Design and Development of Wireless-Based Electric Load Control Monitoring System on Autobuses Vehicles

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Abstract— **The structure of the electrical installation on the autobus is generally still based on the old concept that relies on the fuse, where the fuse is the only safety as well as an indicator of the presence of electrical power to several electrical devices contained in the autobus. For the condition that there is a short circuit on the line to the electrical load, the electrical devices on the autobus cannot be operated again. With the problems in the electrical system on the autobus, a monitoring system for controlling the power of the electric load used on the autobus vehicle was created automatically based on wireless. In this study, the system created using Arduino Uno is functioned as a server node. Then there is a sensor node which will later function to receive incoming data from the Ina219 sensor, then send it using wireless communication to the server node. Then on the server node, all data will be monitored via the LCD display and notification LED, then if there is excessive use the system will turn off the relay where the point is using excess power. From the test results, the sensor node is able to send data from the sensor node readings. Then it is sent to the Node Server and the results obtained are 2% for packet loss. The delay value is 0.29s for the highest result.**

Keywords—*Monitoring Power Load, Network Wireless, Electricity in Autobus*

I. INTRODUCTION

The structure of the electrical installation on the autobus is still based on the old concept that relies on the fuse. Monitoring of short circuit disturbances that may occur in the electrical installation of the autobus is still carried out through the fuse panel. For the condition that there is a short circuit on the path to the electric current load, the electrical devices on the autobus cannot be operated again. As a result, the flow of electric power is very large and if it cannot be anticipated it can result in an explosion or fire [1].

One technology to deal with problems in short circuit fault conditions on the path to the electrical load can be monitored and controlled using a WSN communication system. Wireless Sensor Network (WSN) is the latest technology that utilizes embedded systems and a set of sensor nodes to perform monitoring systems or transmit data wirelessly. The application of a wireless sensor network in a system must consist of at least two sensor network nodes. However, in practice, a WSN can consist of 10,000 to 100,000 sensors in it. The node on the WSN consists of a sensor, an ADC (Analog to Digital Converter) if the data sent is still analog data, an MCU (Micro Controller Unit), a storage unit, power management and an RF (Radio Frequency) Transceiver [2].

So that this system can display monitoring results where the location of the electrical load point that exceeds the usage limit, it will be displayed using the LCD. With an easy interface such as an LCD, it can make it easier to use to view monitoring results that have been arranged and programmed into the microcontroller according to user needs. If there is an excessive use of electric current that exceeds a predetermined limit, the system will give a notification, so that the user understands when there is an excessive use of electric current so that they can take a stand by reducing the use of electric current. If the use of excess current continues beyond a predetermined time limit, the relay will act as a switch to cut off the electric current [3].

In this study, we will discuss the design of a wireless-based power monitoring system for controlling used electrical loads as a load power controller. Data in the form of power consumption of each sensor node will send data to the server node and will display on the LCD screen and send notifications to the LED lights if there is excess power which will be monitored by the bus conductor.

II. RESEARCH METHOD

A. Electrical Power

Electrical power can be defined as the rate at which electrical energy is delivered in order to do work in an electrical circuit. Electrical power can be expressed in units of watts or Hoursepower (HP). In an electric power system, power is the energy used to do work or work, such as heat, sound, mechanics and light. The types of power forms in the AC power network with sinusoidal waveforms are apparent power, active power and reactive power. Active or real power is the power used by consumers used in the load. Its symbol is P and its unit is W (Watt):

The equation is:

$$\mathbf{P = V \times I \times cos} \quad (1)$$

Where:

P is the active power (Watts).

Cos is the power factor [4].

B. Bus Electricity

Based on interviews on data collection by the author of one of the bus mechanics at the bus body company (TENTREM). The electrical schematic on the bus is shown in Figure 1 below:

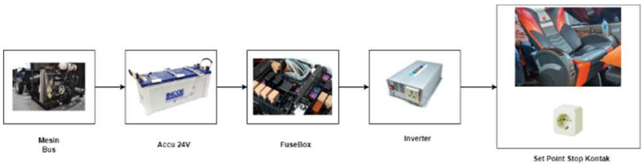

Figure 1. Electrical Schematic on the Bus

The electrical schematic on the bus namely, the first from the bus engine supplying current to the 24V battery. The second is to enter the fusebox, where all the power supplied from the bus is set to the fusebox. Third, after the fusebox, the voltage from the 24V Accu is converted to 220V AC voltage using an inverter. Fourth, after the inverter, it is then channeled to every set point on the bus that uses AC voltage, for example, such as a socket in every seat on the bus, mini-fridge, dispenser, coffee maker, and tv [5].

C. Wireless Sensor Network

Wireless Sensor Network or Wireless Sensor Network is a collection of nodes arranged in a cooperative network. Each node has processing capabilities (one or more microcontrollers, CPUs, or DSP chips), contains several types of memory (memory for programs, data, flash), has a radio frequency transceiver, has a power source (batteries and solar cells), and accommodates a variety of sensors and actuators. The nodes communicate wirelessly and can organize a system with the anticipated 1000 or even 10,000 nodes. Such systems could revolutionize the way we live and work. The increasing number of Wireless Sensor Network applications requires low network delay [6].

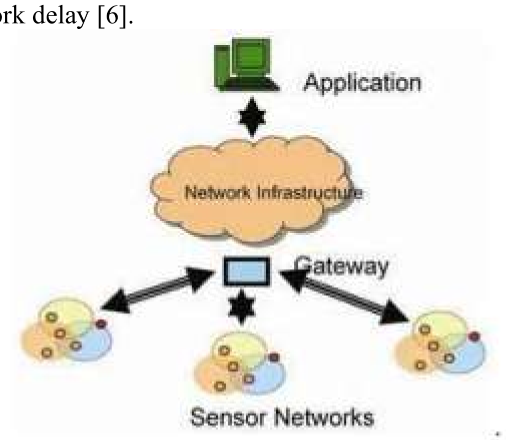

Figure 2. WSN Communication Illustration

D. Arduino Uno Microcontroller

Arduino Mega 2560 is a microcontroller board based on Atmega 2560. Arduino Mega 2560 has 54 digital input / output pins, of which 15 pins can be used as PWM outputs, 16 pins as analog inputs, and 4 pins as UART (hardware serial port), 16MHz crystal oscillator, USB connection, power jack, ICSP header, and reset button. This is all that is needed to support the microcontroller. Simply connect it to a computer via a USB cable or power it with an AC – DC adapter or battery to start activating it. The Arduino Mega 2560 is compatible with most shields designed for the Arduino Duemilanove or Arduino Diecimila. Arduino Mega 2560 is the latest version that replaces the Arduino Mega version [7].

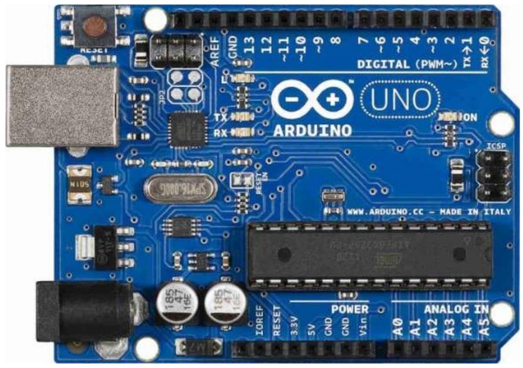

Figure 3. Arduino Uno

E. Ina219 Sensor sensor

INA219 is a sensor module that can monitor voltage and current in an electrical circuit. The INA 219 is supported by an I2C or SMBUS-COMPATIBLE interface where this equipment is capable of monitoring the shunt voltage and supply bus voltage, with program times conversion and filtering. The INA 219 has an amplifier whose maximum input is ±320mV this means it can measure currents of up to ±3.2A. With an internal data 12 bit ADC, the resolution in the 3.2A range is 0.8 mA. With internal gain set at minimum div8, max current is ±400mA and resolution is 0.1mA. INA 219 identifies the shunt voltage on the 0 – 26 V bus [8].

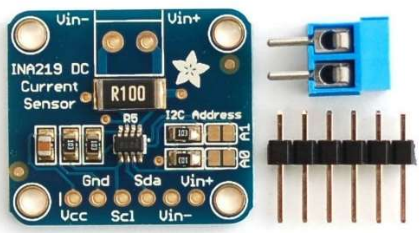

Figure 1. INA 219 Sensor

F. NRF24l01 Module

The NRF24l01 module can use 125 different channels and can create 125 networks in one area [7][10]. Each channel can have up to 6 addresses or in other words, one module can communicate with 6 other modules at the same time [4]. The pins on the NRF24l01 module are VCC, GND, CSN, CE, MOSI, MISO, IRQ. The VCC pin or power pin on the NRF24L01 module serves to input a voltage of 3.3 V. The GND pin or called the ground pin on the NRF24L01 module serves to connect the module to ground on this system. The CE pin or the so-called Chip Enable pin on the NRF24L01 module functions to enable SPI (Serial Peripheral Interface) communication. The CSN pin or the so-called Chip Select Not pin on the NRF24L01 module functions to activate the high input or turn off the SPI in a state other than high.

Figure 2. NRF24101

G. Relay Module

Relay is a switch lever with a winding wire on an iron rod (solenoid) nearby (Figure 4). When the solenoid is energized, the lever will be attracted due to the magnetic force acting on the solenoid so that the switch contacts will close. When the current is stopped, the magnetic force will disappear, the lever will return to its original position and the switch contacts will open again. Relays are usually used to drive large currents / voltages (eg electrical equipment 4 amperes AC 220 V) by using small currents / voltages (eg 0.1 amperes 12 Volt DC) [11][12].

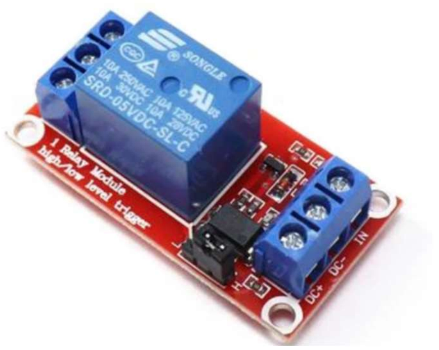

Figure 3. Relay Module

H. LCD Display

A 16 x 2 LCD is an LCD whose display is limited to display characters, especially ASCII characters (such as characters printed on a computer keyboard). While the Graphics LCD = Graphics LCD, is an LCD whose appearance is not limited, it can even display photos. LCD Graphics is what continues to grow like LCD screens commonly seen in notebooks / laptops. In this discussion, we will concentrate on the 16 x 2 LCD. Liquid Crystal Display (LCD) is a component that can display text. One of the types has two lines with each line consisting of sixteen characters. Such LCDs are commonly called 16 x 2 LCDs [13].

Figure 4. LCD Display

I. Block Diagram

To find out the design of the system to be built, a block diagram is made to explain the design of the sensor node system.

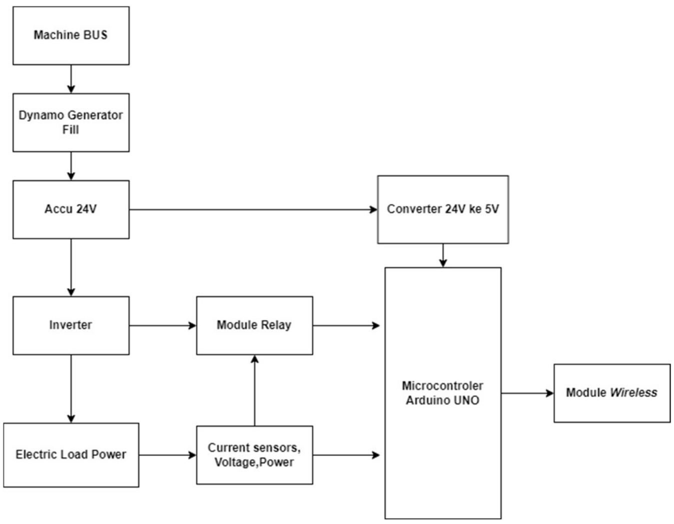

Figure 5. System node block diagram

When the Bus Engine is turned on or started, the charging system converts some of the engine speed into electrical energy through a dynamo generator. Then turn on the power to the 24V Accu. then the inverter will change from DC current to AC current, from this inverter will supply the electrical power needed to facilitate the bus. From the inverter itself, 8 sensors will be installed in the form of current, voltage, and power, to read whether the power used exceeds the output power load. The 5V converter is used for the power supply for the microcontroller. After the sensor receives input from the reading, it will then be processed on the microcontroller and then sent to the controller node using a wireless module. Then the relay here will turn off the line due to the largest use of electrical power so that there is no electric short circuit due to usage that exceeds the maximum limit.

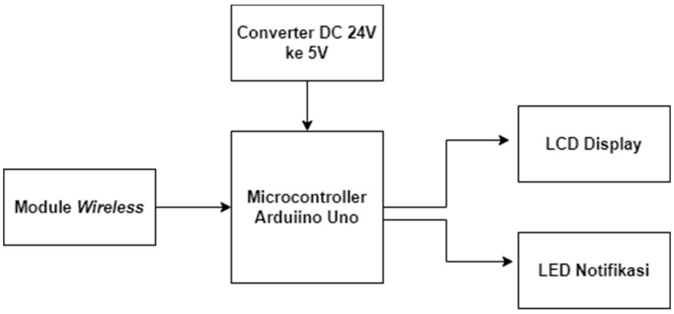

Figure 6. Server Node block diagram

When the wireless module receives data from the microcontroller then it is sent to the Master Node as a data processor. After processing, it will then be sent to the notification LCD and notification LED according to the node point, if the power is still normal or the power exceeds the limit according to the point where the power consumption is too large and will turn off the switch automatically according to the point where it exceeds the greatest power.

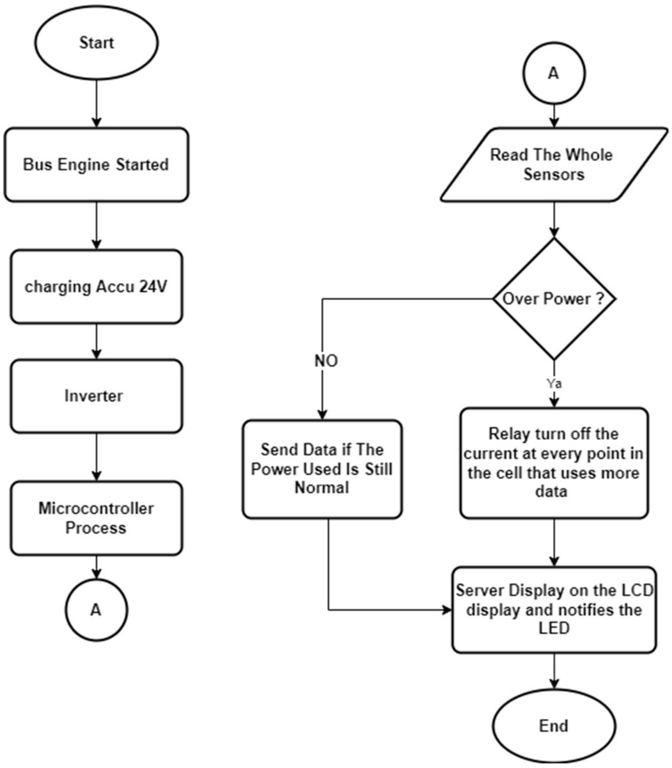

Figure 7. Flowchart of the whole system

First, when the bus engine is turned on, it will supply the contents of the dynamo generator after which the current is channeled to the 24V battery. then it will give current to the inverter, then the inverter will change from 24V DC current to 220V AC current [14]. After that it is processed by the microcontroller because it reads input from the current, power, and voltage sensors that come out of the inverter. then processed whether it exceeds the power or not. If it exceeds the power, the Relay will turn off the power that exceeds at every point of the sensor node and the server node sends a notification from the microcontroller reading to the LCD Display and LED. Otherwise the data will be sent through the microcontroller to the server node that the power is still normal and notify the LCD Display and LED [15].

III. RESULTS AND DISCUSSION

Overall discussion of the results of the hardware design design and discusses the results of system performance testing and discussion. The purpose of testing the system is to find out the designed system can function and work in accordance with the plan in "Design of Monitoring System for Power Control of Electric Loads Used in Autobus Vehicles". In this plan, it will be explained about the description of the communication system on the readings of each sensor node that is made. The data taken is related to the measurement result information data later on point to point communication.

In this test, it is carried out to determine the power used in the bus according to the point where the sensor node is located. This test was carried out on one day with different hours, and implemented an electrical system on the bus with a 24V Accu source, Inverter and loading to each sensor node. Figure 11 shows the results of the sensor nodes and server nodes.

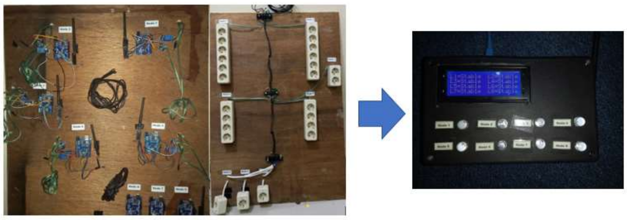

Figure 8. Result of sensor node and server node

Figure 12 shows the data reading by the Ina219 sensor which is processed by the microcontroller. The test scenario is carried out by plugging the load into the outlet to several sensor nodes. Next is observing the results displayed on the LCD display screen and notification LED. If the condition of all sensor nodes is stable or the power used is normal, then the LCD display will display the results of the sensor node process and the notification LED lights will be '0' or all off.

Figure 9. Result Node Server is in Stable state

If there is a condition where one of the sensor nodes detects excess power, the LCD display will display at which point the sensor node exceeds the load and the notification LED light will turn on as a sign of the location of the point that exceeds the load according to the sensor node, as shown in Figure 13.

Figure 10. Node Server results in overloaded

TABLE 1
SYSTEM TEST RESULTS

No	Date/Time	Node 1		Node 2	
		Power (W)	Status	Power (W)	Status
1	19/07/2022 10:30	49,55	stabil	84,55	over
2	19/07/2022 10:35	49,55	stabil	80,46	stabil
3	19/07/2022 10:40	80,46	stabil	80,46	stabil
4	19/07/2022 10:55	80,46	stabil	80,46	stabil
5	19/07/2022 11:15	80,46	stabil	84,55	over
6	19/07/2022 11:30	49,55	stabil	0,01	stabil
7	19/07/2022 11:45	100,21	over	0,01	stabil
8	19/07/2022 12:05	100,21	over	0,01	stabil
9	19/07/2022 12:30	0,01	stabil	84,55	over
10	19/07/2022 12:45	0,01	stabil	0,01	stabil

From the whole experiment, each node can detect power and issue status results from the sensor node which will be sent to the server node for display.

TABLE 2
TEST RESULTS PACKET LOSS SENSOR NODE DATA DELIVERY

No	Distance(m)	Packages Sent	Packages received	Packet Loss
1	1	50	50	0%
2	1	50	50	0%
3	4	50	50	0%
4	7	50	49	2%
5	7	50	49	2%
6	9	50	48	4%
7	9	50	49	2%
8	9	50	48	4%
Average				2%

From Table 2 it can be seen from sending 50 data between 8 nodes, based on testing packets sent with a distance of 1 - 9 meters, the average packet loss value is 2% because in the dominant bus there is no high barrier and minimal interference. The packet loss value for each node in the implementation can be calculated by the formula:

$$\frac{number\ of\ data\ sent\ -\ number\ of\ data\ received}{amount\ of\ data\ sent}\ x\ 100\%$$

TABLE 3
SERVER NODE DATA DELIVERY DELAY TEST RESULTS

Trial 1		Trial 2		Trial 3	
Node	Delay (s)	Node	Delay (s)	Node	Delay (s)
1	0,25	1	0,25	1	0,25
2	0,25	2	0,25	2	0,25
3	0,25	3	0,25	3	0,25
4	0,24	4	0,25	4	0,25
5	0,25	5	0,24	5	0,25
6	0,29	6	0,27	6	0,27
7	0,28	7	0,29	7	0,29
8	0,29	8	0,29	8	0,29

From the results of the delay test which was carried out by taking 3 experimental samples, different values were obtained, from experiment 1 to experiment 3, the lowest average delay value was 0.25s and the highest was 0.29s.

IV. CONCLUSION

The system is designed using the Arduino Uno microcontroller on the the sensor node section and the Arduino Uno microcontroller section, the master node section by using the nRF24101 communication module as a transceiver. Data obtained will be processed in the master node to be displayed on the LCD Display screen and notify the LED, so you can monitored in the use of electric power in autobus vehicles with using wireless sensor network technology. The Ina219 sensor is compared with a multimeter detection tool the difference in value with the percentage of error reached 3.41%. By percentage the error obtained, the Ina219 sensor can be used on the node sensors to determine the current, voltage, and power on autobus vehicles. The results of the communication using the nRF24L01 module from the sensor node to the node server with point-to-point communication model, can communicate on a maximum distance of 10 meters with an average delay of 6.98s and packet loss when sending data as much as 2%.

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