JURNAL INFOTEL
Informatics - Telecommunication - Electronics

Website Jurnal : http://ejournal.st3telkom.ac.id/index.php/infotel
ISSN : 2085-3688; e-ISSN : 2460-0997

Designing a microcontroller-based half-duplex interface device drove by the touch-tone signal

Arief Goeritno[1*], Ika Setyawibawa[2], Dwi Suhartono[3]
[1] Electrical Engineering Study Program, Universitas Ibn Khaldun Bogor
[2,3] PT Panorama Graha Teknologi, Jakarta, INDONESIA
[1]Sholeh Iskandar Street km.2 Kedungbadak Tanah Sareal, City of Bogor 16164, INDONESIA
[2,3]Komplek Perkantoran Graha Mas Pemuda Blok AB-7, Jalan Pemuda, Jakarta Timur 13220, INDONESIA
*Corresponding email: arief.goeritno@uika-bogor.ac.id

Received 8 September 2021, Revised 23 September 2021, Accepted 29 September 2021

Abstract — The interface device for communicating (IDC) as a bridge for the merger between two different systems based on different protocols and standards can be made of several electronic modules. The two Arduino boards (UNO R3 and MEGA2560 R3) have been constructed as the electronic modules of a gateway become a haft-duplex IDC, and are driven by the touch-tone signal. The research objectives, i.e., assembling some of the hardware for the embodiment of the adapter system, making a program structure, and performing a test of the IDC system. The haft-duplex IDC has been carried out by integrating all components by wiring to form an embedded system. Then, programming the microcontroller modules based on the Arduino software is carried outin six stages. Finally, the simulation test with the provision of conditions is carried out and obtained of six conditions for (i) the circuit of ring detection, (ii) the circuit of voice-operated transmit, (iii) the circuit off/on the hook of the telephone module, (iv) the circuit of tone decoder, (v) dial-up telephone numbers via push buttons and switching IC circuits, and (vi) the circuits of voice recording and storage in the form to playback. The test's success with six conditions has been an indication that the microcontroller-based IDC system is functioning as expected. Completing, the conclusion, and recommendationsrelated to measurement on the various purposes and the real conditions for the half-duplex interface adapter can be implemented.

Keywords – board of Arduino, half-duplex system, interface device for communicating, touch-tone signal.

I. INTRODUCTION

Differences in telecommunication networks related to the types of equipment, operating principles, protocols, and frequency band standards have become alternatives in their choice of use [1] and play an essential role in providing users' infrastructure and services [2]. The existence of telecommunication system equipment in the present era includes the electronic equipment for the four systems [1, 3, 4], i.e. (i) the fixed telephone, (ii) the mobile telephone, (iii) the radio communication system (RCS) or known as the radiofrequency system (RFS), and (iv) the satellite telephone (satellite phone or satphone) [4]. The fixed telephone and the mobile telephone are telephony-based systems. The fixed telephone is like an electronic circuit-based network with conventional telephony services or Plain Old Telephone Service (POTS) or better known as the Public Switched Telephone Network (PSTN) [5, 1, 4]. The mobile phone is based on the Global System for Mobile Communications (GSM) network [1, 3, 5]. The propagation of communication systems is closely related to the permeability of brick [6], whereas the frequency utilization is closely related to the atmospheric attenuation [7]. The RCS or RFS is a communication relationship with air media and radiofrequency as a signal that carries both data and audio information [1][3][5][8][9]. The satellite telephone is a telecommunication system with a type of mobile phone connected to a satellite in its orbit, not based on terrestrial communication (earth's surface) [10][1-3]. Electronic equipment as a bridge for the merger between the telephony-based systems and the radio communication system (RCS) has become a necessity. The bridge is better known as the interface device for communicating (IDC) as an

interface for communication systems with different protocols [3]. The term IDC, previously known as communication interface adapter (CIA).

Based on the background, some "states of the art" related to the IDC interface device for communicating (IDC) are described in the following paragraphs. One embodiment of electronic devices for the communication device to be used in two different protocols of course functionally connecting external devices that have interfaces conforming to different standards [3][5]. The end-user drives the combination of communication between the two different communication devices by pressing the push button on the telephone device. The previous push button is a rotary dial that was replaced by a simple telephone keypad on the newer touch-tone units. The keypad found on each telephone or radio device is a telephone number that became the industry standard for cell phones and landlines [11-12]. The keypad is the Dual Tone Multiple-Frequency (DTMF) [1][13][14]. Still, nowadays it is better known as the touch-tone signal which is generally regulated by technical standards created the International Telecommunication Union (ITU) [4].

The existence of the IDC system as a link between communication devices based on radio communication systems [9][1][5]. And telephony-based systems [5][1][4], which is based on communication on the earth's surface (terrestrial) [1, 3, 5, 9]. An electronic device such as an IDC may be portable and a cell phone handset [15]. The mobile handset is equipped with connectors and circuits that allow universal serial bus (USB) and single-ended (SE) data transmission modes with other devices such as personal computers, other mobile phone handsets, or the keyboard [15-17]. The IDC is dedicated to specific peripheral interfacing with a specific line. The communication interface adapter follows the same development philosophy of the multiple board adapter, including the indicators and switches mounted thereon [15].

The “state of the art” then defined the problem formulations related to the manufacture, assembly, and integrated wiring of several electronic modules. There are two modules of IDC that were made as a gateway device for the interface. A gateway is connected to a radio frequency-based communication device, and another gateway is connected to a telephony-based communication device. A block diagram of a microcontroller-based module of gateway driven by a touch-tone signal is shown in Fig. 1.

Based on Fig.1, it is shown that a microcontroller-based system [18] can be droving automatically by the user via the touch-tones signal [14]. The IDC existence is connected to a microcontroller. The microcontroller functions as a processor and determinant input/output (I/O) signal [15]. The signal comes from the sensor circuit, support circuit, and relay circuit .

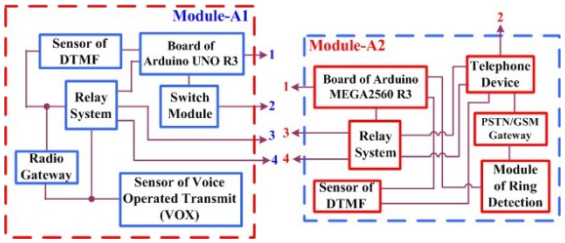


Fig. 1. A block diagram of microcontroller-based module of gateway drove by a touch-tone signal

That the drive is used as in the systems [19][20]. The end-user can be connected or disconnected by pressing the numeric code at the keypad on the communication device used. The IDC system [15] based on a microcontroller driven by the touch-tone signal, is unique as an interface for communication systems with different protocols, but still, half-duplex type, not full-duplex. However, this design is a simple idea to bridge two systems with two different communication protocols.

Guided by the formulation of the problems, the research objectives were set, which included #a) to assembly the main electronic modules and to integrate all of the components and support system by wiring to form an embedded system as an IDC driver, #b) to make a program structure for the Arduino modules based on Arduino software or Arduino Integrated Development Environment (IDE) [18], and #c) to perform a simulation test against the microcontroller-based IDC drove by a touch-tone signal [14].

II. RESEARCH METHODS

A. Materials of Research

To support the implementation of research methods the research materials in the form of hardware and software are needed. The hardware is an electronic component, namely (i) boards of Arduino UNO R3 and MEGA2560 R3, (ii) DTMF module, (iii) the module of Voice Operated Transmit (VOX), (iv) the ISD2560 recording module, (v) the circuit of tone decoder, (vi) module of PSTN telephone, (vii) radio transceiver device, (viii) the GSM to analog phone converter, (ix), some of the resistors, chip 4066, capacitors, transistors, electromechanical relays, and diodes, (x) voltage regulator chip of 7805, (xi) switched-mode power supply of 5 Vdc and 12 Vdc, and (xii) microcontroller downloader. The required software, i.e., Easily Applicable Graphical Layout Editor (EAGLE) [21] and Arduino IDE [18].

B. Flowchart of Research Methods

The research methods flowchart is shown in Fig.2.

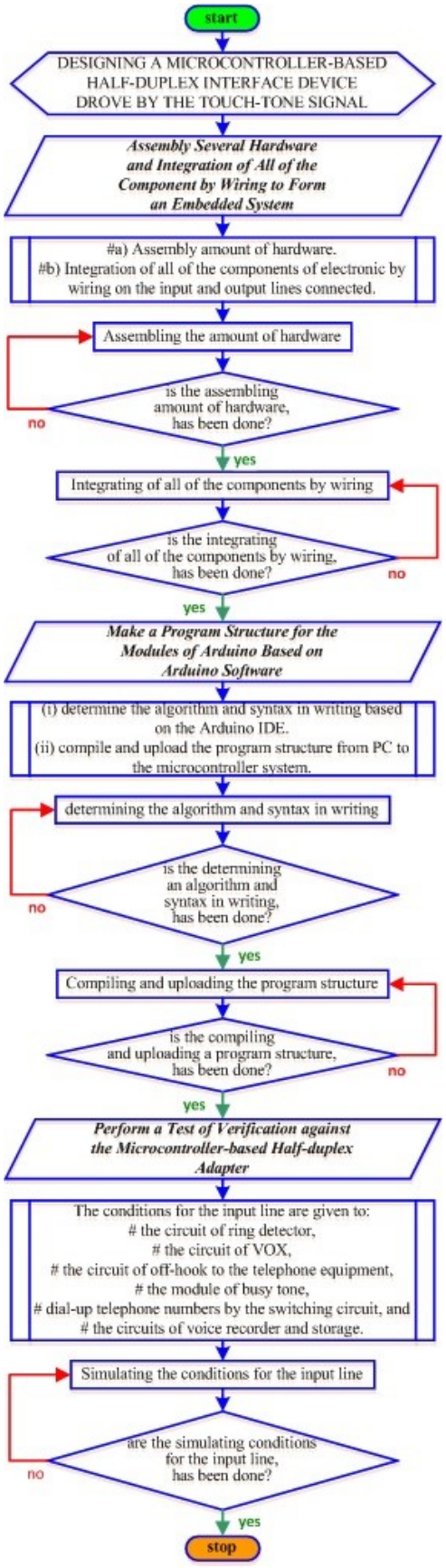


Fig. 2. The research methods flowchart

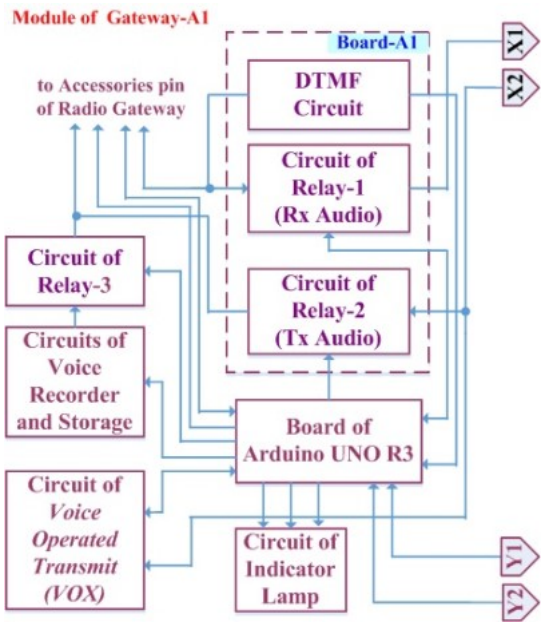
Based on Fig.2, it can be explained that for the achievement of each research objective, some stages must be carried out sequentially, namely assembly several of the hardware, making the programming based on Arduino software, and performing on simulation.

Assembly amount of hardware, i.e., the modules of the Arduino UNO R3 and MEGA2560 R3, the electronic circuits as the main component or subsystem and support systems followed by integrating of all of the components of electronic are carried out by wiring on the input and output lines connected to radio and telephony systems. Make the program structure to the boards of Arduino are carried out (i) by determining the algorithm in the form of a flow chart and syntax in writing based on the Arduino IDE and (ii) by compiling and uploading the program structure from PC to the microcontroller system. Perform the verification test in the form of a simulation against the IDC system, including by providing conditions for the input line and observing the output conditions. The conditions for the input line are given to the circuit of ring detector, the circuit of VOX, the circuit of off-hook to the telephone equipment, the module of busy tone, dial-up telephone numbers by the switching circuit, and the circuits of voice recorder and storage.

III. RESULTS

A. Assembly Amount of Hardware and Integration of All of the Components by Wiring

The block diagram of the relationship between the gateway modules based on the microcontroller system in the IDC system driven by the touch-tone signal is shown in Fig.3.



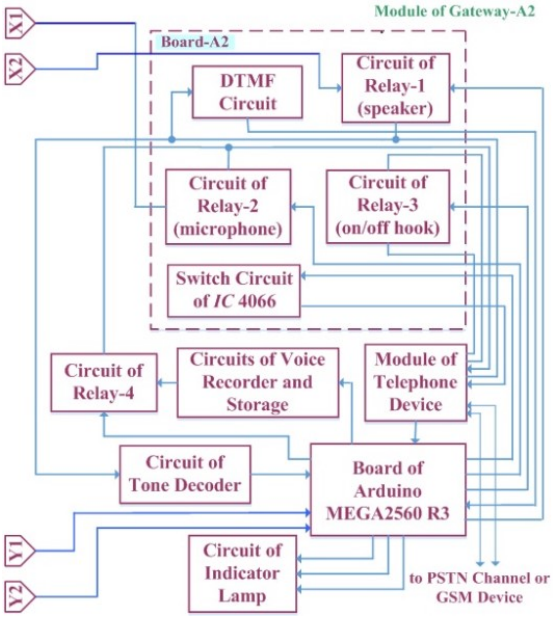


Fig. 3. The block diagram of the relationship between the modules of gateway in the IDC system based on microcontroller system drove by the touch-tone signal

An IDC system based on a microcontroller drove by a touch-tone signal is shown in Fig. 4.

The input/output connection line pins on the Arduino UNO R3 on the module of gateway-A1 is shown in Fig. 5.

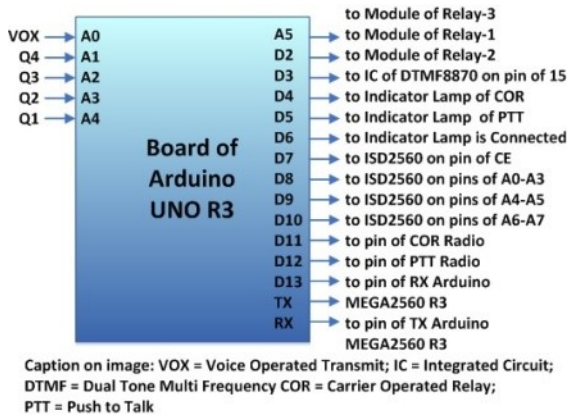
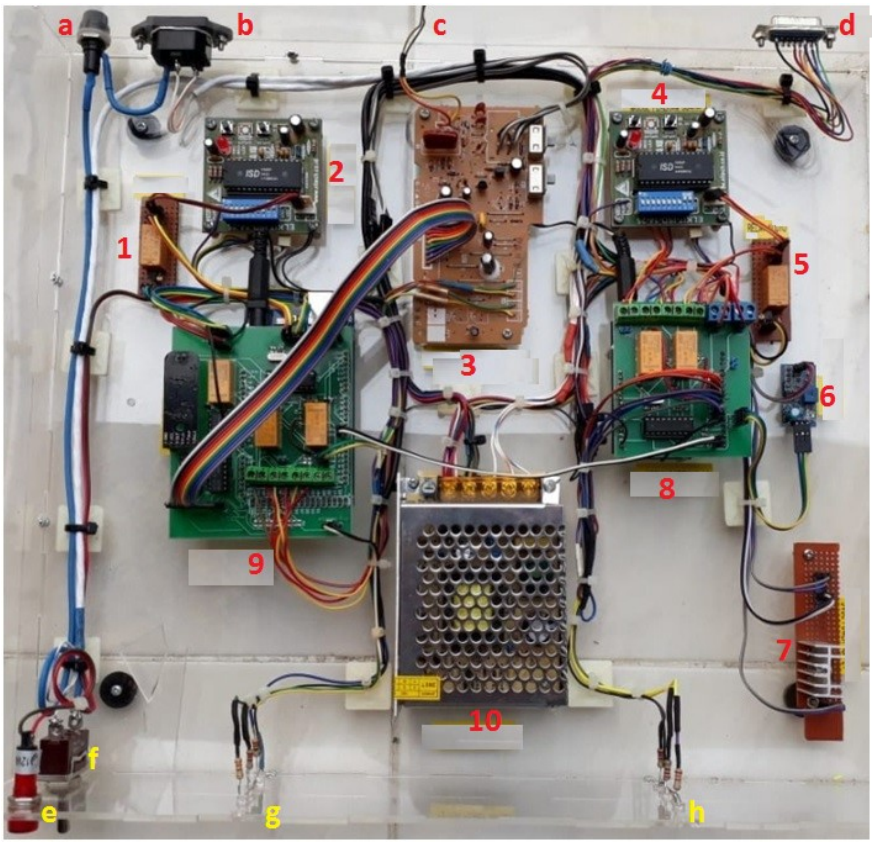


Fig. 5. The connection of the input and output line pins on the module of Arduino UNO R3 on the module of gateway-A1



Captions on Fig.4:
[a] = fuse [b] = inlet male power socket [c] = phone line socket RJ-11 [d] = PTT, e & m wire interface D-Sub 15 female
[1] = relay control audio recorder A2 [2] = A2 audio recorder module [3] = phone interface module
[4] =A1 Audio Recorder Module [5] = relay control audio recorder A1
[6] = voice detected module [7] = 5 Vdc module
[8] = gateway module-A1 and Arduino UNO R3 [9] = gateway module-A2 and Arduino MEGA2560 R3
[10] = 12 Vdc/5 A power supply [e] = power input indicator 220 Vac
[f] = ON/OFF toggle switch [g] = indicators of PTT, COR, & link [h] = indicators of ringer, VOX, & link

Fig. 4. An IDC system based on a microcontroller driven by a touch-tone signal

The input/output connection line pins on the board of Arduino MEGA2560 R3 on the module of gateway-A2 is shown in Fig. 6.

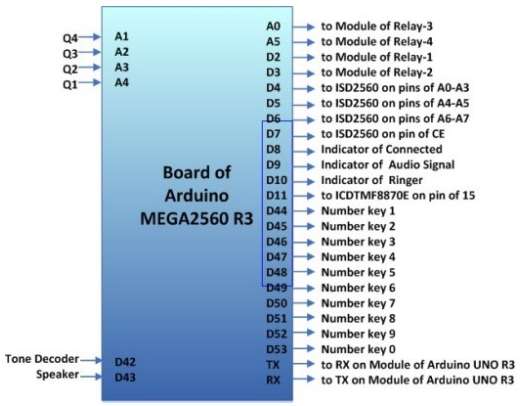


Fig. 6. The connection of the input and output line pins on the board of Arduino MEGA2560 R3 on the module of gateway-A2

B. Make a Program Structure for the Modules of Arduino Based on Arduino Software

Programming the microcontrollers of Arduino UNO R3 and MEGA2560 R3 is used by the Arduino IDE, which is the default application for Arduino using the C programming language. Therefore, before defining the algorithm and syntax in writing, it is preceded by providing the application raw-file for the Arduino module.

B.1. Algorithm determination

Algorithms are made in the form of a flow chart. For example, the flow diagram of the IDC system programming based on a microcontroller driven by a touch-tone signal is shown in Fig. 7.

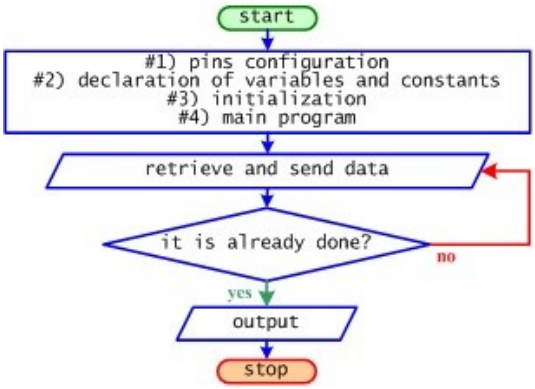
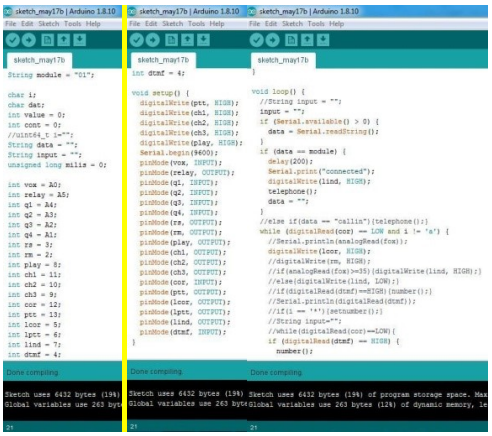


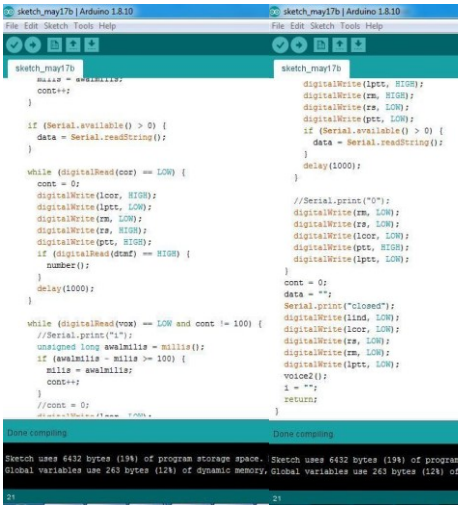
Fig. 7. The flow diagram of the IDC system programming based on the microcontroller system drove by a touch-tone signal

B.2. Syntax in writing

Based on the algorithm's determination, there are six stages of the program structure that cover configuration of pins, variables and constants declaration, initialization, the main program, retrieve and send data, and the output. Therefore, it takes fourteen views for the whole coding. The coding display on the first three views and the last two views from fourteen views is shown in Fig. 8.



#a) the first three of views from fourteen views



#b) the last two of views from fourteen views

Fig. 8. The coding display on the first three and the last two of views from fourteen views

B.3. Compilation and uploading

The compilation of the syntax structure is an effort to obtain several source codes as the principal of operating an integrated system based on the microcontroller, then process the uploading is carried out to the Arduino modules.

C. Performing the Test against the Arduino Module-based Half-duplex Adapter

There are six tests, namely a) test to the circuit of ring detection, b) test to the circuit of VOX, c) test to the circuit of the off/on the hook of the telephone module, d) test to the circuit of the tone decoder, e) test to the dial-up telephone numbers via DTMF buttons and the circuit of switching chip, and f) test the circuits of voice recording and storage in the form of playback. The flowchart of implementation on the communication function test is shown in Fig. 9.

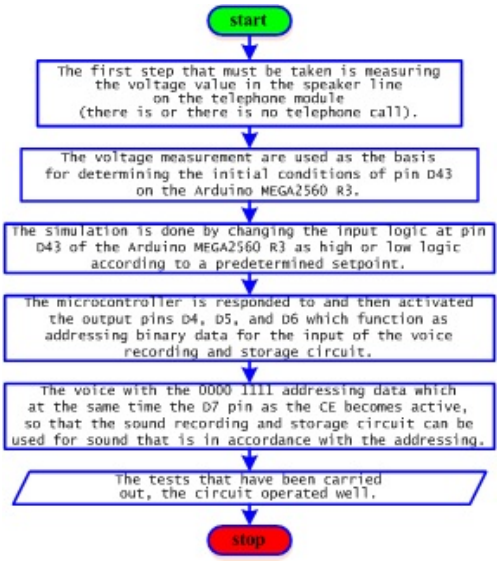


Fig. 9. The flowchart of implementation on the communication function test

C.1. Simulation to the circuit of ring detection

The voltage measurement results when there are, and there are no incoming calls are shown in Table 1.

Table 1. The voltage measurement results when there are, and there are no incoming calls

Condition	Value of voltage (V*dc*)
No ring	0.931
There is ring	13.37

C.2. Simulation to the circuit of VOX

The display of the settings on the Audio Frequency Generator is shown in Fig. 10.

Fig. 10. The display of the settings on the Audio Frequency Generator

The display when conditioning the circuit of VOX by receiving voice signal input from the measuring instrument is shown in Fig. 11.

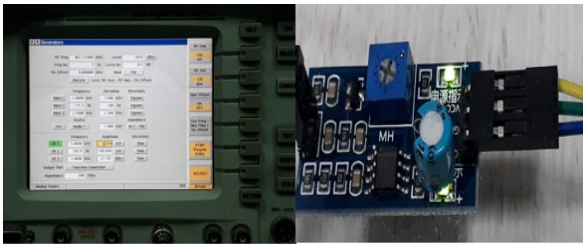


Fig. 11. The display when conditioning the circuit of VOX by receiving voice signal input from the measuring instrument

C.3. Simulation to the circuit of the off/on-hook of the telephone module

The display of the off/on-hook relay on the telephone module is shown in Fig. 12.

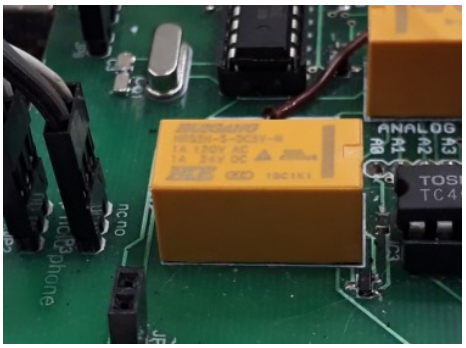


Fig. 12. The display of the OFF/ON-hook relay on the telephone module

The condition of the off/on-hook relay pin is shown in Table 2.

Table 2. The condition of the off/on-hook relay pin

Condition	Status of switch pin	Description of the incident
When no call is made	NC	on-hook
When placing a call	NO	off-hook
When receiving a call	NO	off-hook

C.4. Simulation to the circuit of tone decoder

The measurement results of the tone frequency on the telephone module are shown in Table 3.

Table 3. The measurement results of the tone frequency on the telephone module

Condition	Period (seconds)	Frequency (hertz)
off-Hook	continuous	450
Busy	0.5 second “ON”; 0.5 second “OFF”	450
Made a call	1 second “ON”; 4 seconds “OFF”	450

C.5. Simulation to the circuits of dial-up telephone numbers via DTMF buttons and switching chip

The display of the DTMF encoder application for conditioning the test of DTMF circuits is shown in Fig. 13.

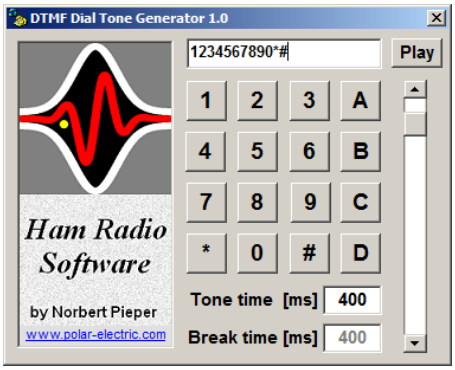


Fig. 13. The display of the DTMF encoder application for conditioning the test of DTMF circuits

The display of the DTMF signal frequency value when pressing number 1 is shown in Fig. 14.

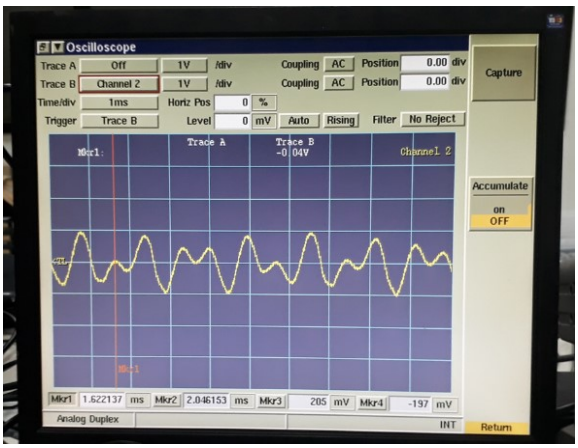


Fig. 14. The display of the DTMF signal frequency value when pressing number 1

C.6. Simulation to the circuit of voice recorder and storage

The simulations are carried out for conditions in the form of voice recording and playback.

#a) Condition of the voice recording

The number of voices that can be recorded on the voice recorder and storage circuit is shown in Table 4.

Table 4. The number of voices that can be recorded on the circuits of the voice recorder and storage

On the module of Gateway-A1		On the module of Gateway-A2	
Address	**Voice**	**Address**	**Voice**
0000 0000	"slot not available"	0000 0000	"slot not available"
0000 1111	02, connect, enter the phone number ending with a key of the pound sign	0000 1111	"enter the slot number"
1111 0011	"disconnected "	1111 0011	"01 connected"
		1111 1100	"disconnected"

#b) Condition of the voice is played back

The system condition when the voice reappears is shown in Table 5.

Table 5. System conditions when the voice reappears

Conditions	Voice	Location
From the HT radio, press the keys of 02 and #, before the communication is connected	"02 connected, enter the phone number ending with a key of #"	The module of Gateway-A1
Before the modules of Gateway-A1 and Gateway-A2 connect, then from HT radio press key other than 02 before pressing the key of #	"slot not available"	The module of Gateway-A1
When Gateway-A1 and Gateway-A2 are connected, then HT radio or caller presses * key, and decoder tone set receive dial tone	"disconnected"	Modules of Gateway-A1 and gateway-A2
Before Gateway-A1 and Gateway-A2 are connected then caller presses anything other than 01 key before press # key	"slot not available"	The module of Gateway-A1
Before the modules of Gateway-A1 and Gateway-A2 are connected, then the circuit of off-hook relay is active, and the telephone module receives the call	"Enter the slot number"	The module of Gateway-A2
After the telephone module is off the hook, the caller presses the key of 01 and # from the used telephone	"01 connected"	The module of Gateway-A2
After telephone module is off hook, Gateway-A1 and Gateway-A2 have not been connected then caller presses anything other than 01 key, before # key	"slot not available"	The module of Gateway-A2

IV. DISCUSSION

A. Assembling and Integrating

Based on block diagram the relationship between gateway modules in the IDC system based on the microcontroller system driven by the touch-tone signal (shown in Fig. 3). It can be explaine, that IDC system based on a microcontroller driven by a touch-tone signal consists of several electronic circuits and components integrated into one unit so that the system can operate optimally.

Shown in Fig. 4 about an integrated IDC system based on microcontroller was driven by a touch-tone signal, it is shown that the minimum system integration includes (i) the module of gateway-A1, which is the interface for radio frequency-based communication systems, (ii) the module of gateway-A2 which is the interface for the telephony-based communication system, and (iii) the switched-mode power supply system. Arduino UNO R3 microcontroller board is used to process input and output (I/O) data on the gateway module-A1.

Based on the input and output connection line pins on the module of Arduino UNO R3 at the module of gateway-A1 (shown in Fig. 5). It can be explained that the board of Arduino UNO R3 is connected to the board of Arduino MEGA2560 R3 in the gateway module-A2 via the TX/RX data pin used as a continuous data communication line. Thus, the board of Arduino MEGA2560 R3 is used for processing input and output data on the module of gateway-A2.

Figure 6 show input and output connection line pins Arduino MEGA2560 R3gateway-A2. It shown connection several circuits in gateway-A2, Arduino MEGA2560 R3 board connected Arduino UNO R3 in gateway-A1 TX/RX data pin used data communication line continuously

B. Program Structure Based on Arduino Software

The programming stages that must be passed consist of algorithm determination, syntax in writing, and compilation and uploading.

B.1. Determinate the algorithm

Determination of the algorithm with the aim of ease for programming is well directed and structured. To program an integrated system based on a microcontroller, the Arduino IDE is used. An integrated and fabricated system in the form of IDC based on the modules of Arduino was driven by touch-tone signals that are operated on a half-duplex system, including algorithm determination, the syntax in writing, and compiling and uploading processes from computer to microcontroller system. Algorithms created in the embedded program for the microcontroller-based IDC system are carried out on the modules of Arduino UNO R3 and MEGA2560 R3. Based on the flow diagram of the IDC system programming based on the microcontroller system driven by a touch-tone signal (shown in Fig. 7), it is shown that the program structure in the minimum system consists of six stages.

B.2. Writing the syntax

In the Arduino IDE, the syntax in writing is generally known as a "sketch" . The programming implementation is adjusted to the algorithmic process in a system, and it is shown that there are six stages on the process of algorithm, namely a) the configuration of pins (shown in Table 1), that (i) the stage of configuration of pins is the stage of determining which pins are used as input or outputs, (ii) pins are used as parameters in the program on the modules of Arduino UNO R3 and MEGA2560 R3 which are connected to the circuit of VOX, the circuit of DTMF, the circuit of tone decoder, the pins on COR, and (iii) the circuit of a relay, circuits of voice recorder and storage, and circuits of IC switch; b) the variable and constant of declarations (shown in Table 2), that the variables and constants of the declaration are done to declare the type of data that must be done; c) initialization stages, that the existence of initialization is expected to be able to shorten the commands in the following program; d) the process of the main program structure with display appearances, that (i) the source of all program control is located in the main program block, (ii) all commands in the program structure are sorted in the main program, starting from initial conditions, data retrieval, and (iii) reactions or outputs from the program created; e) the process of retrieving and sending data (shown in Table 3), that the retrieving and sending data are an order or condition under the input on the sensor sent for and then used as a signal to the actuator drive in the form of a relay; and f) displaying the output (shown in Table 4), that (i) displaying the output is a reaction caused by the input data provided by the sensor which is connected to a pin on the microcontroller's input port and (ii) the program output conditions are used for connecting to relay circuits, circuits of voice recording and storage, and circuits of IC switch.

B.3. Compiling and uploading

The result of the integrated assembly for establishing the IDC, which is equipped with source code based on the Arduino IDE, is an embedded system. The stages of compiling and uploading the source code that has been obtained are the post-stages of determining the algorithm and compiling the program structure of syntax. The process of compiling and uploading from a PC to modules of Arduino aided by a USB cable.

C. Performing the Test of Verification

To ensure that the circuit installed in the microcontroller-based integration system for the IDC system driven by a touch-tone signal is operating properly, the verification tests in the form of the simulation are carried out on several circuits and modules. The verification test in each series is carried out by providing input and observing the output path with the appropriate equipment. In addition, the verification test also functions to observe the presence of hardware and software handshaking between modules or circuits.

In the IDC, half-duplex communication follows the communication principle of radio frequency-based communication equipment. In half-duplex communication, communication takes place alternately between the sender and receiver of the audio signal. Therefore, when one of the communication equipment is sending or transmitting an audio signal, the other communication devices connected to the minimum system are in a condition to receive or receive the audio signal that is sent.

C.1. Performing the circuit of ring detection

Before the conditioning simulation is carried out on the circuit of the ring detector, the first step that must be taken is to measure the voltage value in the ring speaker line on the telephone module when there is a telephone call, and there is no telephone call. The voltage measurement results used as basis for determining initial condition D43 pin on the Arduino MEGA2560 R3 module. Then, the simulation on the ring detection circuit is done by changing the input logic at the pin of D43 on the Arduino MEGA2560 R3 as high or low logic according to the predetermined setpoint.

C.2. Performing the circuit of VOX

The circuit of VOX functioned to detect voice signals while communication was in progress. The output on the pin of the circuit is connected to the module of Arduino at the pin of A0. To detect sound signals, it is necessary to adjust the variable resistors contained in the circuit to obtain digital data 0 and 1. Simulation in the circuit of VOX is carried out by providing input in the form of voice signals using the Aeroflex type 3920 digital radio test set for activating

the Audio Frequency Generator (AF Generator) feature. The measuring instrument is set at the frequency value of the voice signal that humans can hear, which is in the range of 20–20 kilohertz with a voltage level of not more than 200 millivolts. The port of the audio output is connected to the input pin of the circuit of VOX. The test is carried out with a measuring instrument with a frequency setting of 1 kilohertz with a level of 2,314 millivolts.

C.3. Performing the circuit of the off/on-hook of the telephone module

The off/on hook circuit telephone module is series relays attached to Gateway-A2 module connected to the telephone module. The module of the relay driver is used as a substitute for the switch off-hook of the telephone module with the aim that a microcontroller can control the off/on-hook condition of the telephone module. The simulation is carried out when the system receives or does not receive calls. When the system doesn't receive a call, the relay pin is in Normally Open (NO) condition, and when you receive a call, the relay pin is in Normally Closed (NC) condition.

C.4. Performing the circuit of tone decoder

The presence of the circuit of tone decoder in the IDC system is used as a tone frequency-based sensor on the telephone line when the telephone module is on-hook or off-hook. The treatment for the circuit is in the form of measuring the tone frequency on the telephone line at (a) when the PSTN telephone module is off-hook, (b) when the signal reception is busy, and (c) when the telephone module is called. The frequency value of the PSTN telephone module can be determined by using a Radio Digital Test Set measuring instrument of the Aeroflex brand type 3920.

C.5. Performing the circuits of dial-up telephone numbers via DTMF buttons and switching chip

The simulation of the DTMF circuit uses the help of the DTMF encoder application as a DTMF frequency signal generator. And a Digital Radio Test Set (DRTS) brand of Aeroflex type 3920 measuring instrument for indicating the DTMF signal frequency waveform according to the number key pressed.

C.6. Performing the circuit of voice recorder and storage

#a) Condition of the voice is recorded

Based on the number of voices that can be recorded on the circuit of the voice recorder and storage (shown in Table 4), it is shown that the treatment when recording a voice is in determining the address of the recorded voice. Addressing the recorded voice is in the form of 8 bits of binary data via the pins of A0 to A7 with the steps (i) after changing the position of switch S3 (play/record) so that the position of the pin of PR is connected to ground; (ii) change the position of switch S1, so that the pin of PD is not connected to ground; (iii) Press switch S2 to start recording by speaking into the microphone; and (iv) For the end of the recording, switch S1 position is changed, so that the pin of PD is connected to ground and switch S2 is released.

#b) Condition of the voice playing back

The saved voice playback carried out in manner not different from recording. For playback of recorded voice, it is carried out by following steps (i) determining the address of the voice recorded via pins A0 to A7 in the form of a binary 8-bit data combination, (ii) changing the position of switch S3, so that the pin of PR position is not connected to ground; (iii) change the position of switch S1, so that the pin of PD is not connected to ground, and (iv) pressing the push button of S2, so that the voice recorded at the specified address can be heard on the loudspeaker. The calling voice stored process in the circuits of voice recorder and storage is carried out by the microcontroller via activating the digital output line ports on pins of D8, D9, D10, and D11 on the module of Arduino UNO R3 in the module of Gateway-A1 and the digital output line ports on pins D4, D5, D6, and D7 on the module of Arduino MEGA2560 R3 in the module of Gateway-A2.

V. CONCLUSION

Based on the discussions, so the conclusions can be drawn according to the research objectives. The IDC system based on a microcontroller driven by a touch-tone signal consists of several electronic circuits and components integrated into one unit so that the system can operate optimally. The addition to a connection with several circuits in the module of gateway-A2, the board of Arduino MEGA2560 R3 is also connected to the board of Arduino UNO R3 in the module of gateway-A1 via the TX/RX data pin used data communication line continuously.

To program an integrated system based on a microcontroller, the Arduino IDE is used. An integrated and fabricated system in the form of IDC based on the modules of Arduino drove by touch-tone signals that are operated on a half-duplex system, including algorithm determination, syntax in writing, and compiling and uploading processes from computer to microcontroller system. The programming implementation is adjusted to algorithmic process in a system, it is shown there are six stages, namely pin configuration, variable and constant declarations, initialization stages, the main program structure process with display appearances, the process of retrieving and sending data, and displaying the output. The compilation of the syntax structure is an effort to obtain several source codes as the principal of operating an integrated system based on the modules of Arduino. The process of compiling and uploading from a PC to modules of Arduino aided by a USB cable.

The simulation test includes #a) giving conditions to the input line of the ring detector circuit and observing the output conditions of the circuit, #b) giving conditions to the circuit of VOX by providing

conditions in the form of audio on the input line and the output line being connected to a Motorola GM338 radio, #c) providing conditions for the off-hook circuit of the telephone equipment connected to the telephone line, #d) providing conditions for the input on the busy tone module input line with a busy tone with a frequency of 425 hertz in 0.5 seconds, #e) providing conditions for dial-up telephone numbers through a switching circuit for dial-up telephone numbers, and #f) recording and playing back sound with a voice recording and storage module, in the form of (i) voice recording and (ii) voice playback.

Suggestions for research development related to measurement on the various purposes and the real conditions for the half-duplex interface adapter can be implemented. In the IDC, half-duplex communication is carried out following the principle of radio frequency-based equipment.

REFERENCES

[1] 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.

[2] R.S.E-T. Salim, and A.B.A. Mustafa. (2021, Jul-Aug). Mobile Satellite Services and VSAT Technology: A Comparative Study. *IOSR Journal of Electronics and Communication Engineering* (*IOSR-JECE*). [Online]. *16(4)*, 1-6. Available: http://www.iosrjournals.org/iosr-jece/papers/Vol.%2016%20Issue%204/Ser-1/A1604010106.pdf

[3] Abiad, M., Kadry, S., & Ionescu, S. (2018). Cost efficiency of Telecommunication Equipment: A Review. 2018 4th International Conference on Applied and Theoretical Computing and Communication Technology (iCATccT). Mangalore, Karnataka 574225, India 2018, September 6-8. doi:10.1109/icatcct44854.2018.900

[4] ITU. (2020, May 11). The Radio Regulations, Edition of 2020. ITU Publication Notice, 2020.

[5] D. Hindocha, A.K. Bagga, N. Atmande, and D.V. Rojatkar. (2015, March). Next Generation Network: An Overview A Future Telecom Network. *International Journal of Engineering Research & Technology* (*IJERT*). [Online]. *4(3)*, 675-680. Available: https://www.ijert.org/research/next-generation-network-an-overview-IJERTV4IS030913.pdf

[6] A.C. Eska. (2020, Feb.). The Communication System of Building from Outdoor to Indoor with AMC at 10 GHz. *INFOTEL*. [Online]. *(12)1*, pp. 13-17. Available: https://ejournal.st3telkom.ac.id/index.php/infotel/article/view/465/278

[7] A.C. Eska. (2020, Nov.). Doppler Shift Effect at The Communication Systems with 10 GHz around Building. *INFOTEL*. [Online]. *(12)4*, pp. 129-133. Available: https://ejournal.st3telkom.ac.id/index.php/infotel/article/view/483/304

[8] K. Sverian, J. Haule, and M. Kisangiri. (2013, Nov.). Review of Radio Propagation Properties and Applications in Different Frequency Bands. International Journal of Engineering Research & Technology (IJERT). [Online]. *2(11)*, pp. 307-312. Available: https://www.ijert.org/research/review-of-radio-propagation-properties-and-applications-in-different-frequency-bands-IJERTV2IS110054.pdf

[9] M.O. Sultonova. (2016). 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. doi:10.1109/icisct.2016.7777394

[10] S. Nazir, G. Fairhurst, and F. Verdicchio. (2016). WiSE - a satellite-based system for remote monitoring. *International Journal of Satellite Communications and Networking*. [Online]. *35(3)*, 201–214. doi:10.1002/sat.1176

[11] T. Page. (2014). Touchscreen Mobile Devices and Older Adults: A Usability Study, International Journal of Human Factors and Ergonomics. [Online]. *3(1)*, pp. 65-85. Available: http://dx.doi.org/10.1504/IJHFE.2014.062550

[12] Krzysztof Kędzior. (2018, April). Introduction to human factors and ergonomics, *International Journal of Occupational Safety and Ergonomics*. [Online]. *24(1)*, 1. Available: DOI: 10.1080/10803548.2018.1463724

[13] L. Schenker. (2013, July). "Pushbutton Calling with a Two-group Voice-frequency Code," *The Bell System Technical Journal*. [Online]. *39(1)*, pp. 235–255. https://doi.org/10.1002%2Fj.1538-7305.1960.tb03929.x

[14] G. Shreta, K. Subhasree, G. Soumen, G. Tanumay, and G. Suvojit. (2015, October). Dual Tone Multiple Frequency Based Home Automation System. International Journal of Engineering Research (IJER). [Online]. *4(10)*, pp. 542-544. Available: https://www.indianjournals.com/ijor.aspx?target=ijor:ijer&volume=4&issue=10&article=006

[15] R. Brama, P. Tundo, A.D. Ducata, and A. Malvasi. (2014). An inter-device communication protocol for modular smart-objects. *2014 IEEE World Forum on Internet of Things (WF-IoT)*. Seoul, Korea, 6-8 March 2014. doi:10.1109/wf-iot.2014.6803203.

[16] A. McKenzie. (2011). INWG and the Conception of the Internet: An Eyewitness Account. *IEEE Annals of the History of Computing*. [Online]. *3(1)*, 66–71. Available: doi:10.1109/mahc.2011.9.

[17] M. Maemunah, and M. Riasetiawan. (2018). 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*). Yogyakarta, 2018, October 18-19. doi:10.1109/icstc.2018.8528663

[18] B. Massimo, and M. Shiloh, "The Arduino Paltform," *Getting Started with Arduino*, 3rd edition. Sebastopol, CA: Maker Media, 2015, pp. 15-22.

[19] A. Goeritno, J. Irawan, and Sopyandi. (2018, July). Segmentation of Load Groups on a Single Phase kWH-meter Using the Payload Data Handling System. *International Journal of Advanced Research*.

[Online]. *6(7)*, pp. 415-426. Available: http://dx.doi.org/10.21474/IJAR01/7378

[20] A. Goeritno, and M.Y. Afandi. (2019, Aug.). Designing a Security System Based-on Microcontroller Integrated into the Immobilizer System. *International Journal of Electronics and Communication Engineering*. [Online]. *6(8)*, pp. 1-11. Available: http://www.internationaljournalssrg.org/IJECE/2019/Volume6-Issue8/IJECE-V6I8P101.pdf

[21] 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.