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USB Port Based Brushless DC Servo Motor Control

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***Abstract*— As a matter of principle, servo motors consist of a motor and a feedback unit. Motor can be DC or AC and feedback unit can be a tacho generator or an encoder. The important difference between servo motors and other motors is their ability to make acceleration and braking too fast. For this, torque should be high and inertia should be as much as low. Among servo systems, brush DC motor, brushless DC motor, short circuit rotor asynchronous motor and synchronous motor are the most preferred servo motor types. In our day, the systems which require sensitive control such as printer, photocopy machine are generally using brushless DC servo motors but their drives cost higher than themselves in price. Therefore, in this study a new USB port-compliant brushless DC servo motor driver module is developed. The module determines direction and speed information of servo motor according to the commands sent from USB port. In this paper, the operation of developed module and the command program working from USB port will be discussed in detail.**

***Index Terms*— DC Servo motor, USB Port, Driver module.**

I. INTRODUCTION

Servo is a closed-cycle control system that detects error at any mechanism's running, checks it with the help of a side feedback mechanism and informs driver about the error and corrects it. Servo systems are classified in 4 groups according to their control structures. They are speed control, position control, moment control and hybrid control. Servo motors are the mechanisms in which angular velocity and acceleration are controlled. Any of AC, DC or step motors can be in servo motor [1-5]. Also, in addition to motor, it keeps driver and control circuit in itself. Servo motors are classified as shown at Fig.1.1.

At brush DC motors, the current enters into the rotor winding via brush and commutator. When the number of windings on rotor is increased, also the commutator segments which made connection with winding will be increased (Fig.1.2). The raise in number of winding increases rotation of rotor and torque [5-8].

Brushless DC servo motors consists of 4 basic parts. These are PM in other words rotor consisted of permanent magnet (armature), stator on which bobbins are fixed (inductor), commutator (dispensator), sensor which controls rotor condition and control units (Fig.1.3).

In brushless DC servo motors, the structure of rotor can change. As to rotor's structure, there are 3 brushless DC servo motor types [8-10]. These are outer rotor, disc-type and inner rotor permanent magnet (PM) brushless DC servo motors (Fig.1.4).

Regardless of rotor's structure, some physical magnitudes of permanent magnets generally used at the rotors of brushless DC servo motors are given at Table 1. The most apparent differences between brush and brushless DC servo motors are given at Table 2.

As it is seen from Table 2, a computer or PLC (programmable logic checkers) systems are certainly necessary for commutation and rotor position detection. The block diagram of a brushless DC servo motor control is shown at Fig.1.5.

In our study, brushless DC servo motor is used as servo motor. In order to operate this motor faultless and at desired speed, a new USB port-compliant brushless DC servo motor driver module is developed within our study. The module determines direction and speed information of servo motor according to the commands sent from USB port. The output current of driver module is increased and then it is given to DC servo motor. According to the feedback information coming from sensors, a faultless study is done.

In this paper, the operation of developed driver module and the command program working on USB port will be discussed in detail.

II. MATERIAL METHOD

In our study, for brushless DC servo motor control, first of all, a computer-compliant, 3 phase motor driver module is developed, secondly a current amplifier circuit is developed and lastly their connection with the feedback unit of sensor outputs on driver is provided. At driver module, PIC18F4550 microcontroller is used for making communication with USP port and providing feedback cycle, but SLA5060 integrated is used for increasing output current of driver module. In order to control speed and location information, CNY70 reflective sensor, which has got an infrared transmitter and a photo transistor on it, is selected.

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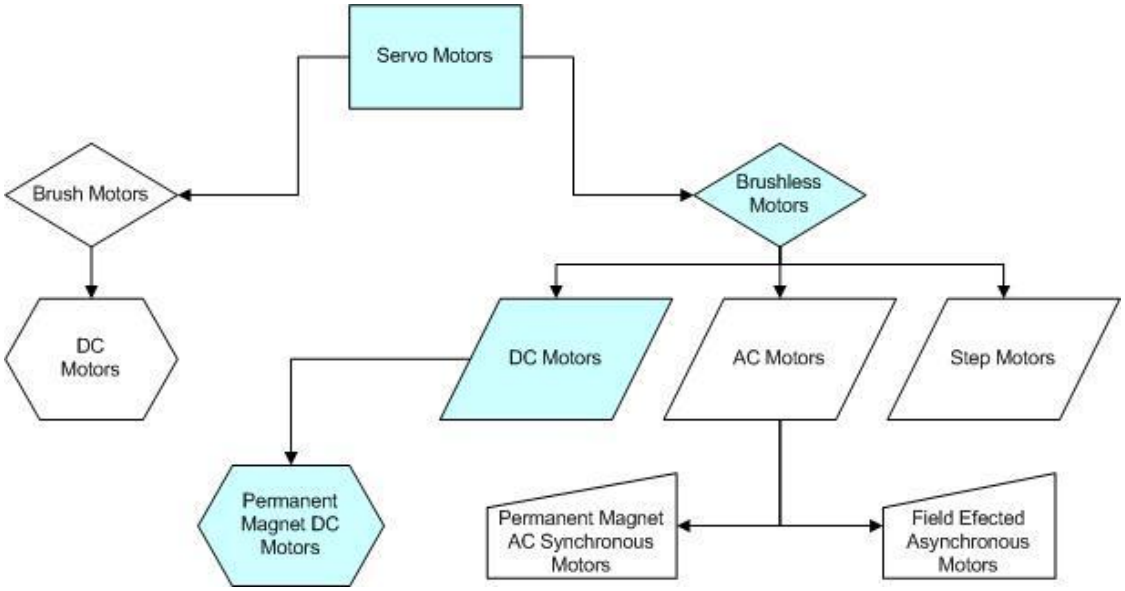
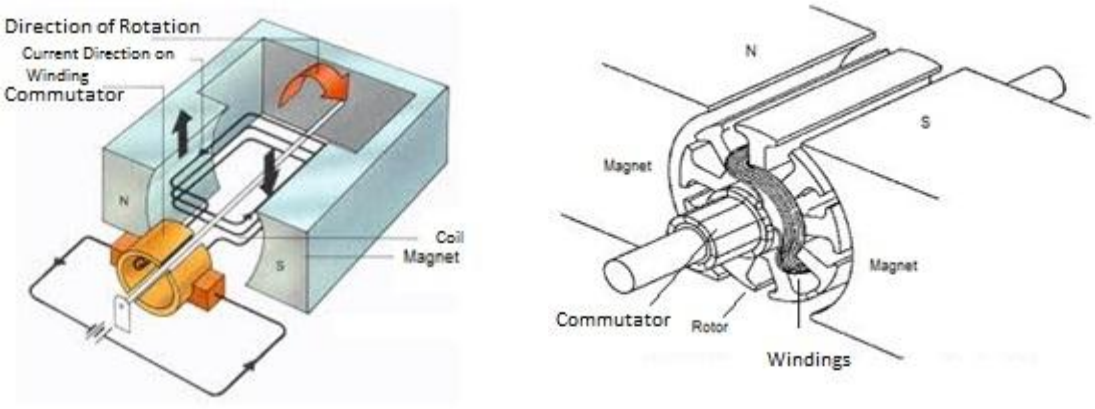
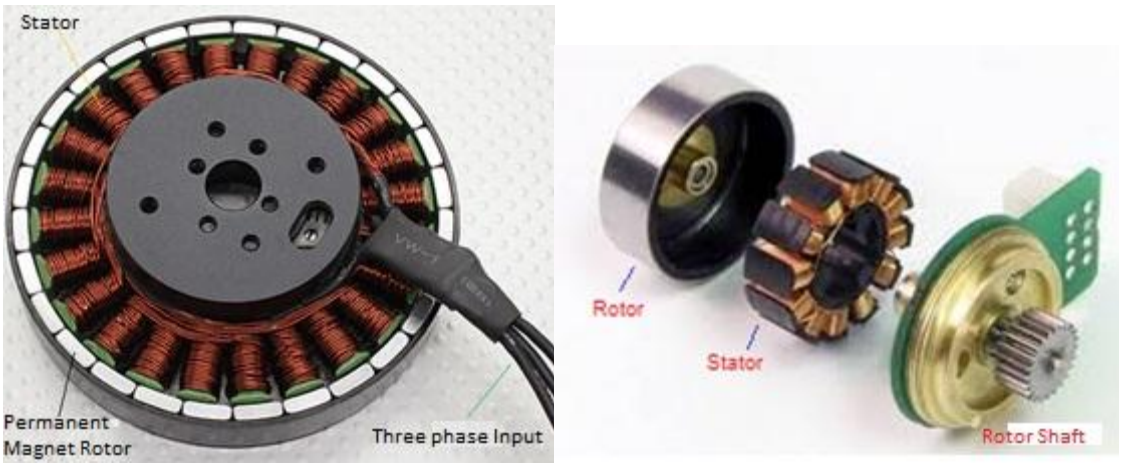


Fig.1.1: The classification of servo motors.



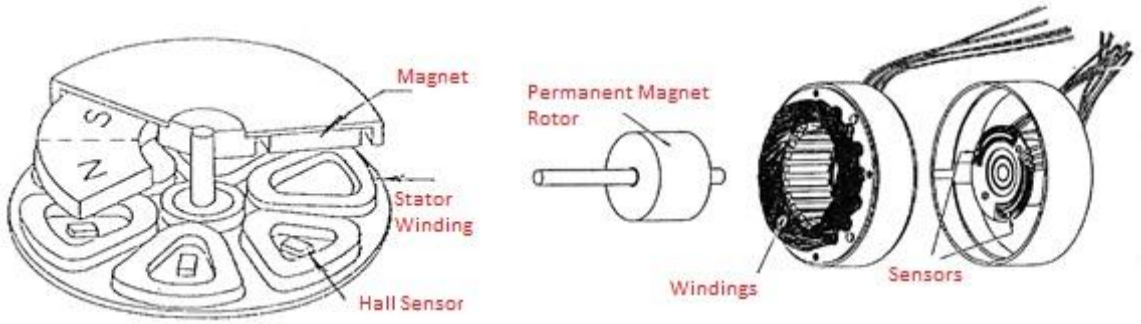
(a) **(b)**

Fig.1.2: (a) Single winding, (b) Multiple winding brush DC motor [3].



(a) **(b)**

Fig.1.3: Brushless DC servo motor's (a) structure (b) parts [3].



(a) **(b)**

Fig1.4: (a) Disc-Type, (b) Inner rotor permanent magnet (PM) brushless DC servo motors [2].

Magnet Type	Magnetic Remanence (B_r) T	Magnetic Field H_c (kA/m)	Operating Temperature (C°)	Curie Temperature (C°)
AlNiCo	1.2	50	500	800
Ferrit	0.4	250	300	450
SmCo	0.9	650	250	720
NdFeB	1.2	900	120	310

Table 1.1: Some features of magnets used at brushless DC servo motor's rotors

	Brush Motors	Brushless Motors
Mechanical Parts	Permanent magnets at stator	Permanent magnets at rotor
Distinictive Property	Quick reaction and excellent control	Long life, easy and cheap overhaul
Winding Connection	Circular and triangle connection	3 phase triangle or Y connection at high applications, 3 phase Y connection at normal, 2 phase connection at basic applications
Commutation Method	With brush or commutator	With electronic switch devices (transistor)
Detection of Rotor Position	With brush	With hall element and optic encoders

Table 1.2: The differences between brush and brushless DC servo motors

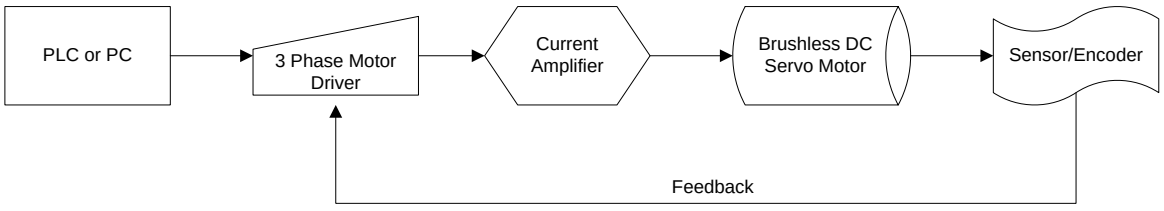


Fig.1.5: The block diagram of a brushless DC servo motor.

The communication from USB port has got more complex and need-to-know hardware features than synchronous serial and asynchronous serial communication. The most important one of them is the sameness of Vendor ID and Product ID number of PIC18F4550 and ID numbers which are identified at the program written for data transfer from USB port of the computer. Another important case is the data intake and transmission speed between USB port and PIC18F4550 programmable microcontroller. If the time of data intake and transmission is longer than operating time of software loaded to PIC18F4550, the communication between USB port and PIC18F4550 will be cut off.

In PIC18F4550 microcontroller, there are totally 33 pins belonging to A-B-C-D-E ports that can be used for input and output. In our study, B port is identified as the output and 6 pins of this port is used under the control of brushless DC servo motor. "A" port of microcontroller is identified as the input and its connection with the outputs of sensors is made. Later on, we continued with developing Visual Basic program that is used for communication of the computer with USB port and PicBasic Pro program that is used for communication of microcontroller with USB port. When 18F4550, which is the central programmable processor of the module, is connected with USB port, first of all, it is insured to be known as HID (human interface device). In this way, Proton Compiler and Easyhid composing procedure is started and Vendor ID and Product ID required for HID communication are typed. In next stage, USB port power settings and data buffer settings are done and data intake or transmission periods are stated. After EasyHid composing procedure is completed, readymade PIC Basic Pro codes will be consisted automatically in the proton file for the purpose of loading them to PIC18F4550 microcontroller. But, these codes only consist of USB port and communication protocols of microcontroller. In order to identify the case that how the data coming from USB port will be processed, it is required to make addition to the software.

In Visual Basic program part that is made automatically after EastHid procedure, we will come across with an empty form and a module named mcHIDInterface. When the code page of the form is opened, again Visual Basic codes about protocols that are necessary for HID communication will be seen. To the rest of these codes, the codes of Visual Basic program which makes required digital signals able to be sent are typed. The interface appearance of VB program developed within our study is shown at Fig.2.1.

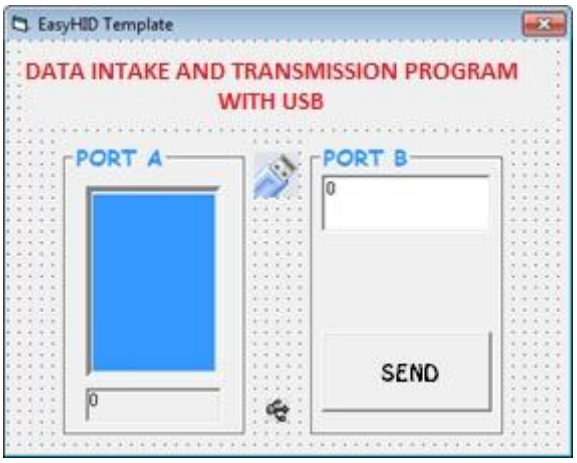


Fig.2.1: The interface of developed VB Program

The program makes us able to see sensor pulse values and it gives permission to digital data input at 6 bit binary order that is required according to spin direction of servo motor. Digital data that will be written in text box in the interface will be activated with "Send" button. Therefore, digital data coming to PIC18F4550 microcontroller via USB port is processed and then it is arrived in B port of the microcontroller. The digital signal that comes to Port B becomes the input signal for SLA5060 that has got MOFSET in it. The output of 5060 is up to 12V, 6A and it is enough for brushless DC servo motor's running. The current value withdrawn from the system is directly related to load of the servo motor. When the load is increased then the withdrawn current will be increased. Digital signals that should come to B port of the microcontroller for the purpose of making our brushless DC servo motor be able to turn in clock wises direction and SLA 5060 output connected to them are shown at Table 2.1.

CNY70 reflective sensor, which is used for identifying speed and location information of motor in our study, is placed straight ahead to the turning rotor. With the help of a reflective apparatus gummed on rotor, after every spin, logic pulse in sensor is insured. Pulse inventory is taken with PIC18F4550 microcontroller that is associated with sensor output. Printed board of driver module developed within our study is shown at Fig.2.2.

PIC 18F4550's B Port Output						SLA 5060 Output		
B0	B1	B2	B3	B4	B5	Pin 3	Pin 7	Pin 10
1	0	1	1	1	1	1	0	0
1	1	1	1	1	0	0	0	1
1	1	1	0	1	1	0	1	0

Table 2.1: The outputs of PIC 18F4550 and SLA 5060.

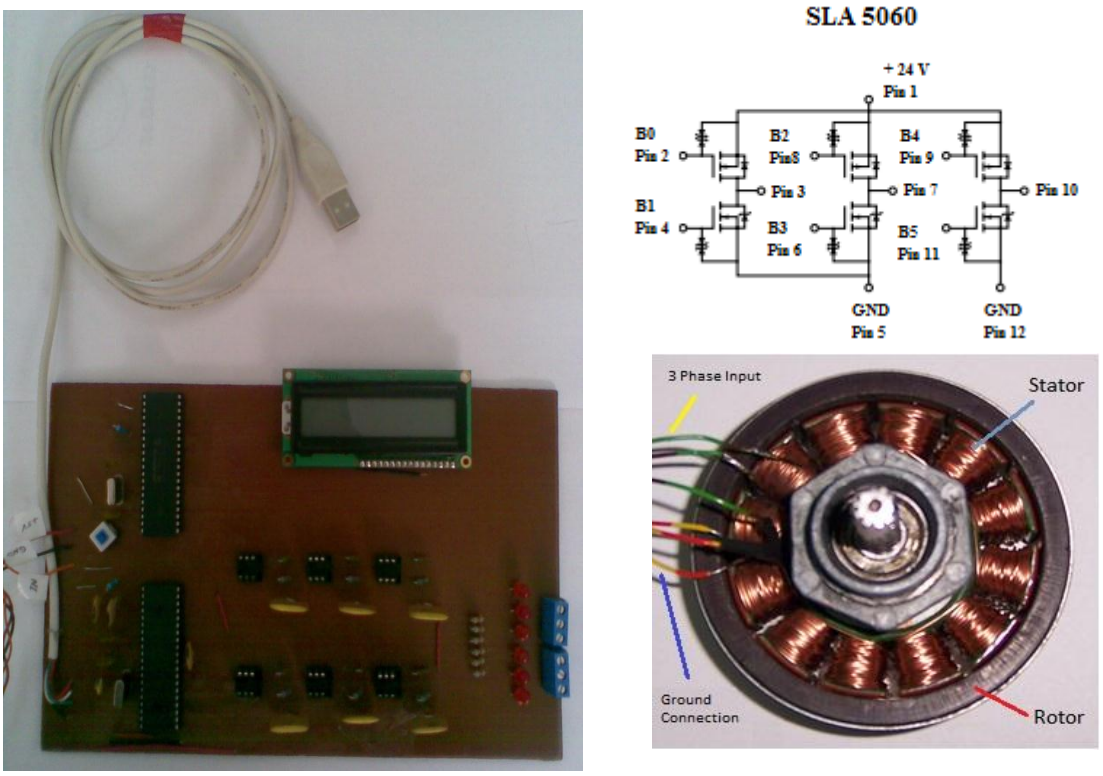


Fig.2.2: The appearance of developed brushless DC servo motor driver module.

III. Discussion and Conclusion

In this study, a new USB port-compliant brushless DC servo motor driver module is developed. Developed module provides approximately 150 watt to motor. If the power required for load of motor is high and the person ignores it and operates, motor windings and SLA 506 integrates can be burnt or motor cannot be turn and stator-rotor disequilibrium can be seen. On the other hand, data intake or transmission speed between USB port and PIC18F4550 programmable microcontroller should be well regulated. If the elapsed time of data transmission or intake is longer than the operating time of the software uploaded to PIC18F4550, the communication between USB and PIC18F4550 can be cut off. In addition, operating such a servo motor at high temperature can be inappropriate due to the fact that it will spoil feature of permanent magnet in rotor.

The cost of electronic elements used at the developed driver module is very low and that is why module is manufactured at low cost. But the real case is to make microcontroller in the module be programmed and make it communicate with USB port. So that, the sale price of these type driver modules and similar ones are high. However, if the researcher knows a computer software (Delphi, C++ or Visual Basic), a microcontroller software (PIC Basic Pro, JAL) , the driver module sold by thousands of dollars can be manufactured much more cheaper and also it can be manufactured as being opened to plugins .

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