Bluetooth Based Control Panel for Smart Home Application

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***Abstract*— Smart home is a term that refers to an application in which electronic devices are controlled using automated system. This paper discusses about an ongoing project that serves the needs of the elderly in their daily life. It uses the Serial Port Profile (SPP) of Bluetooth to establish communication between computer and controller board. The prototype support controlling manual controlling and microcontroller controlling for electrical appliances. By connecting the circuit with a relay board and connection to the controller board it can be controlled by a Bluetooth available computer. This paper address issues related to helping old folks and lame gain control of their living area with reduced cost.**

***Keywords* — Smart Home; Bluetooth; Electronic; Home Appliances; Computer Application**

I. INTRODUCTION

The rapid growth of the information and communication technology (ICT) has reflected the advancement of ICT devices. The trend is clear that the conventional desktop computing environments have fused into daily household appliance. Accordingly, works on interaction styles that effectively compliment recent technology's innovations and applications are getting more attended to [1].

Currently, the Internet has been the obvious first choice option for setting up a local network in Smart Home that can also be controlled via the World Wide Web (WWW). Internet has been proven as a beneficial tool in communication by [2], [3] and [4]. On the other hand, the technology could be supported better if the Internet could be accessed without being wired as discussed by [5], [6], and [7]. The abilities of Bluetooth technology would be a preferred choice because it requires less cost besides less complicated. One of the disabilities among the old folks is less able to move. Many solutions have been recommended by [8]-[10] for assisting them in their daily life. The work in this study proposes a technological solution to be used in a smart home.

In recent years smart home has been associated with many technologies such as sensors and actuators in order to increase the inteligence of the package as a whole. All the additional parts add into additional wiring. With Bluetooth technology, the problem in setting up the local area network will be greatly reduced.

This paper presents an ongoing project that utilizes the Bluetooth technology in helping the elderly in their daily live. As the normal people, the elderly especially those who are less able need to perform daily tasks such as cooking, washing, and cleaning. This paper is organized as follows; section 2 discussed the previous underlying works on Bluetooth technology. The hardware involved in this study is outlined in section 3. The findings are discussed on section 4 and finally section 5, conclusion.

II. RELATED WORKS

Sensor and actuator network (SANETs) as proposed by Dengler et. al. [11] consists of sensors and actuator nodes implemented into a smart home to enable a more independent life for elderly and handicapped people. It is possible by extending their cognition and information processing capacity and tries to compensate for certain handicaps. Sensors implanted into various everyday items to sense immediate environment using various types of sensor and these sensors provide a communication infrastructure while gathering and distributing the

information about the physical environment to the actuator via local network or wireless network. The information is then processed by the actuator to take a suitable action depending on the situation. In addition, the actuator may range from a single task robot to multitasking mobile robots to offer services such as management or maintenance.

Earlier, a Remote Controlled Bluetooth Enabled Environment[12] presents a method of remotely controlling devices present in a Bluetooth enabled environment either in a home or in the office from any part of the world connected to the global network. A web page applet, programmed in Java which can be accessed from any Java-enabled connected to the Internet can be used to control the Bluetooth environment. It also monitors current state of all devices in the environment.

A framework proposed by [13] for end-to-end Secure Wireless Smart Home System is a home monitoring and control system. The communications with all components are done using variety of wireless technologies. The system supports three main services which is monitoring, controlling, and notifying the current status. The smart home system makes good use of wireless communication technologies such as GSM/GPRS, WiFi, WiMax, Bluetooth, and others in order to open a more transparent manner to the smart home concept. The smart home framework consists of five major components which include an external network, a gateway, services, a local network, and home appliances. Further, the service includes the ability of the owners in controlling and monitoring the home appliances and devices remotely.

Another is the Virtual Smart Home Controlled by Thoughts concept as written by [14] is an electroencephalogram (EEG) based on brain-computer interface (BCI) that was connected to a virtual reality (VR) system in order to control smart home appliances. The EEG based BCI measures and analyzes the electrical brain activities EEG in order to control the external devices [15]. BCIs are based on slow cortical potentials, EEG oscillation in the alpha and beta band, the P300 response or the steady-state visual evoked potentials (SSVEP)[16]. P300 is a special controlling mask which acts as the main input to the system. BCI systems are used mainly for moving a cursor on a computer screen, controlling external devices or for spelling purpose [17].

III. System Development

This section discussed how the setting is made among the appliances in the proposed smart home as shown in Fig. 1.

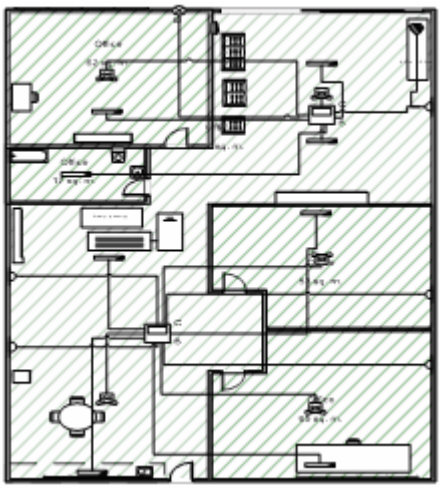

Fig. 1 Circuitry layout on smart home

The architecture of the proposed smart home is depicted in Fig. 2. Human commands are received through computer keyboard and sent the key selections to the Bluetooth Module KC21 (SKKCA21 board) via Bluetooth dongle or any Bluetooth devices.

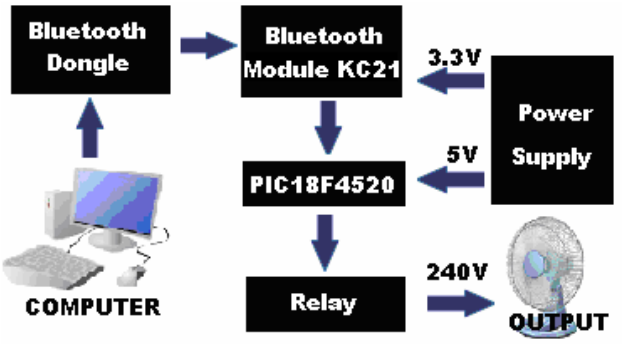

Fig. 2 Smart home architecture

Communication module of the system involves a SKKCA-21 board as shown in Fig. 3. SKKCA-21 use 5V TTL logic interfaces and supports serial port protocol (SPP). In order to provide interfacing to the microcontroller, SKKCA has two pins; KC_RX and KC_TX. The KC_RX is connected to microcontroller's Transmitter pin (TxD), while the KC_TX is connected to microcontroller's Receiver pin (RxD). In order to enable Bluetooth wireless link to be established, KC_RX pin is pull high.

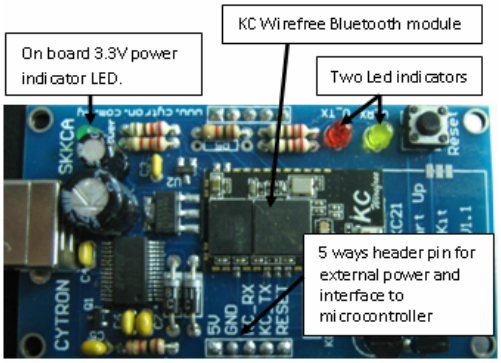

Fig. 3 SKKCA21 Module

Microcontroller is a main controller of the system that interprets key selections and determines whether to activate or deactivate electrical devices. As suggested in [18] – [20], microcontroller PIC18F4520 is used because it has a number of available pins and supports serial communication. USB-UART communication is enabled by providing 20MHz crystal to generate clock inputs and required baud rate of 115.2K baud.

In addition, a 5V power supply is designed as shown in Fig. 4 to provide constant 5V to all components. However, a voltage regulator 7805 is employ to limit microcontroller's voltage to 5V.

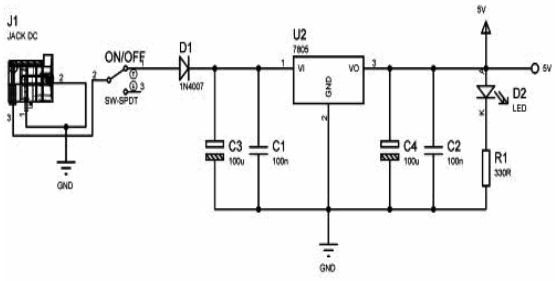

Fig. 4 Power supply

Other pins are used to control decoders The decoders are created with extra pins in which every decoder is equipped with 2 extra pins to be connected. To maintain each pin and the output condition with changing variables and values in the other pins, a latch decoder is used. Controlling decoders with latch requires the control of enabled pins and the data pins to ensure the exact output is obtained. Figure 4 illustrates the MM74HC259N decoder utilized in this study.

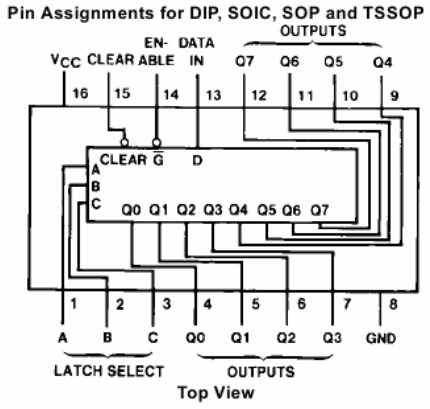

Fig. 5 Decoder MM74HC259N

To enable pins to transfer data to certain addresses, a rule of sequence is required. Table 1 list the key assignment for each pin and latch output. In order to send the data to the output the enabler is set to HIGH. During the transition the data is sent as the output and stored .

TABLE I.
KEY ASSIGNMENT FOR DECODER OUTPUT

Input value	Decoder Output Select			Decoder Output Latch	Output
	A2	A1	A0		
1	0	0	0	0	Light
2	0	0	1	1	Fan
3	0	1	0	2	Output 1
4	0	1	1	3	Output 2

In this proposed smart home application, a user is allowed to control their home appliances manually and remotely. Therefore, there are two relays have been designed to cope with manual and remote control operation.

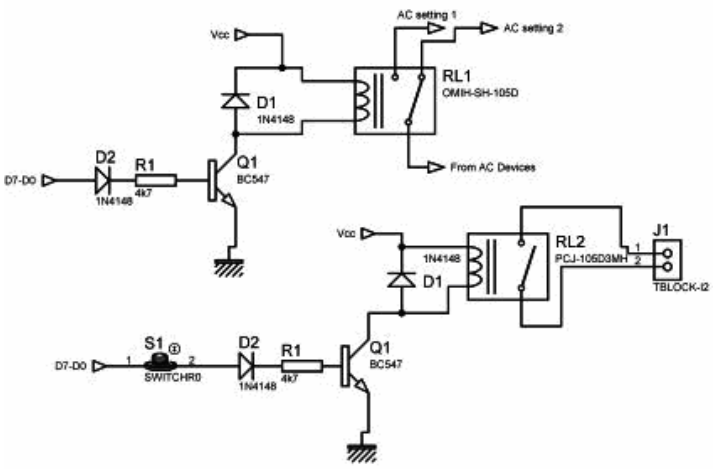

Fig. 6 Relay layout design

As shown in Fig. 6, at top is a design of a relay layout without a switch. This design is use for direct interfacing with the microcontroller to allow remote control. While the bottom design is the relay layout with a switch to cutoff the signals supply. This allows a user to manually control home appliances.

IV. RESULT AND ANALYSIS

Bluetooth based control panel for smart home application are able to control manually and remotely various electrical devices such as lights, fans, and 3-pin socket points. Communications are done with computer via Bluetooth Serial Port Profile (SPP). Fig. 7 shows the full layout of the main controller board.

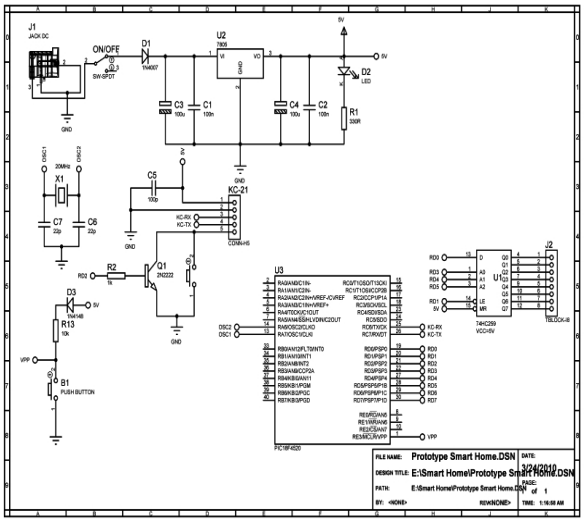

Fig. 7 Schematic of SI2S using Proteus Software

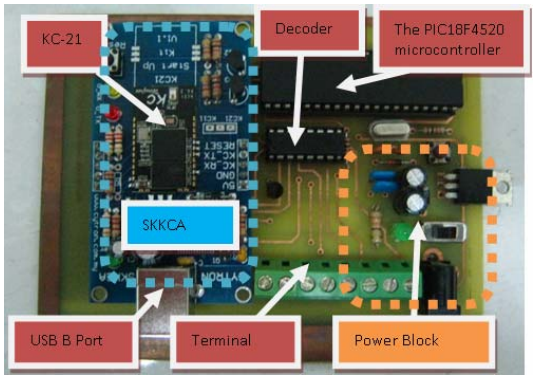

Fig. 8 Hardware on the main controller board

The controller is attached onto the main controller board as shown in Fig.8. The main controller board has been interfaced with the KC-21 module. The microcontroller is the main storage of the system. All the data are accessed from the microcontroller by Bluetooth communication. In fact, the microcontroller also controls the outputs to the decoder and communicates with the computer to receive commands. Further, Fig. 9 shows the control panel block diagram of the communications.

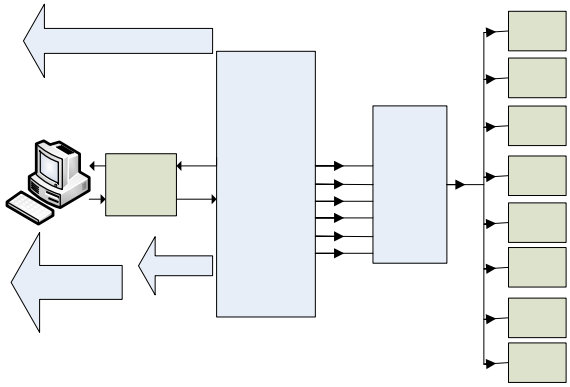

Fig. 9 Control panel block diagram

Computer as the user interaction control panel is able to receive data from the microcontroller such as menu to be displayed on the computer screen. The user keys in the required data and sends the data to the microcontroller. Transmission and receiving are made possible by KC-21 module that enables wireless Bluetooth connection. Bluetooth is the medium between the microcontroller and the computer that receives and transmits data using ASCII format and the serial port profile (SPP) data are received and transmitted by the RX and TX pin of the UART pins of the microcontroller.

On the right side of the microcontroller are all single direction communications. Using maximum of 6 pins the microcontroller controls the decoder to configure the output received from the user. Lastly the output of the decoder will activate the relay accordingly.

For communication using serial port through the UART of microcontroller it is done by initializing the microcontroller and connecting the transmitter to receiver of KC-21 and vice versa for the receiver pin. Fig. 10 depicts the fragment of C code for initialization of serial connection.

```
void init (void)
{
    ADCON1 = 0b00000111;
    TRISCbits.TRISC6=1;
    TRISCbits.TRISC7=1;
    TRISD=0;
    SPBRG=0x0A;
    BRGH=1;
    BAUDCONbits.BRG16=0;
    TXEN=1;
    CREN=1;
    SPEN=1;
```

Fig. 10 Initialization in C code

The application of the relay board, three different interfaces is applied to suit the need of different devices. This is done using the two circuit layouts recommended earlier. In relation, Fig. 11 outlines the interface to the microcontroller. Meanwhile, Fig. 12 outlines the interfaces using two different relay boards and the circuits are able to be controlled by both manual and remote.

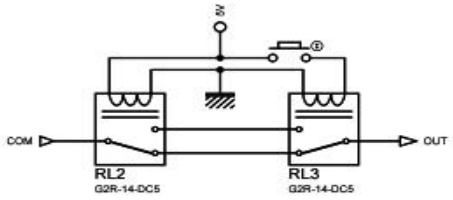

Fig. 11 Microcontroller-controlled

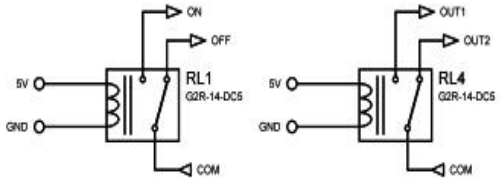

Fig. 12 Microcontroller and manual controller

In using UART interface for the serial port the baud rate is an important part. It is required for initialization.

The crystal used is rated 20MHz and the default baud rate for the KC-21 module is at 115200bps. Equation (1) is used to determine the SPBRG of the microcontroller.

$$SPBRG = \left(\frac{FOSC / BaudRate}{16} \right) - 1 \qquad (1)$$

Comparison is made for BRGH value. It was set to both HIGH and LOW to determine the error and the baud rate. Table 2 displays the results obtained from the comparisons.

TABLE II.
SPBRG CONFIGURATION AND ERROR

BRGH Value	SPBRG Calculated Value	SPBRG	% Error
1	9.85	10	-1.36
0	1.71	2	-9.58

When the BRGH bit is set to HIGH the high speed baud rate are was selected. When the high speed baud rate was used, the SPBRG value was 9.85 and round off to be 10. For the LOW BRGH, the SPBRG obtained was 1.71 and round off to be 2. Comparing the two values of BRGH with HIGH value, the error was recorded at -1.36%. Meanwhile during LOW value, the error increases to -9.58%. As the percentage increases the value of baud rate begins to drop to less than 115200bps. Therefore the HIGH value of BRGH was used. This also verifies the theory that higher baud rate reduces baud rate erro

Communication happens between the TX and RX pins. Also, the receiver at the microcontroller receives data from the KC-21 and interprets it into output signals. Figure 13 illustrates the output when number '5' key is sent to the KC-21 and received by the RX pin.

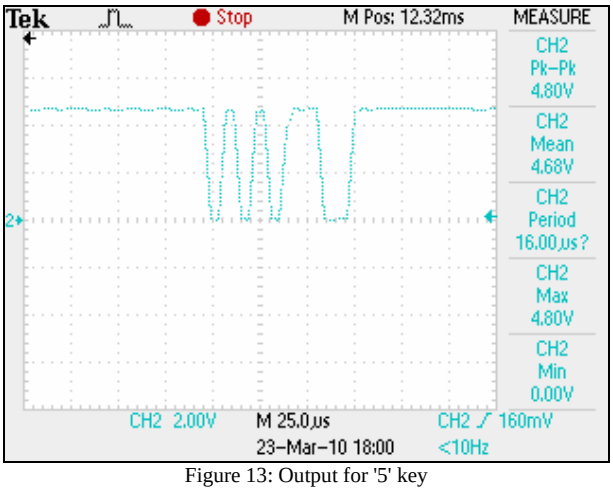

Figure 13: Output for '5' key

A few more data were obtained as the above and the data were compared to determine the communication language and sequence. Table 3 lists the results of the comparison obtained.

TABLE III.
COMPARISON OF TRANSMITTING VALUE

Character entered on keyboard	**Binary from Oscillator**	**Binary after ignoring first and last bit**	**HEX**
5	001101010	0110101	35
6	001101100	0110110	36
7	001110110	0111011	37
8	001110000	0111000	38
9	001110010	0111001	39
A	010000010	1000001	41
j	011010100	1101010	6A

From the data in Table 3, the data send a most significant bit first (MSB). It indicates as transition of HIGH to LOW continued with the data bits. At the end, the stop bit of a LOW to HIGH transition is sent to acknowledge an end to the data. The communication language is in ASCII and the character can contain numbers and alphabets.

V. CONCLUSION

In a house of Bluetooth-enabled house appliances, users are able to control home appliances with a push of a button. This application gives alternative to a user on how to control over their working and house area. Even though the Bluetooth module used has coverage of maximum 20m, a security features become one of the issue that will be implemented in next development.

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