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Speed Control and Parameter Monitoring of Solar Powered BLDC using PWM Technique

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***Abstract*— Nowadays, the BLDC motor is effectively replacing other motors due to its less power consumption and simpler speed control techniques. If this motor is controlled remotely by using current trending technology called IOT, it will reduce lots of human efforts. This project aims to make a cost-effective and remotely controlled solar-powered circuit for the BLDC motor. This can monitor the motor parameters such as speed, temperature, voltage, and power using an android application. These all functions can be integrated using Arduino Uno (Atmega 328P Microcontroller). The speed control can be achieved through ESC Driver by using the Pulse Width Modulation technique, and the parameters such as speed and temperature can be sensed by LM35 Temperature Sensor and A3144 Hall Effect Sensor. Also, the voltage sensor and current sensor ACS712 are used to measure voltage, current, and power. These all generated data can be stored to ThingSpeak cloud server using Node MCU (ESP8266) and can be fetched and controlled through a mobile application. Due to many advantages and extensive applications of BLDC motor, this project can be effectively implemented in irrigation, robotics, and various industrial applications.**

Keywords*— *ESC Driver, LM35 Temperature Sensor, current sensor ACS712, ThingSpeak, Node MCU (ESP8266).

I. INTRODUCTION

After the invention of the electric motor in the 19th century, lots of human efforts and time required to perform various types of work was reduced. After that, different types of motors were developed by various scientists, and each motor was having its different characteristics, advantages, response, and wide varieties of applications. Constantly new motors are replacing old ones because of new technology and research. And now it is an era of Brushless Direct Current Motor due to its various advantages such as high power-to-weight ratio, high speed, nearly instantaneous control of speed and torque, high efficiency, and low maintenance.

Similar to a permanent magnet synchronous motor in construction the BLDC motor can also be a switched reluctance motor or an induction motor. They may likewise utilize neodymium magnets and be out runners (the stator is encircled by the rotor), in runners (the rotor is encircled by the stator), or axial (the rotor and stator are flat and parallel). Brushless engines find applications in such places as PC peripherals (plate drives, printers), hand-held power instruments, and vehicles going from model airplane to cars. In modern washing machines, brushless DC motors have allowed the replacement of rubber belts and gearboxes by a direct-drive design.

In Industries, most of the motor used are conventional motors such as an induction motor. In case of an induction motor, as time passes they become unreliable and inefficient and they consume more energy (due to losses). Induction motor doesn't have much dynamic speed control and for their speed control we have to use special device such as VFD.

Overall maintenance cost is high. Other than that monitoring is expensive using software like SCADA.

As we are upgrading to the digital age our devices will be connected to the internet, remote controllability and inexpensive monitoring of these devices should be possible.

This paper describes a simpler way to control the speed of BLDC motor using PWM control method. The performances of the BLDC system are found from the hardware implementation.

In our project, we have designed the remotely controlled and parameter monitoring circuit for the BLDC motor. The BLDC motor is powered by solar power to reduce energy consumption. However, the sunlight is only available for the daytime, and the intensity of sunlight is variable throughout the day. To control the output voltage of the solar converter to a fixed 12v battery voltage, MPPT solar charge controller algorithm is used, which increases the life and efficiency of the batteries. The solar power is stored in a 3s LiPo battery, so it can be used as per our need to run the motor. The speed control of the BLDC motor can be easily done by the PWM output pin of the Arduino Uno (Atmega 328P Microcontroller), and this output is given to ESC (Electronic Speed Controller). Delivered by an electrical signal, the method of reducing the average power by effectively chopping it up into discrete parts is known as Pulse Width Modulation (PWM).The parameters such as speed and temperature are monitored using the A3144 Hall effect sensor and the LM35 Temperature sensor. The voltage and ASC712 current sensors are used to measure the power consumed by the motor. An android mobile application can monitor all these generated parameters by using IOT.

This project can be successfully implemented for various applications. Such as in irrigation for feeding water to the field by controlling the operation and speed of the motor from a remote location and can be done at any time as per our

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convenience due to use of solar-powered batteries, and can also be used for robotics, household fans, etc.

II. LITERATURE REVIEW

"Brushless DC Motor Speed Control Using Microcontroller" *By* G.Santhosh Kumar, S.Arockia Edwin Xavier.Thiagarajar College of Engineering, Electrical and Electronic Engineering Madurai, Tamil Nadu.

In this paper, a BLDC motor is described and its speed control is achieved by varying duty cycles (PWM technique) from the microcontroller. The % duty cycle input is given through a matrix keypad which is interfaced to the microcontroller and the output if the microcontroller delivers the desired output to change the speed of the motor. [1]

"Speed Control of a BLDC Motor Using PWM Control Technique"- By Arjun V, Akhilesh H Nair, Balakrishnan, Vishnu T, Vidya Sojan. UG Scholar, Dept of Electrical &Electronics Engineering, College of Engineering Munnar, India.

This paper describes a simpler way to control the speed of BLDC motor using PWM control method. The performances of the BLDC system are found from the hardware implementation. [2]

"Microcontroller Based Speed Control Scheme of BLDC Motor using Proteus" -By K. Soumiyaa, R.Vishnu Priya. Department of Electrical and Electronic Engineering IFET College of Engineering, Villupuram Tamil Nadu.

In this paper, the motor model has been designed in Proteus VSM simulation software for direct implementation of the program code. Method to reduce speed oscillations and to run the motor at exact entered speed. This is achieving by using the microcontroller programming. [3]

"Brushless DC Motor Controlled by using Internet of Things" -By Ms.C.Hemalatha, Mr.R.Nagarajan, P.Suresh, G.Ganesh Shankar ,Department of Electrical & ElectronicsEngineeringGnanamani College of Technology Namakkal, Tamilnadu, IndiaGnanamani College of Technology Namakkal, Tamilnadu, India

This paper proposes a new architecture for control the BLDC motor, which uses a versatile industrial based android smartphone at a relatively reasonable price and implemented by Ethernet shield and Arduino UNO also using web domain for system control. A 3G or 4G connection can be used to access the Web page on hosting server using an android app or web domain. [4]

"Speed Control of Brushless DC Motor Using Different Intelligence Schemes" -By Rubi Batham, Rameshwar Singh MTech Scholar, Electrical Engineering Department, NITM, Gwalior, India Assistant Professor, Electrical Engineering Department, NITM, Gwalior, India.

In this paper, this dissertation focuses on speed control of BLDC motor using fuzzy logic technique. The goal is to determine which control strategy delivers better performance with respect to BLDC motors speed these methods are compound on the basis of output response, less rise-time, less setting-time etc. Thus the performance comparison between fuzzy logic controller, PI-controller and I-controller is done. The FLC has minimum transient, minimum overshoot and steady state parameters, which shows that it is more effective and efficient than conventional PID controller. [5]

III. CIRCUIT DIAGRAM

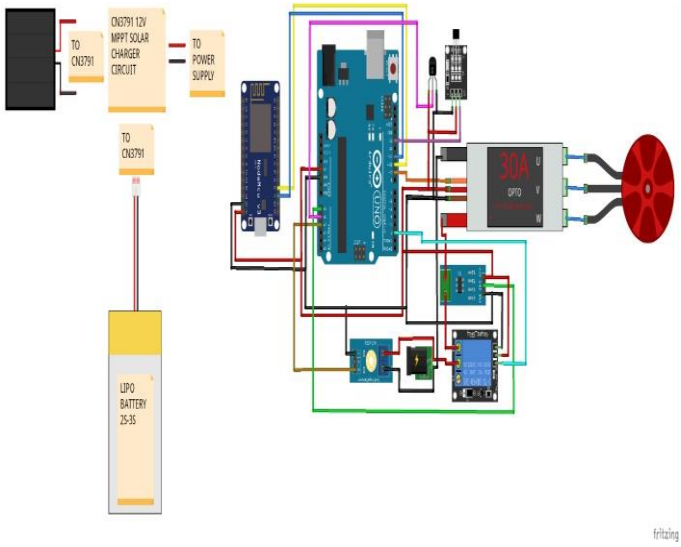

Fig. 1 represents the circuit diagram of the system.

A. SOLAR PANEL

A solar panel has a collection of photovoltaic cells which converts light energy into electrical energy. In our project, we use a 12V solar panel whose output is given to the MPPT module which charges the battery efficiently.

B. MPPT SOLAR CHARGER

The algorithm included in charge controllers that are used to extract maximum available power from a PV module is called Maximum Power Point Tracking (MPPT).This MPPT solar charger provides the power to urge the foremost possible power out of a solar array or other photovoltaic device and into a rechargeable LiPo battery.

C. POWER SUPPLY

In this project, the power supply we use is an 11.1 volt 3 cell Lithium Polymer battery with a capacity of 2200mAh. Li-Po battery is used because these batteries deliver the full rated capacity at a price everyone can afford. Li-Po batteries work best with the ESC driver.

D. RELAY

An electrical switch that is operated by an electromagnet is known as a relay module. The microcontroller activates the electromagnet by a separate low-power signal. At the point when initiated, the electromagnet pulls to open or close an electrical circuit. The relay used here is a single channel Single-Pole Double-Throw High-level trigger, and this relay board can be controlled directly via the Arduino Uno and can perform switching up to 10A at 250 V AC.

E. ESC DRIVER

An Electronic Speed Regulator (ESC) is an electronic circuit that directs and controls the speed of a motor. Reverse operation of the motor is also possible. Here we have used an ESC driver to control the speed of a BLDC motor. This 30A

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BLDC ESC can drive a motor that consumes current up to 30A. It works on 2S-3S LiPo batteries. This variant of the ESC also incorporates backward polarity protection on the 5V receiver line. This means that if we accidentally attach a battery backward, it will not destroy the motor controller.

F. BLDC MOTOR

A Brushless DC electric motor is a synchronous motor that uses a direct current (DC) electric power supply. It utilizes an electronic closed- loop controller for changing DC currents to the motor windings which produce magnetic fields that rotates, and the permanent magnet rotor follows. The motor used is a high-speed brushless motor explicitly designed for Quadcopters, Drones, or toy planes. The motor is OUTRUNNER type where the outer case rotates while the inside stays fixed. It is one of the popular models in the market because of its low cost. It is preferred for small drones and planes. This motor is a 1400KV motor. This means that the speed of the motor is 1400 rpm when 1 volt is applied to it. It can operate in between 7.2V to 12V.

G. ATMEGA 328P MICROCONTROLLER

A micro controller is an integrated circuit gadget utilized for controlling different pieces of an electronic framework, through a microprocessor unit, memory, and so on. The microcontroller used in this project is the Atmega 328P microcontroller, commonly known as “Arduino Uno.” The codes are embedded in the Arduino Uno to perform the required tasks like controlling, communicating with the other electronic components which are used in this project.

H. NODE MCU

The Node MCU board has ESP8266 which is a profoundly incorporated chip intended for the necessities of internet -connected world. It offers a total Wi-Fi arrangement, permitting it to either host the application or to offload all Wi-Fi networking capabilities from another application processor. In our project, this Node MCU will act as a link between Arduino Uno and the cloud server from which the commands are passed through the application.

I. HALL SENSOR

A Hall Sensor is a type of sensor that detects the presence of a magnetic field. Hall Effect sensors are used for positioning, proximity sensing, speed detection applications, etc. The A3144 Hall Effect Sensor Magnet Detector Switch for Arduino used in our project is a sensor that will turn ON or OFF in the presence of a magnetic field. This hall sensor will be used to measure the speed of the bldc motor.

IV. PROPOSED METHODOLOGY

This paper presents the speed control and parameter monitoring of Solar-powered BLDC Motor using the PWM technique. Generally, Brushed drive have short lifetimes due to the wear of brushes and commutator and the brushes need to be replaced and requires regular maintenance. Whereas in brushless motor, they do not use commutation parts; hence it will have a longer life because there will be no brush erosion. It has higher reliability and reduced maintenance.

This project uses Atmega328P as the microcontroller. Along with Atmega328P, a Node MCU ESP12E is used to add Wi-Fi capabilities.

The BLDC motor used in the system is a 1400 KV motor, which means for every volt, it provides 1400 RPM speed. An ESC is used to drive the BLDC Motor. The ESC used in the system is a 30 Amp Electronic Speed Controller.

There are various parameters such as Current, Voltage, Power, Temperature, and Speed of the motor, which are monitored in this project. A Current Sensor (ACS712) is used to monitor the current through the device, while Voltage Sensor is used to monitor the voltage across the device. Then the power is calculated by considering the current and voltage. Another sensor called Hall Sensor is used to measure the RPM or speed of the motor. A temperature sensor (LM35) will be used to monitor the temperature of the BLDC Motor.

Controlling of BLDC motor is possible in this system. The speed of the BLDC motor is controlled using PWM Signals, and switching on/off of the BLDC Motor can be done remotely using Relay that activates/deactivates a signal from Mobile Phone.

The monitoring parameters and controlling parameters of the device are stored on Thing Speak Cloud Server. It has a Write and Read API Key to write data and read data from the cloud server.

An Android App is also designed for Monitoring and Controlling the BLDC motor.

The system is made solar-powered using solar panels that work on the MPPT Algorithm to provide the best efficiency.

The flowchart of the developed system is shown in Fig.2 represents the workflow of the developed system.

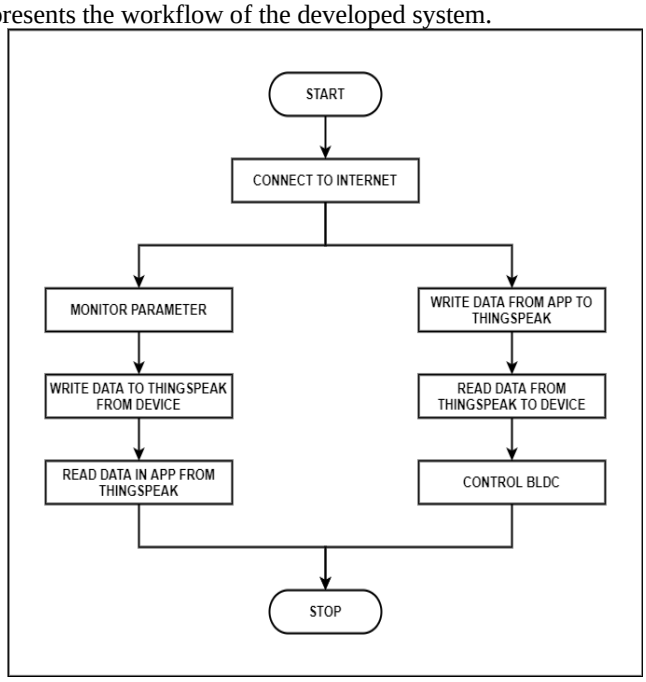

Fig.2 Flow Chart

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V. SIMULATION RESULTS FOR VARIOUS PWM PULSES

The speed control technique used here is the Pulse Width Modulation (PWM).The duty cycle decides the speed of the motor. The speed to be achieved can be obtained by varying the duty cycle. The duty cycle is controlled by the PWM pulses given from the microcontroller.

Average voltage = D * Vin

The average voltage obtained for various duty cycles is also mentioned and as the duty cycle percentage decreases average voltage also decreases from the supply voltage.
Duty cycle is defined as the percentage of time the motor is ON. Therefore, the duty cycle is given as,

Duty Cycle = 100% x Pulse Width/Period
Where,
Duty Cycle in (%)
Pulse Width = Time the signal is in the ON or high state (sec)
Period = Time of one cycle (sec).

A. PWM PULSES at 25%, 50% and 100% RATED SPEED

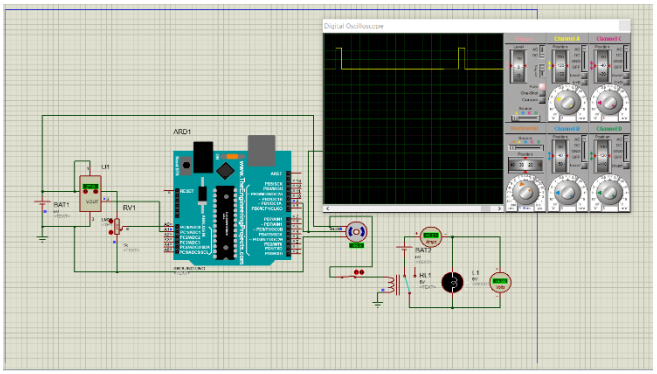

Fig.3 At 25% rated speed

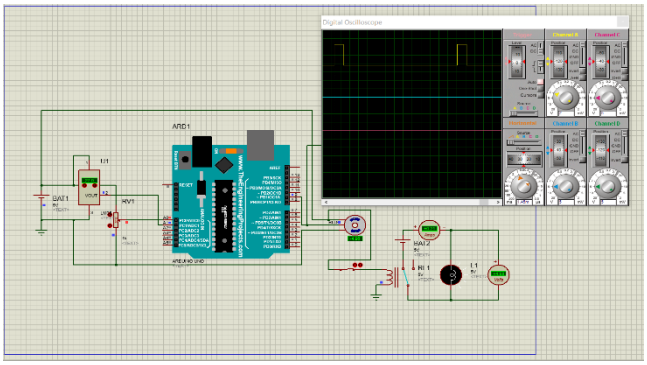

Fig.4 At 50% rated speed

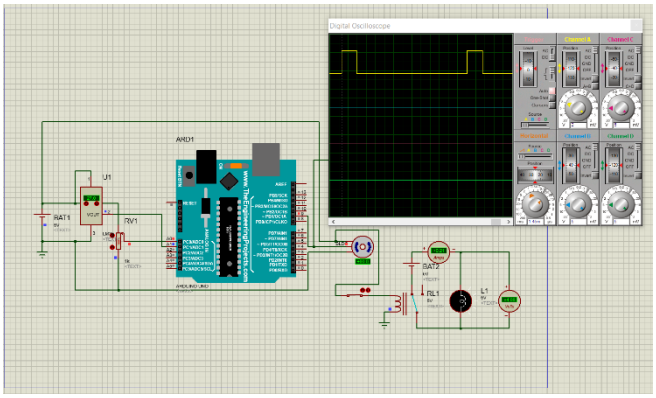

Fig.5 At 100% rated speed

B. HARDWARE IMPLEMENTATION

The hardware and the operation is done as the program written in the Arduino and the speed is also controlled by using PWM technique. The hardware implemented for the project is given below.

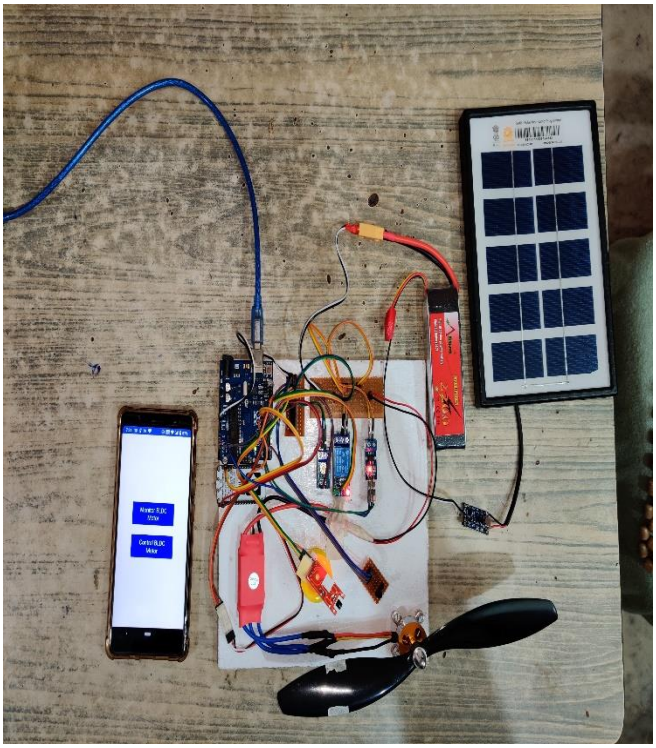

Fig. 6 Hardware Model

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C. APPLICATION INTERFACE

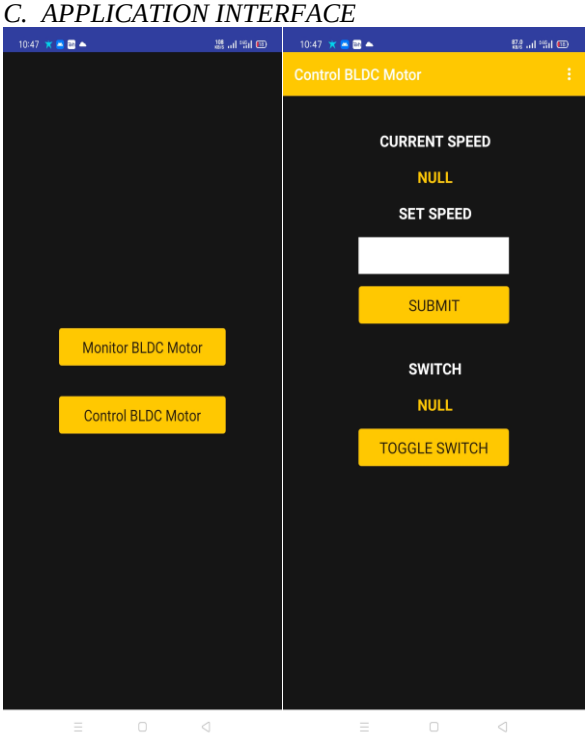

Fig.7 Application Interface

D. RESULTS

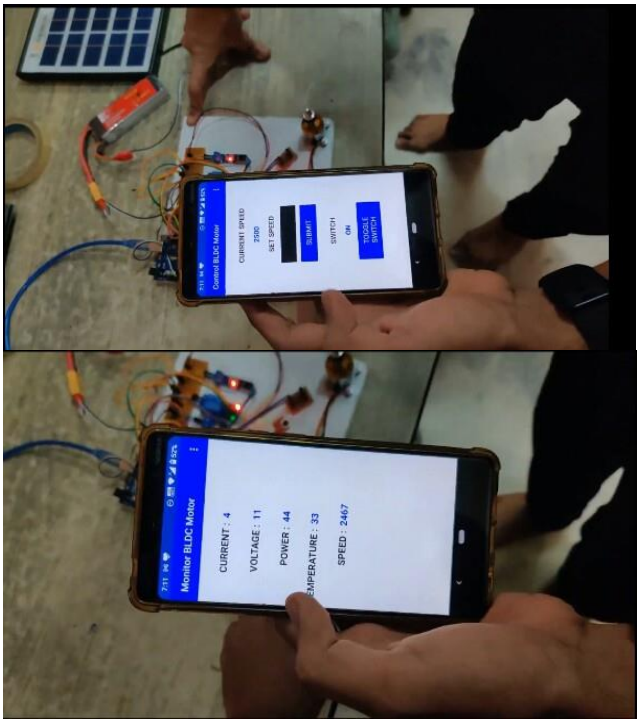

Fig.8 Hardware Results

E. OUTPUT RESPONSE (SIMULATION)

INPUT DUTY CYCLE IN %	OUTPUT VOLTAGE	OUTPUT SPEED IN RPM
25%	3V	4200
50%	6V	8400
100%	12V	16800

VI. CONCLUSION

The proposed system will help the Industrial people to monitor the BLDC motor from their remote location itself. The speed of the motor is controlled with the help of PWM technique and it is made to run at the required or desired speed. Monitoring is done with the help of Internet of Things (IoT).Internet of Things (IoT) plays major role in this system. The communication is made healthier and stronger with the help of this communication module. This brings advantages and has a good scope for Industries. Thus the proposed method is very well suited for Industrial applications.

This setup has some good advantages over the conventional system. The Mobile app is useful in controlling the speed of the BLDC motor and real time monitoring using IOT .As it is a BLDC motor it good life expectancy with less maintenance compared to other motor as a result reducing operation cost.

BLDC motor is a better choice for different applications because of higher efficiency, higher power density and higher speed ranges as compared to other types. The Output characteristics and less complexity of model make it adequately valuable in plan of BLDC motor drives with diverse control algorithms in various applications.

VII. ACKNOWLEDGMENT

We would like to express our sincere thanks to Prof. Garima Gurjar for taking time from her busy schedule to provide us with great deal of help, support and encouragement to work diligently at every aspect of our project.

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