A controlling Strategy for Industrial Machines using Bluetooth Technology

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***Abstract*:** Wireless technology is used to control industrial applications. The control system uses wireless communication to transmit commands between the control station and the controlled object or process. By using a laptop, mobile unit or PC, one can control the equipments and observe the industrial processes using Bluetooth communication which enhance flexibility. This system will control a DC motor status (on or off), speed and direction of rotation. The motor controller takes its commands from the laptop by a wireless link. To make the control operation easier for the user, a Windows based interface is programmed.

***Keywords*:** Control, Wireless, Bluetooth, PIC.

1. Introduction

Nowadays, wireless communications are becoming more and more popular; it gives opportunity to wireless data transfer technology, such as Infra-red, radio frequency (RF) and Bluetooth [1]. With the advancement of RF, researchers are concentrating efforts in developing electronic devices that can communicate within a few meters, the result is Bluetooth. It is a practical idea to control a motor through wireless connection, as wireless technology becomes increasingly more available. One of these technologies is Bluetooth technology [2].

Bluetooth technology provides an unlicensed band that is ISM (Industrial Scientific Medical) band which ranges from 2.4 GHz to 2.4835 GHz enable the goals of global applicability, low power and high aggregate capacity to be met [3]. This is suitable for a wireless home or office environment and industrial applications. Bluetooth wireless technology is a short-range communications system intended to replace the cables connecting portable and/or fixed electronic devices. The key features of Bluetooth wireless technology are robustness, low power, standardized protocol, Upgradeable and low cost [4].

The proposed system can be divided into the control circuit that controls the DC motor, the Bluetooth module, the adaptor, and the user interface. The control parameter controls the DC motor speed; direction of rotation and status (on-off) is the value of the duty cycle. By changing the duty cycle value, the user can change the magnitude of the input voltage and so the power delivered to the motor, which changes the speed. So to do this, a control unit and a power electronic circuit are needed. The control unit is a Peripheral Interface Controller (PIC) that generates the necessary output signal that controls the duty cycle value which is a Pulse Width Modulation (PWM) signal. The power electronic circuit is H-bridge which is attached to the terminals of the DC motor and the H-bridge output is controlled by the PWM signal coming from the PIC.

The user will change the duty cycle value and the Bluetooth wireless system is responsible of transmitting the new value of the duty cycle to the PIC. So the design of the PIC microcontroller, the wireless Bluetooth system and the user interface is as shown in Figure 1.

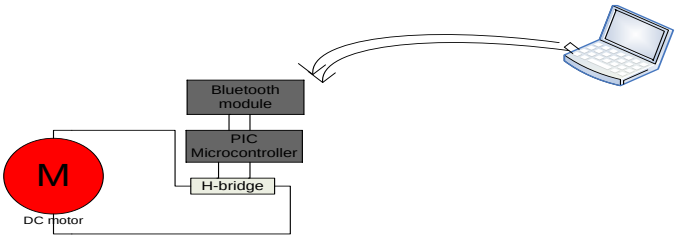

Figure 1: system description

2. System model

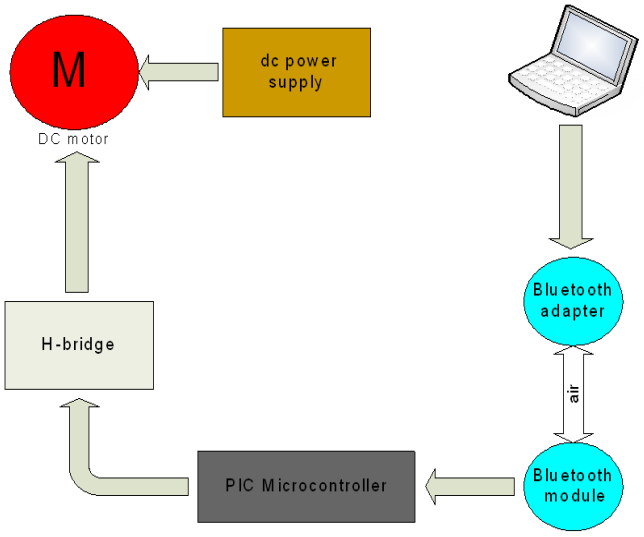

Figure 2: Block diagram

The general view of the system can be described in the Figure 2

The design depends on the duty cycle value, how to transmit it from the user interface to the PIC microcontroller and how to generate the corresponding PWM signal. The control circuit consists of two main devises: the PIC microcontroller and the H-bridge, the H-bridge –as shown in Figure 3- is a power electronic circuit consists of switches that controls the voltage applied to the motor with freewheeling diodes not shown for simplicity, this circuit takes its control signal (PWM signal) from the PIC [5].

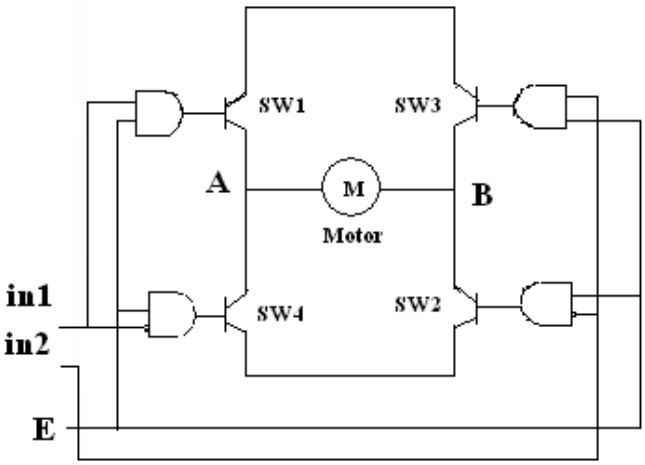

Figure 3: H-bridge connected to motor

Pulse width modulation is the most efficient method of generating control signal with constant volts and frequency control requirement, PWM involves taking a square wave and, without changing the frequency, changing how long in each cycle the wave spends high and low [6]. Thus by changing the duty cycle the average voltage can be changed as will be shown in the results.

If a PWM signal is applied to sw_1 and sw_2 with a specific duty cycle, the motor may rotate clockwise with speed corresponding to the duty cycle value, if sw1 and sw2 are turned off, and the same PWM signal is applied to sw_3 and sw_4, the motor will rotate counterclockwise at the same speed. To achieve this, a square wave is applied on in_1 with duty cycle ρ and the opposite one on in_2; The H-bridge that will be used in the design is L298N which is a good choice because it is small so it is suitable to a 12v DC motor. This H-bridge can take an input voltage range from 2.5-46 volt [7].

The microcontroller acts like the brain of the DC motor speed control system. The microcontroller chip that has been selected for the purpose of controlling the speed of DC motor is PIC16F877A manufactured by Microchip. The function of the PIC is to generate a PWM output signal corresponding to the received value from the Bluetooth module. PIC16F877A can be programmed to receive an input signal from the Bluetooth transmitter.

RS232 is a popular communications protocol for connecting modems and data acquisition devices to computers. It can be plugged straight into the computer's serial port (also known as the COM port). The PIC provides a serial RS232 transceiver built-in function; which can communicate any device that provides this communication protocol which PARANI ESD200 provides. This function identifies the receiver pin, the transmitter pin and the baud rate. Another built in function that corresponds to the RS232 function is getc( ). When an 8-bit character is sent to the PIC, this function waits for a character to come over the RS232 receiver pin and returns the character value in hexadecimal. The PIC is programmed by using C-programming language, after writing the program compiling and checking the program of errors can be done using PIC C Compiler software. This software compiles the program and if there was no errors it generates many files one of them the HEX file; this file is used by the programmer kit to download the program on the PIC.

In order to have a wireless data transmission, the system must include a transmitter unit and a receiver unit, in this system, the transmission unit may be a laptop built in device or a Bluetooth device connected serially or via a USB port to the computer, the receiver is a Bluetooth module (chip); this module has its own system that should be programmed to maintain the communication process.

The chosen Bluetooth module is Parani-ESD200. This Series is designed for integration into user devices by on-board installation. They are connected to the device via built-in UART interface and communicate with other Bluetooth device. Parani-ESD is a module device for wireless serial communication using Bluetooth technology that is international a standard for short range wireless communications. Parani-ESD can communicate with other Bluetooth devices that support the Serial Port Profile.

A Bluetooth device can play a role as a master or slave. Master tries to connect itself to other Bluetooth devices, and slave is waiting to be connected from other Bluetooth devices. A Bluetooth connection is always made by a pair of master and slave devices. A slave can be in two modes, Inquiry Scan or Page Scan mode. Inquiry Scan mode is waiting for a packet of inquiry from other Bluetooth device and Page Scan mode is waiting for a packet of connection from other Bluetooth device. Every Bluetooth device has its unique address, called BD (Bluetooth Device) address, which is composed of 12 hexadecimal numbers.

Parani-ESD supports two security options, Authentication and Encryption. If the Authentication option is enabled, a Pin Code value must be entered. If the authentication is enabled, the connection, between the Master and Slave device must share the same Pin Code. In case that Parani-ESD connects to another Bluetooth device, that requires authentication, you must know the other device's Pin Code. In general, most Bluetooth devices have a pin code of 1234 or 0000. If you check Encryption option, the Parani-ESD will encrypt packets and send it to the device. The Encryption options works well in case that only one of the devices between Master and Slave use the Encryption option.

The user interface is a program that allows the user to control the motor. The operation of this program is to send the new value of the motor speed and the direction of rotation which means to send the duty cycle value. It is a program that allows the user to change the status and the speed of the

motor by clicking an Icon making it user friendly. The interface is a window with four icons these include an icon to increase the speed, another to decrease it. A third icon is used to start the motor and a fourth to stop the motor. The user can increase and decrease the speed of the motor by pressing the relevant icon and each press changes the motor speed by 0.1 of the rated speed; in other words 0.1 increase in the duty cycle value.

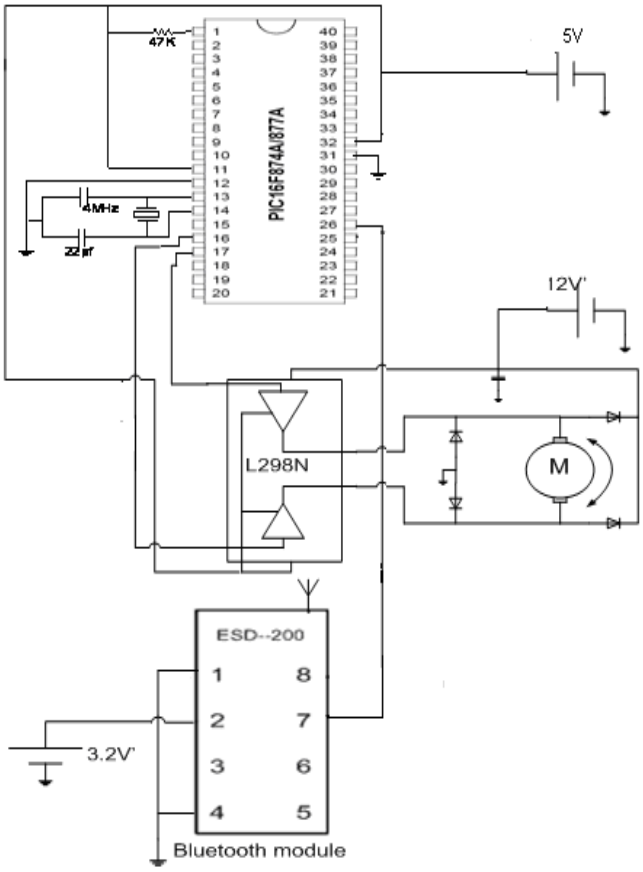

Figure 4: Full Schematic

In order to change the direction of rotation, the motor must be stopped first and then the direction of rotation is changed, if the user sends a command to change the direction while the motor is rotating at a high speed, the system will not respond as it may damage the control circuit. So to prevent this, the program doesn't respond to a sudden change, the program allows a change in direction just when the motor speed is zero then the user can increase the speed in the other direction. This interface is programmed in java programming language, java language provides an easy to use graphical interface functions which is very important in our program also it provides a class that can communicate and identify any Bluetooth device attached to the computer and identifying this class in the program you can send and receive data to and from the Bluetooth device.

The full schematic diagram is shown in Figure 4, while the flow chart of the program that has been downloaded to the PIC is shown in Figure 5.

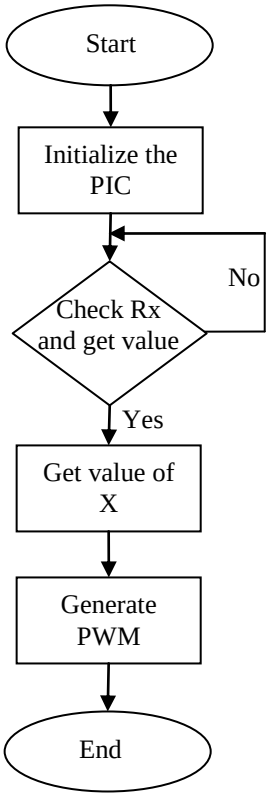

Figure 5: Program flow chart

3. Results and discussion

A control unit that is able to run a DC motor wirelessly using Bluetooth technology is designed, to transmit control signals from the user interface (PC side) to the receiver on the motor side. This controller functions through a software application on a laptop or desktop computer from within 10 meters of the motor. Controlling a dc motor means controlling the status of the motor (on or off); changing the direction of rotation and the speed.

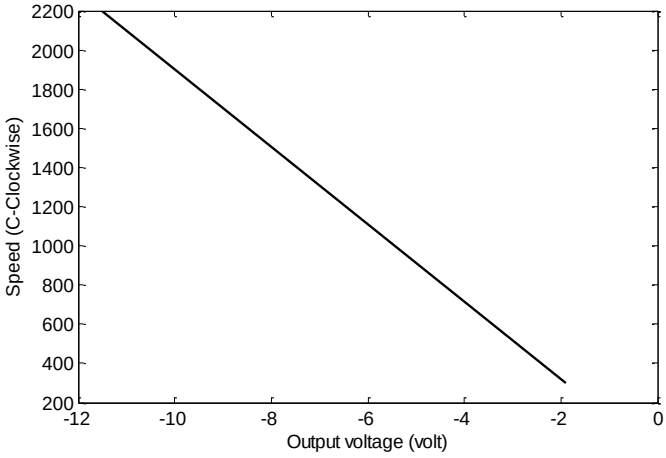

Figure 6: Relationship between speed and voltage in counterclockwise

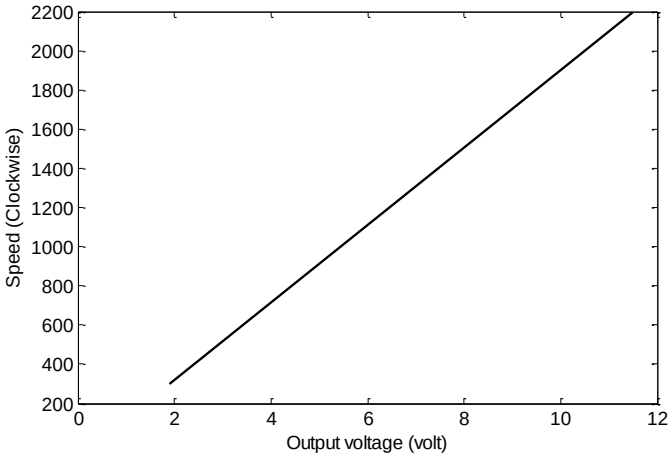

Figure 7: Relationship between speed and voltage in clockwise

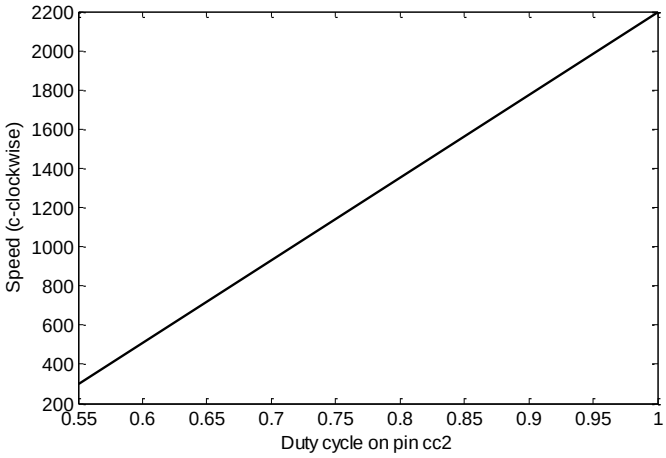

Figure 9: Relationship between the duty cycle and the speed in c-clock wise

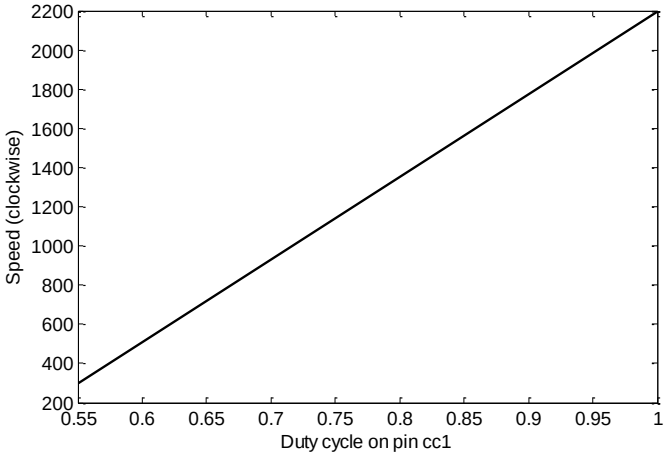

Figure 8: Relationship between the duty cycle and the speed in clock wise

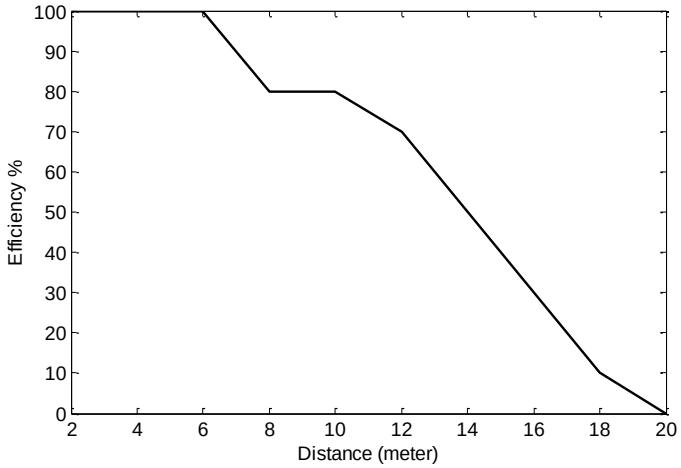

Figure 10: Relationship between distance (in meters) and efficiency of the system

Figures 6 and 7 show the relationship between the speed and the average voltage at the output of the H-bridge in both counterclockwise and clockwise respectively. It is clear that reducing the voltage will increase the speed in counterclockwise, while it will give the opposite effect for clockwise

In Figures 8 and 9, the relationship between the duty cycle and the speed are plotted. Applying the duty cycle on Pin cc1 in the PIC, the direction of the rotation is in clock wise while it is counterclockwise if the signal is applied on cc2. In both cases, the speed will increase by increasing the duty cycle.

The system efficiency is checked in Figure 10. It shows relationship between the transmitting distance and the response of the system. This is done by transmitting 10 orders from each distance and count how many times the system responds correctly to the orders. The efficiency was introduces as the number of correct responds divided by the number of total tries.

4. Conclusion

In this design, a prototype of a wireless Bluetooth control of DC motor is developed and implemented. It is a system that controls a DC motor speed and direction of rotation, A small 12v dc motor is used as a sample of the industrial applications where the project goal to be used in. This model provides an easy to use graphical interface that the user can control from a PC or laptop**.**

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Arafat Zaidan received his B.Eng. in Electrical & Electronic Engineering from University of Leicester in 1993, and the MPhil/PhD in Digital Control Engineering, University of Salford in 2000. The research was primarily concerned with deriving mathematical models and implementing a pole placement controller for a powered orthosis He was a control System Engineer with research experience in modern control strategies and plant supervision, and worked for five years at the Hashemite University in Jordan as an assistant professor in the department of Mechatronics. Currently working as an assistant professor in the Department of Electrical Engineering, Palestine Technical University (Kaddorie), Tul Karm, Palestine. Dr. Arafat Zaidan has a number of publications to his credit in various international journals and conference proceedings. He is a member of IEEE, Palestinian Engineers Association.

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