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An Electronic Device Reviewed by Diagnosing on the Modules Embodiment

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Abstract

An electronic device with various purposes needs in-depth study from the very beginning of the idea, before getting the final product. It relates to an essential role in providing user's infrastructure and service. The research objectives are to obtain the electronic circuits, modules, and devices by integrating the wiring. The research methods are conducted in the form of designing, manufacturing, assembling, and diagnosing. Designing stage is to obtain several electronic circuits as a liaison and the manufacturing stage to obtain the printed circuit board. The assembling stage is to obtain the gateway boards which controlled by the Arduino modules and diagnosing stage to obtain the interface device for communicating (IDC) is formed by integrating the wiring. Integrating several electronic circuits, modules, and devices have resulted in an IDC. Operating the IDC uses two different systems, i.e. from the telephony system to the radio-frequency system or vice versa with a half-duplex mechanism.

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INTRODUCTION

The electronic devices have used on the telecommunication networks in general [1] and as a radio communication system [2] are related to the types of equipment, operating principles, protocols determined, and frequency band standards to get automatic traffic [3], [4]. They have been become alternatives in choice of uses [5], variety of shapes and colors, and play an essential role in providing users' infrastructure and services [6]. An important stage to diagnose the relationship between components of the broad area in the form of an electronic module or mini motherboard is better known as the electronic circuit analysis [7]. In the scopes of electronics or telecommunication engineering or the others related to the electronic circuit design and analysis, the aspects in design and analysis are dealt with in the essential stages [8], [9]. The strategy in general of circuit analysis is to create and solve a system which is very closely related [10], [11]. Even though an electronic system formed from various electronic circuits has been fabricated and verification tests carried out, it is still possible to recheck related to the existence and connection between its components and figure out the values of voltage and current in each element [12], [13].

Related research for reviewing to diagnose the relationship between the electronic devices are described in the following paragraphs. The activity on electronic circuit analysis is one of the fundamental steps which help on the reviewing to the design results or finished product of electronic board or module that used for several purposes [14]. Even though efforts are made to minimize typing errors, printing mistakes, and other topographical errors, still there could be found some

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omissions [15]. The activity of analysis to the electronic circuit is very essential for any electronics engineer or someone whom expertise on the electronic circuit. Reviewing with the purposes is the activity to secure a job or to learn the concepts, the proper effort must be made is so important [16]. It is also for transferring a piece of new knowledge and skills, keeping it there from short-term to long-term memory. The reviewing activity is a more valuable or complex effort that needed to be put in [17].

The electronic device under tests (EDUTs) has captured responses after the signal coming from the electronic test equipment (ETE) is given to it [18]. The EDUTs with proper operation can be proven or faults in the device can be traced. Using the ETE is essential to make serious work with electronic devices and systems [8]. In the practical and assembly electronics engineering require the use of a lot of different kinds of ETE that range from the very simple and cheap price to very complex and sophisticated and highly price such as the automatic test equipment (ATE). The ATE often includes a lot of instruments in real-time and simulated forms [19]. The advanced gear test is necessary when and for developing circuits or modules and systems that are needed when doing the test of production or when existing with troubleshooting in the field of production units [4].

Based on the related research to review diagnose, then defined the problem formulations related to design some electronic circuit, fabrication of mini motherboard, assembly between modules, and the integrated wiring of several electronic circuits, modules, and devices [20]. The research on the design of an interface device between the communication systems based on Arduino modules has been well-drafted out [21]. Assembly amount of hardware, i.e., the modules of Arduino UNO R3 and MEGA2560 R3, the electronic circuits as the main component or subsystem and support systems followed by integration of all the components of electronic are carried out with wiring on the input and output ports connected to the radio-frequency and telephony systems [20]. The block diagram of the relationship between the gateways in the interface device system [20] is shown in Figure 1.

Making a workable specification is needed to start producing a prototype for the design so that the design specification is well-drafted out. The electronic circuit design is often a race against time in prototypes to turn into deployable of the production units. To get there, some stages are needed to go through the design, i.e., planning, schematic drawing, printed circuit board (PCB) layout, and prototyping. The microcontroller-based electronic prototype [22], [23] or the other is unique as an interface device for communication system with different protocols and standards, but still half-duplex type not full-duplex [20]. However, this design is a simple idea to bridge two different systems that can be communicated [24].

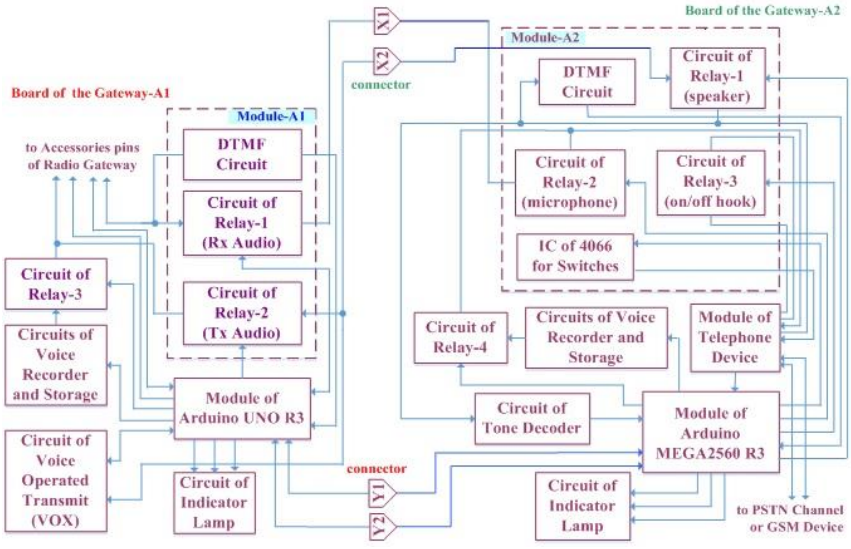


Figure 1. The block diagram of relationship between the gateways in the interface device system

Guided by the formulation of the problems, so that described the analysis between the electronic circuits that have been made or over the several modules. Based on some stages that are needed, the research objectives were set which included diagnosing a) several the electronic circuits as a liaison and combining them in an integrated board, b) the gateway boards are controlled by the Arduino modules, and c) the IDC is formed through integrated wiring.

METHOD

The research materials in the form of hardware and software are needed to conduct all the research objectives. The hardware related to the manufacture of several electronic circuits is the MT8870E IC type DTMF decoder, chip of 4066, electromechanical relays, and some resistors, capacitors, transistors, and diodes. The hardware related to obtaining the two gateway modules is (i) Arduino modules (UNO R3 and MEGA2560 R3) [21], (ii) the module of Voice Operated Transmit (VOX), (iii) the ISD2560 recording module, (iv) the circuit of tone decoder, (v) module of PSTN telephone, (vi) radio transceiver device, (vii) the GSM to analog phone converter, and (viii) microcontroller downloader. For the purposes of supplying electrical power, selected switched-mode power supply of 12 volts and 5 volts via voltage regulator chip of 7805. The required software, i.e., Easily Applicable Graphical Layout Editor (EAGLE) [25] and Arduino IDE [21].

This research is designing and manufacturing a mini motherboard, assembling several electronic circuits, modules, and devices, and carrying out integrated wiring with the time span of the activity is two months at the Laboratory for Instrumentation and Automation, Electrical Engineering Study Program, Faculty of Engineering and Science, University of Ibn Khaldun Bogor. The acquisition of the three research objectives is an effort to realize the half-duplex interface device for communicating based on the modules of Arduino UNO R3 and MEGA2560 R3 are controlled by the touch-tone signal or otherwise known as the dual-tone multiple-frequency (DTMF) signal [26].

The step for achieving the first research objective is in the form of the electronic circuits and integrated module by designing and manufacturing, whereas the second research objective is in the form of the electronic device through integrated wiring by assembling and diagnosing. The step to over the electronic circuits, modules, and devices as the integrated device by integrating the wiring. The flowchart for research methods is shown in Figure 2.

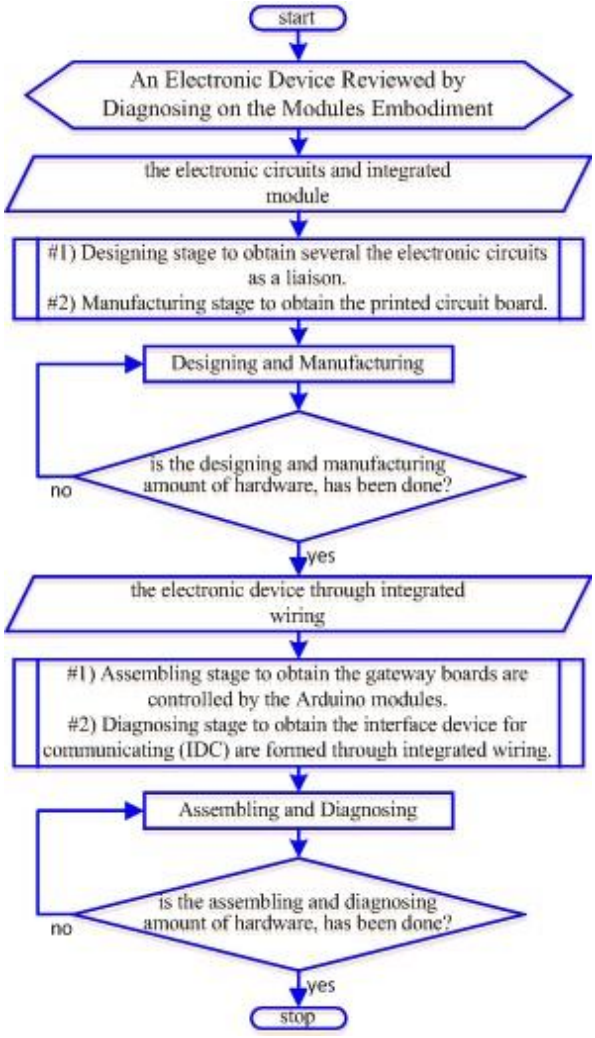


Figure 2. The flowchart for research methods

Based on Figure 2 it is shown that the research methods are carried out in stages related to the research objectives.

RESULTS AND DISCUSSION

Electronic Circuits and Integrated Module

This section contains an explanation of the design and manufacture, while the integration of the circuit is realized in the form of a mini motherboard or printed circuit board (PCB) as a form of the integrated module with several electronic circuits integrated into a single unit.

Electronic Circuits

This subsection contains an explanation of the electronic circuits for DTMF signal detection, switching, indicator lamp, and relay drivers.

1) DTMF signal detection circuit

The electronic circuit for detecting the frequency of the DTMF signal, e.g., the chip of MT8870E type DTMF decoder is used in which added with electronic components in the form of resistors, capacitors, and crystal oscillators with a frequency of 3.5796 Mhz., so that the circuit can operate to detect the frequency of DTMF signals. The DTMF signal frequency detection circuit which is used as a controller in accordance with the program created.

The schematic diagram of the circuit and electronic components for frequency detection of DTMF signals is shown in Figure 3.

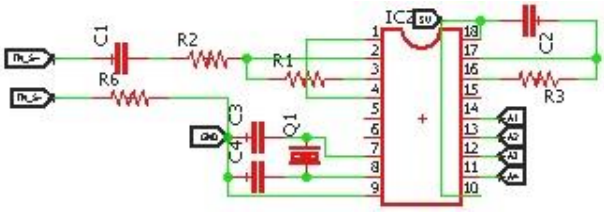


Figure 3. The schematic diagram of the circuit and electronic components for frequency detection of DTMF Signals

Based on Figure 3, it is shown that the electronic circuit for detecting the frequency of the DTMF signal.

2) Switching circuit

The circuit is installed on the A2 gateway module which functions as a gateway interface for telephone-based communication systems. Each IC component consists of four electronic switches in each switch consisting of one pin of input driver and two pins functioned as switches. The switch operates, if the pin of input driver is given a high input in the form of a voltage in the range of 3 to 5 volts. Installation of the resistors in parallel and connected to the ground line is function for a large reduction in the current flowing at the pin of input driver.

The schematic diagram of an electronic circuit using the IC of 4066 is shown in Figure 4.

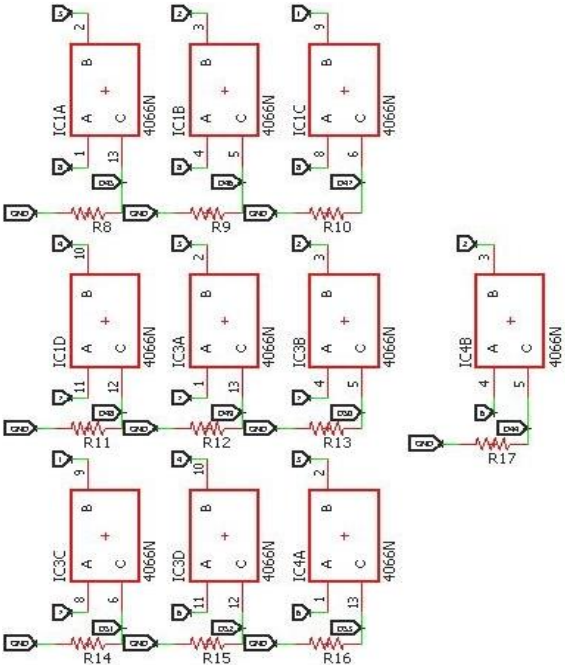


Figure 4. The schematic diagram of an electronic circuit with IC of 4066

Based on Figure 4 can be explained that the switch circuit with IC of 4066 is a replacement circuit for the push button (keypad) 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, *, # on the telephone module used by the system for calls to a specific telephone number.

3) Indicator lamp circuit

For conditions where the gateway-A1 board is connected when the module indicators of Push to Talk (PTT) radio, Carrier Operated Relay (COR), and the gateway-A1 and the gateway-A2 are connected, while the gateway-A2 board is connected when the module indicators of the ringer, voice signal, and the gateway-A1 and the gateway-A2 are connected. The indicator circuits are functioned as a visual indication when communicating between communication devices based on the radio-frequency and the telephony communication systems.

The schematic diagram of the indicator lamp circuit is shown in Figure 5.

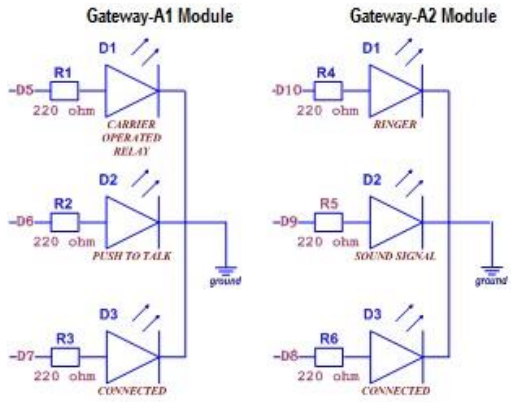


Figure 5. The schematic diagram of the indicator lamp circuit

Based on Figure 5 it is shown that the indicator circuit is a circuit of a series of indicator lights between the resistor and LED components.

4) Relay driver circuit

There are three relay driver circuits in the gateway-A1 board. The relay driver circuit is used for connecting the TX and RX voice signal lines from radio-based communication devices and to the microphone and speaker lines of telephony-based communication device, so that communication can be carried out between radio-based communication device and telephone-based communication device. The relay driver circuit to disconnect the voice signal is in the sound recorder and storage circuit.

The schematic diagram of the relay driver circuit in the gateway-A1 board is shown in Figure 6.

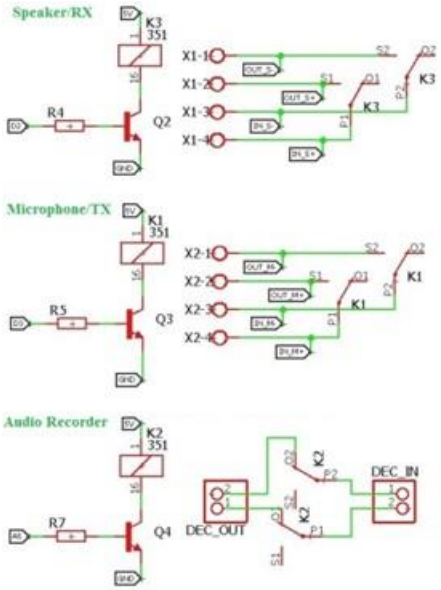


Figure 6. The schematic diagram of the relay driver circuit in the gateway-A1 board

Based on Figure 6 can be explained that the relay driver circuit is installed in the gateway-A1 and gateway-A2 boards.

The existence of a relay driver circuit on the gateway-A2 board consists of four relay driver circuits. In addition to the relay used for connecting voice signals to the microphone and speaker, there is also a relay as a substitute for the ON/OFF hook switch for the telephone module, so that the telephone module can be used for reception or telephone calls, and a relay driver circuit to disconnect voice signals of a sound recorder and storage circuit and a relay driver circuit used to disconnect of a voice signal from a sound recording and storage circuit.

The schematic diagram of the relay driver circuit in the gateway-A2 board is shown in Figure 7.

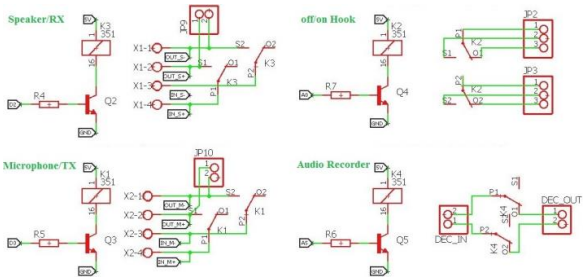


Figure 7. The schematic diagram of the relay driver circuit in the gateway-A2 board

Based on Figure 7 it is shown that the relay driver circuit is installed in the gateway-A2 boards.

Integrated Boards and Power Supply System

Manufacturing boards for the gateway-A1 and gateway-A2 boards are used for DTMF circuits, relay driver circuits, and IC for switches circuits. The processes of creating a board are assisted by the Easy Application Graphical Layout Editor (EAGLE) application. The Arduino's boards-based electronic device controlled by DTMF signals for a system consisting of several electronic circuits and components that are integrated into a single unit, so that the system can operate optimally. In the integration process required wiring of all electronic circuits. The electronic circuits in the interface device system are divided into two gateway boards. The gateway-A1 board is an interface for communication system based on radio-frequency and the gateway-A2 board is an interface for telephony-based

communication system. The circuits are integrated into the interface device system in the form of boards and supported by the power supply system. The PCB of gateway-A1 is shown in Figure 8.

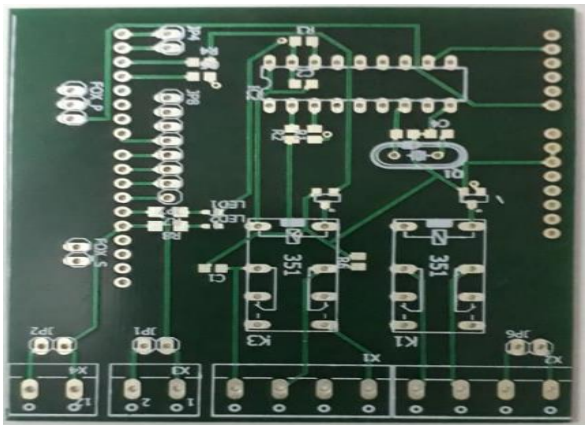


Figure 8. The PCB of gateway-A1

The PCB of gateway-A2 is shown in Figure 9

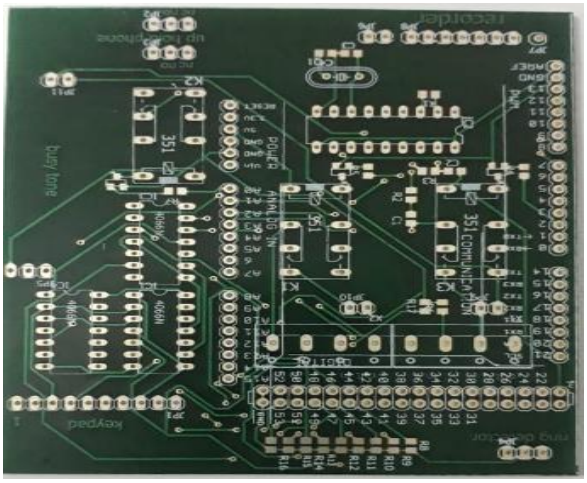
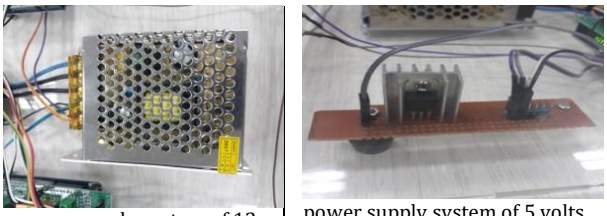


Figure 9. The PCB of gateway-A2

Based on Figure 8 and Figure 9 can be explained that the board is used for placing electronic components which include resistors, capacitors, transistors, relays, diodes, ICs, and others.

The main power supply used in the interface device system is a switched-mode power supply with 12 volts and a maximum current of 5 amperes. The systems are also made for supplying voice recording and storage circuits installed on the boards of gateway-A1 and gateway-A2. The measured output voltage is 12.20 volts when there is no load and 11.90 volts when there is a load. The measured output voltage value is 5.08 volts. Based on the results of these measurements, the indicated voltage value is relatively stable and can be used for power supply requirements at the minimum system.

The cross-section of the power supply device is shown in Figure 10.



power supply system of 12 volts

power supply system of 5 volts

Figure 10. The cross-section of the power supply device

Electronic Device through Integrated Wiring

This section consists of (a) the gateway-A1 board, (b) the gateway-A2, and (c) the integration of interface device.

Gateway-A1 Board

The grouping of several modules on the gateway-A1 board includes (i) module of Arduino UNO R3, (ii) circuits of DTMF and relay on the gateway-A1 board, (iii) voice recorder and storage circuit, (iv) circuit of Voice Operated Transmit (VOX), and (v) circuit of indicator lamp on gateway-A1 board.

1) Module of Arduino UNO R3

Several additional explanations in the following descriptions.

- The input pins are enabled, including pins A0, A1, A2, A3, and A4, while the output pins, including pins A5, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, and D13.
- In addition to the input and output pins, on the Arduino UNO R3 module there is also TX and RX pins for data communication purposes with other microcontroller device or device for continuous data communication purposes.
- The Arduino UNO R3 module is connected to the Arduino MEGA2560 R3 module in the gateway-A2 module via the TX/RX data pin which is used as a data communication line continuously.
- The power supply is used of 12 volts from a switched-mode power supply connected through the power supply port.
- The A0 pin is connected to the out pin of the VOX sound detection circuit, while the pins

of A1, A2, A3, and A4 are connected to the output pins of Q1, Q2, Q3 and Q4 of the DTMF tone detection circuit.

- Pin of D4 is connected to pin of 15 on the DTMF MT8870E IC in the DTMF signal detection circuit which functions as a detector for the presence of keypad button presses, pin of A5 is connected to the base of transistor Q4 through a resistor to drive the relay driver circuit-3, output pin of D2 is connected to the pin of transistor base Q2 through a resistor to drive the relay driver circuit-1, pin of D3 is connected to the base pin of transistor Q3 through a resistor to drive relay driver circuit 2, pins of D5, D6, and D7 are connected to the indicator light circuits, pins of D9, D10, and D11 are connected to the addressing input pins of A0, A1, A2, A3, A4, A5, A6, and A7, pin of D8 is connected to the CE pin on the sound recording and storage circuit, pin of D12 is connected to pin of the Carrier Operated Relay (COR) and pin of D13 is connected to the pin of the Push To Talk (PTT) on the accessories of radio device.
- The Arduino UNO R3 module is connected to the Arduino MEGA2560 R3 module in the gateway-A2 module via the TX/RX data pin which is used as a data communication line continuously.
- The power supply is used of 12 volts from a switched-mode power supply connected through the power supply port.

Configuring the pins on the Arduino UNO R3 module on the gateway-A1 board is shown in Figure 11.

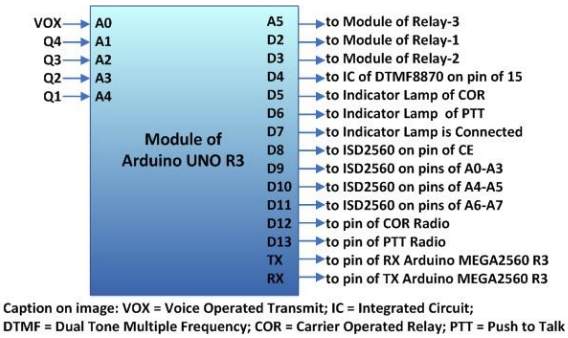


Figure 11. Configure the pins on the Arduino UNO R3 module on the gateway-A1 board

Based on Figure 11 can be explained that the Arduino UNO R3 module functions for processing input and output (I/O) data on the gateway-A1 board.

2) Circuits of DTMF and Relay on the gateway-A1 board

The DTMF signal input path is located at pin 2 (-IN), and as an output at pins 11 (Q1), 12 (Q2), 13 (Q3), and 14 (Q4). The input pin is connected to the RX sound line of the radio device at pin of 8, while pin of 15 is connected to pin of D4 on the Arduino UNO R3 module. The gateway-A1 board contains two relay driver circuits that function to connect voice lines between radio-based communication device and telephony-based communication device.

The circuit of relay-1 contains a transistor Q1 and in the circuit of relay-2 there is a transistor Q2 which functions as an electronic switch with the base pin connected to the Arduino UNO R3 module on pins of D2 and D3, the collector pins of the transistors Q2 and Q3 connected to one of the relay coil pins, the pin of emitter is connected to the ground line, while the other relay coil is connected to 5 volts of power supply. For the relay switch of pin of 1 is connected to the RX voice signal path from the radio-based communication device and the voice signal from the microphone on the telephone module. For the relay switch of pin 2, it is connected to the TX voice signal line from the radio-based communication device and the voice signal from the speaker on the telephone module.

The circuits of DTMF and relays on the gateway-A1 board are shown in Figure 12.

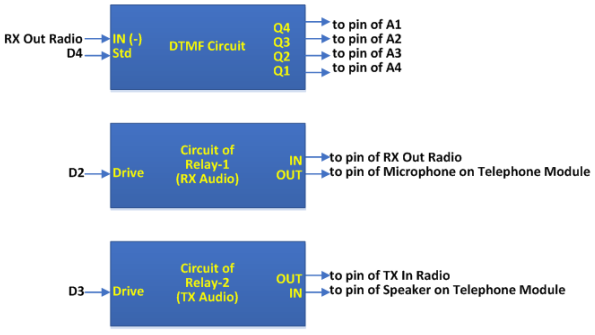


Figure 12. The circuits of DTMF and relay on the board of gateway-A1

Based on Figure 12 it is shown, that the DTMF circuit is mounted on the gateway-A1 board.

3) Voice recorder and storage circuit

Voices that have been recorded are used for automatic announcements according to the end user (end user) pressing the bottom push button/DTMF keypad. The input pins of A0 to

A7 of the sound recording and storage circuit are connected to the Arduino UNO R3 module at pins of D9, D10, and D11, and pin CE is connected to the Arduino UNO R3 module at pin of D8.

The connection of the circuit of sound recorder and storage in the board of gateway-A1 is shown in Figure 13.

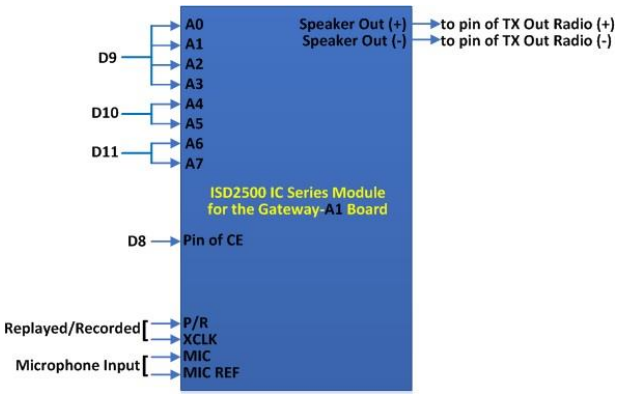


Figure 13. The connection of the circuit of sound recorder and storage in the board of gateway-A1

Based on Figure 13 can be explained that the function for voice recording and sound that is heard after recording.

Connection at the pins of D9, D10, and D11 for sound playback are shown in Table 1.

Table 1. Connection at the Pins of D9, D10, and D11 for Sound Playback

No.	Pins of D9, D10, D11	Address
1	000	0000 00 00
2	011	0000 11 11
3	101	1111 00 11
4	110	1111 11 00

4) Circuit of Voice Operated Transmit (VOX)

For conditions where the presence of a sound signal is detected on the input line, the output pin is logic of low, the output pin of this circuit is connected to the Arduino UNO R3 module on the gateway-A1 board; module at pin A0 as one of the input pins on the module of microcontroller. The input pin of circuit of VOX is connected to the speaker line in the telephone module installed in the gateway-A2 board.

The circuit of VOX connection in the gateway-A1 board is shown in Figure 14.

Figure 14. The circuit of VOX connection in the gateway-A1 board

Based on Figure 14 it is shown that the circuit of VOX functions to detect the presence of a signal that is used to drive pin of the Push to Talk radio (PTT), so that the radio signal is transmitted.

5) Circuit of indicator lamp on gateway-A1 board

The input lines on the indicator lamp circuit are connected to the output port on the Arduino UNO R3 module at pins of D5, D6, and D7. The connection of the indicator lamp circuit is shown in Figure 15.

Figure 15. The connection of the indicator lamp circuit

Gateway-A2 Board

The grouping of several modules on the gateway-A2 board includes (i) module of Arduino MEGA2560 R3, (ii) circuits of DTMF, switching IC, and relay, (iii) sound recorder and storage circuit, (iv) ring detector circuit, (v) tone decoder circuit, (vi) telephone device module and (vii) circuit of indicator lamp on the gateway-A2 board.

(1) Module of Arduino MEGA2560 R3

A number of additional explanations in the following descriptions.

- The activated-on input port are pins of A1, A2, A3, A4, D42, and D43, while the output port are pins of A0, A5, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D44, D45, D46, D47, D48, D49, D50, D51, D52, and D53.
- The pins of A1, A2, A3, and A4 are connected to the output of the DTMF signal detection circuit at pins of Q1, Q2, Q3, and Q4, while pin of D42 is connected to the out pin of the tone decoder circuit, and pin of D43 is connected to the speaker for detecting the ringing sound of the onboard module of telephone device (ring detector).

- The output port at pin of A0 is connected to the base pin of Q4 through a resistor to drive the circuit of relay-3, pin of D2 is connected to the base pin of the transistor Q2 through a resistor to drive the circuit of relay-1, pin of D3 is connected to the base of the transistor Q3 through a resistor to drive the circuit of relay-2, pin of A5 is connected to the base of transistor Q5 through a resistor to drive the circuit of relay-4, pins of D4, D5, and D6 are connected to address input port on pins of A0, A1, A2, A3, A4, A5, A6, and A7, while pin of D11 is connected to the CE pin (pin of 15) on the sound recording and storage circuit, pins of D8, D9, and D10 are connected to the indicator light circuit, while pins of D44 to D53 are connected to the IC pins which is used to drive the switch IC circuit as a substitute for the keypad as the push button on the telephone device module.
- Moreover, while being connected to several circuits in the gateway-A2 board, the Arduino MEGA2560 R3 module is also connected to the Arduino UNO R3 module in the gateway-A1 board via the TX/RX data pins which is used as a data communication line continuously.
- The power supply voltage used is 12 volts of power supply system that comes from a switched-mode power supply connected through the power supply port.

Pins on the Arduino MEGA2560 R3 module connected to the gateway-A2 board is shown in Figure 16.

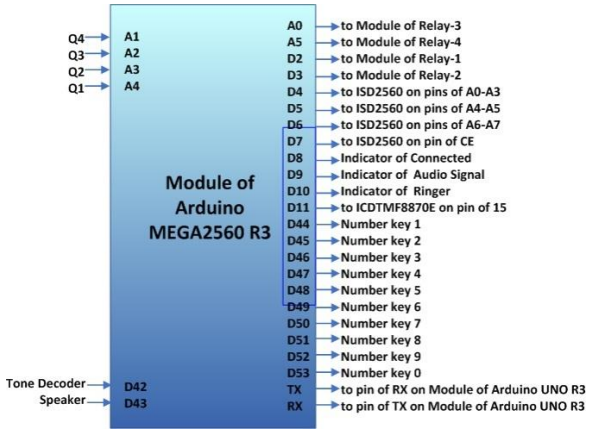


Figure 16. Pins on the Arduino MEGA2560 R3 module connected to the gateway-A2 board

Based on Figure 16 it is shown, that the module of Arduino MEGA2560 R3 functions for processing input and output data on the gateway-A2 board.

(2) Circuits of DTMF, switching IC, and relay

The difference lies in the gateway-A2 board which is equipped with a switching IC circuit that is used to connect to the telephone module instead of the bottom push button (keypad) which functions for telephone call activities. The DTMF circuit with input port at pin of 2 (-IN) and connected to the speaker line of the telephone module, while as output port, pins of 11 (Q1), 12 (Q2), 13 (Q3), and 14 (Q4) are connected to input port on pins of A1, A2, A3, and A4 on the Arduino MEGA2560 R3 module. The gateway-A2 board includes two relay sets that are used for connecting voice lines between telephony-based devices and radio-based devices in the pins of TX and RX voice lines, and one relay driver circuit used for activating the on/off hook switch of the telephone module. The circuits of relay-1 and relay-2 contains transistors Q2 and Q3 which function as electronic switches with the base pin connected to the Arduino MEGA2560 R3 module on pins of D2 and D3, the collector pins of transistors Q2 and Q3 are connected to one of the relay coil pins, while pins of the emitter is connected to the ground line, the other relay pin is connected to the power supply of 5 volts.

The detailed explanation, i.e.: a) the switch on the circuit of relay-1's pins are connected to the voice signal line from the speaker on the telephone module and the TX voice line from radio equipment, b) the switch on the circuit of relay-2's pins are connected to the voice signal line for the microphone from the telephone module and the RX voice signal line from radio equipment, and c) the switch on the circuit of relay-3's pin is connected to the on/off hook switch of the telephone module. The pins of the switch IC devices have been described previously that each IC for switch contains 4 switches in it, so that for the adequacy of needs in the interface device system, three ICs for switch are used. Each IC switch has one pin that functions to drive the IC switch and two pins that function as a contact point.

The IC switch pin of 1 is used to drive the switch on pins 5, 6, 12, and 13 which are connected to pins D46, D47, D48, D45, and switch pins 1, 2, 3, 4, 8, 9, 10, 11 connected to the telephone module. The IC of switch's pin of

3 is used to drive the switch on pins of 5, 6, 12, and 13 which are connected to pins of D50, D51, D52, and D49 and switch pins of 1, 2, 3, 4, 8, 9, 10, and 11 connected to the telephone module. The IC of switch's pin of 4 is used to drive the switch on pins of 5 and 13 which are connected to pins D44, D53, D52, and D49 and switch pins 3, 4, 10, and 11 which are connected to the telephone module.

The block diagram of the board of gateway-A2 is shown in Figure 17.

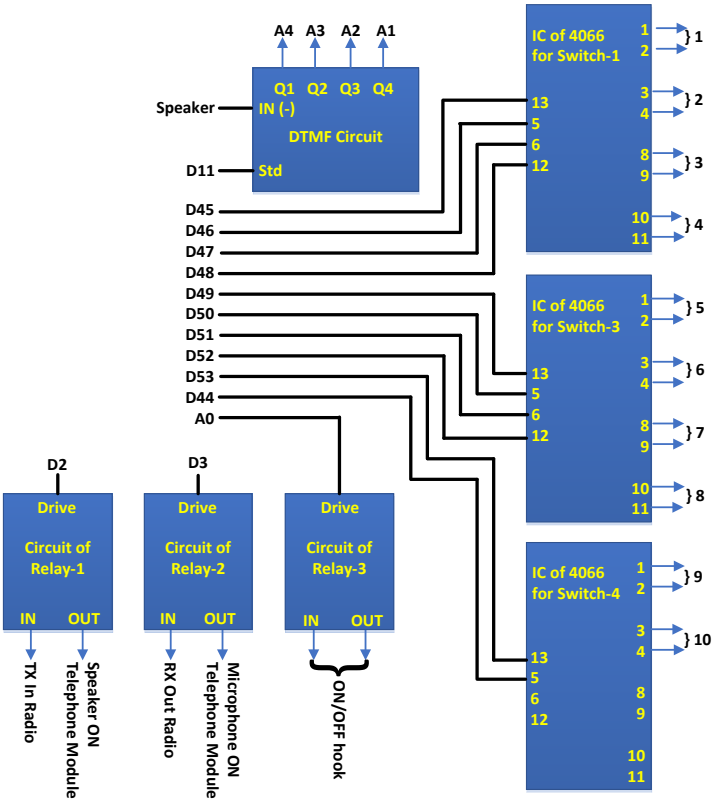


Figure 17. The block diagram of the gateway-A2 board

Based on Figure 17 can be explained that the circuits of DTMF, switching IC, and relay are installed on the gateway-A2 board with a circuit installation structure almost the same as the circuit installation in the gateway-A1 board.

(3) Sound Recorder and Storage Circuit

The recorded voice is used as an automatic announcement in accordance with the DTMF pushbutton/keypad pressing by the end user. The A0-A7 input pins of the circuit are connected to the microcontroller at pins D4, D5, and D6, and the CE pin is connected to the microcontroller at pin D7.

The connection of the circuit of sound recorder and storage in the gateway-A2 board is shown in Figure 18.

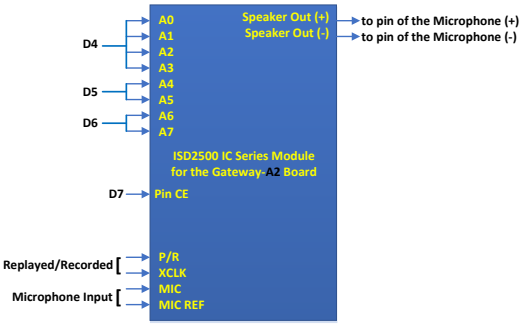


Figure 18. The connection of the circuit of sound recorder and storage in the gateway-A2 board

Based on Figure 18 it is shown that functions for voice recording and sound that is played back after being recorded.

Connection at Pins of D9, D10, and D11 for sound playback is shown in Table 2.

Table 2. Connection at pins of D9, D10, and D11 for sound playback

No.	Pins of D9, D10, D11	Address
1	000	0000 00 00
2	011	0000 11 11
3	101	1111 00 11
4	110	1111 11 00

(4) Ring detector circuit

The ring detector circuit is a circuit that functions to detect the ringing of the telephone module when there is a telephone call that enters the minimum system and then by the microcontroller input from the circuit is used to relay activation. The existence of a ring detection circuit in the minimum system only consists of a connecting cable for the pin D43 of the Arduino MEGA2560 R3 microcontroller with the ring speaker line located on the telephone module.

(5) Tone Decoder Circuit

The circuit is in the form of a module that contains components of resistors, capacitors, crystal oscillator 3.579545, and IC of LM567. The input pin of the tone decoder circuit is connected to the audio speaker line in the telephone module, while the output pin is connected to pin of D42 on the microcontroller which functions as an input pin.

The circuit of tone decoder circuit connection to the system is shown in Figure 19.

Figure 19. The circuit of tone decoder circuit connection to the system

Based on Figure 19 can be explained that the circuit of tone decoder is used to detect the tone frequency on the telephone line.

(6) Telephone device module

The push button (keypad) is replaced with an IC of switch circuit that is connected to the gateway-A2 board which functions for telephone call activities. The microphone line is connected to the sound recording and storage circuit, and the relay driver circuit is connected to the gateway-A1 board which is then connected to the RX radio audio line. The speaker line is connected to the Voice Operated Transmitted (VOX) circuit which functions as a trigger for the Push To Talk (PTT) pin of the radio device, so that it can be transmitted when sound is detected. The module of telephone device is used as a gateway interface to the telephone line.

Pins connection on the module of telephone device is shown in Figure 20.

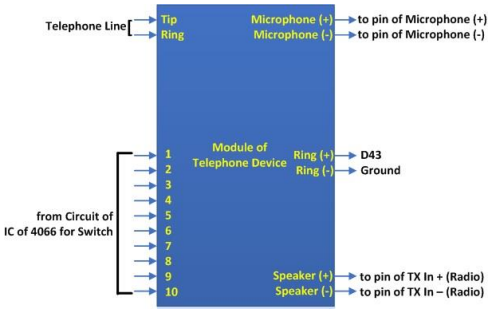


Figure 20. Pins connection on the module of telephone device

Based on Figure 20 it is shown that the module of telephone device that has been modified by removing the bottom push button (keypad), microphone, and speaker.

(7) Circuit of indicator lamp on the gateway-A2 board

The gateway-A2 board is connected to the Arduino MEGA2560 R3 module on pins of D8, D9, and D10 with their respective functions as a connected indicator, VOX, and ringer. The connection pins in circuit of indicator lamp on the gateway-A2 board is shown in Figure 19.

Figure 21. The Connection Pins in Circuit of Indicator Lamp on the Gateway-A2 Board

Integration of Interface Device System

The gateway-A1 is an interface for radio frequency-based communication systems and the gateway-A2 is an interface

for telephony-based communication systems. The interface device system controlled by DTMF signals is a system consisting of several electronic circuits and components that are integrated into a single unit, so that the system can operate optimally. In the integration process required wiring of all electronic circuits.

The block diagram of the relationship between modules on an interface device system based on the modules of Arduino UNO R3 and MEGA2560 R3 is shown in Figure 22.

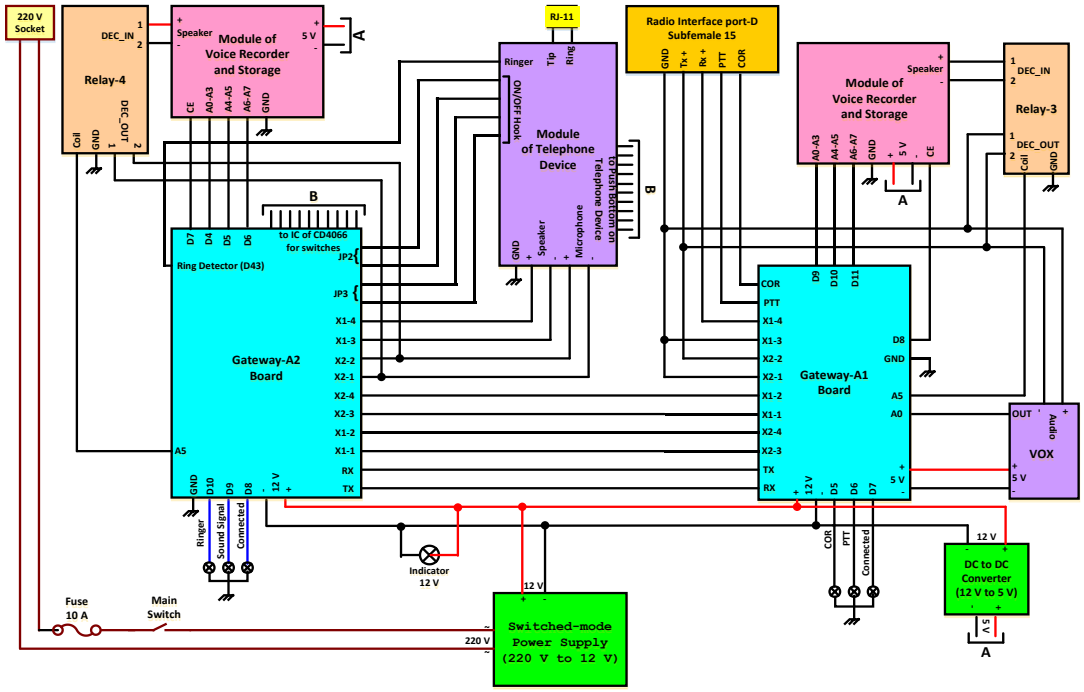
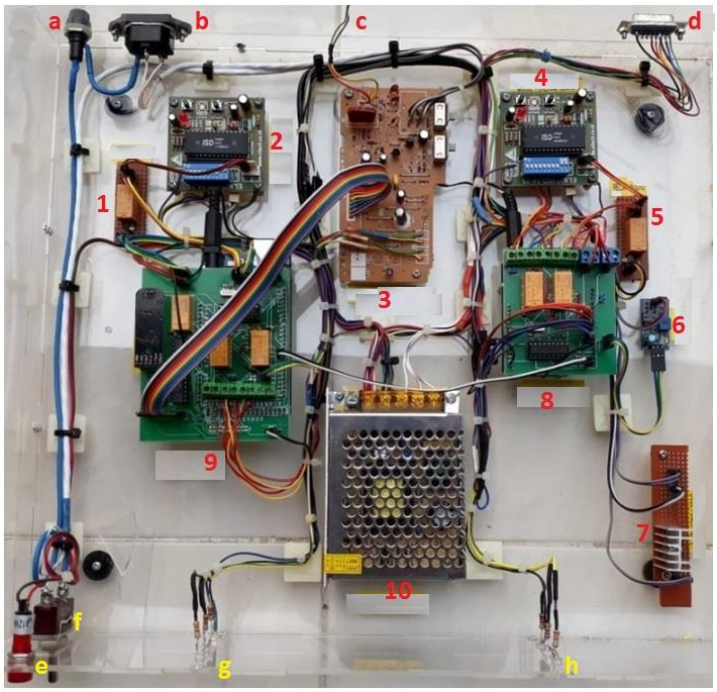


Figure 22. The block diagram of the relationship between modules on an interface device system based on the modules of Arduino UNO R3 and MEGA2560 R3

Based on Figure 22 it is shown that all modules are integrated in the interface device system as a whole in the form of the gateway-A1 and gateway-A2 boards and the switched-mode power supply system.

The gateway-A1 is an interface for radio frequency-based communication systems and the gateway-A2 is an interface for telephony-based communication systems. The interface device system controlled by DTMF signals is a system consisting of several electronic circuits and components that are integrated into a single unit, so that the system can operate optimally. In the integration process required wiring of all electronic circuits. The integration of interface device system to obtain the modules embodiment through integrated wiring is shown in Figure 23.



Captions on Figure:

[a] = fuse
[b] = inlet power socket (male)
[c] = phone line socket of RJ-11
[d] = PTT, e & m wire interface D-Sub 15 (female)

[1] = control relay for audio recorder of gateway-A2
[2] = A2 audio recorder module
[3] = module of phone interface
[4] =A1 audio recorder module
[5] = control relay for audio recorder of gateway-A1
[6] = voice detected module
[7] = module of 5 volt power supply
[8] = gateway-A1 board and Arduino UNO R3
[9] = gateway-A2 board and Arduino MEGA2560 R3
[10] = 12 volt, 5 A switched-mode power supply

[e] = input power indicator of 220 volt
[f] = ON/OFF toggle switch
[g] = indicators of PTT, COR, and link
[h] = indicators of ringer, VOX, and link

Figure 23. The integration of interface device system to obtain the modules embodiment through integrated wiring

CONCLUSION

Based on the results and discussion, then the conclusions are determined according to the research objectives. The Arduino-based electronic device is controlled by DTMF signals in the form of integration of two gateway boards, namely gateways A1 and A2 which are integrated into a unified system which consists of several electronic circuits, modules, and devices. The gateway-A1 board is an interface device that is connected to a radio-based communication device, while the gateway-A2 board is an interface device that is connected to a telephony-based communication device. The interface device can be carried out from the communication devices based on radio and telephony communication systems (PSTN or GSM).

Completing the conclusion, programming the minimum system based on Arduino IDE includes determining algorithms and writing syntax to control the minimum system. The recommendation for further work is; (i) in the form of application a verification test by providing voltage magnitudes at the input port and observing the response at the output port uses the measuring instrument and (ii) implementing a validation test on the IDC, through the provision at the input port and observing the response at the output port.

REFERENCES

[1] M. Maemunah and M. Riasetiawan, "The Architecture of Device Communication in Internet of Things Using Inter-Integrated Circuit and Serial Peripheral Interface Method," 2018 4th International Conference on Science and Technology (ICST), 2018, pp. 1-4, doi: 10.1109/ICSTC.2018.8528663.

[2] A. Goeritno, I. Setyawibawa, and D. Suhartono, “Simple Methods for Coverage Prediction of the Digital Trunking Radio Communication System”, INFOTEL, vol. 13, no. 4, Dec. 2021. doi: 10.20895/infotel.v13i4.674

[3] R.K. Morrow, Telecommunications Network. Encyclopedia Britannica”, 2016. https://www.britannica.com/technology/telecommunications-network

[4] M. Abiad, S. Kadry and S. Ionescu, "Cost efficiency of Telecommunication Equipment- A Review," 2018 4th International Conference on Applied and Theoretical Computing and Communication Technology (iCATccT), 2018, pp. 275-280, doi: 10.1109/iCATccT44854.2018.9001962.

[5] J. T. J. Penttinen. “Introduction,” in The Telecommunications Handbook: Engineering Guidelines for Fixed, Mobile and Satellite Systems. Chichester, WS: John

Wiley & Sons, Ltd., 2015, March 16, pp. 1-19.

[6] R. S. E-T. Salim, and A. B. A. Mustafa, "Mobile Satellite Services and VSAT Technology: A Comparative Study," IOSR J. of Electronics and Commun. Engineering (IOSR-JECE). vol. 16, no. 4, pp. 1-6, Jul-Aug. 2021. http://www.iosrjournals.org/iosr-jece/papers/Vol.%2016%20Issue%204/Ser-1/A1604010106.pdf

[7] H. Yevhen. "Methods of Assessment and Diagnosis of the Quality of Knowledge in E-Learning," J. of Commun. and Comp. vol. 12, no. 6, pp. 286-296. Dec. 2015 http://dx.doi.org/10.17265/1548-7709/2015.06.002

[8] T. Mei, D. Xiang, and D. Mayer, "A crucial step for molecular-scale electronics: a stable and reversible single-molecule switch. National Science Review," vol. 4, no. 5, pp. 666–667. Feb. 2017. https://dx.doi.org/10.1093/nsr/nwx017

[9] A. Zemliak, "Analysis of strategies of circuit optimization on basis of maximum principle," COMPEL-The Intern. J. for Comp. and Mathem. in electrical and electronic eng. vol. 37, no. 1, pp. 484-503, 2018. https://dx.doi.org/10.1108/compel-12-2016-0540

[10] T. Aven, Improving the foundation and practice of reliability engineering. Proceedings of the Institution of Mechanical Engineers, Part O: Journal of Risk and Reliability," vol. 231, no. 3, pp. 295–305, Apr. 2017. https://journals.sagepub.com/doi/pdf/10.1177/1748006X17699478

[11] T. Aven, "The reliability science: Its foundation and link to risk science and other sciences," Reliability Eng. & Sys. Safety, 215, 2021. 107863. http://dx.doi.org/10.1016/j.ress.2021.107863

[12] R. Brama, P. Tundo, A.D. Ducata, and A. Malvasi, "An Inter-device Communication Protocol for Modular Smart-Objects," 2014 IEEE World Forum on Internet of Things (WF-IoT). Seoul, Korea, March 6-8, 2014. doi:10.1109/wf-iot.2014.6803203

[13] G. Comina, A. Suska, and D. Filippini, "Towards autonomous lab-on-a-chip devices for cell phone biosensing," Biosensors and Bioelectronics, 77, 1153–1167, 2016. doi:10.1016/j.bios.2015.10.092

[14] D. Hindocha, A.K. Bagga, N. Atmande, and D.V. Rojatkar, "Next Generation Network: An Overview A Future Telecom Network. International Journal of Engineering Research & Technology (IJERT)," vol. 4, no. 3, pp. 675-680, 2015. http://dx.doi.org/10.17577/IJERTV4IS030913

[15] D. M. Fitzpatrick, "Transient Analysis," Analog Design and Simulation Using OrCAD Capture and PSpice, 2nd ed. Burlington, MA: Newnes, 2018, pp. 117–129. doi:10.1016/b978-0-08-102505-5.00007-0

[16] M. Xia, H. Shao, D. Williams, S. Lu, L. Shu, and C.W. de Silva. (2021). Intelligent fault diagnosis of machinery using digital twin-assisted deep transfer learning. Reliability Eng. & Sys. Safety, vol. 215, 107938, 2021. Available: https://dx.doi.org/10.1016/j.ress.2021.107938

[17] K. Kędzior, "Introduction to human factors and ergonomics" Int. J. of Occupational Safety and Ergonomics. vol. 24, no. 1, p. 1, 2018. http://dx.doi.org/10.1080/10803548.2018.1463724

[18] G.-A., Capolino, J. A., Antonino-Daviu, and M. Riera-Guasp, "Modern Diagnostics Techniques for Electrical Machines, Power Electronics, and Drives. IEEE Transactions on Industrial Electronics, vol. 62, no. 3, 1738–1745, 2015. doi:10.1109/tie.2015.2391186

[19] M. O. Sultonova, "Development of wireless telecommunication systems with the use of technologies of cognitive radio," The 2016 International Conference on Information Science and Communications Technologies (ICISCT). Kuala Lumpur, 2016. http://dx.doi.org/10.1109/icisct.2016.7777394

[20] A. Goeritno, I. Setyawibawa, and D. Suhartono, "Designing a Microcontroller-based Half-duplex Interface Device Drove by the Touch-tone Signal," J. INFOTEL, vo. 13, no. 4, 2021. https://dx.doi.org/10.20895/infotel.v13i4.712

[21] B. Massimo, and M. Shiloh, "The Arduino Paltform," Getting Started with Arduino,

3rd edition. Sebastopol, CA: Maker Media, 2015, pp. 15-22.

[22] A. Goeritno, J. Irawan, and Sopyandi, "Segmentation of Load Groups on a Single Phase kWH-meter Using the Payload Data Handling System," Int. J. of Advanced Research," vol. 6, no. 7, pp. 415-426, 2018. Available: http://dx.doi.org/10.21474/IJAR01/7378

[23] A. Goeritno, and M.Y. Afandi, "Designing a Security System Based-on Microcontroller Integrated into the Immobilizer System. Int. J. of Electronics and Commun. Eng.," vol. 6, no. 8, pp. 1-11, 2019. http://www.internationaljournalssrg.org/IJECE/2019/Volume6-Issue8/IJECE-V6I8P101.pdf

[24] K. Sverian, J. Haule, and M. Kisangiri, "Review of Radio Propagation Properties and Applications in Different Frequency Bands. Int. J. of Eng. Research & Tech. (IJERT)," vol. 2, no. 11, pp. 307-312, 2013. https://www.ijert.org/research/review-of-radio-propagation-properties-and-applications-in-different-frequency-bands-IJERTV2IS110054.pdf

[25] M. Scarpino, "Introducing EAGLE," Designing Circuit Boards with EAGLE: Make High-Quality PCBs at Low Cost. New York City, NY: Pearson Education, 2014, pp. 1-5.

[26] T. Page, "Touchscreen Mobile Devices and Older Adults: A Usability Study," Int. J. of Human Factors and Ergonomics," vol. 3, no. 1, pp. 65-85, 2014 http://dx.doi.org/10.1504/IJHFE.2014.062550