Speed control analysis of voltage source inverter fed brushless DC motor

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ABSTRACT

The brushless DC (BLDC) motor requires to be controlled at the preferred speed in order to operate. A brushless DC motor's speed can be adjusted by adjusting the input voltage. In general, speed increases with voltage. The application of a Luo converter is made to satisfy the load demand, get rid of output voltage ripples, and reduce parasitic effects. The magnitude of stator input voltage to BLDC motor is controlled through the pulses applied by ATMEGA 328P micro controller to voltage source Inverter which in turn controls the magnitude of speed of BLDC motor. The position of the brushless DC (BLDC) motor is continually monitored by infrared sensors, which are then processed by a PIC16F872 microcontroller to produce the necessary pulses for BLDC motor speed regulation. The BLDC motor speed can be regulated by the pulses applied to voltage source inverter through the IR sensors placed at the motor. The outcomes of controlling the speed of a BLDC motor using voltage variation values have been shown.

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1. INTRODUCTION

The brushless DC (BLDC) motors are frequently utilized in a variety of applications, including instruments, industrial automation equipment, automobiles, aircraft, and home appliances [1]. A synchronous motor known as a BLDC motor has synchrony with the magnetic fields of the stator and rotor to produce mechanical torque. The electrical separation between the stator windings is 120 degrees [2]. The BLDC motor's architecture also prevents it from having brushes or an electromechanical commutator, making its electrical commutation and operation more complicated. Designing a speed control that is faultless even in the phase of instabilities and parameter changes is one of the key concerns in this field of motors [3]. The BLDC electrical motor is made with magnets embedded within the steel rotor core as opposed to surface-mounted permanent magnet motors that appear to have been glued on [4].

For speed regulation in a typical BLDC motor, a voltage source inverter (VSI) with a continuous DC supply and a pulse width modulated (PWM) system is required. Significant switching losses will result from the high rate switching in VSI. The inductor and capacitor that make up the additional parts of the Luo converter [5]-[8] with switching mode controller (SMC) naturally serve as a filter to eliminate ripples and parasitic effects on the output voltage [9]. Due to the inverter's low switching operation and variable voltage control, switching losses have been reduced [10]-[12].

2. SPEED CONTROL OF BLDC MOTOR

The permanent magnet brushless DC (PMBLDC) motor's speed control block diagram is presented in Figure 1 [13]. The driving unit, converter unit, controller unit, and indicator unit are the four components that make up the overall arrangement. The project's main controlling elements are the microcontrollers ATMEGA328 and PIC16F872A. The brushless DC (BLDC) motor's speed in this project is controlled by a resistance potentiometer (POT) [14]-[16]. A BLDC motor's speed is shown on a liquid crystal display (LCD). BLDC motor and ATMEGA328 microcontroller are connected to a voltage source inverter, Luo converter, and a potentiometer (POT). When a BLDC motor's speed [10] is adjusted by the user using the POT, the ATMEGA microcontroller reads the data and, using that information, generates PWM signals for the metal-oxide-semiconductor field-effect transistor (MOSFETs) switching [17]-[20]. The voltage source inverter circuit in this case is designed using MOSFETs as switching devices. The inverter circuit will produce the AC supply based on the switching speed. This AC supply enters the Luo converter, this increases the voltage to regulate the BLDC motor's speed.

The microcontroller is interfaced with an infrared sensor (IR) sensor and LCD display. PIC microcontroller [21] continually reads the BLDC motor's speed from the IR sensor and shows that information on the LCD displays. The input voltage of the BLDC motor is observed by digital storage oscilloscope as illustrated in Figure 1. The voltage magnitude is controlled by PWM pulses [22]-[25] which is varied by the ATMEGA controller. A voltage sensor detects the input voltage to the BLDC motor while an IR sensor measures the fluctuation speed in the LCD display when the speed input is changed by a potentiometer, resulting in a 10:1 ratio change in voltage to the voltage source inverter.

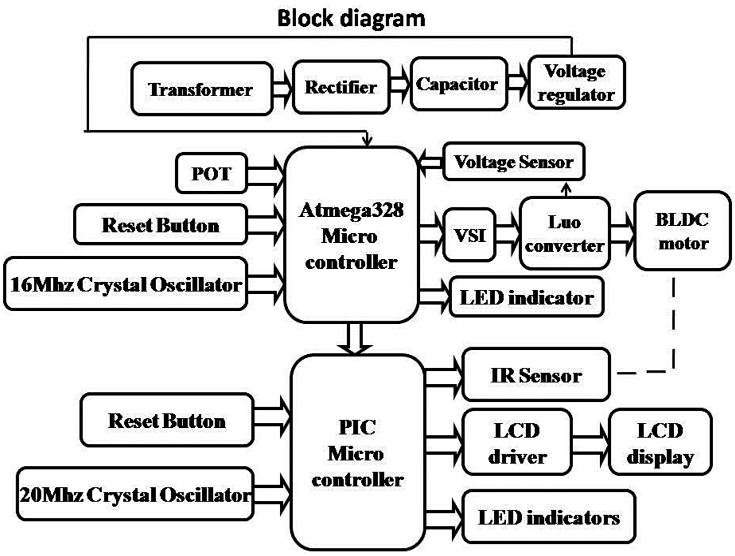

Figure 1. BLDC motor speed control block diagram

The main controlling device of the project is ATMEGA328 and PIC16F872A microcontrollers. In this work, the POT is used to control the BLDC motor's speed. The speed in the regulated power supply (RPS) of a BLDC motor is measured using an IR sensor. The speed of a BLDC motor is displayed on an LCD screen. BLDC motor along with voltage source inverter and Luo converter and POT is interfaced to the ATMEGA328 microcontroller. When the user regulates the speed of BLDC motor through POT, it will be read by ATMEGA microcontroller and based on that it will generate the PWM signals to the MOSFETs for switching. The voltage source inverter employs MOSFETs in this manner. Based on the switching speed, the inverter circuit will generate the AC supply, and this AC supply is fed as input to the Luo converter that is employed to step up the voltage to regulate the BLDC motor's speed as depicted in Figure 2. IR sensor and LCD display is interfaced to the microcontroller. PIC Microcontroller will continuously read the speed of BLDC motor through IR sensor and display the speed of the BLDC motor on LCD display as shown in Figure 3.

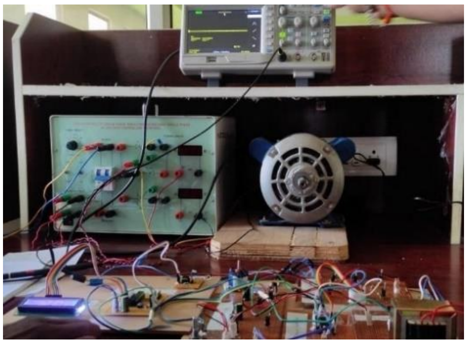

Figure 2. Prototype testing

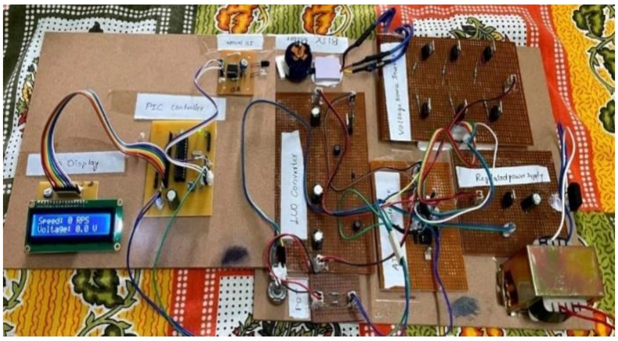

Figure 3. Hardware model of speed control of BLDC motor

3. RESULTS AND DISCUSSION

The voltage to the voltage source inverter varies in a 10:1 ratio when the potentiometer is adjusted. According to Table 1, the BLDC motor's input voltage is rising while its speed is also, and this is seen in Table 1 and the graphical representation of the voltage and speed is as shown in Figure 4. The LCD display shows the voltage of the BLDC motor as well as the fluctuation in speed as recorded by the IR sensor and voltage sensor, respectively. As shown in Figure 5, a digital storage oscilloscope is used to monitor the BLDC motor's input voltage. The waveforms of the voltage controlled by PWM pulses which is varying by the ATMEGA controller are shown in Figure 5.

Table 1. Voltage and current variations

Voltage (Volts)	Speed (RPS)	Voltage (Volts)	Speed (RPS)
0.4	120	0.8	177
0.5	132	0.9	200
0.6	160	1.0	210

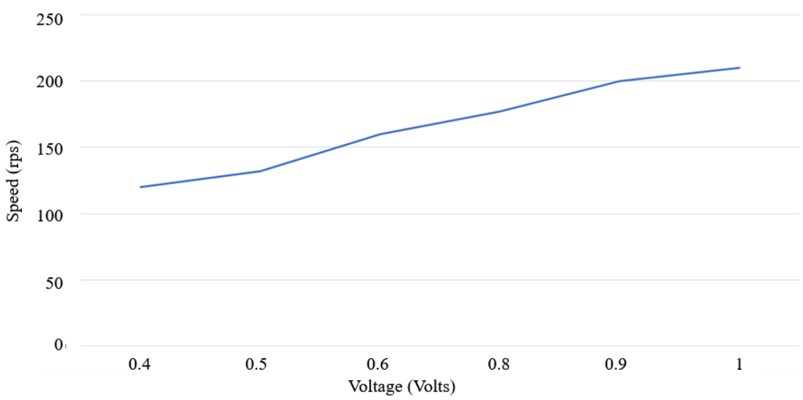

Figure 4. Graphical representation of speed control (speed vs voltage) of brushless DC motor

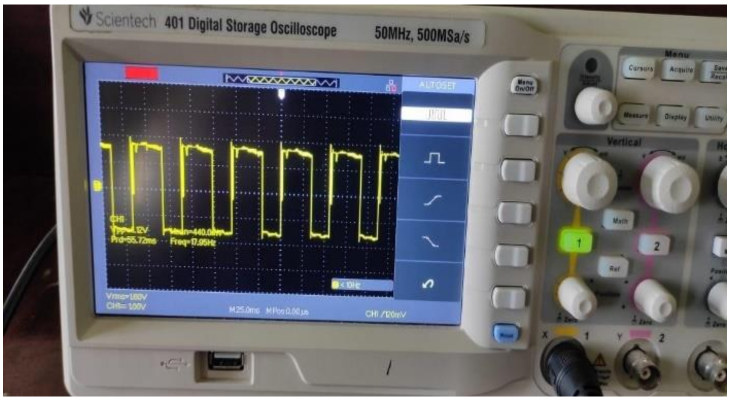

Figure 5. Graphical representation of input voltage waveform of brushless DC motor

4. CONCLUSION

In this paper, BLDC motor speed control is achieved by controlling stator input voltage using a voltage source inverter and obtaining regulated pulses from the microcontrollers. IR sensors placed at the motor end continuously monitor the speed provide signals to the processor and generate the required number of pulses to regulate the BLDC motor's speed by variable input voltage obtained from the voltage source inverter. The ripples and harmonics can be eliminated by using Luo converter. The user will give the motor input through POT which is interfaced to the microcontroller. Based on that microcontroller generate the PWM signals to the voltage source inverter to control the BLDC motor's speed via Luo converter and this speed are measured by IR sensor and will be displayed on LCD module. The speed variations of BLDC motor with reference to applied voltage can be analysed from the results and graphs.

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