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Speed Control of DC Motor Using Bluetooth Devices

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Abstract: *The electric drive systems should possess some benchmark properties like linear control, reliability and steady operation. DC driven machines gain some advantage in these aspects. The speed control methods of DC motor plays a vital role in the performance of drive. The main purpose of speed controller is to focus on how we can use Bluetooth based device to control speed and direction of a DC motor at a desired speed and the main objective of dc drive is to maintain a system with the stable speed irrespective of load condition. In this paper, we describe a recently developed “Android based speed control of DC motor”, a smart phone control experimental setup that can be accessed via the Bluetooth. This setup consists of two basic primary elements communicating with each other: i) Bluetooth of smart phone which is connected to the 8051 microcontroller, IC and DC Motor interfaced with a motor driver IC and ii) a Bluetooth module. The smart phone sends/receives data to/from the microcontroller using the wireless technology via Bluetooth. An application based on Android is created and downloaded in the phone which acts as a display panel for the user to send/receive/view the input and output of the DC motor. In this paper visual display of the current position of the motor using sensors can be sent by the microcontroller to the smart phone. Our microcontroller-based remote control methodology using an android based smart phone can be readily applied and control the speed of DC motor through it.*

Keywords: *Android; Bluetooth module; Smartphone; DC Motor; Microcontroller; Speed Control; authentication.*

I. INTRODUCTION

Advancements in power electronics made motor drive as one of the crucial components for industrial benefits. The motor drive must have superior dynamic stability and steady state response. DC motors provide reliable speed control environment for acceleration and deceleration. Usually control of DC motors can be done through electrically as well as mechanically. A conventional speed control technique of dc drives consists of mostly mechanical parts which require large size & frequent maintenance. This made huge emphasis on drives of dc motors. Some important applications are: paper mills, machine tools, hoists, traction, forklifts.[4] Also the DC motors are widely used for variable speed drive system throughout the world in industries, electric traction, and military equipment, due to their high efficiency, smooth and quiet operation, compact, reliability and rare maintenance. Due to the popularity of wireless technology, there are several options such as GSM, Wi-Fi and Bluetooth. Each of them has their own advantages, disadvantages, concepts and applications, but the Bluetooth technology is often made in use. The speed control was implemented using Bluetooth technology to provide communication access from smart phone, laptops etc. On the other hand we have the 8051 microcontroller that we can use to quickly prototype electronic systems. Bluetooth based device like phone act as a transmitter and the received by Bluetooth receiver interfaced to the microcontroller which send data to the Bluetooth module and which in-turn run the motor. Motivation for this work arises from the need to establish a prototype for future development and improvement in wireless technologies (like Bluetooth) - as we can communicate with multiple devices through Bluetooth, in intelligent buildings and cars which can work on smart phones.

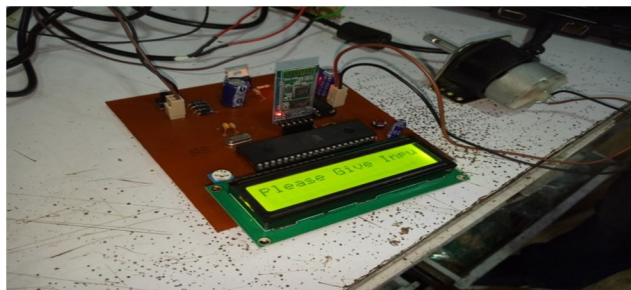


Fig. 1 Image of speed control of DC motor using display

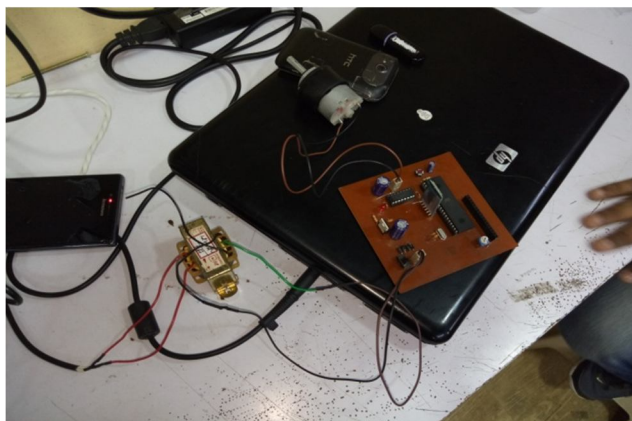


Fig. 2 Image of speed control of DC motor using Android

The circuit is designed to control the speed of a DC motor using an 8051 series microcontroller with Bluetooth device. As we know that speed of DC motor is directly proportional to the voltage applied across its terminals. Hence, if voltage across motor terminal is varied, then speed can also be varied. This system uses the above principle to control the speed of the motor by varying the duty cycle of the pulse applied to it (popularly known as PWM control). Remote operation is achieved by any smart-phone/Tablet etc., with Android OS, upon a GUI (Graphical User Interface) based touch screen operation. [4]The system uses Bluetooth device, interfaced to the microcontroller, which are used to control the speed of motor. PWM (Pulse Width Modulation) is generated at the output by the microcontroller as per the program. The program written in Assembly language or in embedded C. The average voltage given or the average current flowing through the motor will change depending on the duty cycle (ON and OFF time of the pulses). So the speed of the motor will change. A motor driver IC is interfaced to the microcontroller for receiving PWM signals and delivering desired output for speed control of a DC motor. Speaking hardware wise, it is an embedded system project comprising of a Bluetooth module (HC-05), 8051 microcontroller, motor driver IC L293D, Android mobile phone, 5 Volt DC motor, connecting wires and sensor system. All these devices are integrated on a single PCB. Microcontroller is programmed with Android algorithm and can perform speed control of DC motor. The speed and its rotating action can be regulated and monitored through smart phone. Here, we can provide electricity through main power supply.

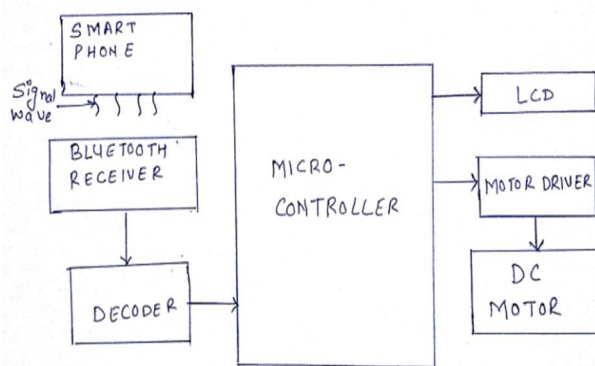


Fig. 3 Connection diagram or block diagram

II. HARDWARE COMPONENTS

In this paper, a micro-controller is interfaced with a motor driver IC L293D which is used to control a 12V DC motor via Bluetooth. The micro-controller interfaces with the DC motor sensors using an analog to digital converter (ADC) and with the DC motor using a digital to analog converter (DAC). The various hardware components used in this project are 8051 microcontroller, Bluetooth module (HC-05), motor driver IC (L293D), IC base smart phone (Android), resistors, capacitors, diodes, Light emitting diodes, voltage regulators, step down transformer, printed circuit board (PCB), PCB drilling machine breadboard, holder strips, cutter, wooden box, wire cutter, soldering materials, (iron, wire and flux), wire rolls, computer, adapter(12V). The signal flow diagram and connection diagram is given below:-

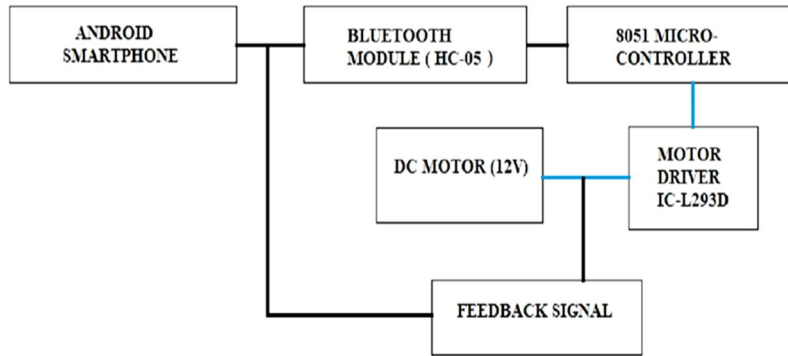


Fig. 4 Signal flow diagram

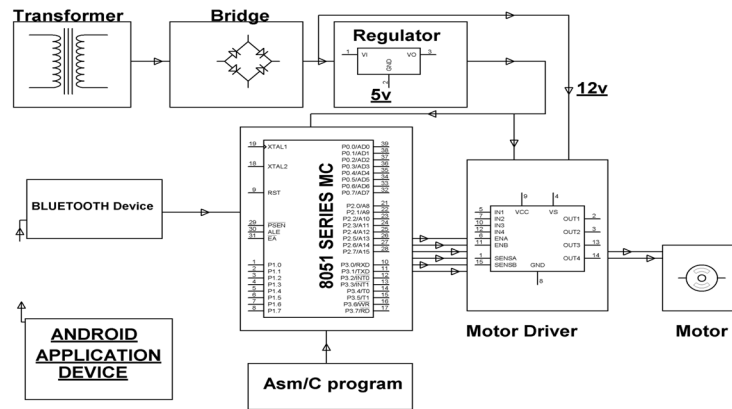


Fig. 5 Schematic circuit diagram

A. Microcontroller

A Microcontroller is a small computer on a single chip microcomputer that has everything in-built. It consists of a processor core, memory, and programmable input /output peripherals. It has many bit manipulation instructions which is suited to control of I/O devices requiring a minimum component count which contains the circuitry of microprocessor and has built-in RAM, ROM, I/O devices, timers, counters, ADC. It also has various numbers of multifunction pins. Microcontrollers can be used in various controlled products and devices, such as automobile engine control systems, appliances, telephones, remotes controls, security systems, paging, exercise equipment. It has a separate memory map for data and code. By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes.

Microcontrollers based system require less hardware reducing PCB size and increase reliability which takes less access time for built-in memory and I/O devices. Because of less access time, speed of operation time is high.

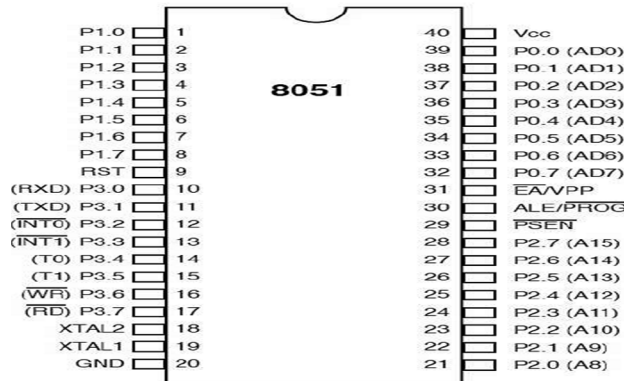


Fig. 6 Microcontroller

B. Bluetooth Module

Nowadays Bluetooth technology is scarcely used because of other improved and high tech wireless technologies, as these technologies beat the other technology but in some process Bluetooth module plays a vital role in operating the system. The Bluetooth Module is used to send signals and receive data between mobile phone and any other devices. It is used to communicate to/from other devices. Bluetooth Technology is standard for short-range radio communication. It is a cheap technology which is bi-directional wireless interface between mobile devices which provides appropriate low power consumption. In microcontroller we use Bluetooth module as it is very convenient and secured as compared to other wireless connectivity technologies. So Bluetooth Module will communicate here with Android Device. HC-05 Bluetooth module is used here in this project.

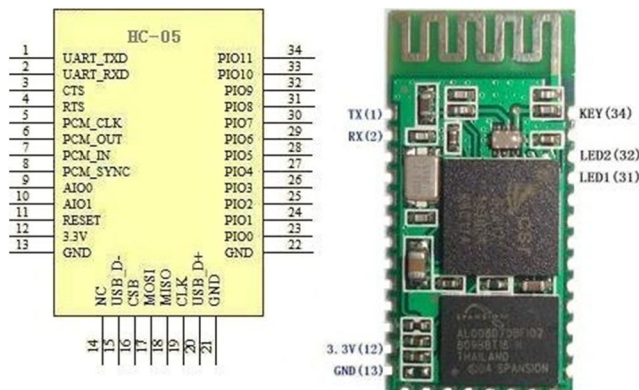


Fig. 7 Images of Bluetooth module HC-05

The aim is to eliminate the usage of cables. Bluetooth system operates in worldwide unlicensed 2.4GHz Industrial-Scientific-Medical (ISM) frequency band. Bluetooth devices can form a network. The basic network is Pico net where there are master's node and other act as slave node/s. At least 2 nodes are required to form Bluetooth network, either one of the nodes can be master. The role of master is just to search and initiate the connection, once the link is established; the role of each node is equal.

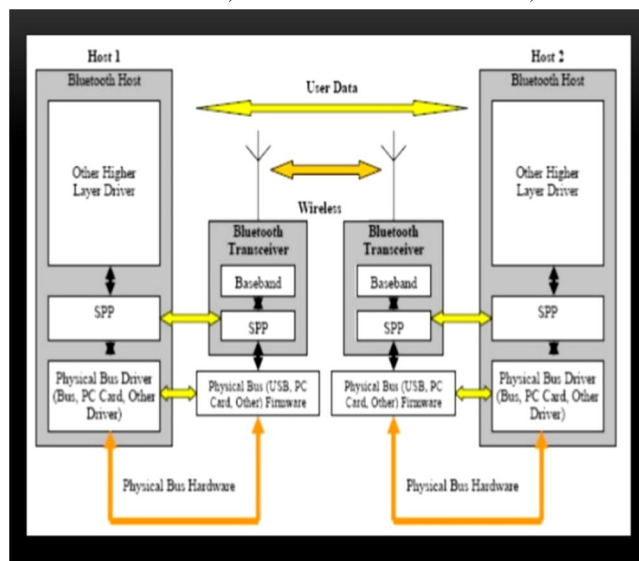


Fig.8 Host to host communication through Bluetooth Transceivers

Bluetooth transceiver is a wireless transceiver that transmits and receives. Signal wirelessly through Bluetooth protocol, thus a host, or in other words a controller is necessary if data processing is required in the application. As shown from the above figure, there are two hosts (Host 1 and 2, it can be microcontroller, computer, PDA, 8 etc) and two Bluetooth transceivers. Both host need to communicate (exchange data), while Bluetooth transceiver is the tools to transfer the data between host. A controller is required to process data and operate Bluetooth transceiver. There are few methods to connect Bluetooth transceiver to host, where most common used are UART and USB. KC Bluetooth transceiver use UART to communicate. SPP (Serial Port Profile) is a Bluetooth standard profile which provides the platform for a host to communicate with Bluetooth transceiver serially.[3] The Bluetooth

Module enables us to communicate between the microcontroller and the Mobile Phone. Many other modules are also available in the market for a better range of wireless operation and good signal strength and also a better connectivity. HC-05 Bluetooth is the most suitable Bluetooth Module because it needs very less power and it is operated only at +5V supply. Connections are very easy because only four terminals are there i.e. two for supply; one is for transmission of data and other is for receiving of data.

The hardware features for low power operational range of 1.8 to 3.6V input/output. The default baud rate of this module (9600, 19200, 38400, 57600, 115200, 230400, 460800) with data control and no parity. The pulses PIO0 and PIO1 are generated to connect blue and red light emitting diodes separately which can also disconnect low and high signals. When master and slave are paired together red light starts to blink and after every 2 second interval blue light blink 1 time. This module has auto pairing with pin code "0000" to connect to the last device on power and auto-reconnect after 30 minutes when disconnected during beyond the range of connections used as default setup. [1]

C. Motor driver IC L293D

Motor Driver is an Integrated Circuit on a single chip which is typically used for motor interfacing. Since microcontrollers work on +5V supply motor drivers also need above +5V supply.[2] At a higher supply voltage Motor Driver IC synchronizes the motors with microcontrollers. Motor Driver act as a bridge between motor and controller in which circuits are current amplifiers. At low current input signal is to be given to motor driver IC. The main purpose of the circuit is to transform the low current signal to a high current signal which is then given to the motor. The motor can be a brushless DC motor, brushed DC motor, stepper motor, other DC motors etc.

The main features of motor drivers have high level functionality, provides high current and high voltage with better performance. They include protection scheme to avoid the failure of motors due to defect. A low voltage and small amount of current is a primary requirement for the operation of motor interfacing with controllers. But the motors require a tremendous voltage and current for its application. In other words we can say the output of the controller or processor is not enough to drive a motor. In such a case direct interfacing of controllers to the motor is not possible. So we use a Motor Driver Circuit or Motor Driver IC.

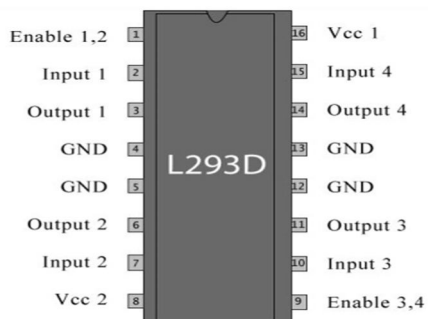
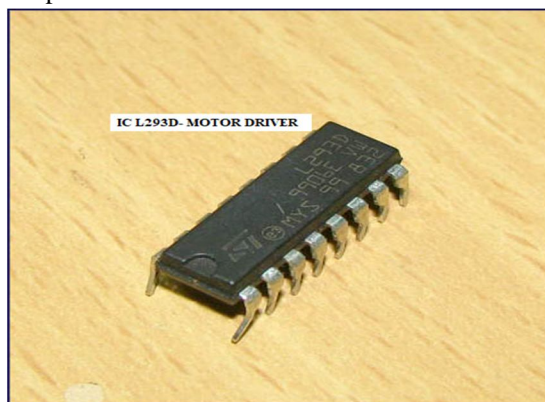


Fig.9 Pin diagram along with description

L293D is a classic motor driver IC which allows DC motor to drive on either direction. It is a 16-pin IC which can be driven simultaneously in any direction which means it can control two DC motor as well as drive small and large motors with single L293D IC. It works on concept of H-bridge which allows the voltage to be operated in either direction. H-bridge IC are ideal for driving a DC motor, as the voltage need to change the direction for being able to rotate the motor in clockwise or anti-clockwise

direction. The two enable pins i.e. pin 1 and pin 9 are able to drive a motor, both the pins need to high to drive the motor. By enabling pin 1 to high, the left H-bridge can be driven similarly, by enabling pin 9 to high, the right H-bridge can be operated. Both pin 1 and pin 9 acts as switch if anyone of corresponding section goes low, then the motor stops working.

D. Direct Current motors

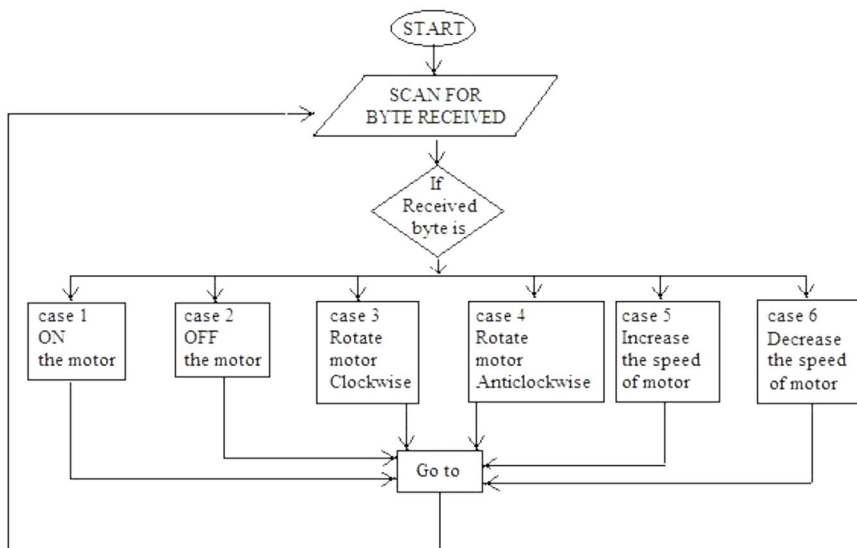


Fig.10 Image of brushless DC motor

DC motor plays an important role in modern industrial drive, the excited motors are normally used as variable speed drive both series and separately. Due to commutators, DC motors are not suitable for high speed application and require more maintenance than AC motor. A DC motor consist of three main parts namely a current carrying conductor called as armature, a circuit for magnetic field provided by magnets of poles, a commutator that changes the direction of the current in the armature winding as it passes a fix point in space. DC motors have variable speed characteristics and are extensively in variable-speed drive. The DC motor converts electrical energy into mechanical energy with the help of two magnetic fields. Out of two fields one field is produced by a pole magnet while other field is produced by an electrical current flowing in motor winding. It is based on the fact for similar poles to repel and dissimilar poles to attract each other. The method of speed control of DC motor is normally simpler and less expensive as compared to AC motor. It provides a high starting torque with speed control over a wide range. The winding is wound around armature is known as armature winding that uses conductor wires to wrapped around stack teeth. The current in the coil, size of the coil and material wrapped around the coil are dependent on EMF's strength. The sequence of turns in a coil and number of turns depends on direction of EMF. Brushless DC motors are rapidly gaining suitability in industries such as appliances, automotive, aerospace, medical industrial automation equipments, etc. A DC motor has linear Torque–Speed relationship. Here, load and speed are inversely proportional to each other. It provides protection against overload current, locked rotor, RFI/EMI caused by PWM control, and also protects against instantaneous reversing and dynamic braking.

III. PROGRAMMING

A. Flow Chart



B. Control Algorithm

Step 1: START

Step 2: L: SCAN FOR BYTE RECEIVED

Step 3: Switch (received Byte)

Step 4: Case 1 ON the motor

Step 5: Case 2 OFF the motor

Step 6: Case 3 Rotate Clockwise

Step 7: Case 4 Rotate Anticlockwise

Step 8: Case 5 Increase the speed

Step 9: Case 6 Decrease the speed

Step 10: Go to L

IV. ADVANTAGES AND DISADVANTAGES OF OUR PROJECT

The advantages of this project are that it is cost effective, eco-friendly and environment friendly. It is energy efficient and saves energy and time. It is hack free and has end to end security channel (HTTPS) with secure socket and channel. It does not require any manual operations. It has authentication. It has remote capability. It can be controlled via Bluetooth of smart phone. It can be integrated with other objects. It can be used for wide range of applications. It also has advanced sensing technology via Bluetooth. It is based on wireless and also password protected technology.

The disadvantages of this project are it cannot be controlled through internet. It cannot be controlled and manoeuvred through GPS (Global positioning systems) systems. It lacks artificial intelligence. It cannot be worked beyond Bluetooth range. It cannot work for less than 12Volts supply. Minimum 12 volt supply is required and is necessary. It does not respond to multiple users and signals and can only respond to one signal at a time. Device can get damaged if the energy supplied is more than 12 Volts. It can work only with the motor driver IC L293D and not with any other IC. [1]

V. CONCLUSION

We demonstrated and integrated a system which consists of electrical, electronics, programming (encryption and coding). The hard lesson of this work is the need of research in wireless and Bluetooth enabled devices. Android apps provide a seamless interface for control, monitoring and visualization. Bluetooth terminal application and 8051 microcontroller was used to operate and control the switching action of the D.C motor of 12V. It was observed that we are able to control the D.C motor from a range of Bluetooth device within the range of ten meters. The motor, microcontroller, motor driver IC L293D were completely operational, working and responding properly to all the commands provided by the smart phone to the Bluetooth module and was giving proper response to the system.

VI. ACKNOWLEDGEMENT

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We take this opportunity to thank all our teaching and non-teaching staff who have directly or indirectly helped our project.

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