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To cite this article: N Sulaiman *et al* 2018 *IOP Conf. Ser.: Mater. Sci. Eng.* **342** 012074

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Development of wireless vehicle remote control for fuel lid operation

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Abstract. Nowadays, the evolution of the vehicle technology had made the vehicle especially car to be equipped with a remote control to control the operation of the locking and unlocking system of the car's door and rear's bonnet. However, for the fuel or petrol lid, it merely can be opened from inside the car's cabin by handling the fuel level inside the car's cabin to open the fuel lid. The petrol lid can be closed by pushing the lid by hand. Due to the high usage of using fuel lever to open the fuel lid when refilling the fuel, the car driver might encounter the malfunction of fuel lid (fail to open) when pushing or pulling the fuel lever. Thus, the main aim of the research is to enhance the operation of an existing car remote control where the car fuel lid can be controlled using two techniques; remote control-based and smartphone-based. The remote control is constructed using Arduino microcontroller, wireless sensors and XCTU software to set the transmitting and receiving parameters. Meanwhile, the smartphone can control the operation of the fuel lid by communicating with Arduino microcontroller which is attached to the fuel lid using Bluetooth sensor to open the petrol lid. In order to avoid the conflict of instruction between wireless systems with the existing mechanical-based system, the servo motor will be employed to release the fuel lid merely after receiving the instruction from Arduino microcontroller and smartphone. As a conclusion, the prototype of the multipurpose vehicle remote control is successfully invented, constructed and tested. The car fuel lid can be opened either using remote control or smartphone in a sequential manner. Therefore, the outcome of the project can be used to serve as an alternative solution to solve the car fuel lid problem even though the problem rarely occurred.

1. Introduction

Nowadays, the vehicle technology in this era involved the development of the remote control to control the operation of the vehicle especially car's door and rear bonnet locking system which was powered up by the battery. In addition, this type of remote control can be used to handle the operation locking and unlocking system from outside of the car. For the current vehicle technology, in order to open the fuel lid of the car, the operation merely can be done inside the car's cabin. Here, the car driver is required to push or pull up the fuel lever to release the car fuel lid. The existing configuration of car fuel lid is illustrated by figure 1 and figure 2 which involves the mechanical-based operation of car fuel lid.



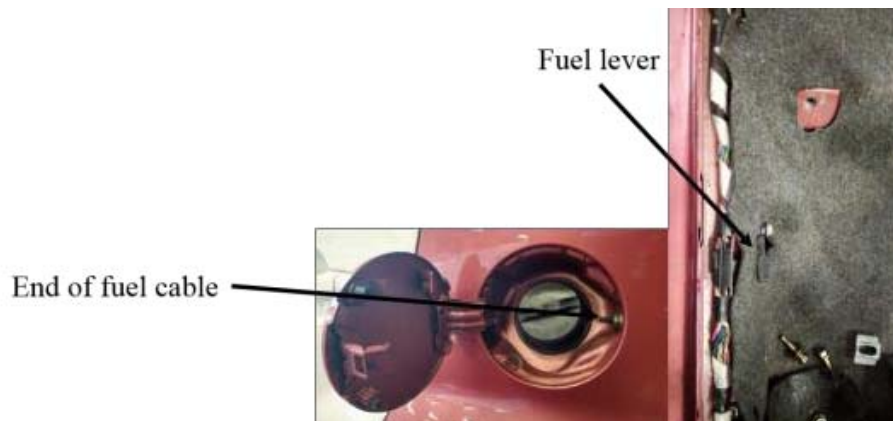


Figure 1. Existing petrol lid and fuel lever configuration.



Figure 2. Example of car fuel lever.

As depicted in figure 1 and figure 2, the assembly of fuel cable is used to lock and release the hook that located inside the car's fuel cap compartment. The mechanical configuration of the fuel cable among the vehicle manufacturer or type of vehicle might vary which depends on the design of fuel cable assembly for each car. The end of fuel cable will pull in when the fuel lever is being pushed or pull up which resulting the fuel lid to open. Even though the current operation of the fuel lid is easy and the malfunction of the fuel lid seldom occurred, the vehicle manufacturer still need to consider the operation of the fuel lid seriously. It is because if the malfunction of fuel lid occurred, the car driver absolutely cannot open the petrol lid from inside the car to refill the petrol. Figure 3 illustrates the example of the damaged assembly of the fuel cable which might occur due to the high usage of the fuel lever by the car user to re-fill the petrol.



Figure 3. Example of damage assembly of fuel cable.

Since the operation of fuel lever is mechanical-based and might subject to malfunction due to the high usage of the fuel level, it is a must to have another alternative method to open the fuel lid. Therefore, this project is implemented to have wireless remote control to open the fuel lid from outside of the car which can be integrated with the existing car remote control. Here, the car remote control applied wireless communication to control the operation of the car door and rear bonnet. Therefore, to equip the existing car remote control with another function to open the car fuel lid, the type of the wireless sensor network needs to be selected. In this project, the *XBee* wireless sensor network based on IEEE 802.15.4 is selected due to its wide range coverage up to 100 meters in distance and apply low power consumption [1]. In order to process the wireless data more precisely, Arduino Bluetooth microcontroller is selected since Bluetooth is one of the wireless technologies to exchange the data over the short distances. Here, the Bluetooth device for locking system is very practical as the users can store and manage lock information in real-time [2]. The previous researchers have applied Bluetooth in many wireless communication applications. One of them, Srikanth, *et. al* had proposed *XBee* wireless sensor integrated with the Arduino to develop the remote access for streetlight maintenance and control [3-4]. As the results, the streetlight condition can be monitored via the wireless monitoring system for the maintenance and control works. *XBee* is the family of ZigBee where the USB cable can be easily connected and enable the microcontroller to use the services of ZigBee protocol [5-7]. Hence, this study is carried out to enhance the existing vehicle remote control where the car driver can control the operation of the fuel lid outside of the vehicle.

2. Methodology

In this project, the operation of fuel lid is stimulated with two different techniques which are remote control and smartphone. The implementation of the operation can be done in the sequence, one by one. The car driver can start the operation of the fuel lid first and then followed by the smartphone or vice-versa. Figure 4 illustrate the graphical block diagram of the project implementation which requires the use of Arduino UNO Rev3 as the main microcontroller, Arduino shield, servo motor, *XBee*, push button, Bluetooth and smartphone. To provide better communication between *XBee* transmitter and receiver and also to process the data efficiently, two Arduino microcontrollers are required.

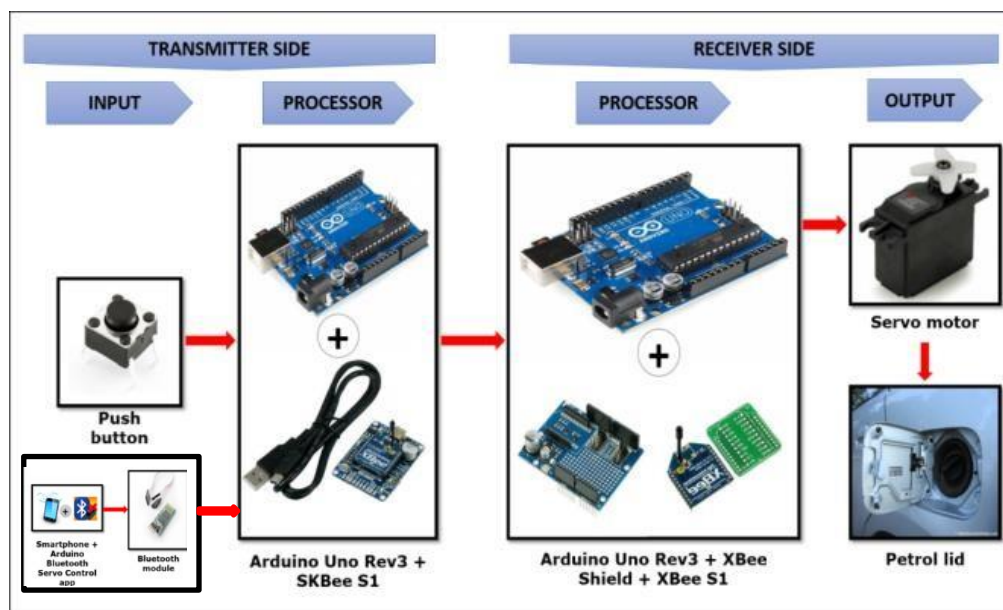


Figure 4. Graphical block diagram for remote control-based and smartphone-based technique.

The overall process flow to implement the project is depicted by figure 5. As illustrated by figure 5, the project involved the construct of the circuit and simulation for both remote control and mobile phone techniques. The communication for both techniques is implemented using XCTU software. It is simulated first using Proteus software. Once the simulation is successfully done, both the remote control will be tested to run the servo motor attached to the fuel lid. If the servo motor fail to open the fuel lid, need to trouble shoot the system at the circuit parameters and Arduino coding.

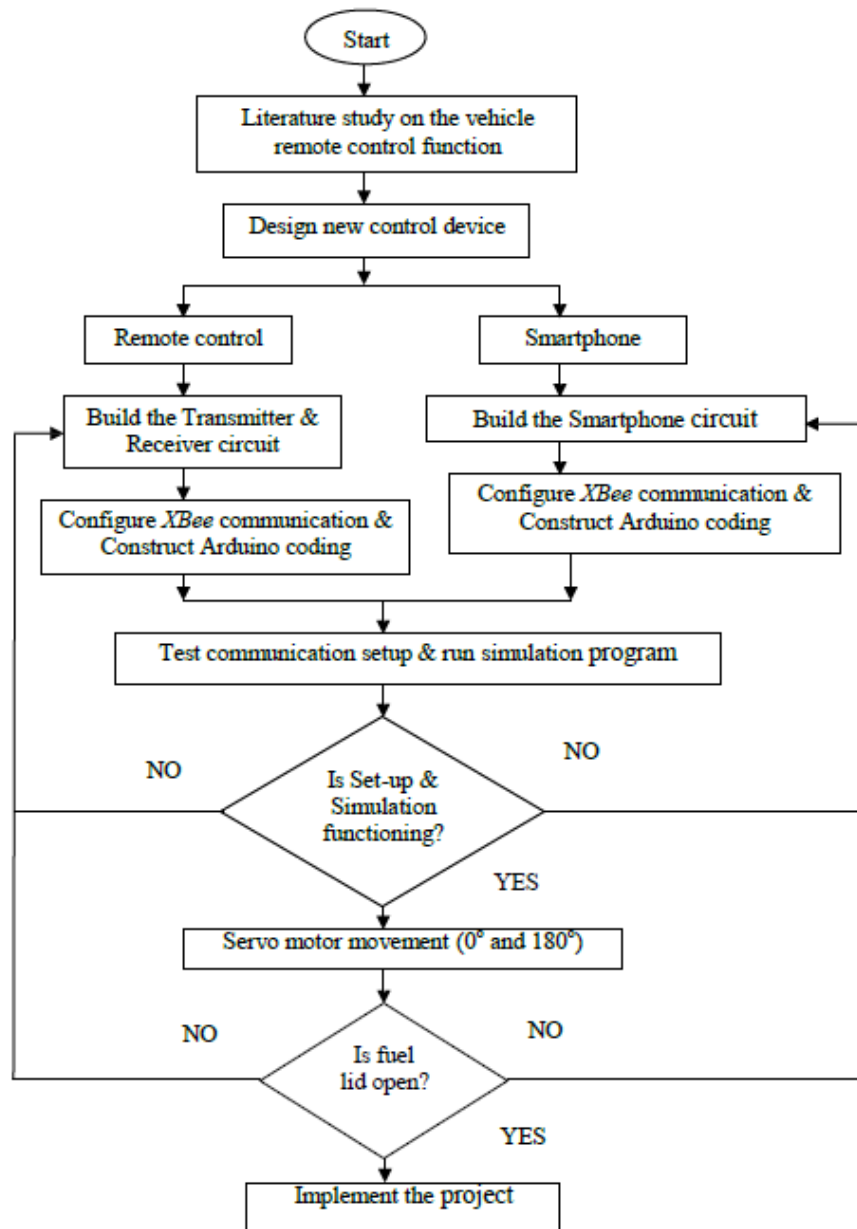


Figure 5. Overall process flow for remote control-based & smartphone-based technique.

2.1. Communication process flow

For the communication process, figure 6 depicts the process flow on the communication process between *XBee* at the transmitter and receiver part with the Arduino microcontroller. Here, when the push button at the remote control is pressed, *XBee*'s transmitter will send value '1' or '0' to the

XBee's receiver. If the *XBee*'s received value '1', the Arduino will instruct the servo motor to rotate to 180 degree. As a result, the fuel cable will be stretched inward, and the fuel lid will be released. On the other hand, if the *XBee*'s received value '0', the Arduino will instruct the servo motor to rotate to 0 degree. As a result, the fuel cable will be stretched out, and the fuel lid will remain closed.

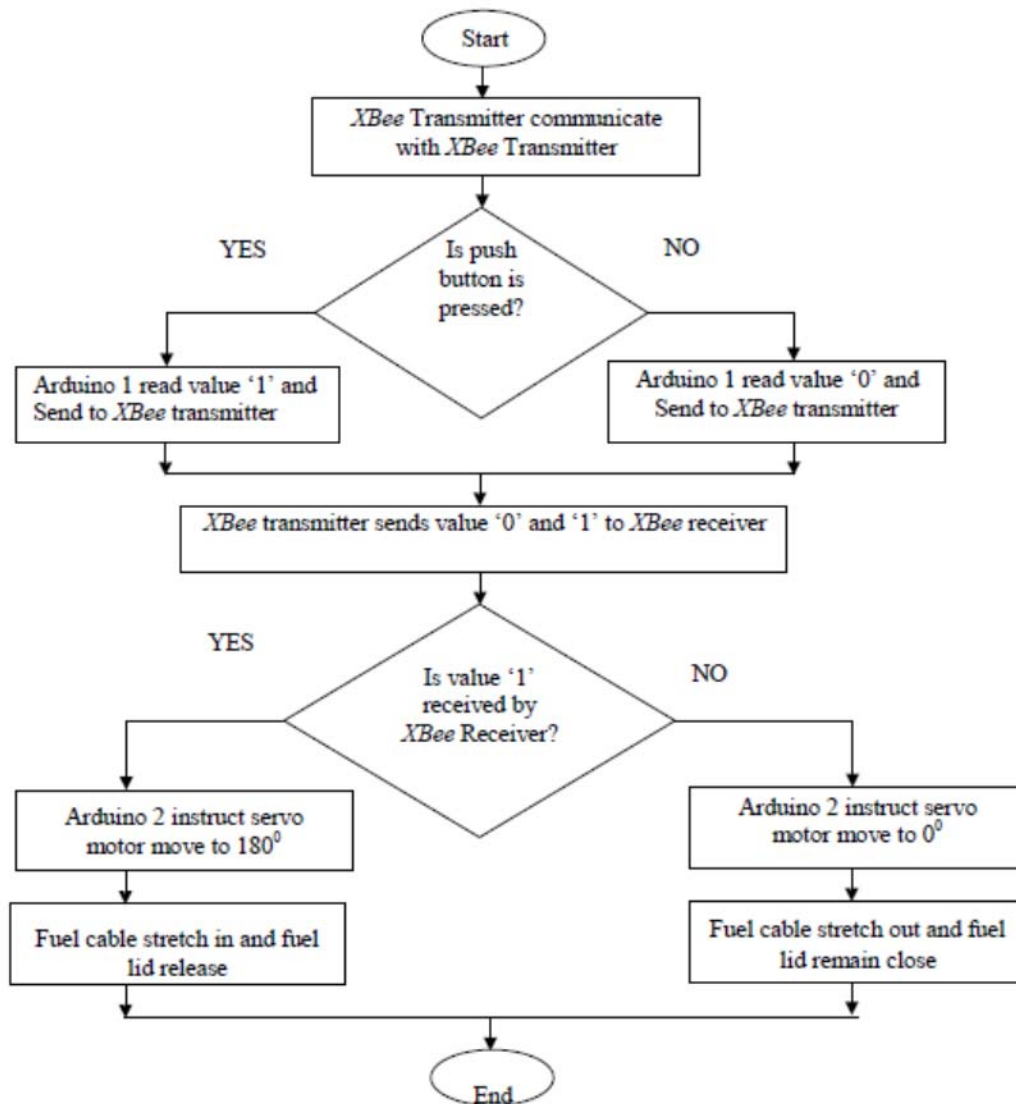


Figure 6. Process flow for remote control-based technique.

The communication process between the smartphone with the Arduino microcontroller to control the operation of the fuel lid is elucidated by figure 7. Here, the car driver need to use servo motor apps in the smartphone to give instruction to Arduino to rotate the servo motor to servo motor to rotate to 180 (to open the fuel lid) or 0 (to let the fuel lid remain closed).

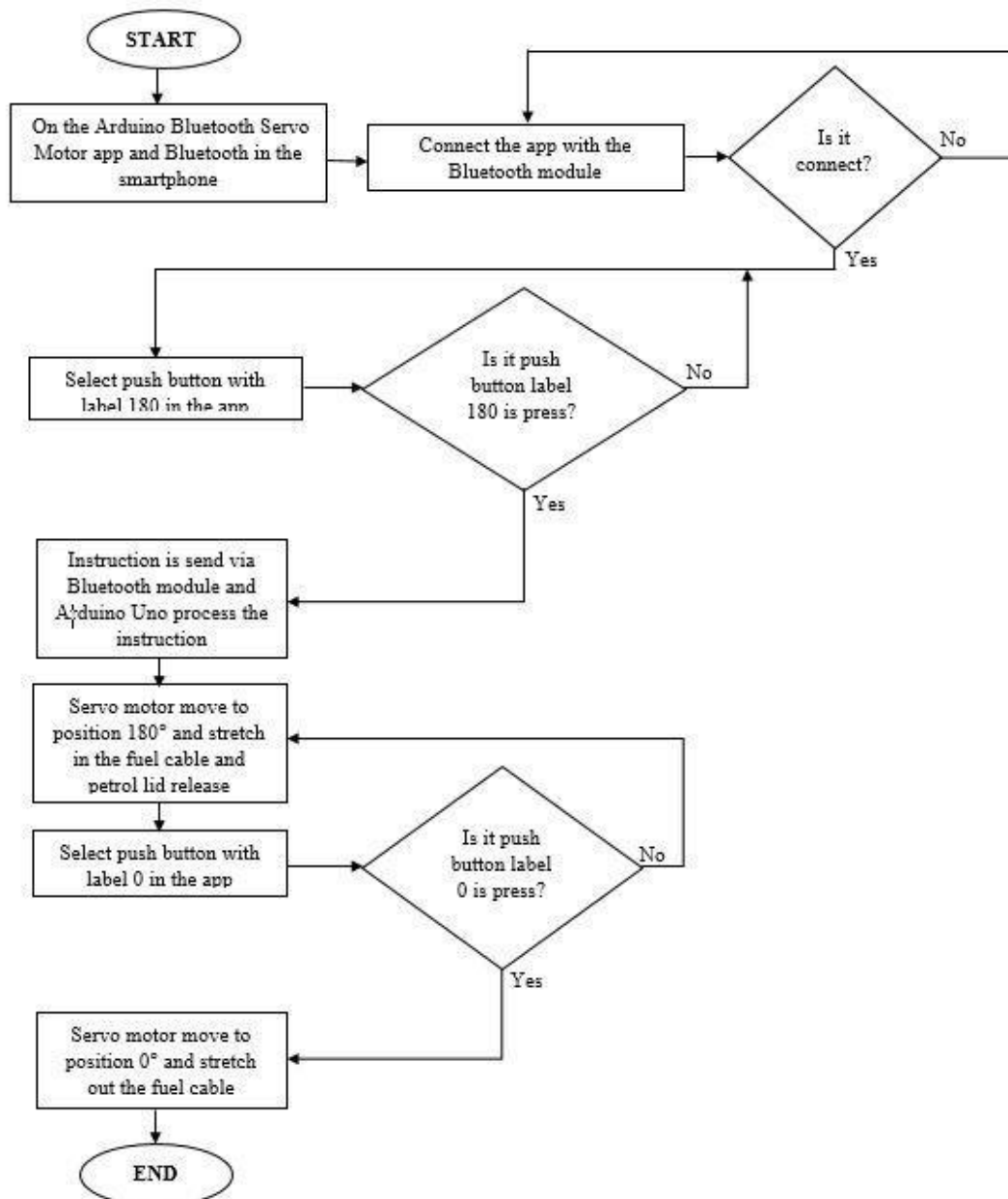


Figure 7. Process flow for smartphone-based technique.

2.2 Setup of XCTU Software and XBee

In order to run *XBee*, the installation of the Future Technology Devices International (FTDI) and Combined Driver Model (CMD) in the computer is required as shown in figure 8. Here, each *XBee* is assigned to different port to communicate with each other using *XCTU* software. There are

several steps in order to configure *XBee* as illustrated in figure 8. *XBee* must be configured by *XCTU* software before the device be used to transmit or receive signals.

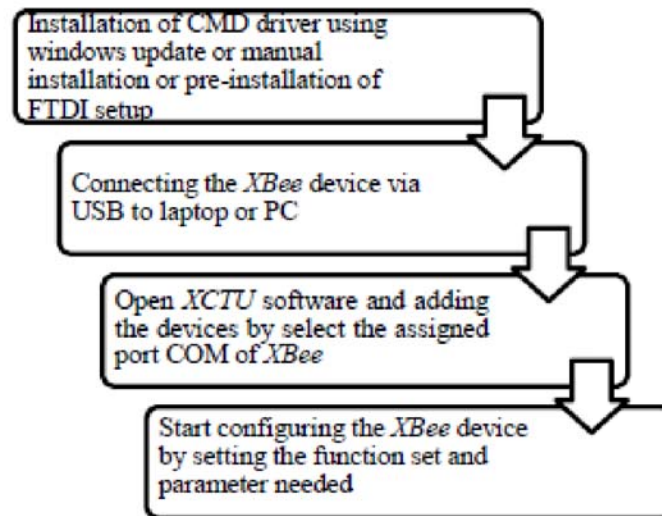


Figure 8. Steps for *XBee* configuration.

The configuration parameter for *XBee* is shown in Table 1. According to table 1, the configuration parameters for *XBee* are set using *XCTU* software. Here, both *XBee* transmitter and receiver are set with the same Network ID (3110) and Baud rate (9600). In order to allow the communication between 2 *XBee* devices, both devices must be in the same network which is defined by Personal Area Network (PAN). Then, the source address (MY) and the destination address is defined for each to recognise each other. The lower byte of the destination address (DL) is enough to enter the *XBee* S1 into the broadcast mode by setting the value of 0xFFFF. The entry channel (CH) is in the range of 0B until 1A but it will be easier to set it to the default channel as 0C. The baud rate is set to the default rate, 9600.

Table 1. *XBee* configuration parameters for *XCTU* software.

Parameters	Transmitter	Receiver
Network ID	3110	3110
Channel(CH)	0C	0C
Baud Rate (BR)	9600	9600
Source Address (MY)	0010	0011
Destination Address (DL)	0011	0010

Meanwhile, the configuration of the communication port to communicate between *XBee*, *XBee* shield and *XCTU* software is illustrated by figure 9. As illustrated by figure 9, Com 3 port is used to communicate with *XBee*. Meanwhile, Com 4 port is used to communicate with *XBee* shield and Arduino microcontroller.

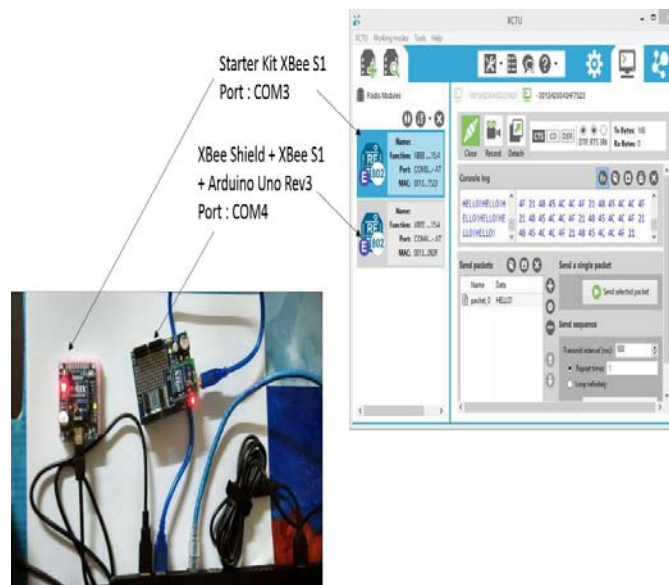


Figure 9. XCTU port setting for *XBee*, *XBee* shield and Arduino microcontroller.

3. Results and Discussion

In this section, the results of the development of the remote control, smartphone mode and system prototyping and model will be discussed.

3.1. Development of remote control technique

The remote control technique is constructed using 2 wireless *XBee* S1 devices to act as transmitter and receiver. Figure 10 shows the overall schematic diagram for fuel lid operation in remote control mode which is built and analysed using Proteus software before set-up the hardware components. According to figure 10, the schematic diagram consists of 2 *XBee* S1 and each *XBee* S1 is connected to one Arduino microcontroller to process the radio signals that are received or transmitted by the *XBee* S1. The simulation in Proteus software is conducted to test the communication between 2 *XBee* S1. The Proteus software is also used to calculate the required power supply by the *XBee* S1. Once the push button of remote control is pressed, the communication between *XBee* transmitter and receiver occurred. It is indicated by the change of serial monitor in Arduino microcontroller from '0' to '1'. Besides, the simulation results also show that the required power supply by the *XBee* is merely 3.31V.

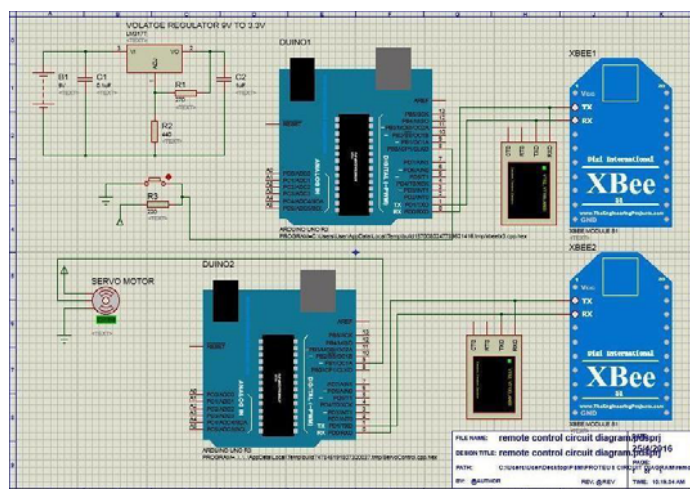


Figure 10. Schematic of remote control mode in Proteus software.

In this project, the 9V battery is used to power up the remote control. The voltage calculation is required in order to make voltage regulator LM317 to produce output voltage about 3.3 V. Equation (1) is used to decide the resistor values to be used in the schematic in order to get the desired output voltage which is 3.3V. Thus, it is required to calculate the value of R_1 , R_2 and R_3 based on the desired output voltage and adjustment of the current (I_{adj}) which can be obtained from the analysis of the circuit in Proteus software. Meanwhile, in constructing remote control technique, the push button is used as a switch for the remote control to open the fuel lid. Here, the push button is connected to the pin 8 of the input port of the Arduino microcontroller.

$$V_o = 1.25(1 + (R_1 + R_2) / R_3) + (I_{adj})R_2 \quad (1)$$

3.2. Development of smartphone technique

In the smartphone technique, the circuit consists of Bluetooth module HC-05 as a wireless communication device to the smartphone in order to control the operation of fuel lid. Figure 11 elucidates the schematic diagram for the operation of fuel lid using smartphone. The circuitry is analysed using Proteus software. Here, the Bluetooth module HC-05 is connected to the “TX” and “RX” port of Arduino microcontroller to receive the instruction from the smartphone. Then, the “TXD” pin at the Bluetooth module HC-05 is connected directly to the “RX” pin 0 of the Arduino microcontroller. However, in order to avoid the Bluetooth module HC-05 to get burnt out due to the high voltage in the circuit, the voltage divider circuit is applied to regulate voltage of 5 V from “TX” Arduino microcontroller in pin 1 to become 3.3 V. It is because the Bluetooth module HC-05 can be damaged easily if the “RXD” pin at Bluetooth module HC-05 received voltage more than 3.3V. Hence, the simulation of the smartphone mode must be run and analyzed in Proteus software to ensure the correct voltage is supplied to the Bluetooth module. Besides, the software simulation will ensure the correct parameters are selected for voltage divider circuit.

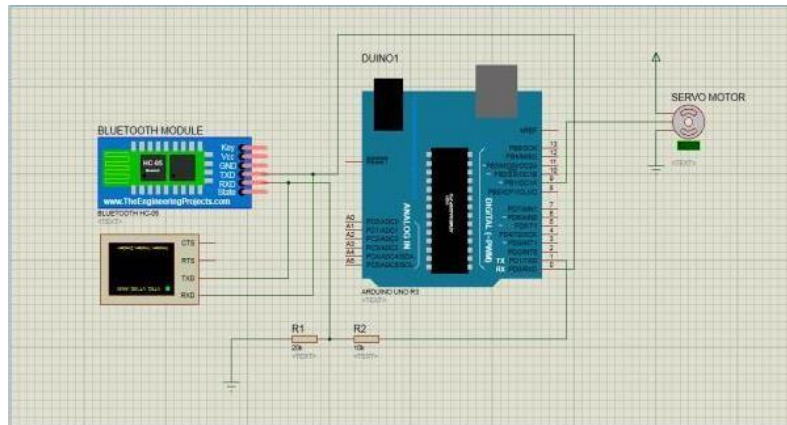


Figure 11. Schematic of smartphone mode in Proteus software.

Furthermore, the servo motor which is connected to the pin 9 of Arduino microcontroller will move according to the instruction received from the smartphone. The rotation of the servo motor will release the hook of fuel cable and then, open the petrol lid. In addition, the movement of the servo motor is controlled by an Android application that can be downloaded from the Android Play Store. The name of the application is Arduino Bluetooth Servo Motor. Here, the movement of the servo motor can be controlled by this application. Figure 12 depicts the diagram of the Arduino Bluetooth Servo Motor application which can be used to communicate between Arduino, servo motor and smartphone.

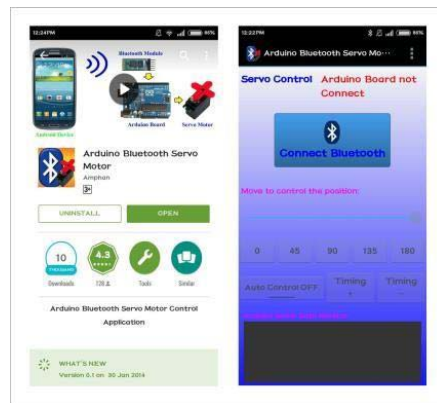


Figure 12. Application of Arduino Bluetooth Servo Motor for smartphone.

3.3. Development of the prototype of remote control technique

Once the remote control and smartphone techniques are successfully simulated, a prototype of the remote control mode is constructed as shown in figure 13 and figure 14 respectively. The prototype is built according to the schematic shown in figure 10. Meanwhile, the prototype of smartphone technique is elucidated by figure 15 and it is developed according to the schematic shown in figure 11.

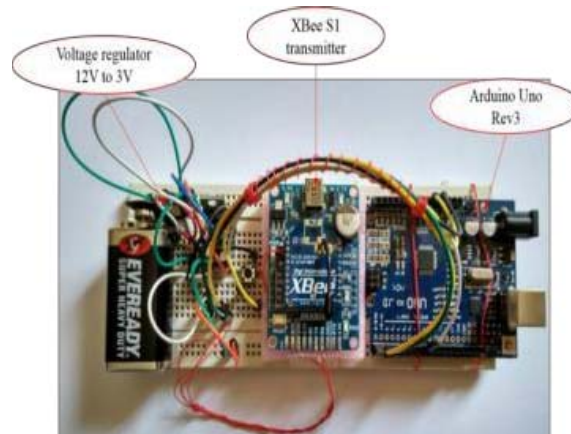


Figure 13. Transmitter part of remote control prototype.

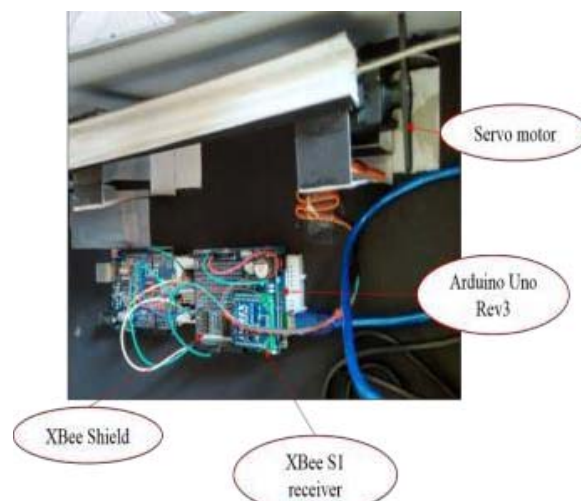


Figure 14. Receiver part of remote control prototype.

The smartphone technique for the operation of the petrol lid consist of three major part of circuit diagram as shown in figure 15. For the first part, the Bluetooth module is employed as an input device that received the instruction from the Android application in smartphone. Meanwhile, for the second part, Arduino microcontroller is employed to process the value send by input device. The final part is the movement of servo motor which acts as an output device that moves according to the direction given by the input device.

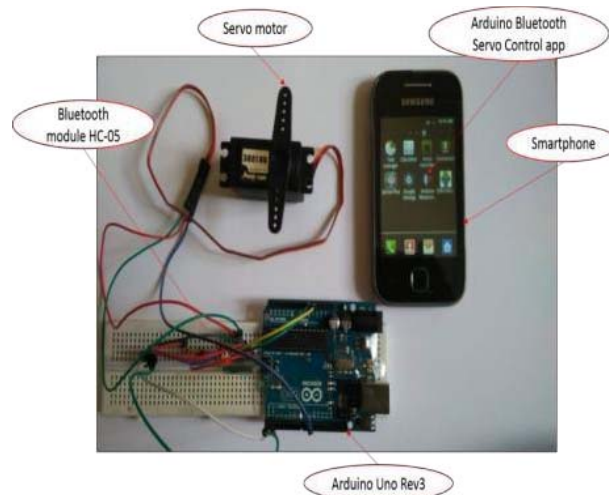


Figure 15. Smartphone prototype to control servo motor movement.

3.4. Implementation of the remote control and smartphone prototyping

Before implementing the proposed design to the real car, the model of car is built in order to demonstrate the operation of car fuel lid using remote control and smartphone techniques. The model of car is constructed using cardboard paper and the plastic cable to represent the cable fuel at the petrol lid mechanical part as shown in figure 16. Once the remote control or smartphone is activated, it will send instruction to servo motor attached to petrol lid to release the cable fuel.



Figure 16. Model of car for operation of fuel lid and fuel cable.

Figure 17 shows the placement of the servo motor, remote control, microcontroller and Bluetooth circuit inside the compartment of the model of the car. Finally, the prototyping model of car is built and produced to demonstrate the operation of car fuel lid by using remote control and smartphone. Both remote control and smartphone mode are functioning and successfully tested to release the fuel cable hook and open the fuel lid. The testing and verification is done several time to test the robustness of the system. The testing is implemented in the sequence manner; either the system is started using remote control first and then follow with smartphone or vice versa.

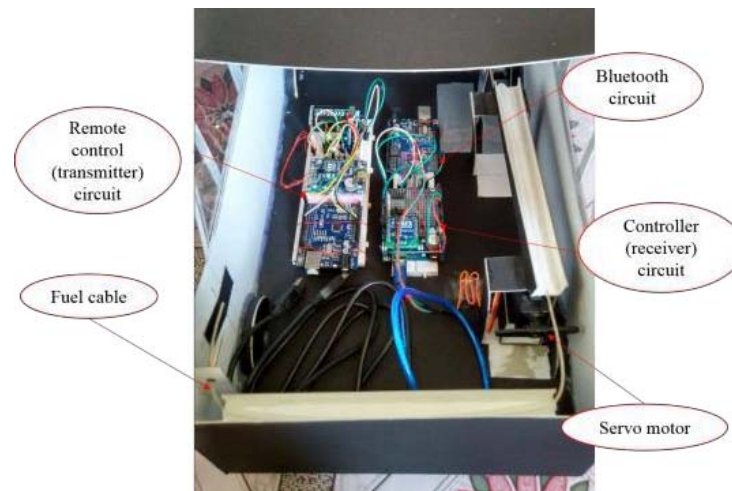


Figure 17. Application of Arduino Bluetooth Servo Motor.

3.5 Testing of the Servo Motor movement

The Servo Motor is tested using Pulse Width Modulation (PWM) technique. The electrical pulse is given to the servo motor with the variable pulse to determine how far the servo motor will move. Figure 18 illustrates the basic movement of servo motor by the given PWM which can be used for micro-controller. It indicates that the servo motor will take about less than or equal 1.5ms to move from 0 degree direction to 90 degree direction. Meanwhile, it will take about less than or equal 2ms to move from 90 degree to 180 degree direction. The plot of the duration of the pulse versus direction of servo motor is shown in Figure 19. It shows that the 1.86ms or about 2ms of the pulse is required to move the servo motor from 0 degree to 190 degree direction which provides enough time to control the fuel lid operation if the operation is done using smartphone. The graph also shows that the car driver has enough time to operate the fuel lid using remote control as well.

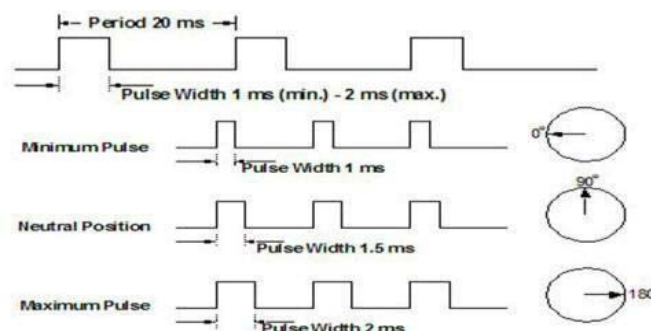


Figure 18. Servo motor movement according to PWM which is applied to microcontroller [5].

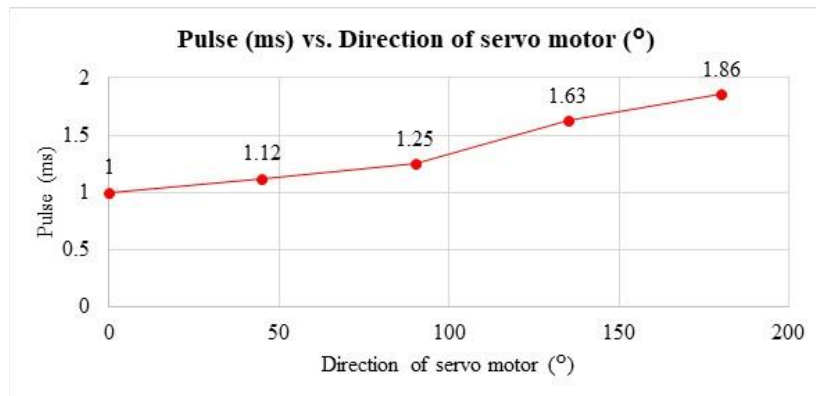


Figure 19. Servo motor movement according to PWM.

4. Conclusion

This project is implemented to provide an alternative method to open the car fuel lid from outside of car's cabin. Even though there is seldom case of malfunction of car fuel lid, when the malfunction of fuel cable occurred, the fuel lid absolutely cannot be opened. Thus, it will create troublesome to car driver. The project output shows that both remote control and smartphone technique can control the operation of the fuel lid with duration less than 2ms. Hence, the project succeed in providing multi- function of the car remote control where the existing vehicle just capable to control merely the car door and rear bonnet. In the case that if the proposed car remote unable to operate the car fuel lid, the car driver still has another option to open the fuel lid using smartphone beside using the existing car fuel lever. The project output proved that it is very beneficial to develop the vehicle remote control to operate car fuel lid wirelessly via remote control and smartphone techniques. This project is developed to overcome the malfunction of fuel lid which the car driver can open the fuel lid in wireless manner. Hence, for the future work, it will include the implementation of the project at the real vehicle and communication performance between the 2 techniques will be studied and improvised. Besides, the appropriate sensor will be allocated either at the fuel lever or fuel lid to alert the car driver about the malfunction of the fuel lid.

Acknowledgment

The author would like to acknowledge the great supports and contributions given by the final year Undergraduate student and project team members. High appreciation also goes to the faculty of Electrical & Electronics Engineering and University Malaysia Pahang by providing financial support through research grant (RDU170365) to make the project succeed.

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