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PULSE WIDTH MODULATION TECHNIQUES FOR PERFORMANCE REFINEMENT OF BRUSHLESS DC MOTOR DRIVES

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Abstract –The use of brushless DC (BLDC) motor drives has become popular due to their high efficiency, reliability, and dynamic response. Although conventional PWM strategies like SPWM and SVPWM are successful in reducing total harmonic distortion and improving the fundamental component, they are not effective in reducing the spectral distribution of harmonic power which causes auditory disturbance and quivering in drives, as well as electromagnetic interference (EMI). A superior speed controller is not enough to ensure optimal performance of the drive system. A better PWM scheme is also necessary. Therefore, this project aims to analyze the electrical characteristics and functioning of numerous PWM methods of BLDC motors, including SPWM, SVPWM, Random Pulse Width Modulation (RPWM). The project also involves comparing the results obtained from these PWM methods with those obtained from conventional PWM methods. The purpose is to identify the best PWM method for improving the control performance of high-speed BLDC motors. MATLAB software is used to validate the performance of the PWM methods.

Keywords – BLDC motor ,PWM methods, MATLAB

INTRODUCTION

Overall, BLDC motors are becoming increasingly popular due to their numerous advantages over conventional brushed DC motors. They offer high efficiency, high speed capabilities, and better heat dissipation, making them ideal for a wide range of applications, including actuating drives, machine tools, electric propulsion, robotics, computer peripherals, and electrical power generation. The construction of a BLDC motor is different from a brushed DC motor as it employs electronically controlled commutation with a permanent magnet rotor and a stator with a sequence of coils. The armature coils are switched electronically, and the rotor position is sensed using hall sensors or rotary encoders, enabling precise control over the motor's speed and position. There are various types of BLDC motors available in different physical configurations, such as single-phase, two-phase, or three-phase motors. However, three-phase BLDC motors with permanent magnet rotor are the most commonly used due to their efficiency and performance. In summary, BLDC motors are a reliable, efficient, and versatile option for modern drive technology, and their popularity is likely to continue to grow as technology continues to improve. The rotor of a BLDC motor is made up of permanent magnets arranged in a specific pattern, such as trapezoidal or sinusoidal, depending on the motor's design. The figure of poles on the rotor must match the figure of poles on the stator windings for the motor to operate efficiently. The rotor can be either external or internal to the stator, depending on the motor's configuration. The electronic commutation system in a BLDC

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motor involves using sensors, such as Hall sensors or rotary encoders, to determine the position of the rotor and switch the armature current at the correct time. This process is controlled by an electronic circuit, which is responsible for delivering the correct current to the appropriate winding at the precise time. Overall, BLDC motors offer several advantages over brushed DC motors, including higher efficiency, smoother operation, and lower maintenance requirements. They are widely used in various applications, such as robotics, electric propulsion, and machine tools. The construction of a BLDC motor can vary depending on the desired specifications, with options for different stator winding configurations and rotor magnet patterns. Hall sensors provide essential feedback for synchronizing the stator and rotor of a BLDC motor. With electronic commutation, the windings of stator must be invigorated in a specific arrangement to drive the motor forward. To determine the appropriate winding to energize at a given time, the Hall sensors embedded within the stator detect the rotor's position. Typically, a BLDC motor has three Hall sensors, each of which results Low and High signals when a rotor pole passes close by it. By analysing the signals from these sensors, the control circuitry can determine the exact commutation sequence needed to drive the motor. There are various PWM methods like SPWM SVPWM, and Trapezoidal Commutation which are used for controlling the motor speed and torque. A Brushless DC (BLDC) motor is an electric motor that operates on the principle of electromagnetic induction. Unlike brushed DC motors, BLDC motors do not have brushes, and they rely on electronic commutation to determine the direction of rotation. The main components of a BLDC motor include a stator with windings, a rotor with permanent magnets, and a set of sensors to detect the position of the rotor. The stator windings are arranged in a three-phase configuration, and they generate a rotating magnetic field when a three-phase current is applied. The rotor, which is made up of permanent magnets, is attracted to the rotating magnetic field generated by the stator windings, causing it to rotate. The electronic commutation system consists of a set of Hall effect detector that locates the position of the rotor and a controller that determines the timing of the commutation signals. The controller sends signals to the power electronics, which switch the current flow in the stator windings to keep the rotor aligned with the rotating magnetic field. The commutation process is continuous, and it ensures that the magnetic field generated by the stator windings is always in phase with the magnetic field of the rotor. This results in smooth and efficient operation of the motor, with minimal power loss due to friction and heat.

PWM Techniques.

There are various PWM techniques like SPWM SVPWM, and Trapezoidal Commutation which are used for controlling the motor speed and torque.
The Techniques we describe.

1) Sinusoidal PWM
2) Space vector PWM
3) Random PWM

1. Sinusoidal Pulse Width Modulation

SPWM methodology is widely used in power electronics to engender switching pulses for controlling the inverters. This method involves comparing a low frequency sinusoidal signal (such as a sine wave) is used as a reference signal, and a high frequency triangular waveform (such as a triangle wave) is used as a carrier signal. The amplitude of the sinusoidal signal represents the desired output voltage or current, while the frequency of the carrier signal determines the switching frequency of the inverter. Inverter usually have six switching devices, and the output of each phase of the inverter is connected to the center of each leg of the inverters. In a two-level voltage source inverter, each leg of the inverter has two switches - one is a high-side switch (connected to the DC voltage source) and the other is a low-side switch (connected to the ground).At any given moment of time ,only one switch will be active in one leg of the inverter since they are operated in a complementary sequence only one switch at any given moment will be active. This results in the generation of a three-phase AC voltage waveform that can be used to power various types of loads, including motors and other electrical devices. Overall, the SPWM technique offers a simple and effective way to control an inverter's output voltage, and it is widely used in variety of applications including sustainable energy systems, motor drives, and power supplies.

2. Space Vector Pulse Width Modulation

SVPWM is a technique used to control the three-phase inverter's output voltage. It is a vector approach to pulse width modulation and uses a reference voltage vector and a high-frequency triangular carrier signal to generate pulses for inverter switches to command the voltage and frequency. In SVPWM, three-phase voltages are converted into two-phase voltages in either stationary or synchronous rotating reference frames. Voltage vector control is achieved by adjusting the timing and duty ratio of the eight switching states of the inverter. There are eight voltage vectors, including two zero voltage vectors and V1, V2, V3, V4, V5, and V6 which are named as active voltage vectors. Each of these vectors has a fixed magnitude and is 60° apart from each other. The magnitude of each vector is determined by the DC voltage source available for the inverter. The reference voltage vector is resolved into a combination of the eight voltage vectors, depending on its location in the six sectors. The duration for which each voltage vector is applied is determined by d1, d2, and d3. SVPWM has many advantages when compared to SPWM, such as few switching losses, slight total harmonic distortion, and better usage of the DC-bus voltage as compared to SPWM.

3. Random Pulse Width Modulation

RPWM is a method that adds randomness to the PWM waveform, which may generate the harmonics power to propagate beyond the harmonic spectrum, resulting in reduced audible switching noise and electromagnetic interference (EMI). The passage reviews the principles of RPWM, means of randomization, existing RPWM techniques, power spectra, and implementation issues. It also highlights the documented effects of RPWM on electric drive systems and the advantages of conventional SPWM and SVPWM strategies in reducing Total Harmonic Distortion (THD), lowering the filtering necessity, and make better the fundamental component. However, these strategies may not be effective in reducing issues such as spectral distribution of harmonic power and EMI. The passage also mentions a novel method for precise reckoning of power spectra of the PWM voltage-source inverter with randomized switching frequency and investigations in harmonic spreading effects using SVPWM switching patterns in VSI-fed AC drives. Finally, the passage emphasizes that the optimal procedure to decrease hearable switching disturbances in BLDC motors is to increase the PWM switching frequency, but this may rise the switching loss of the inverter.

PROPOSED SYSTEM CONFIGURATION

We have a wide range of applications for BLDC motor keeping a note on it we have different types of PWM techniques in order to get the best outputs from the motor. We have different PWM techniques in existence.

But in our proposed system configuration we are taking some of the techniques SPWM, SVPWM, RPWM and comparing their results based on speed and torque. So, by comparing these techniques we can say the better technique to use in order to get the best outputs from the BLDC motor. To implement these techniques, we are using the MATLAB software.

RESULTS

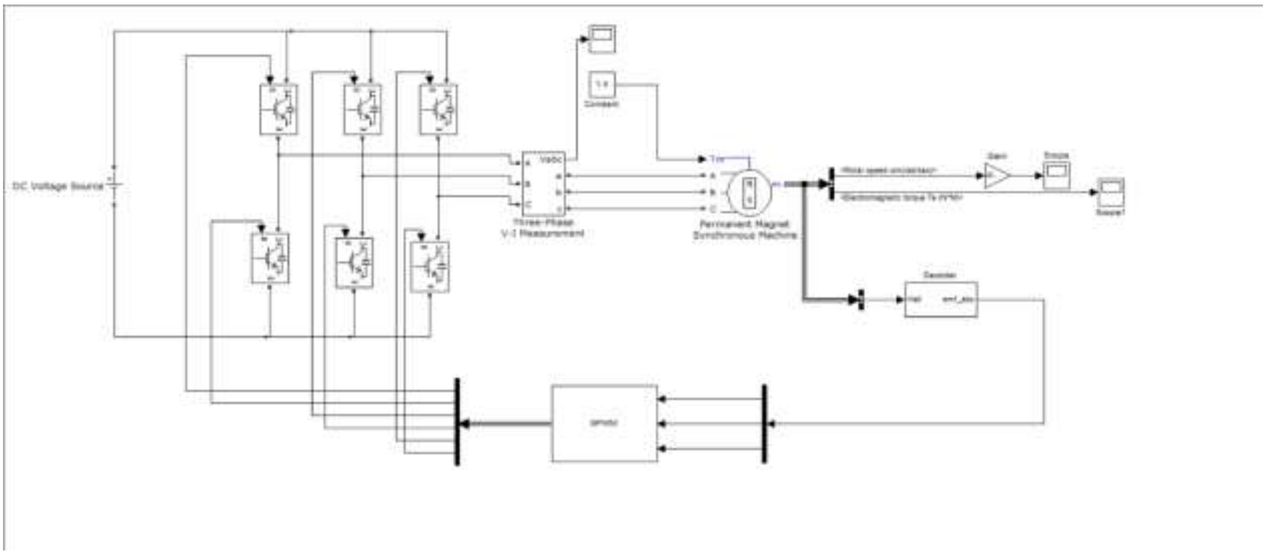
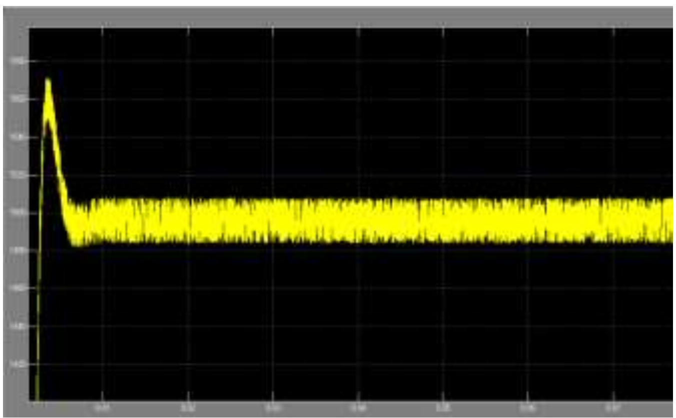
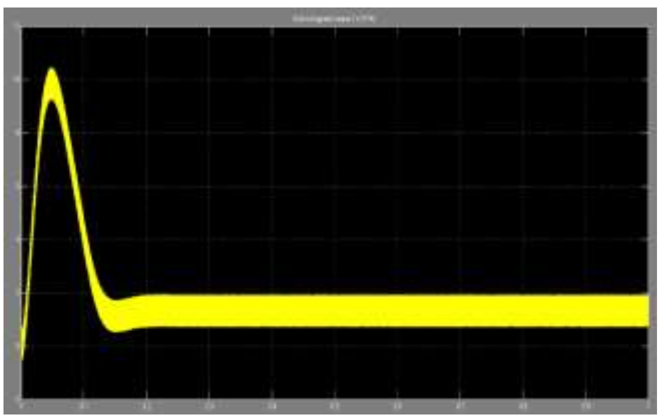


Fig 1:Simulink model of SPWM

Fig 2:speed waveform

Fig 3:Torque waveform





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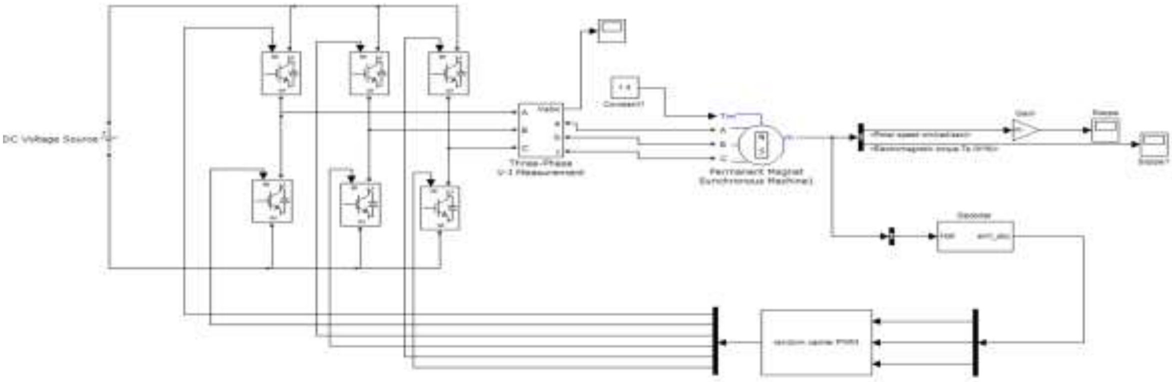
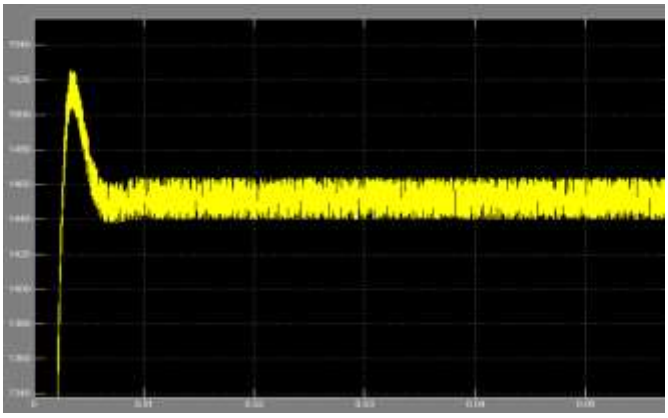


Fig 4: **Simulink model of rpwm**



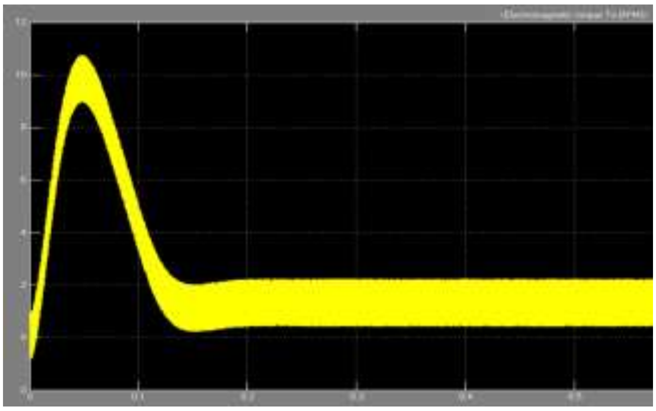
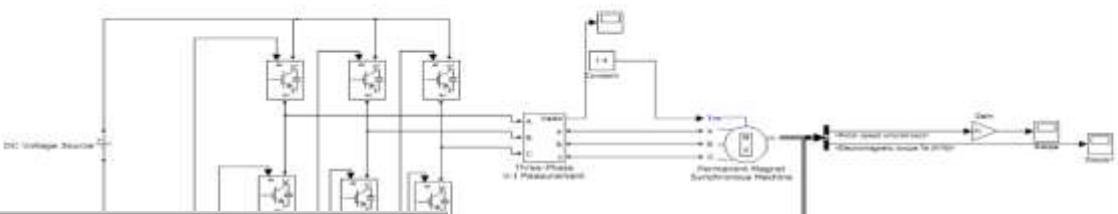
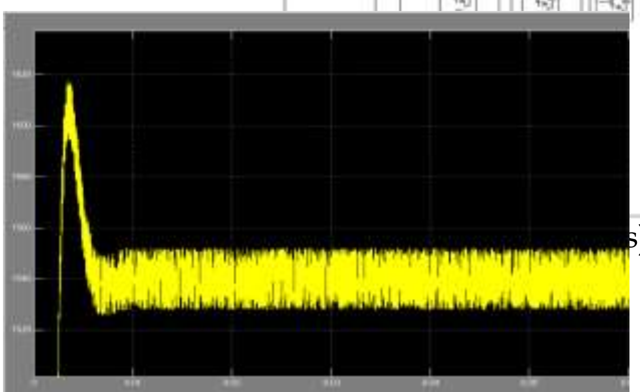


Fig 5: Speed waveform

Fig 6:Troquge waveform





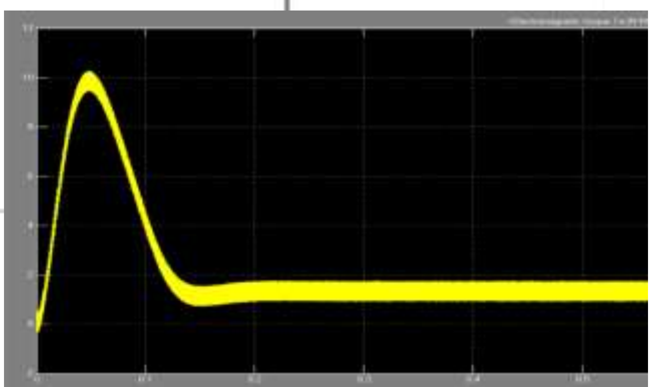


Fig 7: **Simulink model of svpwm**

Fig 8: Speed waveform

Fig 9: Torque waveform

CONCULISION

By the following results means by considering the speed torque characteristics of the motor we can conclude that out of these three PWM techniques (RPWM, SPWM, SVPWM),
The best technique to improve the control characteristics of high-speed BLDC motor is **Space vector pulse width modulation (SVPWM)**

S.NO	Type of PWM Technique	SPEED	TORQUE
1	RPWM	1440-1465	0.4 - 2.2
2	SPWM	1485-1510	0.7 - 1.9
3	SVPWM	1525-1555	0.95 – 1.65

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