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IMPLEMENTATION OF UNMANNED GROUND VEHICLE WITH A SMARTPHONE

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Abstract: In this study, design and implementation of a remote controlled unmanned vehicle with a smartphone was aimed. Connection of the unmanned vehicle and the smartphone was carried out with a Bluetooth module installed in the vehicle. The smartphone was mounted on the unmanned vehicle. An application sending live broadcast from camera of the smartphone to a web server was developed on Android operating system. 3G internet connection of the smartphone was used to send video data. Additionally the unmanned vehicle could be controlled via buttons on the developed web page. It was observed that implemented system worked successfully. It can send the live video display and the controller of the unmanned vehicle successfully direct it via developed web page as well. Because the smartphone connects to the internet via 3G technology of GSM network, the implemented system can successfully works everywhere GSM network is present.

Keywords: Android Operating System, Smartphone, PIC, Remote Control, Unmanned Vehicle

1. Introduction

Unmanned vehicles are tools which contain no pilot or are remotely controlled. Additionally they can carry cameras, sensors, and even weapons [1]. Unmanned vehicles will be the most important device serving humanity in the near future. Unmanned vehicles can be divided into 4 parts. These are unmanned underwater vehicles (UUVs), unmanned surface vehicles (USVs), unmanned aerial vehicles (UAVs), and unmanned ground vehicles (UGVs) [2]. Unmanned vehicles have recently accessed unprecedented levels of growth in different military and civilian applications with the arrival of new technologies such as digital cameras, satellite navigation, and computer microprocessors [3]. In recent decades, the development of unmanned autonomous vehicles has been of great interest, and different kinds of autonomous vehicles have been studied and developed all over the World. Especially, unmanned vehicles have many applications in emergency situations; humans often cannot come close to a dangerous natural disaster such as an earthquake, a flood, an active volcano, or a nuclear disaster. Since the development of the first unmanned vehicles, research efforts have been focused on military applications [4]. Unmanned vehicles were firstly used for World War I. Because early unmanned vehicles were very unreliable and inaccurate, their importance was not recognized by most people. If small group of people had not kept alive after World War I, the concept of an unmanned vehicle would have not been possible in today’s world. It is essential to state that unmanned vehicles are not only utilized for military applications, but also used in nonmilitary applications such as pipelines and power lines inspection and surveillance, border patrol, rescue missions, region surveillance, oil and natural gas search, fire prevention, topography and natural disasters [5]. Unmanned vehicles play an important role in case of loss possibility of human life for especially military purpose [6]. For instance, it is of much importance in areas containing nuclear (components), chemical or biological gases. Additionally, unmanned systems can be also used in some situations including security risk for human beings to measure some parameter values with detectors [6]. These are mostly remotely controlled devices by a human, that is, they cannot make a reaction autonomously [7]. Remote control of the unmanned vehicles can be carried out via infrared, radio frequency

(RF) or GSM technology. The infrared systems cannot provide communication over obstacles. RF systems have limited working range [7, 8].
In this study, a smartphone [3G technology] mounted on the vehicle was used to remotely control the unmanned ground vehicle. Thus, unmanned vehicle can be used everywhere 3G base stations work. The unmanned vehicle is controlled via a web page developed. The person controlling it can observe camera display of the smartphone on the web page. The communication between the smartphone and the vehicle was carried out via Bluetooth technology. A Bluetooth module was used on the vehicle to make Bluetooth connection with the smartphone.

2. Material and Method

The aim of this study was carried out with the equipments of a smartphone working with Android operating system, a Bluetooth module, an unmanned vehicle. The block diagram of the implemented system is shown in Figure 1.

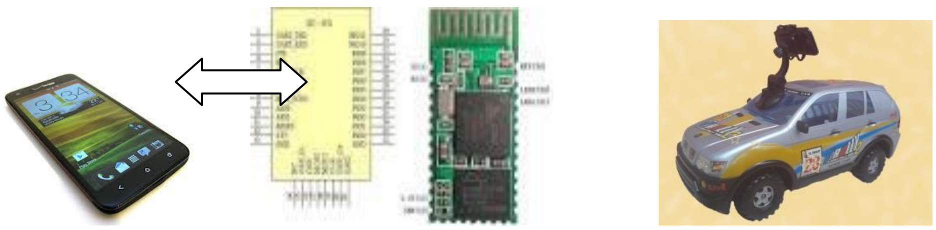
Android phone Bluetooth Module Unmanned vehicle

Figure 1. Block diagram of the designed and implemented system

As shown in Figure 1, the unmanned vehicle is controlled via a control circuit composed of a microcontroller (PIC16F628), DC motor driving chip (L293D), a Bluetooth module (HC- 05), a voltage regulator (7805), and two double contact relays. A smartphone is mounted on the unmanned vehicle and connected to unmanned vehicle via Bluetooth technology. 16F628 is in 3 different cases (PDIP, SSOP, and QFN). PDIP case is the favourite one [9]. Pin diagrams of PIC16F628 for all case types is shown in Figure 2.´

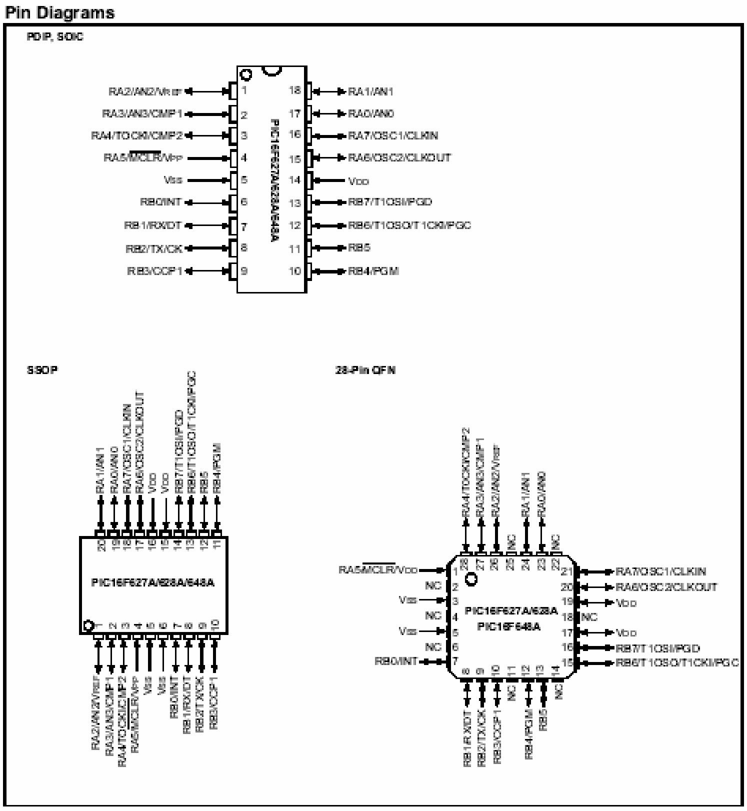

Figure 2. Pin diagrams of PIC16F628 used in the implemented system for all case types [9].

PIC16F628 uses a Harvard architecture, in which, program and data are accessed from separate memories using separate buses. This improves bandwidth over traditional Von Neumann architecture where program and data are fetched from the same memory. Separating program and data memory further allows instructions to be sized differently than 8-bit wide data word [10]. This can be easily understood in Figure 3 [9].

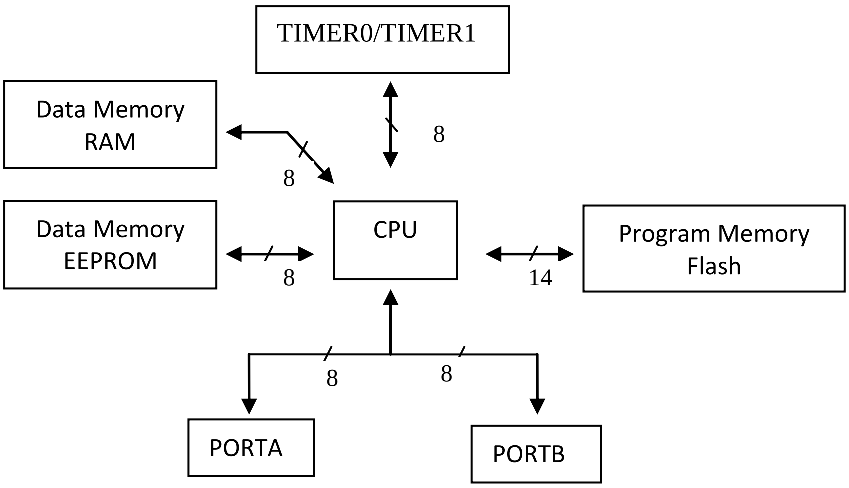

Figure 3. The simplest block diagram of PIC microcontroller [9].

CPU is the part in which program counter and arithmetic logic unit work, which organizes working among the other blocks and makes user program in flash memory work. Flash is the memory in which programs are saved and deleted. EEPROM is the memory in which the data is not deleted even in case of lack of supply voltage. User can repeatedly save and delete programs in EEPROM. RAM is the memory used for the temporary data during execution of the program. It is also named as GPR (General Purpose Register). The values of variables used during execution of program are saved in this memory. Additionally, special function registers (SFR) are present in this memory. The data determining the type of execution of PIC is saved in these registers. PORT A and PORT B are electronic outputs of microcontroller. All data inward or outward PIC is executed via electronic circuits in these blocks. TIMER 0 / TIMER 1 / TIMER 2 is an eight bit register counting in binary independently from execution of the program. It counts up to 255 by once increase the number for each 4 clock signal. It starts again with 0 after 255. Working of a microcontroller can be summarized as: 1- CPU obtains command from flash memory and operates it by decoding, 2- data can be obtained from the other units or sent to them according to the work carried out by the command, 3- if needed, program commands can obtain data from timer, 4- data is sent to the unit controlled by the microcontroller via PORT A and PORT B. The output data of the microcontroller can be logical 1 / 0 or analog voltage value. 25 mA current at 5 V voltage output of the microcontroller cannot be enough to drive most of electronic circuits [9]. In these conditions, extra driving circuits must be used.
Supply voltage of PIC microcontroller is applied on 5th and 14th pins. The supply voltage can be selected between 3 and 5.5 V from -40 °C to 125 °C. A square wave signal is needed to execute program commands in PIC memory. This signal is called as clock signal. The frequency of clock signal determines the speed of execution of commands. Maximum clock signal frequency of PIC16F628 can be 20 MHz. There are two pins (15th and 16th pins) for clock signal inputs in PIC16F628. Clock signal oscillator types and frequencies of PIC microcontroller can be classified as in Table 1.

Table 1. Oscillator types and frequencies of PIC microcontroller.

Oscillator type	**Frequency**
RC	0 – 4 MHz
LP (Low Power)	5–200 KHz
XT (Xtal)	100 KHz- 4MHz
HS (High Speed)	4–20 MHz

I/O ports are used to enter data to program executed in PIC microcontroller. There is USART (Universal Synchronous Asynchronous Receiver Transmitter) unit which communicates synchronously or asynchronously in PIC16F628. Program counter, digital / analog converter, analog / digital converter, and EEPROM are communicated by using USART. The reason of selecting PIC16F628 is that asynchronous communication is used in the implemented system.
There are two different memory blocks (Flash program memory and RAM Memory) in PIC microcontroller. 14 bit program commands are saved in 2 Kbyte program memory in PIC16F628. Although program memory is flash, it is not possible to write data during execution of the program. If the program is desired to be modified, the program should be stopped and the new program should be transferred to PIC [9]. There are 8 bit special function registers (SFR) and general purpose registers (GPR) in RAM memory [9]. SFRs are registers in which some data is written to execute CPU, PORT A, PORT B, and USART of PIC in a desired way. GPRs are registers in which some data of parameters (variables) used in the program is saved.
Because 9 V battery was considered insufficient due to 110 mA current, 12 V battery which was only 350 g was used in unmanned ground vehicle. Because higher voltage batteries were heavier, they were not used in this system not to decrease the mobility performance of the unmanned vehicle.
Double contact relay shown in Figure 4 was used to direct the vehicle right - left, and forward - backward. The relay can conduct up to 2 A.

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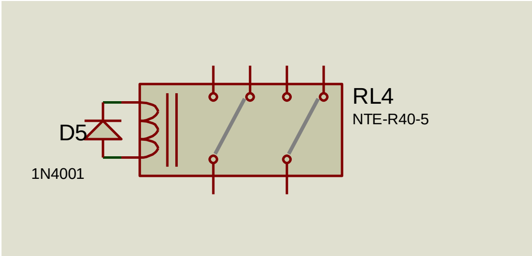

Figure 4. Double contact Relay

When the relay is not supplied with voltage, the unmanned vehicle goes forward. If it is supplied with voltage, the unmanned vehicle goes backward because the DC motor turns backward.
Because the battery was 12 V, 5 V potential necessity of PIC microcontroller and some chips were provided using 7805 voltage regulator chip which is shown in Figure 5.

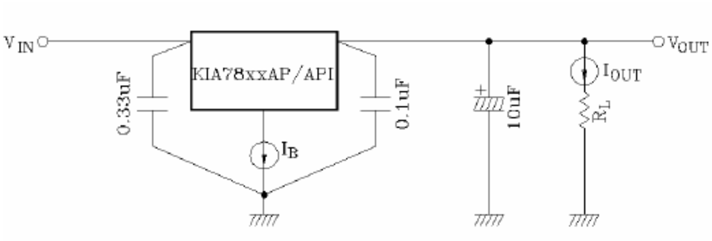

Figure 5. Connection diagram of 7805 voltage regulator used in the implemented system.

Since the supply voltage of HC- 05 Bluetooth module was 3.3 V, LM 1117-3.3 voltage regulator whose connection diagram is shown in Figure 6 was used to provide 3.3 V to Bluetooth module. Thus, LM 1177-3.3 serially connected to 7805 voltage regulator converted 5 V to 3.3 V in the implemented system.

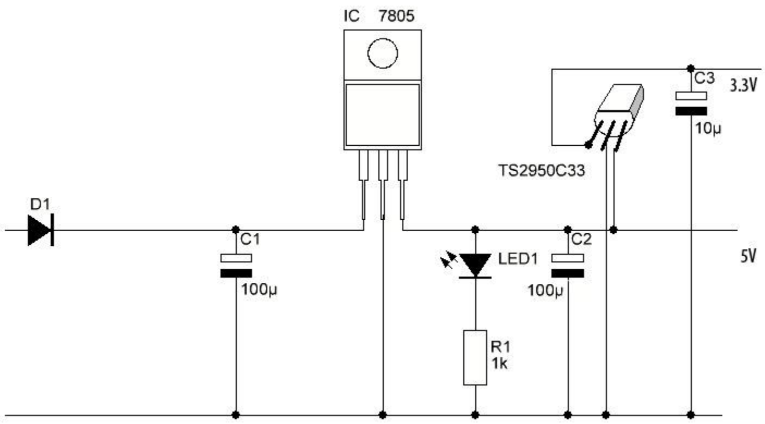

Figure 6. Connection diagram of LM 1117-3.3 voltage regulator

A web page and Android application working on the smartphone were developed as shown in Figure 7 and Figure 8. When the controller of the unmanned vehicle clicks a direction button on the web page, the web page directs the command to the android application working on the smart phone connected to internet via 3G technology. Additionally the developed Android application sends video data obtained from the camera of smartphone to the web page. Thus, the controller can see on the web page the live camera vision of the unmanned vehicle. The video sent by the unmanned vehicle has 640 x 480 pixel resolution and 3 fps. The resolution and frame number of the video sent by the unmanned vehicle can be adjusted to different values according to the controller's desire. Of course, high resolution and frame numbers of the video affect the time of sending the video data. Thus, playing the video may not be fluently due to high resolution. Because of this limitation, the resolution was determined as 640 x 480 pixel and frame number was 3 fps.

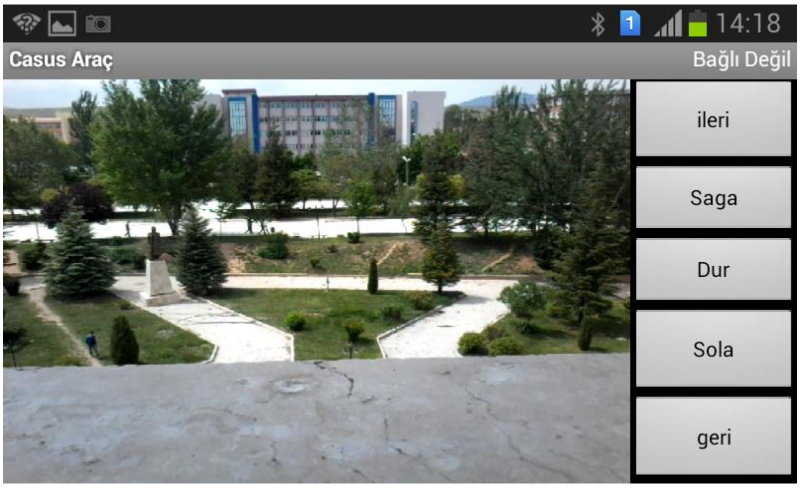

Figure 7. Display of developed android application.

HC- 05 was preferred as a Bluetooth module connecting the unmanned vehicle with the smartphone because it is an easy to use Bluetooth SPP (Serial Port Protocol) module and also cheap. Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3 Mbps Modulation with complete 2.4 GHz radio transceiver and baseband. It uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature). It has the footprint as small as 12.7mmx27mm. Its working range for communication is between 20 and 50 meters. Because smartphone was fixed exactly on the unmanned vehicle, the working range is not very important for this purpose. Bluetooth module and its connection diagram are shown in Figure 9.

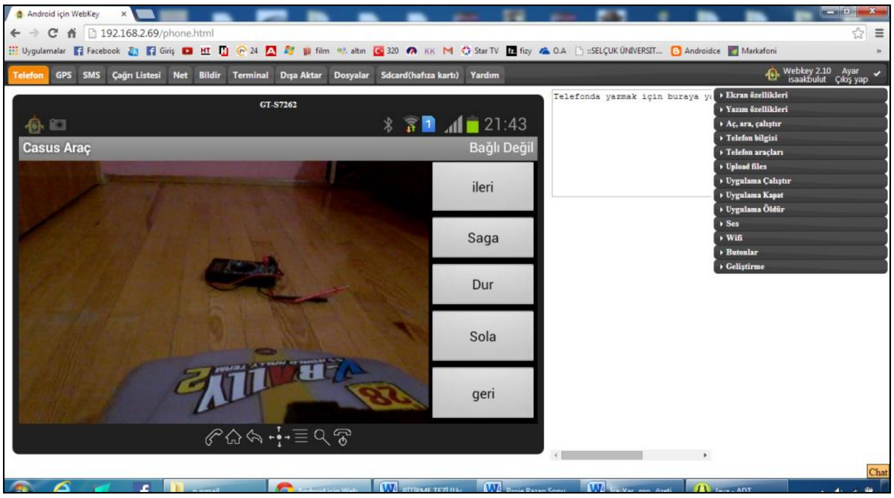

Figure 8. Display of developed web page.

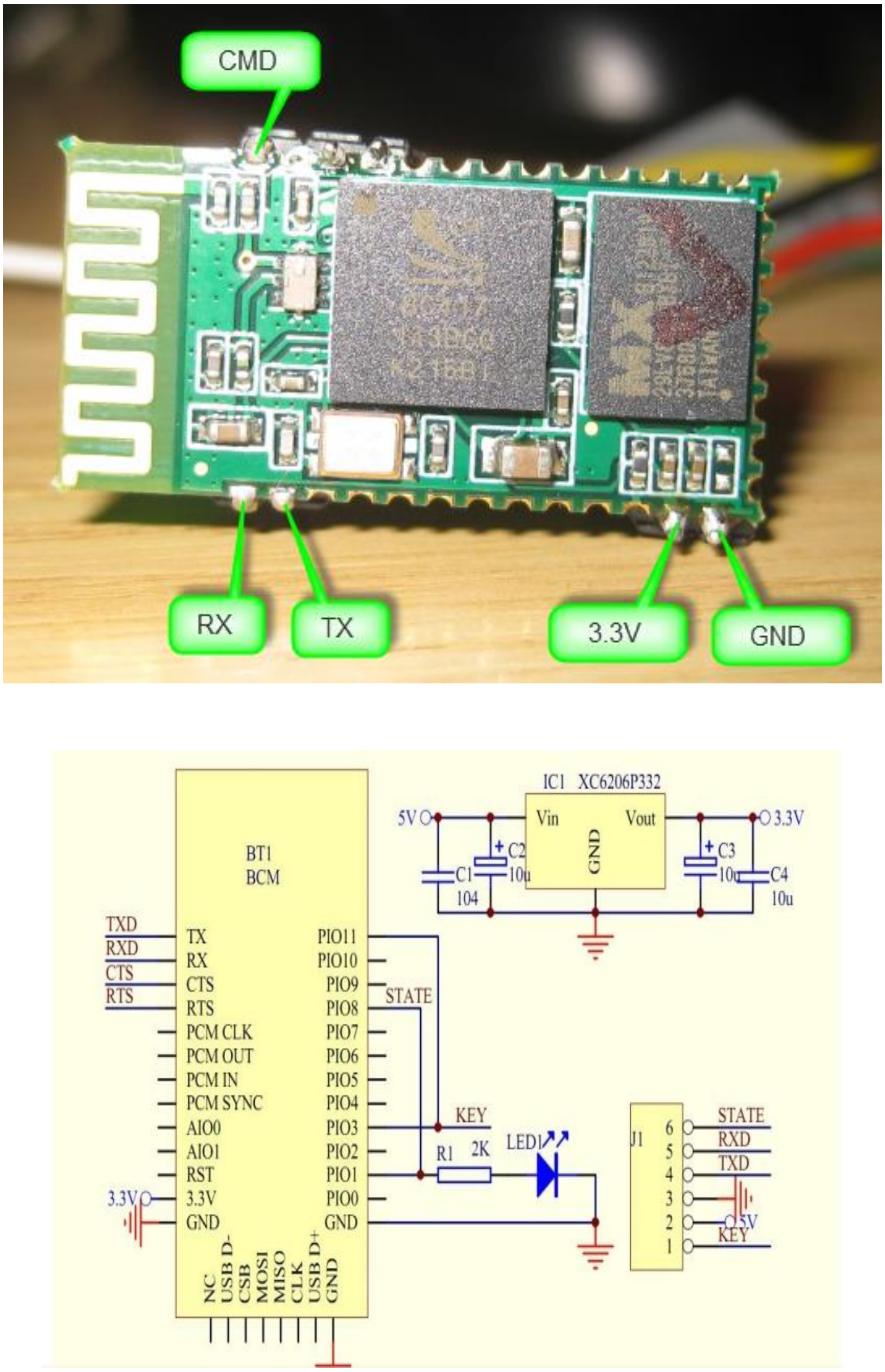

Figure 9. HC- 05 Bluetooth module and its connection diagram

Two DC motors were used to move the unmanned vehicle to the desired place of controller. One DC motor was in front of the vehicle and used to direct it to the left and the right side. The other DC motor was behind the vehicle and used to move it forward and backward. These DC motors were driven over two relays as shown in Figure 10.

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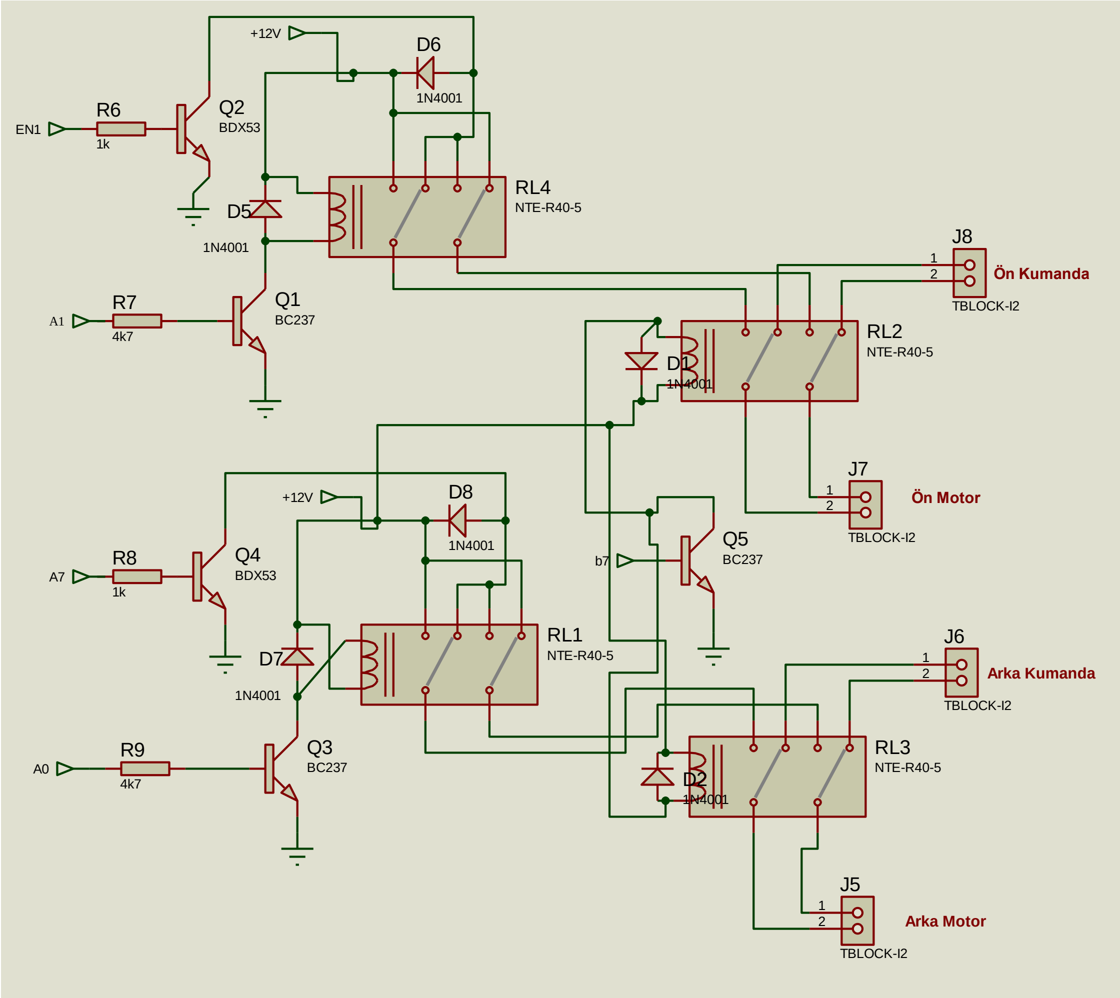

Figure 10. Connection diagram of DC motors moving unmanned vehicle in the implemented system

The general circuit diagram which was fixed on the vehicle is shown in Figure 11.

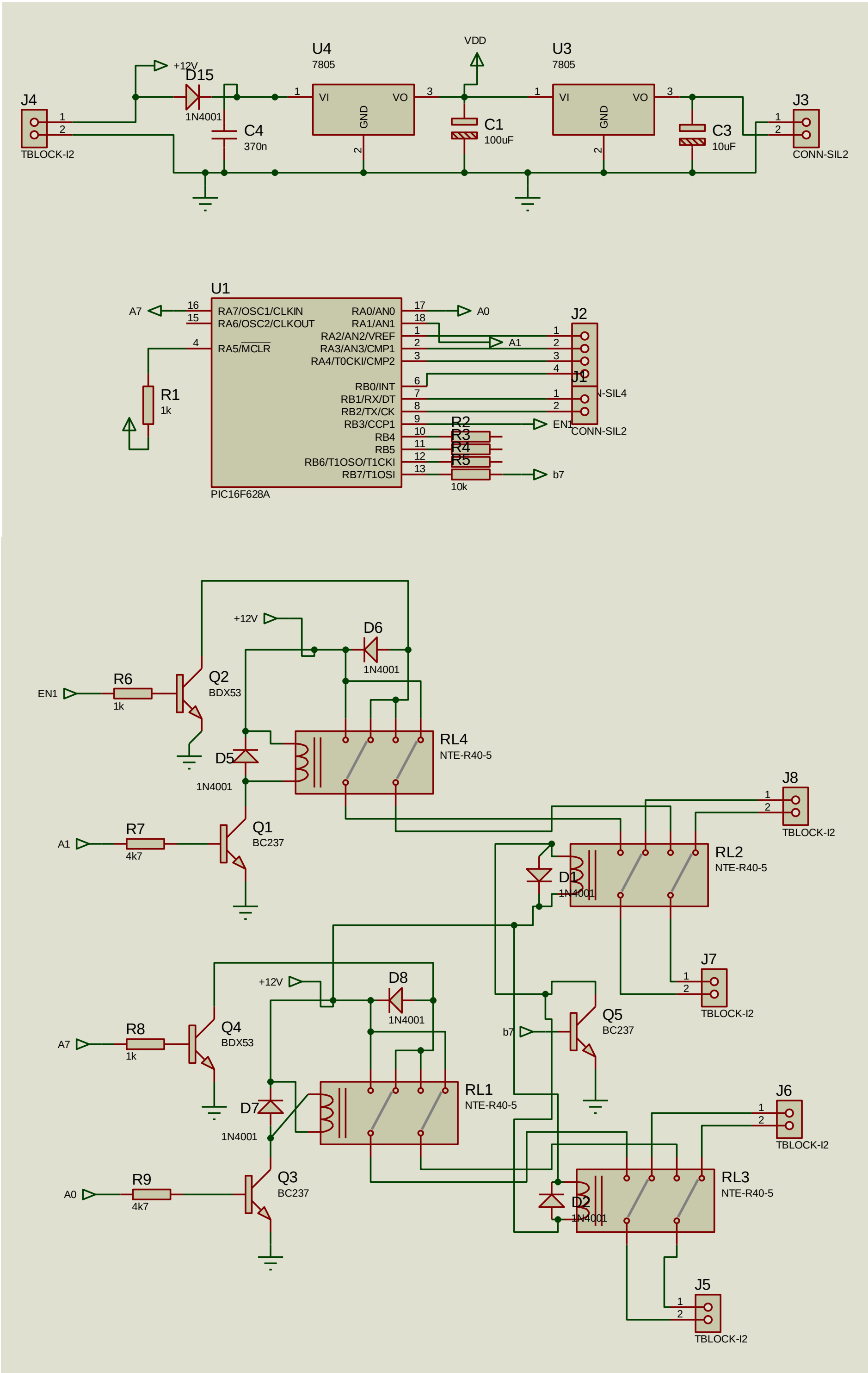

Figure 11. The general circuit diagram which was fixed on the unmanned vehicle.

3. Conclusion

Unmanned vehicles are what containing no pilot or being remotely controlled. Unmanned vehicles can be classified as 4 titles such as unmanned underwater vehicles (UUVs), unmanned surface vehicles (USVs), unmanned aerial vehicles (UAVs), and unmanned ground vehicles (UGVs). In this study an unmanned ground vehicle controlled remotely on internet was carried out. A smartphone was used for wireless communication of it. Additionally live video display of unmanned vehicle's vision was transferred to controller thanks to camera of the smartphone. It is observed that implemented system works successfully everywhere GSM network is accessed. It can send the live video display and the controller of the unmanned vehicle successfully direct it via developed web page as well. Because the smartphone connects to the internet via 3G technology of GSM network, the implemented system can successfully works everywhere GSM network is present.

References

[1] S.L. Hamilton, UAVs: Unmanned Aerial Vehicles, 2012, ABDO Publishing Company

[2] Yan, R. J., Pang, S., Sun, H. B. and Pang, Y. J. (2010). Development and Missions of Unmanned Surface Vehicle. Journal of Marine Science and Application, 9, pp. 451–457.

[3] Ian Palmer, unmanned aerial vehicles, robotic air warfare 1917-2007, 2012, Osprey Publishing

[4] Kenzo Nonami, Farid Kendoul, Satoshi Suzuki, Wei Wang and Daisuke Nakazawa, Autonomous Flying Robots Unmanned Aerial Vehicles and Micro Aerial Vehicles, 2010, Springer, Japan

[5] Kimon P. Valavanis (ed.), advances in unmanned aerial vehicles,2007 Springer, Netherland

[6] Dey, G. K., Hossen, R., Noor, M., & Ahmmed, K. T. (2013, May). Distance controlled rescue and security mobile robot, 2013 International Conference on Informatics, Electronics & Vision (ICIEV), pp. 1-6.

[7] Banerji, S. (2013), Design and Implementation of an Unmanned Vehicle using a GSM network with Microcontrollers, International Journal of Science, Engineering and Technology Research, 2:2: pp. 367-374.

[8] Kelkar, A. (2014), Implementation of Unmanned Vehicle using GSM Network with Arduino, International Journal of Advanced Research in Computer Science and Software Engineering, 4:4, pp. 509-516.

[9] Altınbaşak, O., (2006), Mikrodenetleyiciler ve PIC Programlama(PIC16F628A)

[10] http://ww1.microchip.com/, access date:21.07.2014

A Brief Author Biography

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