega, and the LCD as a display monitor. For remote practice via the internet, an ESP8266 module and application software can be accessed through a smartphone or Personal Computer, as shown in Figure 1.

Figure 1. General description of hybrid laboratory systems.

The flow of accessing the training module is shown in Figure 2. Through the flow can be seen, the user can choose to use the training module directly or through the internet network [3]. The topic provided is serial and parallel data communication. Both ways of practice are equipped with a guide and job sheet features, but only through direct access, users can practice wiring.

Figure 2. Flowchart access trainer.
The training module that is designed has two main features, namely direct practice and remote practice with different access settings.

![Figure 3. The main component of the system.](image)

3. Results and discussion

3.1. Hands on
Practicum directly allows users to experiment and read the characteristics of the data generated. Each data entered will produce a different signal on the screen, depending on the choice of a data type [4]. Figure 3 shows the training module features for hands-on practice.

The characteristics of RS232 with Max232 IC convert serial data into TTL or vice versa [5]. For TTL data generated from Arduino Mega will be connected to the transmitter (Tx). At this stage, there is learning about the characteristics of TTL data that is active in 5V voltage and brings the data and its drivers in one wire [6].

The next step is the conversion of data from TTL to serial using RS232 that is connected to the user's computer. At this stage, learning to read data sent with TTL characteristics and received in the form of serials [7]. At this stage, the user will be asked to analyse the data transferred.

The next step is to analyse the characteristics of RS232 itself by wiring each RS232 pin and checking the success of data transfer. At this stage, the serial data to the TTL process is also carried out at the same time. Serial data sent is sourced from the user's computer, which will be read by Arduino Mega and displayed Nextion graphic. At this stage, the user will be asked to analyse each DB9 pin which is a connector for Max232 and regarding serial data transfer to TTL.

The main components of the trainer consist of Nextion graphic, Arduino Mega, RS232, and ESP8266. Each part is interconnected through several communication techniques.

![Figure 4. Trainer architecture.](image)
The data that is input in this stage comes from the input Nextion, then is processed by Arduino and RS232. After processing, the data is then displayed again in the Nextion graphic in the form of a signal.

![Figure 5. Nextion graphic main menu.](image)

On the Nextion Graphic main menu, the user will be asked to choose the practicum to be performed. The options offered are serial data, parallel data conversion, and as shown in Figure 5. At this stage, the user can also see the guide or the practical work sheet.

![Figure 6. (a) Parallel data, (b) serial data, and (c) data conversion.](image)

The parallel menu consists of four bits of data inputted simultaneously as shown in Figure 6 (a), while the serial menu consists of eight bits of data inputted one by one as characteristic of serial data. At this stage, there is learning about the characteristics of serial and parallel data where parallel data works with four wires for four-bit data and eight-bit serial data using one wire [8]. The data conversion feature is an additional feature that functions to convert character data inputted into ASCII, Binary, Hexa, and Octal, as shown in Figure 6 (c). Arduino will process serial or parallel data input and displayed in the form of a signal.

![Figure 7. (a) Output signal serial and (b) output signal parallel.](image)

The output signal from the serial input will be different, the serial input will produce signal characteristics consisting of start, data, and stop bits. The signal also consists of two different voltage...
orders, namely TTL with 5V and Serial with 15V, as shown in Figure 7 (a). Parallel input will produce 4 data, namely D0 to D3, as shown in Figure 7 (b) according to the inputted data.

3.2. Remote laboratory

The main component of this feature is the ESP8266 module. ESP8266 is a component that functions to connect between Arduino Mega and the internet [9]. In ESP8266 coding, the WiFi ID and password settings are set to be used as a router so that Arduino can communicate with the internet. Arduino Mega functions as a processing device for every input, be it from Nextion or via the internet. Every input that is entered will be processed Arduino both inputting to generate signal and input data conversion. Making an android app is done by using firebase as a database and connecting the app with ESP8266. While coding using Android Studio.

This tool is a hybrid system that can be accessed directly or remotely, besides that this tool can also be used with a fix or portable techniques [10]. Remote access or remote laboratory uses ESP8266 for trainer communication with local routers to be accessed from anywhere. In the remote practicum can only do practicum reading characteristics and data conversion.

![Figure 8](image1)

(a) Remote data conversion and (b) remote data communication.

On remote systems, materials and job sheets are also provided, but with different rules and guidelines, as shown in Figure 8 (b). Additional features for data conversion are also still available in remote systems. The technique of generating signals on a remote system is different from Nextion, in Android studio, the nature of the graph is an image.

4. Conclusion

Based on the results and discussion, it can be concluded that the design of the data communication trainer with hands-on and remote laboratory hybrid systems was successfully made according to plan. This can be seen from each component can run well, starting from reading RS232 data, RS232 data conversion, serial data, parallel, and additional data conversion features. In addition, guides and worksheets also make the trainer more comprehensive so that the depiction of data communication becomes apparent. The remote system also works well, this can be seen from the trainer can be accessed both directly and via the internet.
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