# Digital Logic Speed Control of Brushless DC Motor

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*Abstract* — **This is aimed towards closed loop speed control of Brushless DC motor with fundamentals. The Brushless DC motor is essentially configured as a permanent magnet DC machine. We developed a mathematical model of the PMBLDC motor by considering the behavior of commutation phenomenon and wave forms in 120 degree mode of operation. Used it to examine the performance of a PMBLDC motor speed servo drive system when fed from pulse width-modulated ( PWM) current controllers for comprehensive analysis and prediction of dynamic characteristics. Torque is generated by the patterns of wave forms in MATLAB. The control circuit determines the switching action to be performed, based on the rotor position feedback. The rotor position is estimated based on the Hall sensor signals.**

## I. INTRODUCTION

As the name implies, BLDC motors do not use brushes for commutation; instead, they are electronically commutated. BLDC motors have many advantages over brushed DC motors and induction motors. The ac machines like induction motors, in control characteristics, the flux control is introduced and the decoupling is achieved at the cost of complexity. Moreover it has poor power factor which reduces efficiency. The introduction of Permanent magnet brushless dc motor increases the efficiency to a much extent up to 95% with alloy of Neodymium, Ferrite and Boron (Nd_Fe_B) magnet rotors by eliminating the field copper loss. So Brushless Direct Current (BLDC) motors are rapidly gaining popularity. BLDC motors are used in industries such as Appliances, Automotive, Aerospace, Consumer, Medical, Industrial Automation Equipment and Instrumentation. In addition, the ratio of torque delivered to the size of the motor is higher, making it useful in applications where space and weight are critical factors.

## II. MECHANISM AND WORKING PRINCIPAL

BLDC have three basic parts: Stator, Rotor and Hall sensor.

The **stator of a BLDC motor** consists of stacked steel laminations with windings placed in the slots that are axially cut along the inner periphery as shown. Traditionally the stator resembles that of an induction motor; however, the windings are distributed in a different manner. Most BLDC motors have three stator windings connected in star fashion. Each of these windings is constructed with numerous coils interconnected to form a winding. One or more coils are placed in the slots and they are interconnected to make a winding. Each of these windings is distributed over the stator periphery to form an even numbers of poles.

A **Permanent magnet rotor** is used in DC brush less DC motors. The construction of PMDC commutators motor is similar to conventional DC motor whose electromagnetic excitation is replaced by permanent magnets. The permanent magnet rotor can vary from two to eight pole pairs with alternate North (N) and South (S) poles. Based on the required magnetic field density in the rotor, the proper magnetic material is chosen to make the rotor. Ferrite magnets are traditionally used to make permanent magnets. As the technology advances, rare earth alloy magnets are gaining popularity. The ferrite magnets are less expensive but they have the disadvantage of low flux density for a given volume. In contrast, the alloy material has high magnetic density per volume and enables the rotor to compress further for the same torque.

**Hall Sensors:** Most BLDC motors have three Hall sensors embedded into the stator on the non-driving end of the motor. Whenever the rotor magnetic poles pass near the Hall sensors, they give a high or low signal, indicating the N or S pole is passing near the sensors. Based on the combination of these three Hall sensor signals, the exact sequence of commutation can be determined.

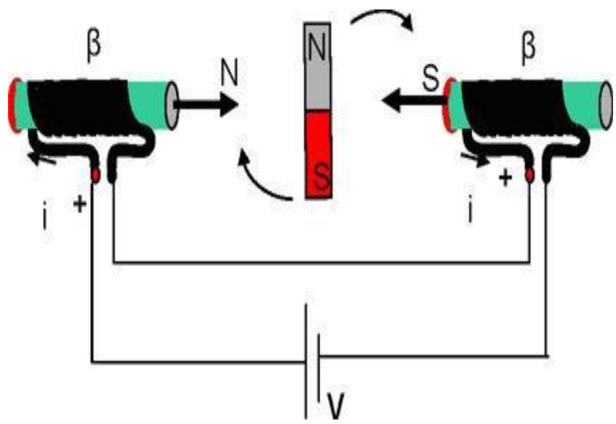



Fig.-1 Rotor Torque Developed by stator current

***Hall Effect Theory:*** If an electric current carrying conductor is kept in a magnetic field, the magnetic field exerts a transverse force on the moving charge carriers which tends to push them to one side of the conductor. This is most evident in a thin flat conductor. A buildup of charge at the sides of the conductors will balance this magnetic flux, producing a measurable voltage between the two sides of the conductor. The presence of this measurable transverse voltage is called the Hall Effect after E. H. Hall who discovered it in 1879.

**PRINCIPLE:** The BLDC motor is based on a fundamental principle of magnetism, which tells us that similar poles repel each other, while opposite poles attract. When a current is passed through two coils, it generates a magnetic field with a polarity that creates torque on the central magnet—in this case, the rotor. When a current is passed, the central rotor rotates clockwise. When the rotor reaches a certain position, the direction of the current is changed so that the torque continues further in the same direction. When necessary, the current direction is changed again to continue generation of the torque.

## III. CONTROL OF BLDC

Control systems are broadly classified as either CLOSED-LOOP or OPENLOOP. Closed-loop control systems are the type most commonly used in the industry because they respond and move the loads they are controlling quicker and with greater accuracy than open-loop systems. The reason for quicker response and greater accuracy is that an automatic feedback system informs the input that the desired movement has taken place. Upon receipt of this feedback information, the system stops the motor, and motion of the load ceases until another movement is ordered by the input.

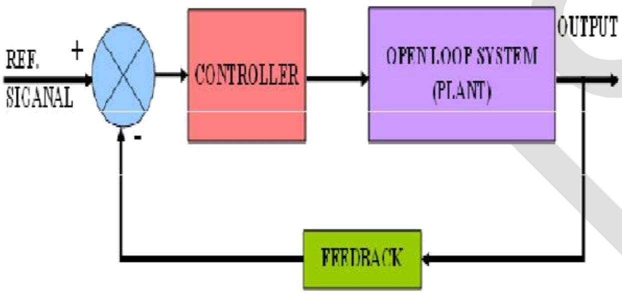
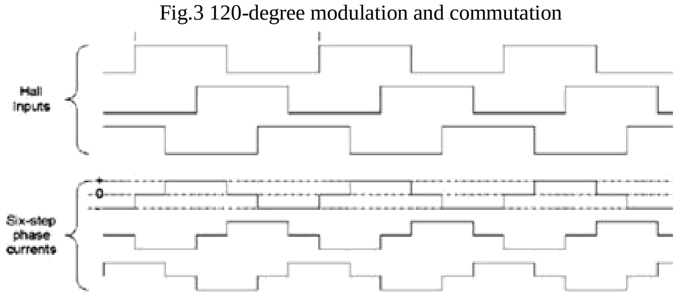



Fig.2 Closed loop Control Brushless DC Motor

Typical hardware used to control a BLDC motor are the converter and inverter. Six power-MOSFET or insulated-gate bipolar transistor (IGBT) switches are used in the inverter. A BLDC motor also has sensors. For example, Hall sensors and an encoder may be used to provide information about the position of the rotor.

Fig.3 120-degree modulation and commutation




Depend upon the position two types of control, if hall sensors are 60 –deg apart from each other then this type of control is known as 60-deg.and if they are 120 degree apar5t from each other then this type of control is known as 120 degree control. Now we can examine the sequence of Hall signals easily, turning the motor by hand for one complete rotation. The signals can also be viewed on a scope as the motor is rotated to determine whether or not they are 120-degree Hall signals.

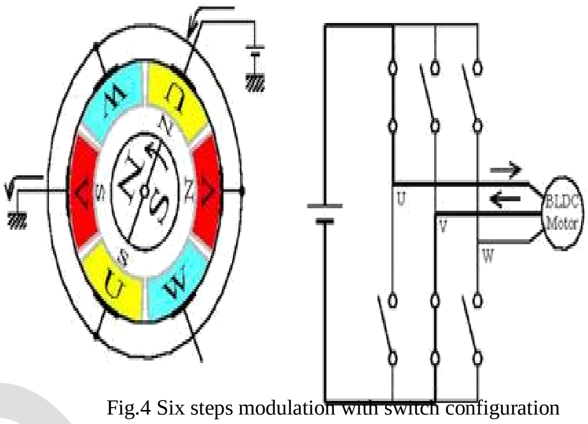



Fig.4 Six steps modulation with switch configuration

## IV. SIMULATION & RESULTS

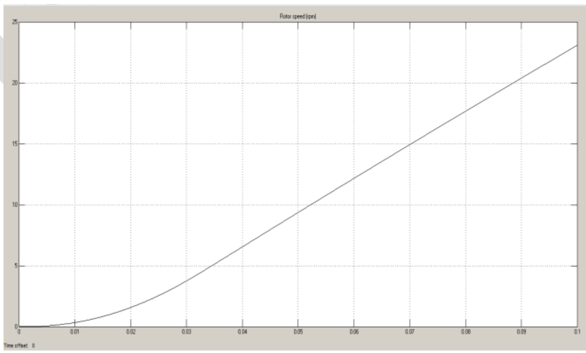


Fig.5 Speed variation without Load

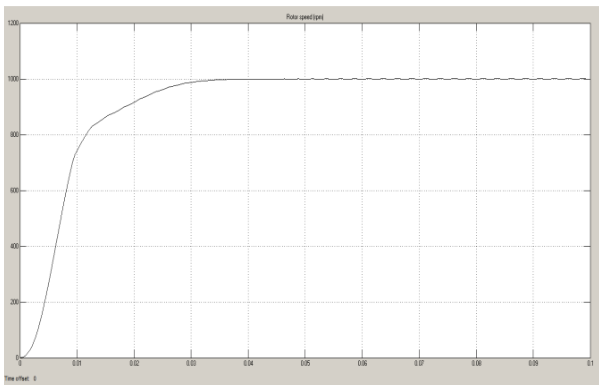


FIG.6 SPEED VARIATION WITH LOAD

## CONCLUSION

Here we developed a simulation model for the closed loop drive of a PMBLDC motor to give an insight into the dynamic performance of the motor realized with this work that BLDC motor can be controlled in closed loop with very quick response to any disturbance in the load.

**The torque** climbs to high and stabilizes rapidly to its reference value. The nominal torque is applied at t = 0.1 second and the controller react rapidly and increase the DC voltage to produce the required electric torque. This property can be utilized for an application where precise position control is required.

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