Design and Implementation of Wireless Based Android Controlled Spy-vehicle

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Abstract: *A new version of wireless controlled vehicle is proposed for spying purposes. This research will apply the smart phone to transmit bluetooth wireless data to the Arduino-Uno then it will give the data for vehicle's movement. This robot supposes a movable spy robot with wireless system by using Arduino-Uno as a main controller. The spy robot is made up of an IP camera, DC motors, servo motors for camera rotation, lithium rechargeable ion batteries, and four movable wheels. Smart phone camera is used as an IP camera to capture livestreaming video surrounding the robot and that information will be appeared in user's smart phone GUI window. In this vehicle, the bluetooth signals transmitted from the user's smartphone are used for vehicle motion and then the camera mounted on robot will take the video livestreaming. This livestreaming information is sent back to the user's smart phone via wifi wireless system. For the system, the simulation result is done by using Proteus Professional schematic software. Arduino programming language is used for Arduino-Uno and Basic4 Android programming is used to write desired App in smart phone.*
Keywords : *Basic4 Android Programming, Bluetooth Wireless System, DC motor, Spy-vehicle, Wifi Wireless System*

I.   Introduction

Nowadays spy-vehicles have been widely used in various kinds of fields like industries, academic, research and development, militaries and so on. The spy-vehicles are small vehicles designed for spying, surveillance and inspection purposes. They can be customized for specific applications and are made with some special features. They are remotely controlled vehicle, equipped with a camera, transmitting video data to the intervention troop. Troopers can access the situation in the room where the small vehicle is thrown. They are made to be small and compact enough to easily transport. Most of them are designed for use in rough terrain. In brief, spy vehicles must be small and lightweight, robust, mobile, tele-operated (wireless) [1]. In this research, a movable spy-vehicle with a smartphone controller is implemented. The vehicle is not quite huge one and designed to be easy in transportation. The remote controller, smartphone is to control the robot to reach the desirable destination. The spy-vehicle is fundamentally made up of smartphone, Arduino-Uno microcontroller, L298 motor driver, DC motors and four movable wheels. When the user drives the robot with bluetooth wireless technique via written App, the spy-vehicle will move to desired destination and spies video around the vehicle. The vehicle will transmit the video livestream that are spied around the vehicle and retransmit to the driver's smartphone via wifi wireless technique for a good spying system. By watching the video, the user will know the required information. The overall block diagram of the wireless based spy-vehicle is shown in Fig. 1.
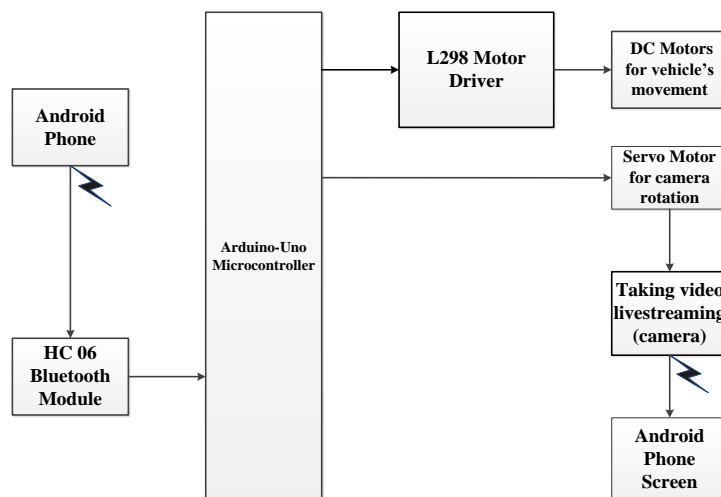

Fig. 1. Overall Block Diagram of the System

II. Hardware Configuration

In this paper, the system is mainly composed of Arduino-Uno microcontroller, L298 motor driver, four robot wheels and dc motors, servo motors, HC06 bluetooth module, two smartphones and boost converters respectively.

1. Modeling a dc motor

DC motors are widely used in robotics because of their small size and high energy output. The key characteristics of DC motors are high speed, low torque and its reversibility. The spy robot uses four 3V~6V DC motors as shown in Fig. 2. This DC motor is dual axis gear motor, which reduction ratio is 1:48.Working voltage of this motor is 3V to 6V. The unload current is 200mA at 6V and 150mA at 3V respectively. Motor's unload speed is 200 ±10%RPM at 6 V and 90±RPM at 3V.

Fig. 2. DC motor and Wheel

To be modeling a DC Motor, simple circuit of its electrical diagram as shown in Fig. 3 is considered. To be modeling and simulate the DC motor, the following steps are to be made step by step;
Step1: Represent the DC motor circuit diagram
Step2: Represent system equations
Step3: Calculate the Transfer function
Step4: Convert to model block

1.1 Closed-loop System consideration

To perform the simulation of the system, an appropriate model needs to be established. Therefore, a model based on the motor specifications needs to be obtained. Fig. 3 shows the DC motor circuit with Torque and Rotor Angle consideration.
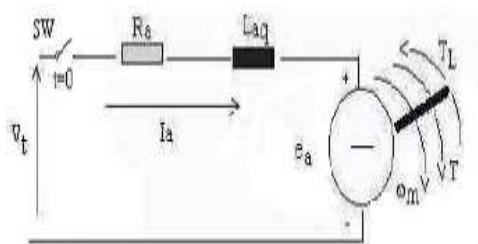
Fig. 3. Schematic Diagram of a DC Motor [2]

1.2 System Equation

The motor torque **T** is related to the armature current, **i** , by a torque constant **K**;

$$T = Ki \qquad (1)$$

The generated voltage, **e_a** is relative to angular velocity by;

$$e_a = K\omega_m = K\frac{d\theta}{dt} \qquad (2)$$

From Fig. 3 we can write the following equations based on the Newton's law combined with the Kirchoff's law:

$$J\frac{d^2\theta}{dt^2} + b\frac{d\theta}{dt} = Ki \qquad (3)$$

$$L\frac{di}{dt} + Ri = V - K\frac{d\theta}{dt} \qquad (4)$$

1.3 Transfer Function

Using the Laplace transform, equations (3) and (4) can be written as:

$$Js^2\theta(s) + bs\theta(s) = KI(s) \tag{5}$$

$$LsI(s) + RI(s) = V(s) - Ks\theta(s) \tag{6}$$

where *s* denotes the Laplace operator. From (6) we can express **I**(*s*):

$$I(s) = \frac{[V(s) - Ks\theta(s)]}{(R + Ls)} \tag{7}$$

and substitute it in (5) to obtain:

$$Js^2\theta + bs\theta(s) = \frac{K(V(s) - Ks\theta(s))}{R + Ls} \tag{8}$$

This equation for the DC motor is shown in the block diagram in Fig. 4 From equation (8), the transfer function from the input voltage, **V** (*s*), to the output angle, □, directly follows:

$$Ga(s) = \frac{\theta(s)}{V(s)} = \frac{K}{\{s[(R + Ls)(Js + b) + K^2]\}} \tag{9}$$

From the block diagram in Fig. 4, it is easy to see that the transfer function from the input voltage, **V** (*s*), to the angular velocity, **ω**, is:

$$Gv(s) = \frac{\omega(s)}{V(s)} = \frac{K}{\{[(R + Ls)(Js + b) + K^2]\}} \tag{10}$$

The motor specification of DC Motor which will be used in Spy-vehicle as shown in below.
Power P = 1.2 watts, Speed N = 200 rpm $_{(max)}$, rotor inertia J is assumed to be 0.01 and Supply voltage Vt= 6 volts. Therefore for the max speed rpm of 200, it can be calculate the torque constant K ;

$$\omega_m = \frac{Vt}{K} = \frac{(2\pi N)}{60} \tag{11}$$

      K = 0.2857 and ω_m = 21 radsec^{-1}

By using equation 3, for $\omega = \dfrac{d\theta}{dt}$

$$K \times i = \frac{d\omega}{dt} + b\omega$$

At the steady state (used as analyzed data), both **I** and **ω** are stabilized;

$$\frac{d\omega}{dt} = 0$$

Therefore, the total equivalent damping **b** can be chosen the value of;
(0.2857*0.2) – b (21) = 0
        b = 0.0027
By calculating and assuming the require data as above, the following value are assigned to be used for our desire DC Motor Model.
   Vt = 6V ; J=0.01; b =0.0027; K =0.2857 ; R=1.617 ohms and L =0.001H;
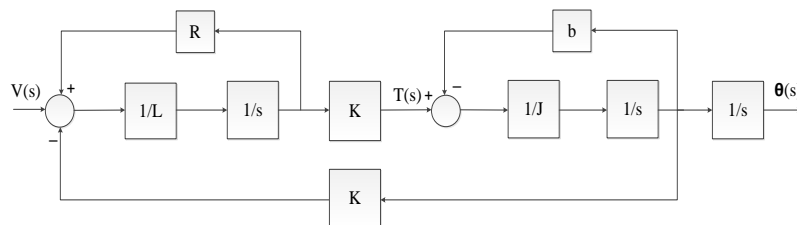

Fig. 4. A Block Model System of DC motor

In this research, the spy-vehicle is implemented by using two wireless systems such as bluetooth and wifi. Bluetooth data via smart phone is used for the vehicle movement and wifi is applied for the livestreaming video from spy-vehicle. Internet Protocol (IP) address is used to get the livestream on reality. And the required App is invented by using the Basic4 Android programming language. Thus, this section will explain the two wireless systems, IP address, basic4 Android App written method and livestreaming video.

1. Bluetooth wireless technology (BWT)

Bluetooth wireless technology is a short range radio communication system designed for communication of devices like mobile phones, PDAs, notebooks, PCs, printers and headsets. Bluetooth technology operates in the unlicensed Industrial, Scientific and Medical (ISM) band at 2.420- 2.485 GHz, using a spread spectrum, frequency hopping, full-duplex signal at a nominal rate of 1600 hops sec^{-1} [3]. Bluetooth technology's Adaptive Frequency Hopping (AFH) capability was designed to reduce interference between wireless technologies sharing the 2.4 GHz spectrum. AFH works within the spectrum to take advantage of the available frequency. This is done by detecting other devices in the spectrum and avoiding the frequencies they are using. This adaptive hopping allows for more efficient transmission within the spectrum, providing users with greater performance. The signal hops among 79 frequencies at 1 MHz intervals to give a high degree of interference immunity. The heart of the Bluetooth specification is the Bluetooth protocol stack. By providing well layers of functionality, the Bluetooth specification ensures interoperability of Bluetooth devices and encourages adoption of Bluetooth technology. There are three classes of BWT radio devices, each with a different maximum range Class 1 (100 meters), Class 2 (50 meters) and Class 3 (10 meters) respectively. In this research, Class 3 is used for testing.
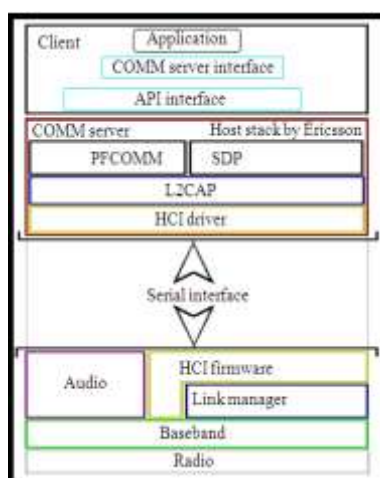

Fig. 5. Bluetooth protocol stack [4]

2. Wireless fidelity

WiFi is a universal wireless networking technology that utilizes radio frequencies to transfer data. WiFi allows high-speed internet connections without the use of cables. The term WiFi is a contraction of "wireless fidelity" and is commonly used to refer to wireless networking technology [5]. It is almost 10 times faster than a regular dial-up connection. It is also known as 802.11 networking and wireless networking. The 802.11 standard is defined through several specifications of WLANs. It defines an over-the-air interface between a wireless client and a base station or between two wireless clients. There are several specifications in the 802.11 family such as 802.11a, 802.11b and 802.11g.The standard 802.11 pertains to wireless LANs and provides 1- or 2-Mbps transmission in the 2.4-GHz band using either frequency-hopping spread spectrum (FHSS) or direct-sequence spread spectrum (DSSS). The 802.11a is an extension to 802.11 that pertains to wireless LANs and goes as fast as 54 Mbps in the 5-GHz band. The 802.11a employs the orthogonal frequency division multiplexing (OFDM).The 802.11b is an extension to 802.11 that pertains to wireless LANs and yields a connection as fast as 11 Mbps transmission in the 2.4-GHz band. The 802.11b specification uses only DSSS. The 802.11g pertains to wireless LANs and provides 20+ Mbps in the 2.4-GHz band. WiFi networks operate in the unlicensed 2.4 radio bands, with an 11 Mbps (802.11b) or 54 Mbps (802.11a) data rate, respectively [6]. The big advantage of WiFi is its simplicity. The higher frequency allows higher data rates. WiFi radios use much more efficient coding techniques that also contribute to the much higher data rates. For 802.11a and 802.11g, the technique is known as orthogonal frequency-division multiplexing (OFDM). For 802.11b, it is called Complementary Code Keying (CCK). The advantage of frequency hopping is that it is much more immune to interference.

3. Internet Protocol (IP) Address

An IP address is a numerical label assigned to each device participating in a computer network that uses the Internet Protocol for communication [7]. In this spy-vehicle, the livestream video is taken via android camera. It is used as an IP camera.To get the livestream video and information, the IP address of the camera is essential. IP address of android camera can be known via Droid IP camera App. Thus Droid IP camera App

must be installed in the spy-vehicle's android camera. This IP address is encoded in basic4android program.The required App to drive the spy robot is written with B4A programming languages. The internet protocols consist of a suite of communication protocols, of which the two best known are the Transmission Control Protocol (TCP) and the Internet Protocol (IP). The Internet protocol suite not only includes lower-layer protocols (such as TCP and IP), but it also specifies common applications such as electronic mail, terminal emulation, and file transfer. An IP address is an identifier for a computer or device on a TCP/IP network. Each host on a TCP/IP network is assigned a unique 32-bit logical address that is divided into two main parts: the network number and the host number. The network number identifies a network and must be assigned by the Internet Network Information Center (Inter NIC). The host number identifies a host on a network and is assigned by the local network administrator. The 32-bit IP address is grouped eight bits at a time, separated by dots, and represented in decimal format (known as dotted decimal notation). Each bit in the octet has a binary weight (128, 64, 32, 16, 8, 4, 2, 1). The minimum value for an octet is 0, and the maximum value for an octet is 255. Fig. 6 illustrates the basic format of an IP address. IP addressing supports five different address classes: A, B, C, D, and E. Only classes A, B, and C are available for commercial use [8]. In this spy-vehicle, class C IP address is applied.
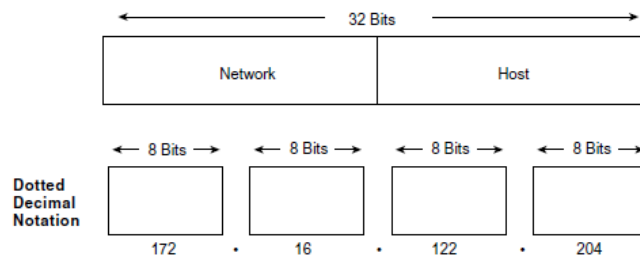
Fig. 6. An IP address consists of 32 bits, grouped into four octets [8]

Address Class	First Octet in Decimal	High-Order Bits
Class A	1 Đ 126	0
Class B	128 Đ 191	10
Class C	192 Đ 223	110
Class D	224 Đ 239	1110
Class E	240 Đ 254	1111

Fig. 7. A range of possible values exists for the first octet of each address class [8]

4. Basic4 Android Programming

Basic4Android is a rapid application development tool for native Android applications, development and marketed by anywhere Software Ltd. B4A is an alternative to programming with Java and the Android SDK. It is mainly operates in Microsoft Windows [9]. Basic4android depends on two additional (free) components such as Java JDK and Android SDK. When the Basic4Android application is started to write, the important software to install are Java JDK, Android SDK and Basic4 Android software on the computer. This programming can be used not only on 32-bit but also on 64-bit operating system. Then, it is needed to create Android Virtual Device (AVD) or emulator. Emulator is a software that simulate like real device on computer. Each Basic4 Android program runs in its own process. A process has one main thread which is also named the UI thread which lives as long as the process lives. A process can also have more threads which are useful for background tasks. A process starts when the user launches the application, assuming that it is not running already in the background. A Basic4 Android application is made of one or more activities, as in [10]. When a new activity is created, it will start with the following code;
The Basic Program without any additional code:
Sub Process_Globals
'These global variables will be declared once when   the application starts.
'These variables can be accessed from all modules.
End Sub
Sub Globals
'These global variables will be redeclared each time the activity is created.

'These variables can only be accessed from this module.
End Sub
Sub Activity_Create (FirstTime As Boolean)
'Do not forget to load the layout file created with the visual designer.
'Activity.LoadLayout("Layout1")
End Sub
Sub Activity_Resume
End Sub
Sub Activity_Pause (UserClosed As Boolean)
End Sub

In the B4A programming code, variables can be either global or local. Local variables are variables that are declared inside a sub other than Process_Globals or Globals. Global variables can be accessed from all subs. There are two types of global variables. They are process variables and activity variables. Process variables are the variables that live as long as the process lives. These variables must declare inside sub Process_Globals and this sub is called once when the process starts. Activity variables are contained by the activity. These variables must declare inside Sub Globals.

5. Video livestreaming

Video streaming over wireless networks is compelling for many applications, ranging from home entertainment to surveillance to search-and-rescue operations. Interesting technical challenges arise when the unpredictable nature of the wireless radio channel meets the requirements of high data rate and low latency for video transport. Video streaming over wireless networks is compelling for many applications, and an increasing number of systems are being deployed. Video streaming of news and entertainment clips to mobile phones is now widely available [11]. In this research, video livestreaming was accomplished by making use of wifi Direct from spy-vehicle's camera to driver's phone. Wifi direct was used to maintain the goal of the vehicle being mobile and able to be used in any location and situation. By using wifi system, it allows connections between two mobile devices without the availability of a router. When compares to bluetooth, Wifi Direct surpasses it in both speed and range with speeds of up to 250Mbps, which was a perfect fit for video streaming purposes. Wifi allows the high-speed connections without the use of cables. Instead of having router as an access point to communicate between two devices, Wifi direct allows a device to take the role of the access point. Fig. 8 is the B4A programmed GUI design for the research.
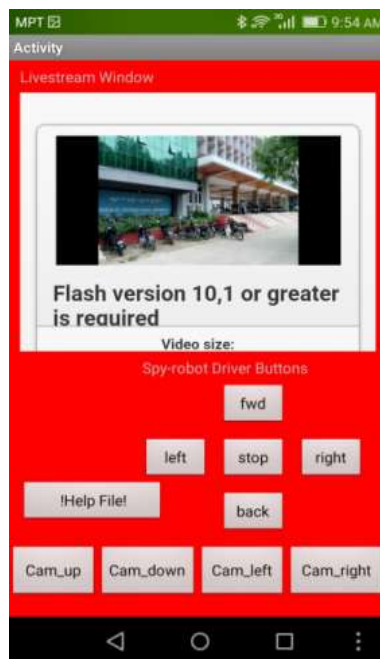

Fig. 8. B4A programmed GUI design for the spy-vehicle

In B4A GUI, livestream window on the top is to watch the vehicle where it arrives, what does camera take and to know the required information. There are five buttons to drive the robot in forward and backward directions, to turn left and right and completely stop. The button on the left corner is the help file for the users to

direct how to use the App for spy-vehicle. There are four bottoms for vehicle's camera rotation such as camera up, camera down, camera left and camera right. This B4A App will enhance the spy-vehicle other than the analog remote control using RF modules. And it can lead to more comfortable and easy to control the robot just having a smartphone.

III. Operation of the system

In this research, the main controller is the Arduino-Uno that is given the data via HC06 Bluetooth module from user's android phone. The motors are driven via L298 motor driver. Servo motor is rotated for spy-vehicle's camera. Then, the information that is taken by camera will sent back to the user's phone screen for video livestreaming. The circuit diagram of spy-vehicle is shown in Fig. 9.The spy-vehicle is made up of Arduino-Uno microcontroller, L298 motor Driver, four robot Wheels and DC motors, HC06 Bluetooth Module and smartphone camera. This camera is used as an IP camera. In this vehicle, the Arduino-Uno acts as a main controller.
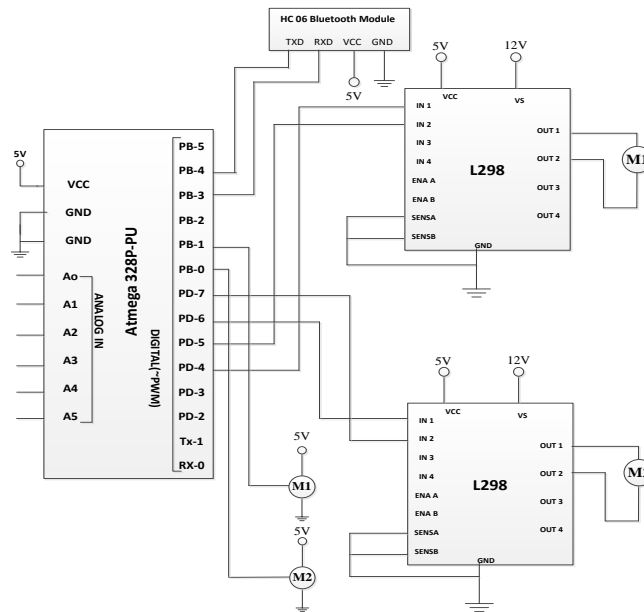

Fig. 9. Circuit diagram of the spy-vehicle

Each of the IN1, IN2 pin of L298 motor driver are connected by Arduino-Uno pin 4,5,6 and 7 respectively. The servo motors are connected by pin 8 and pin 9 of the Arduino-Uno. The bluetooth module is connected by pin 11 and pin 12 of Arduino for receiving and transmitting the data. This vehicle can move forward, backward , stop, left and right directions. The smartphone camera will rotate in four directions. The users can see the view about the surrounding conditions of the spy-vehicle in livestreaming window. Fig. 10 is the hardware result of the spy-vehicle.
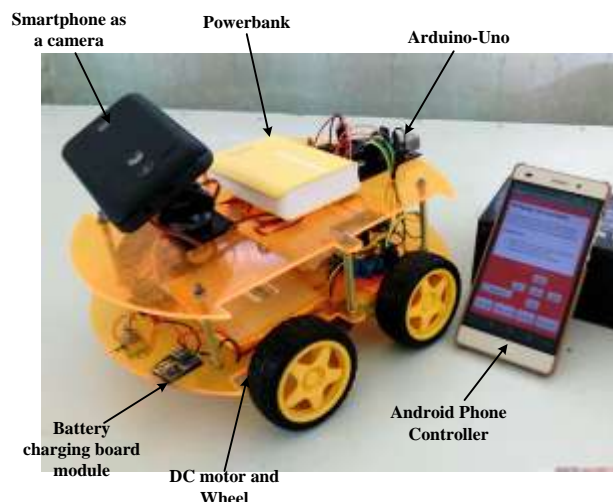

Fig. 10. Hardware result of the spy-vehicle

1. Spy-vehicle App Software

In this paper, the smartphone App is implemented to use as the main driver of vehicle. App is written by Basic4n Android Programming language. Basic4 Android is the programming that is flexible for both android phones and tablets. Thus, it can be applied in our daily lives. In Fig. 11(a), the required App software is shown. The icon is named "Spy-vehicle" as it is aimed for spying purposes. In Fig. 11(b), the page is designed to describe the developer's university, department, thesis's title, and his name. Fig.11(c) is the help file view. In help file, the user will easily know how to use the App software by the given instructions. This help file can easily help the user to use spy-vehicle in reliability. Fig. 11(d) is the design of the warning message whether to quit or not. In addition, there are five buttons to control the spy-vehicle's direction. These buttons are designed as spy-robot diver buttons in B4A GUI design. The four buttons for camera rotation are also present. The final Basic4Android GUI design is shown in Fig. 8.

| (a) | (b) | (c) | (d) |

Fig. 11. (a) Icon of the spy-vehicle on smartphone (b) Design of the developer profile (c) Design of the Help File in Spy-vehicle (d) Dialogue box for warning to quit

2. Simulation test and result

In this paper, the simulation and test result are divided by two sections. The first section is done for spy-vehicle's motors and servo motors testing. And, the second section is done for video livestreaming testing. The simulation result is done by using Proteus professional schematic software and. After the Arduino program is compiled as hex file, the compiled code is sent to the ATMega328P-Pu in Proteus diagram. In Proteus Simulation, the two DC motors are connected by output pins of the L298 motor drivers. The servo motors are connected with the pin 8 and 9 of Arduino. The two DC motors will rotate in four directions and stop. The servo motors will rotate within the range of -90 to +90 degree. The simulation result is shown in Fig. 12. The second section is tested for livestream testing. The spy-vehicle is made up of a smartphone camera that give out of IP address and it operates with wifi wireless system. The user will know the information by watching the livestream video in livestream window in user's smartphone. For the whole system, the spy-vehicle is not quite huge one and designed to be easy in transportation.
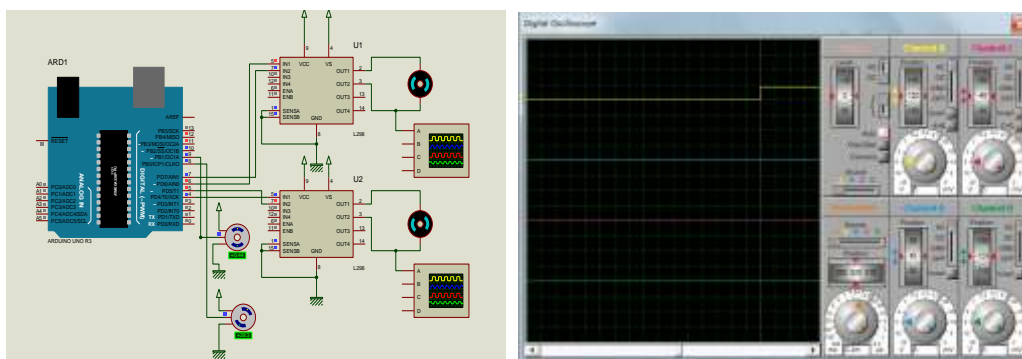

Fig. 12. Proteus Simulation of the DC motors and output waveforms

IV.   Conclusion

In conclusion, this paper describes wireless based spy-vehicle. In this research, two wireless systems are bluetooth and wifi system. This wireless systems are better than wireless RF communication. As BWT-enabled devices operate in the unrestricted 2.4 - Gigahertz and wifi system can operate more than100 feet, this

research can overcome the wireless limitation range rather than RF radio signal. Moreover, this research is aimed for using the smartphone to drive robot and to watch livestream. So, it is not necessary to use PC, Capture Card or TV Tuner Card to watch livestream video and images. Thus, the cost of this robot is inexpensive and suitable for research and scientific works.

Acknowledgements

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