



ST. ANNE'S COLLEGE OF ENGINEERING AND TECHNOLOGY

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ANGUCHETTYPALAYAM, PANRUTI – 607 106.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

LAB MANUAL

EE 3009 - SPECIAL ELECTRICAL MACHINES

V SEMESTER

Prepared by

Mrs. J. Arul Martinal, AP/EEE

EX.NO.01

DATE:

SIMULATION OF BLDC MOTOR

AIM:

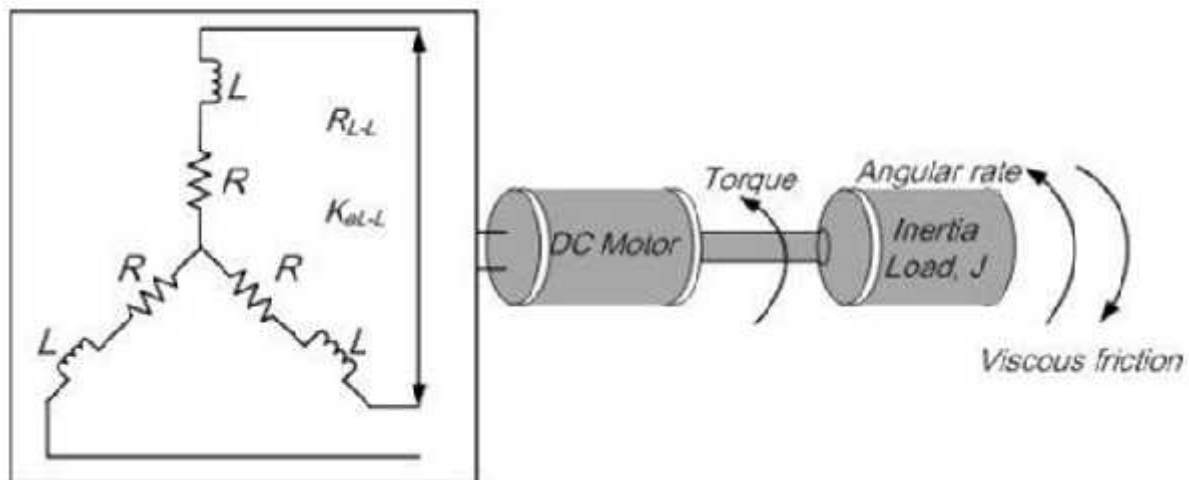
To simulate the dynamic characteristics of Brushless DC Motor using MATLAB Simulink.

SOFTWARE REQUIRED:

1. Sim Power System
2. MATLAB

THEORY:

The BLDCM is form of electric motor that kind perspective of modelling appears like a traditional DC motor having a liner relationship between voltage and current. Its commutation is controlled electronically when put next to the DC motor (having brushed contacts) wherever commutation takes place automatically. And in BLDCM, the armature remains static having stator coil windings whereas the rotor is static magnet that rotates. Commutation between the stator coil and also the rotor takes place by electronic controller that performs same distribution of power as brushed DC motor. Benefits of brushless DC motor over brushed DC motor build it helpful in applications like part wherever house and weight of the motor are important factors. BLDCMs offer benefits over brushed DC motors and induction motors in terms of efficiency and performance. Faster and more responsive than ever before due to their improved performance in terms of speed and torque. Additionally, because of the increased torque, the smaller motor may be used in situations where weight and size are important considerations. BLDCM, on the other hand, requires position data to generate torque. Devices like position encoders, resolvers, and Hall Effect sensors are often used to collect precise location data.

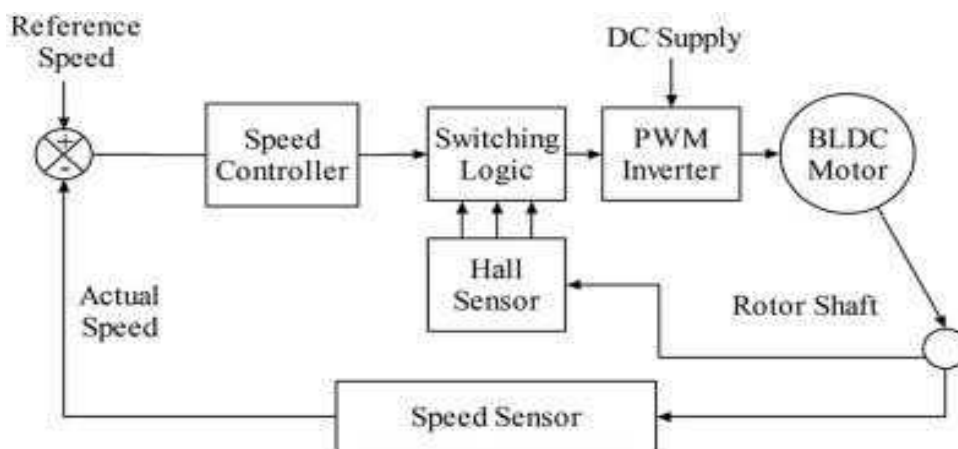


Equivalent Circuit of BLDC Motor

BLOCK DIAGRAM

Brushless direct current motors (BLDCM) are a kind of synchronous motor in which the coil is made of permanent magnets. These are the motors that do not have brushes or commutators to allow for the passage of current or the commutation of the motor. It's for this reason that these kinds of motors are sometimes referred to as electronically commutated motors. In fact, they are not controlled directly but rather

via an associated electrical converter that turns the phases of BLDCM ON/OFF in response to the position of the rotor. 1200 conductivity mode and 1800 conductivity mode are selectable through the switches located inside the electrical converter. This figure depicts a block design of the open loop BLDCM.

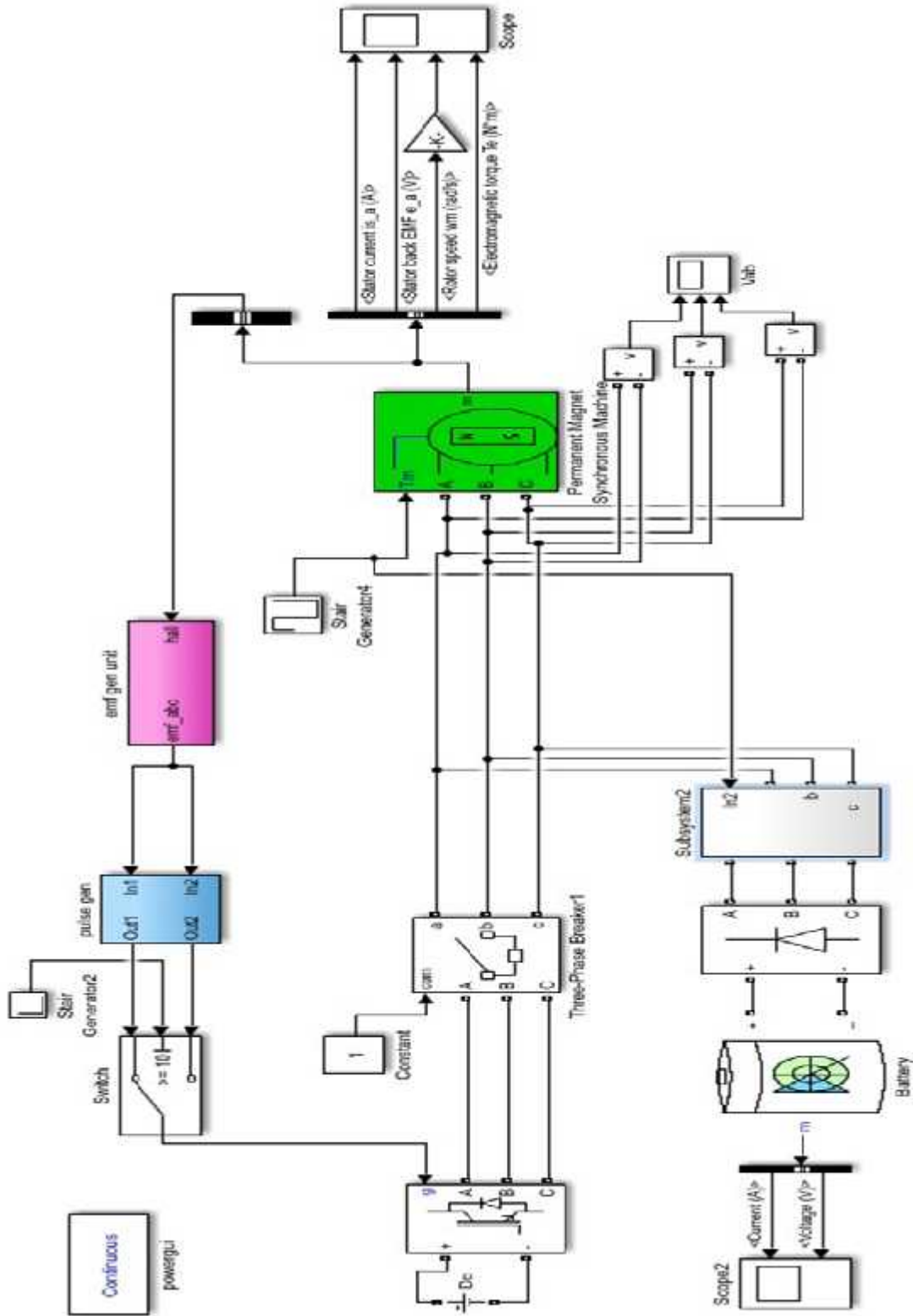


Stator resistance and inductance, and the back EMF constant of the motor are all factors that influence motor control responsiveness. For maximal overshoot, an unsteady condition with increased transient reaction and reduced time response of the control actuation system, look to the motor settings.

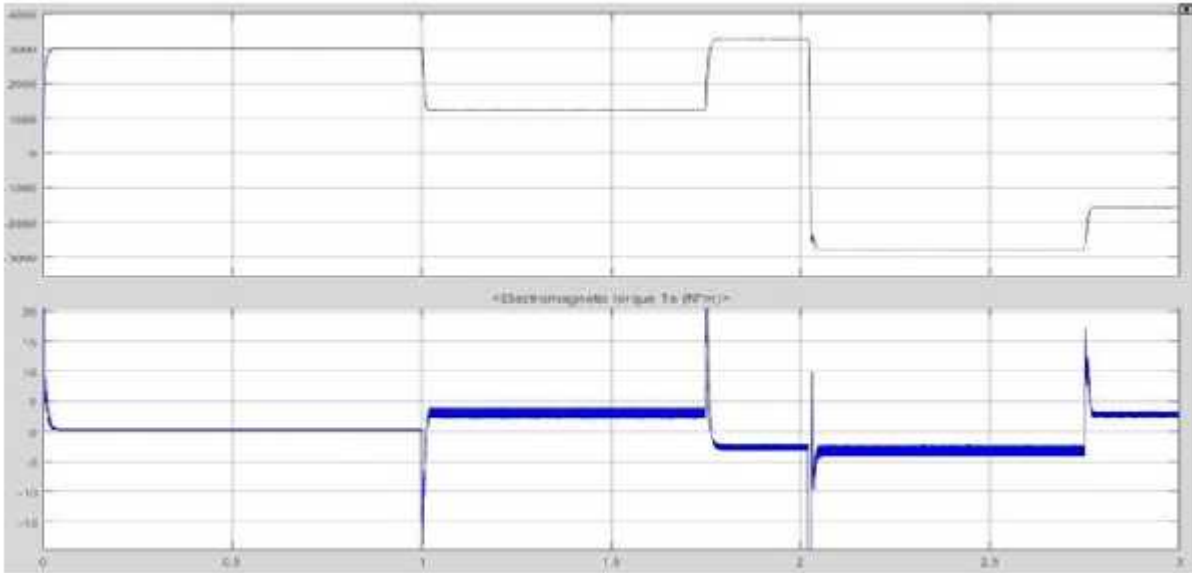
As an IGBT-based inverter circuit, the BLDC Motor Driver creates three-phase voltage to power BLDC motors using a switching PWM signal as input. Using three hall sensors, the controller is able to monitor the rotor's position at 120 electrical degrees. For six input combinations, three hall sensors with eight combinations provide hall signals with 120electrical-degree sensor phasing.

A quadrature encoder is used to obtain rotor position information from the BLDC motor as a feedback to the controller while modelling the control actuation system. The BLDC motor shaft is connected to the shaft encoder model subsystem. There will be an output from this encoder block that includes the rotor speed and phase shifting location, as well as a pulse frequency and velocity. The motor's speed, location, and direction may all be calculated using the shaft encoder pulses. The whole calculation is based on a MATLAB Simscape model and a triggered subsystem for calculating information from an encoder's square wave.

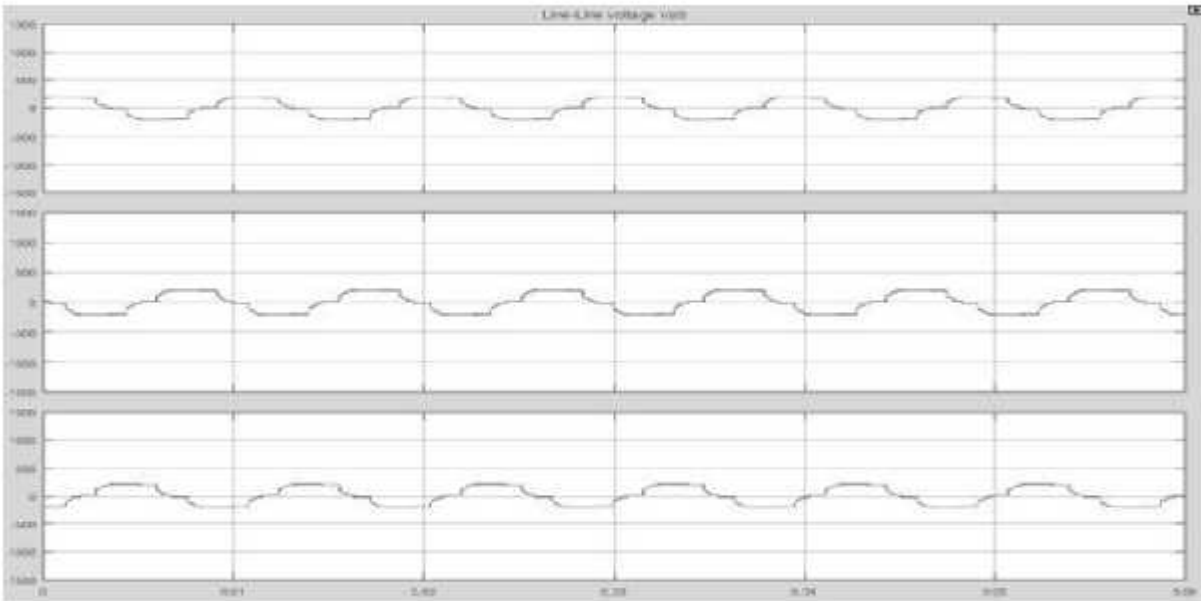
SIMULINK DIAGRAM



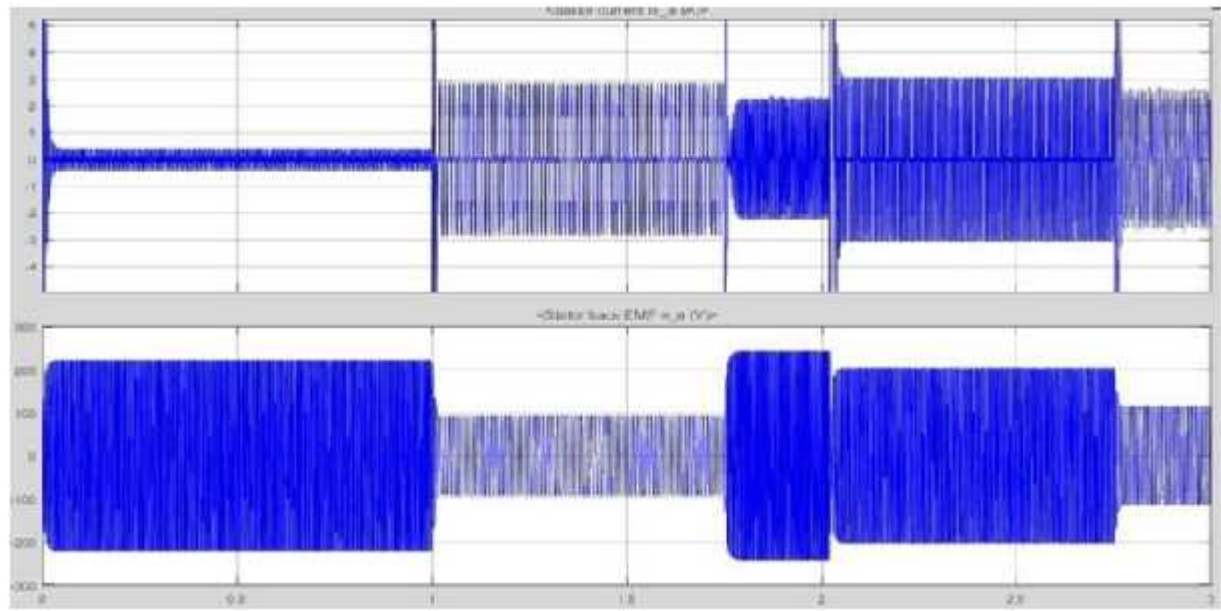
OUTPUT WAVEFORMS:



Four Quadrant operation torque and speed responses



Three Phase Line to Line Voltage responses



Stator Current and Backup Emf Waveform

PROCEDURE:

1. A model is created by using the component available in the simulink browser
2. Go to the voltage measurements block & set the magnitude as 24 V.
3. Give step reference to the converter.
4. Give a staircase Generator input to PMSM.
5. Verify all the model parameters values & re-enter for the various firing angle for the required rating of the parameter block.
6. Then run the program by clicking the arrow in the top box (Or) Go to the simulink parameter and click the start.
7. Double click the scope to see the output waveform.
8. Then output is printed for result analysis.

RESULT:

Thus, the dynamic characteristics of Permanent Magnet Synchronous Motor using MATLAB Simulink was simulated.

EX.NO.02

DATE:

SIMULATION OF SWITCHED RELUCTANCE MOTOR

AIM:

To simulate the output characteristics of Switched Reluctance Motor (SRM) using MATLAB Simulink.

SOFTWARE REQUIRED:

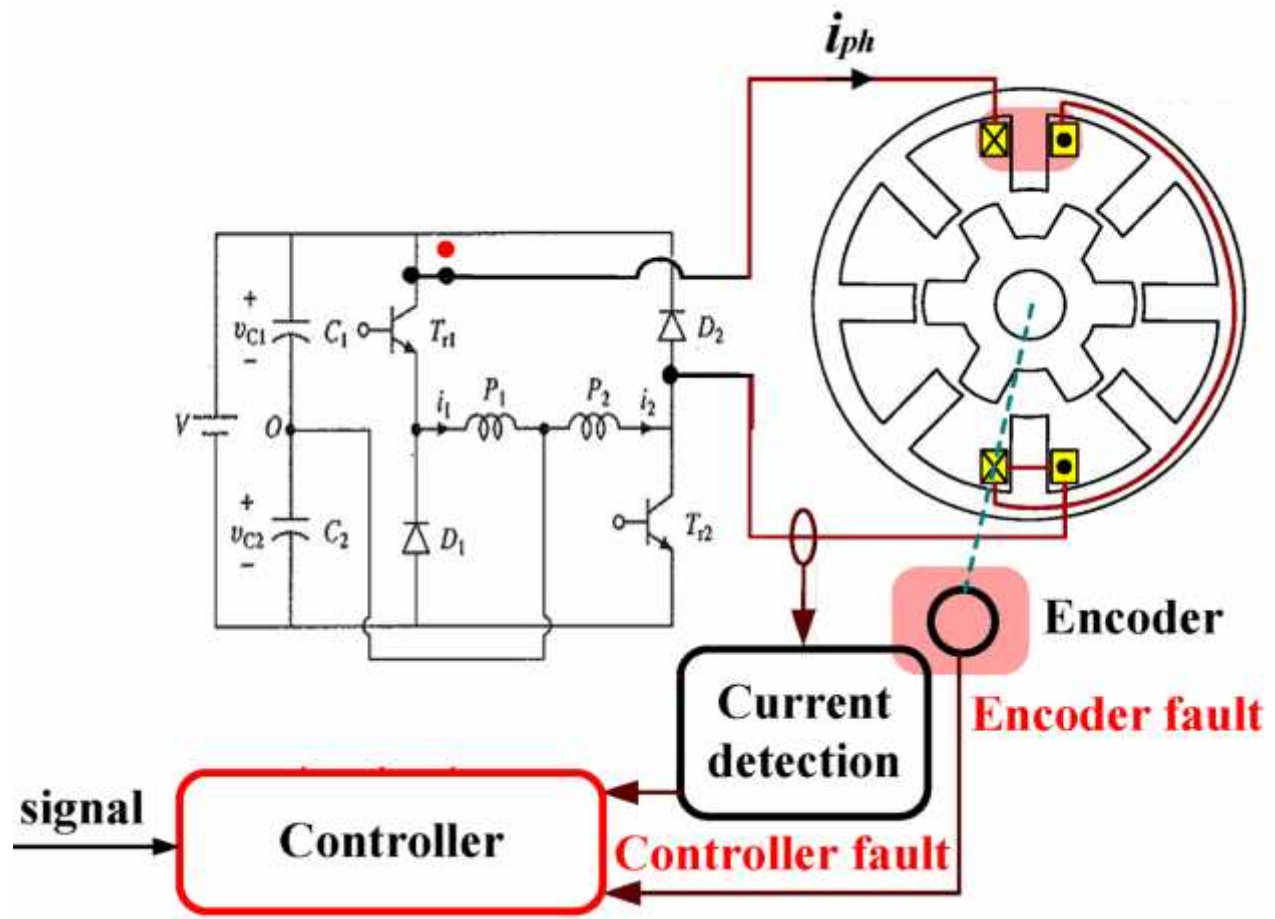
1. Sim Power System
2. MATLAB

THEORY:

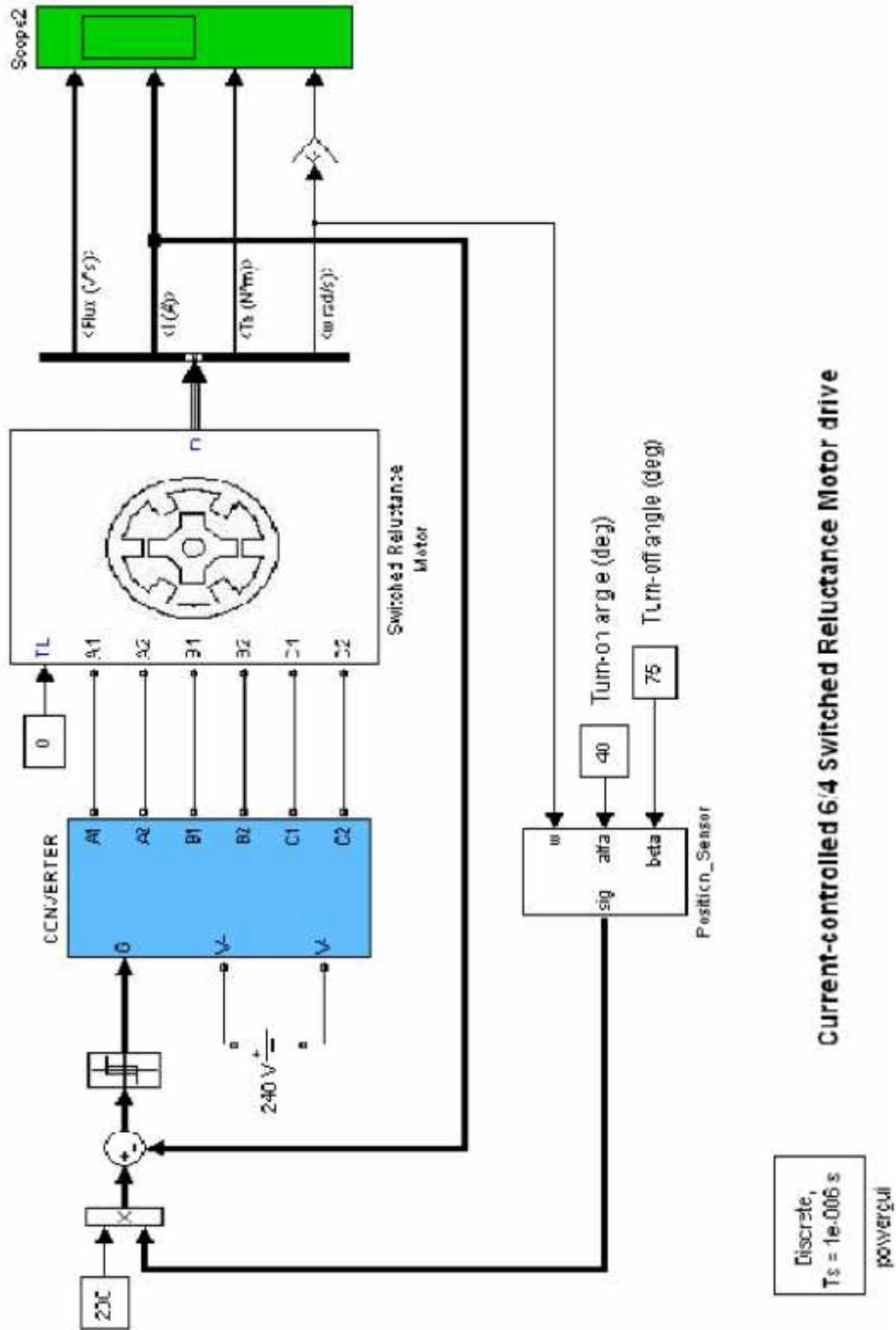
The switched or variable reluctance motor (SRM) is a synchronous machine. It has wound field coils as in a DC motor for the stator windings. The rotor however has no magnets or coils attached. Motion is produced as a result of the variable reluctance in the air gap between the rotor and the stator. When a stator winding is energized, producing a single magnetic field, reluctance torque is produced by the tendency of the rotor to move to its minimum reluctance position. This phenomenon is analogous to the force that attracts iron or steel to permanent magnets. In those cases, reluctance is minimized when the magnet and metal come into physical contact. In order to achieve a full rotation of the motor, the windings must be energized in the correct sequence.

BLOCK DIAGRAM

The SRM is fed by a three-phase asymmetrical power converter having three legs, each of which consists of two IGBTs and two free-wheeling diodes. During conduction periods, the active IGBTs apply positive source voltage to the stator windings to drive positive currents into the phase windings. During free-wheeling periods, negative voltage is applied to the windings and the stored energy is returned to the power DC source through the diodes. The fall time of the currents in motor windings can be thus reduced. By using a position sensor attached to the rotor, the turn-on and turn-off angles of the motor phases can be accurately imposed. These switching angle can be used to control the developed torque waveforms. The phase currents are independently controlled by three hysteresis controllers which generate the IGBTs drive signals by comparing the measured currents with the references. The IGBTs switching frequency is mainly determined by the hysteresis band.

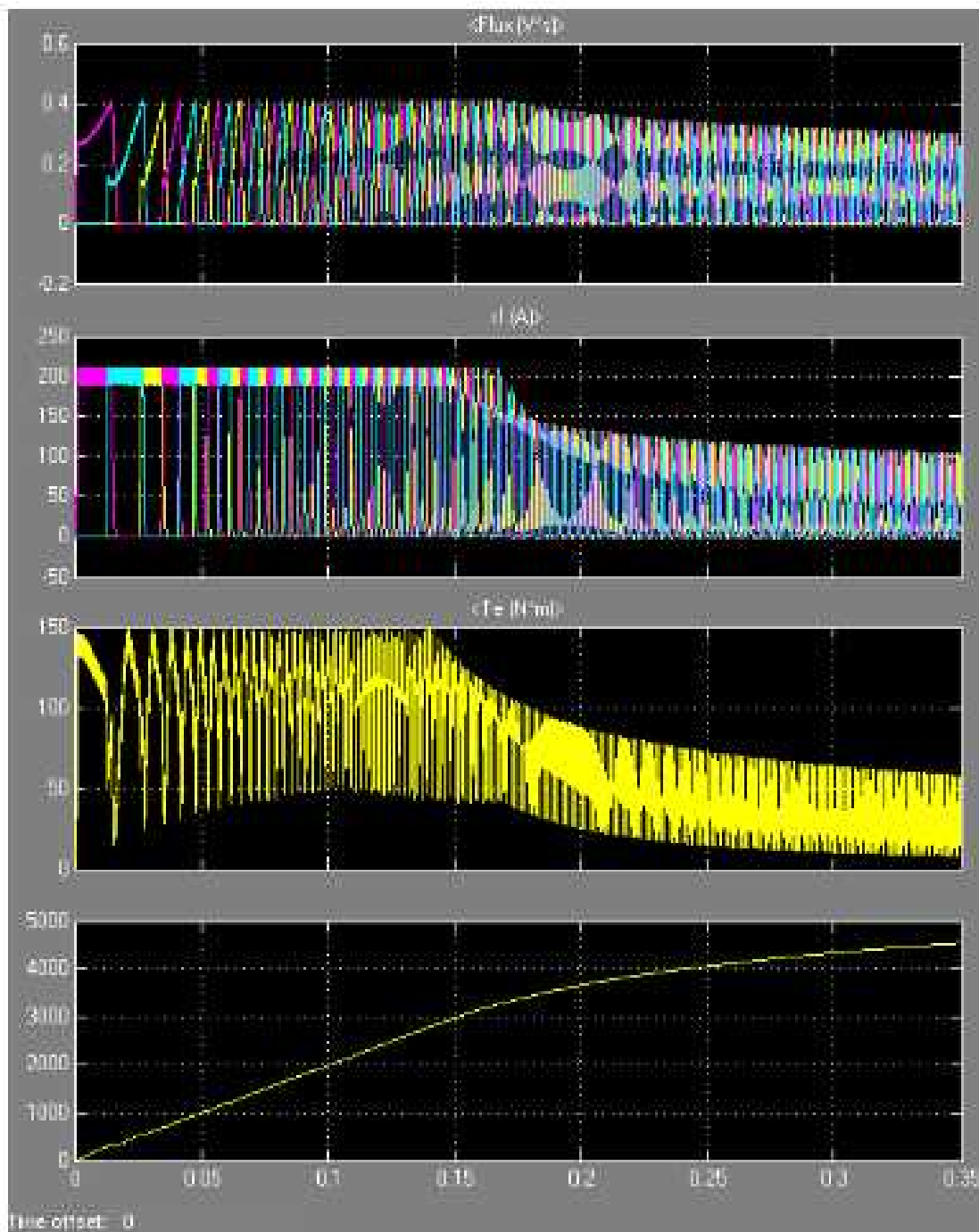


SIMULINK DIAGRAM



Current-controlled 6/4 Switched Reluctance Motor drive

OUTPUT WAVEFORMS:



Output of the SRM

PROCEDURE:

1. A model is created by using the component available in the simulink browser
2. Connect 240V DC supply to Converter.
3. Give step reference to the regulator input.
4. Verify all the model parameters values & re-enter for the various firing angle for the required rating of the parameter block.
5. Then run the program by clicking the arrow in the top box (Or) Go to the simulink parameter and click the start.
6. Double click the scope to see the output waveform.
7. Then output is printed for result analysis.

RESULT:

Thus, the output characteristics of Switched Reluctance Motor (SRM) using MATLAB Simulink was simulated.

EX.NO.03

DATE:

SIMULATION OF STEPPER MOTOR

AIM:

To simulate the performance characteristics of Stepper Motor using MATLAB Simulink.

SOFTWARE REQUIRED:

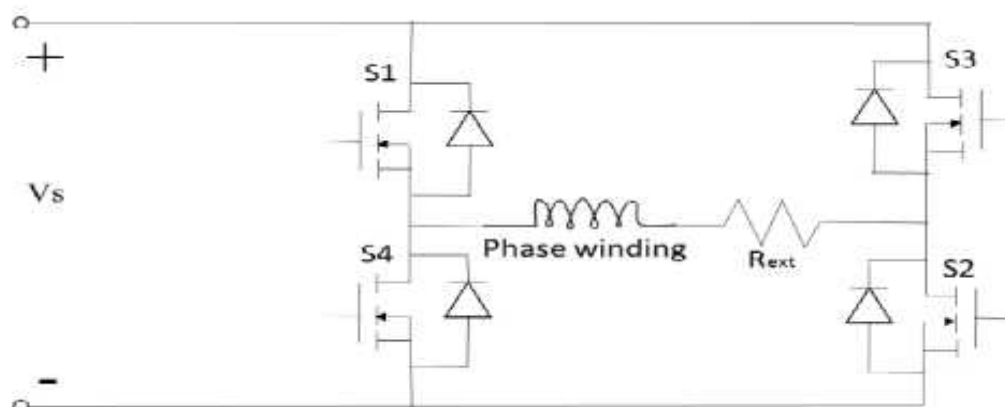
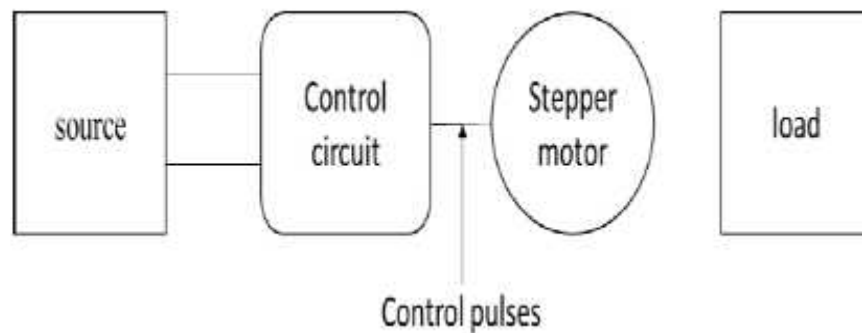
1. Sim Power System
2. MATLAB

THEORY:

The stepper motor has a wide popularity in the digitally control system means with changing the input pulses the position of the rotor can be controlled. Stepper motor widely used in numerical control of machine tools, tape drives, floppy disk drives, printers, robotics, X-Y plotters, textile industry, integrated circuit fabrication, electric watches etc. Application of simulation packages has considerably improved electrical machines analysis replacing the expensive laboratory equipment and enabling performing of different experiments easy and with no cost.

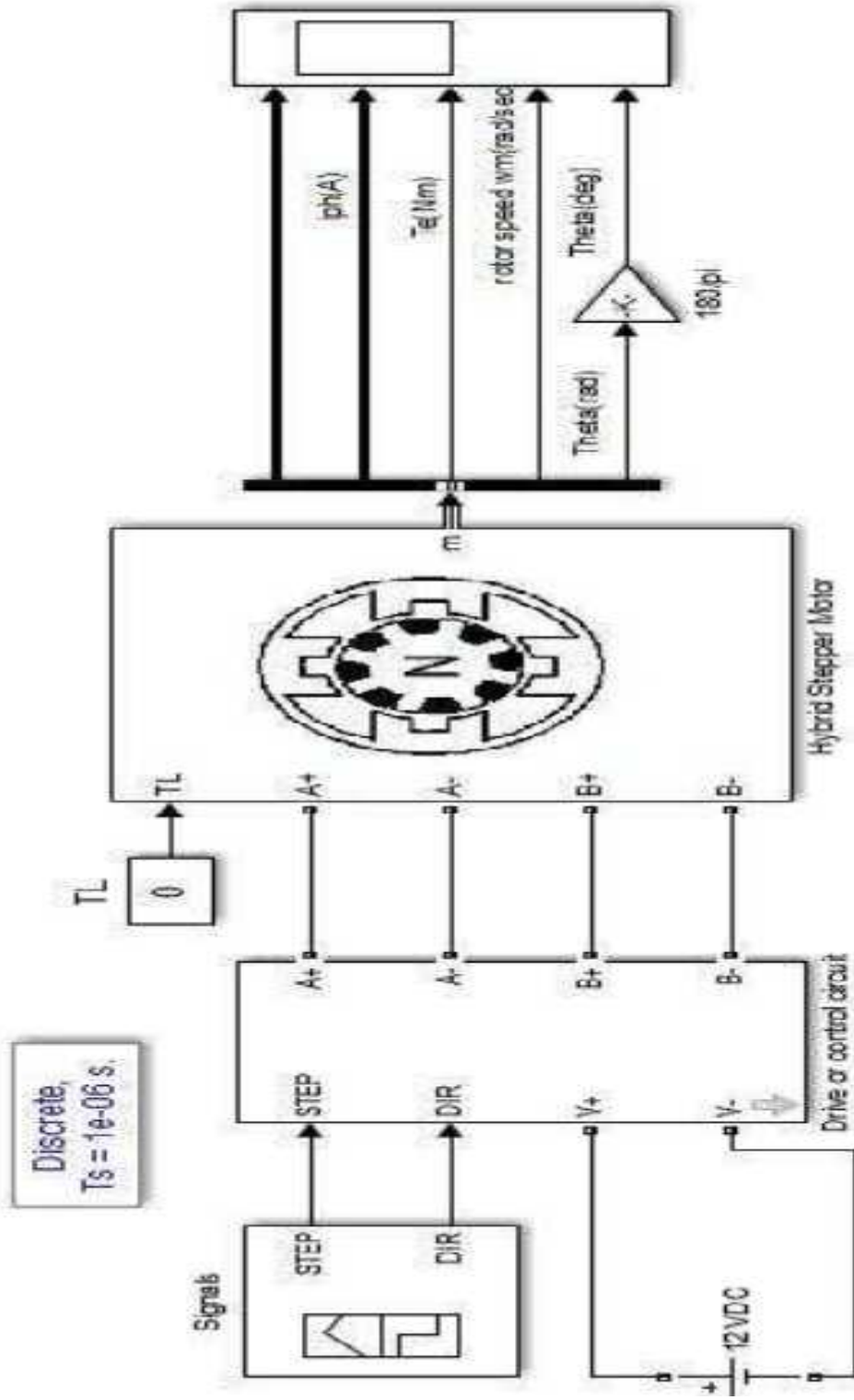
BLOCK DIAGRAM

The system we are using can be represented by following block diagram as shown in figure.1. It consists of dc supply batteries are rated of 12V, 24V, 48V and may be higher as per the requirement, control or drive circuit to control the pulses, stepper motor and load. Load will be the angular movement of an object or translational. Control circuit is consisting of semiconductor switches and hysteresis comparator to achieve the sequential energization and de-energization of the phase winding.

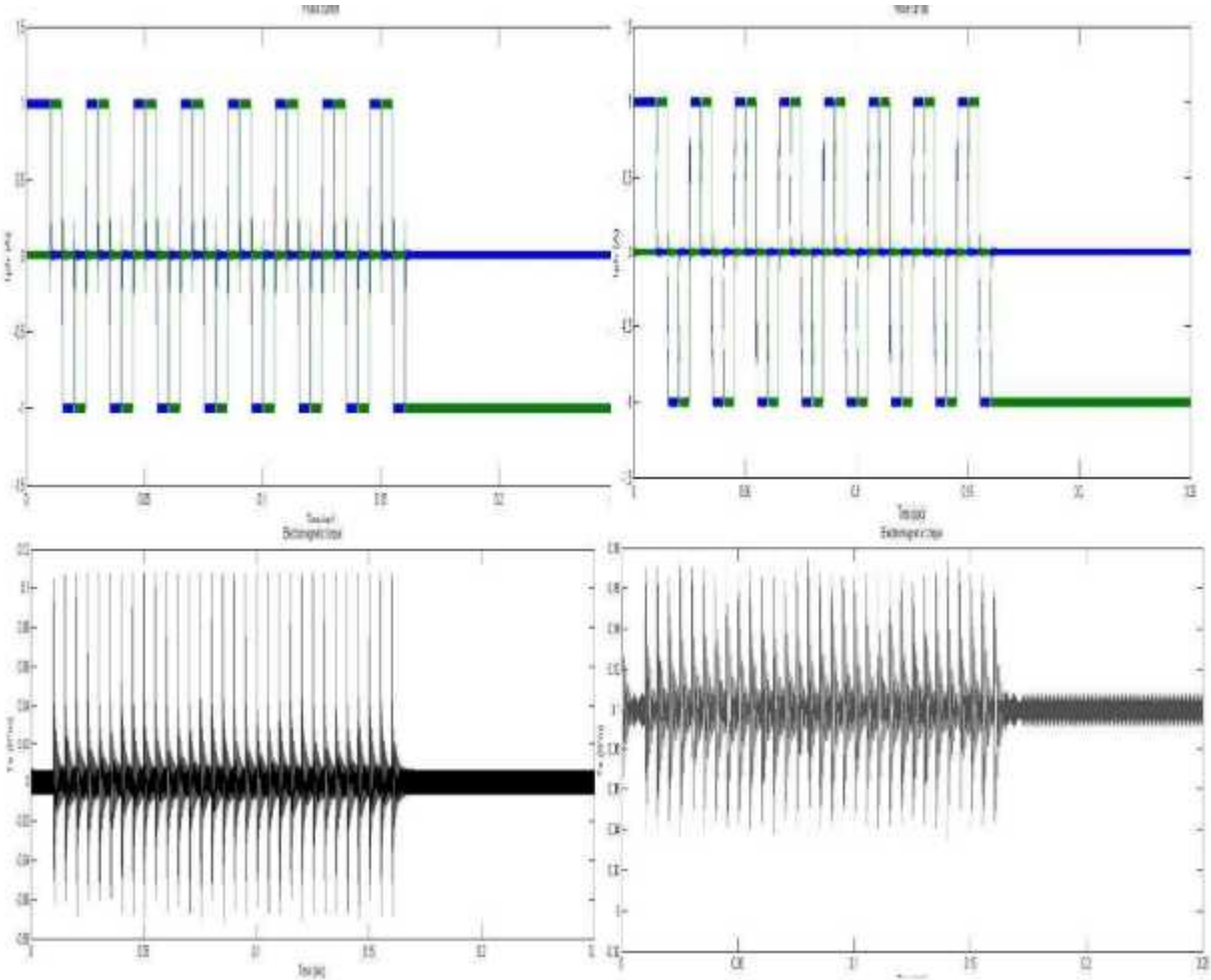


One phase of a Bi-polar drive circuit for hybrid stepper motor

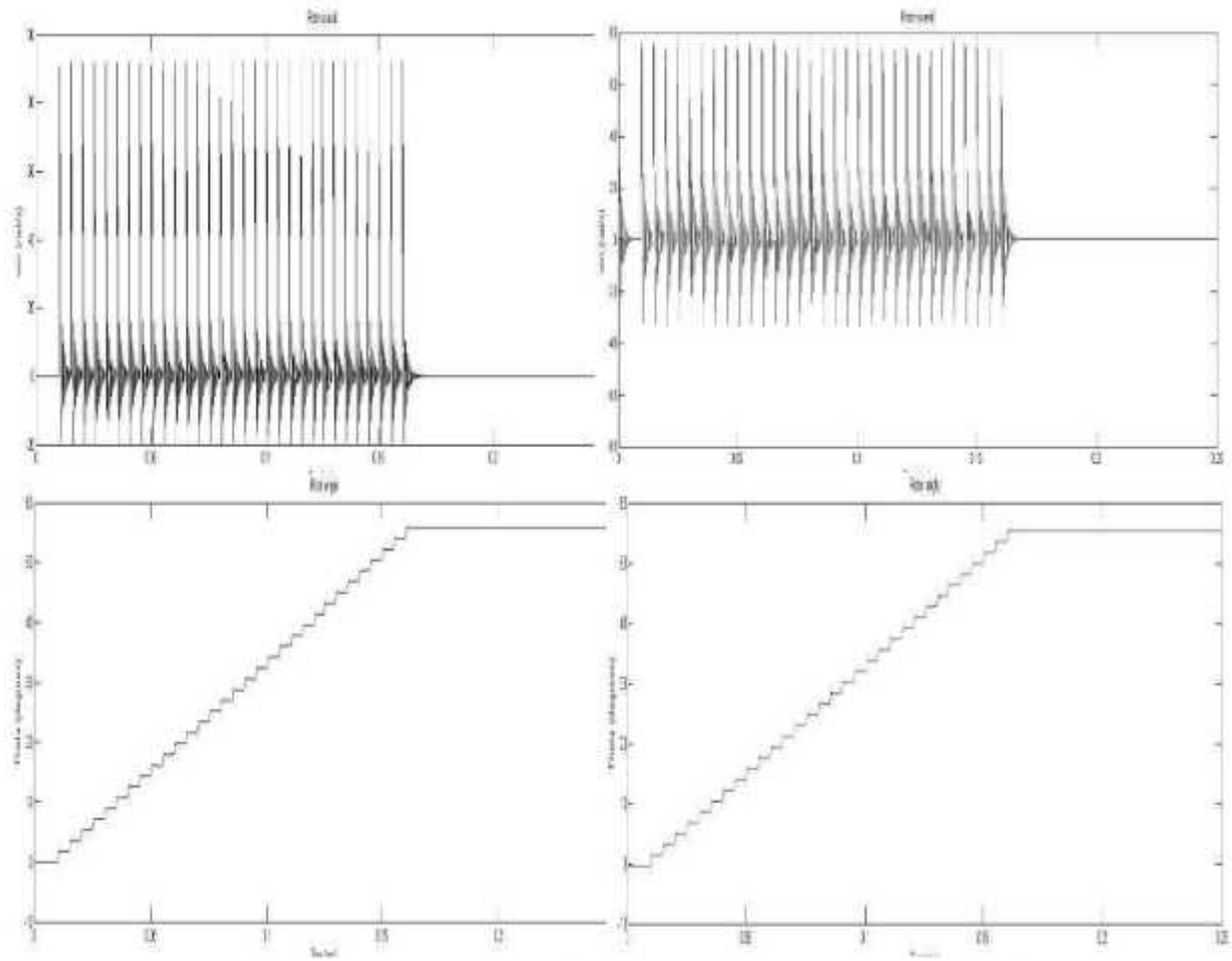
SIMULINK DIAGRAM



OUTPUT WAVEFORMS:



Motor transient performance at no-load



Motor transient performance for load 0.1 N-m

PROCEDURE:

1. A model is created by using the component available in the simulink browser.
2. Connect 12V DC supply to Drive circuit.
3. Give a step input signal for a period of 1ms.
4. Verify all the model parameters values & re-enter for the various firing angle for the required rating of the parameter block.
5. Then run the program by clicking the arrow in the top box (or) Go to the simulink parameter and click the start.
6. Simulate the circuit to measure voltage and current under no load condition.
7. Simulate the same circuit for a step load of 0.1 N-m.
8. Double click the scope to see the output waveform.
9. Then output is printed for result analysis.

RESULT:

Thus, the performance characteristics of Stepper Motor using MATLAB Simulink was simulated.

EX.NO.04

DATE:

SIMULATION OF PERMANENT MAGNET SYNCHRONOUS MOTOR

AIM:

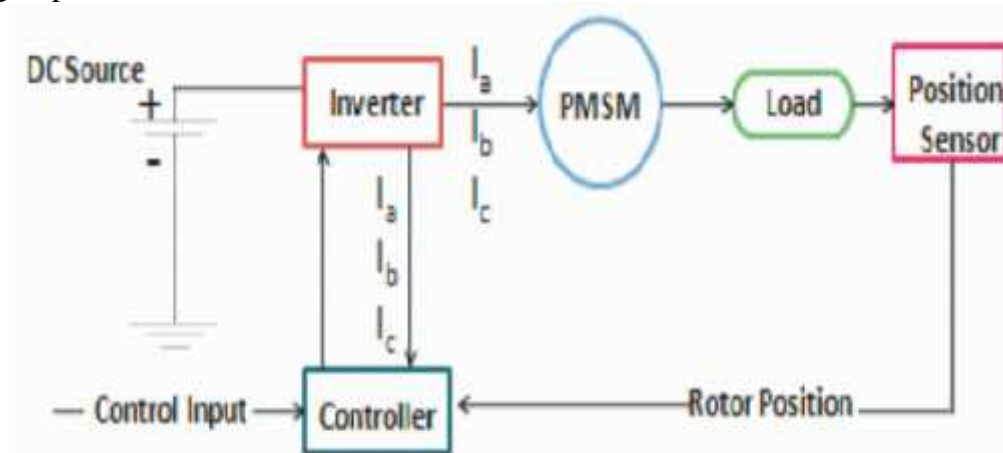
To simulate the dynamic characteristics of Permanent Magnet Synchronous Motor using MATLAB Simulink.

SOFTWARE REQUIRED:

1. Sim Power System
2. MATLAB

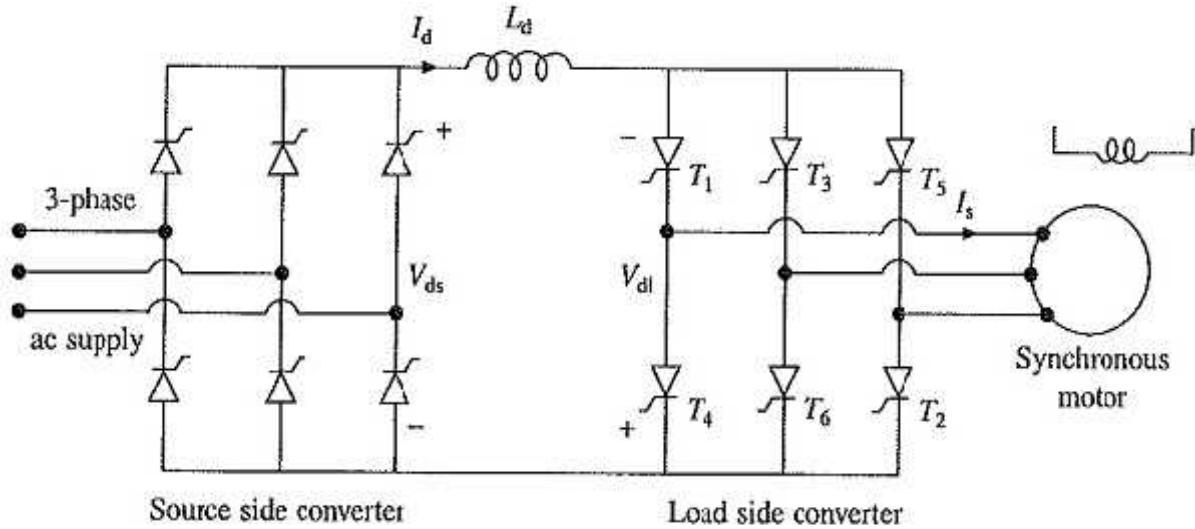
THEORY:

PMSM is high-performance different speed motors for many automated applications. Basic advantages of using a PM synchronous motor (PMSM) drive includes high reliability, less maintenance, high efficiency. The PMSM motors are generally chosen in the high-performance drives, where the specific performances justify the costs, higher than other motors with the same torque but realized with a different technology. PMSM are used in highly reliable direct-drive applications mainly due to their advantages. Compared to stranded DC motors, they have no brushes or mechanical commutators, which eliminate the issues due to mechanical wear of the moving parts. In addition, the better heat dissipation characteristic and ability to operate at high speed make them a better option. Figure 1 shows PM Synchronous Motor Drive system. It consists of the stationary member of the machine called stator. Stator laminations for axial air gap machines are frequently formed by winding sustained strips of soft steel. Varied parts of the laminations are the teeth slots whichever carry the armature windings. Yoke finishes the magnetic path. Armature windings are a commonly duplex layer (two coil side per slot) and lap wound. Individual coils are connected successively to form phasor groups.



MATLAB/SIMULINK includes a graphical editor for constructing models as simulink block diagrams, the editor allow to draw the models. Simulink also includes a substantial library of the sink, source, basic linear and nonlinear elements, and connector blocks. If the given blocks do not meet your needs, you can also design your own blocks. The interactive environment simplifies the modelling process, eliminating the need to formulate differential and difference equations in a language or program. Models are pecking order, so you can build models using both top-down and bottom-up access. You can point of view the system at a high level, and then drill down to see increasing levels of model detail.

CIRCUIT DIAGRAM



Self-Controlled Synchronous Motor Drive employing a load commutated thyristor inverter is shown in Fig. 7.10. In large power drives wound field synchronous motor is used. Medium power drives also employ permanent magnet synchronous motor. The drive employs two converters, which are termed here as source side converter and load side converter. The source side converter is a 6-pulse line-commutated thyristor converter. For a firing angle range $0 \leq \alpha < 90^\circ$, it works as a line-commutated fully controlled rectifier delivering positive V_{ds} and positive I_d , and for the range of firing angle $90^\circ \leq \alpha < 180^\circ$ it works as a line-commutated inverter delivering negative V_{ds} and positive I_d .

When Self Controlled Synchronous Motor Drive operates at a leading power factor, thyristors of the load side converter can be commutated by the motor induced voltages in the same way, as thyristors of a line-commutated converter are commutated by line voltages. Commutation of thyristors by induced voltages of load (here load is a motor) is known as load commutation. Firing angle is measured by comparison of induced voltages in the same way as by the comparison of line voltages in a line commutated converter. Converter operates as an inverter producing negative V_{dl} and carrying positive I_d for $90^\circ \leq \alpha < 180^\circ$. For $0 \leq \alpha < 90^\circ$ it works as a rectifier giving positive V_{dl} . For $0 \leq \alpha < 90^\circ$, $90^\circ \leq \alpha < 180^\circ$ and with $V_{ds} > V_{dl}$, the source side converter works as a rectifier and load side converter as an inverter, causing power to flow from ac source to the motor, thus giving motoring operation.

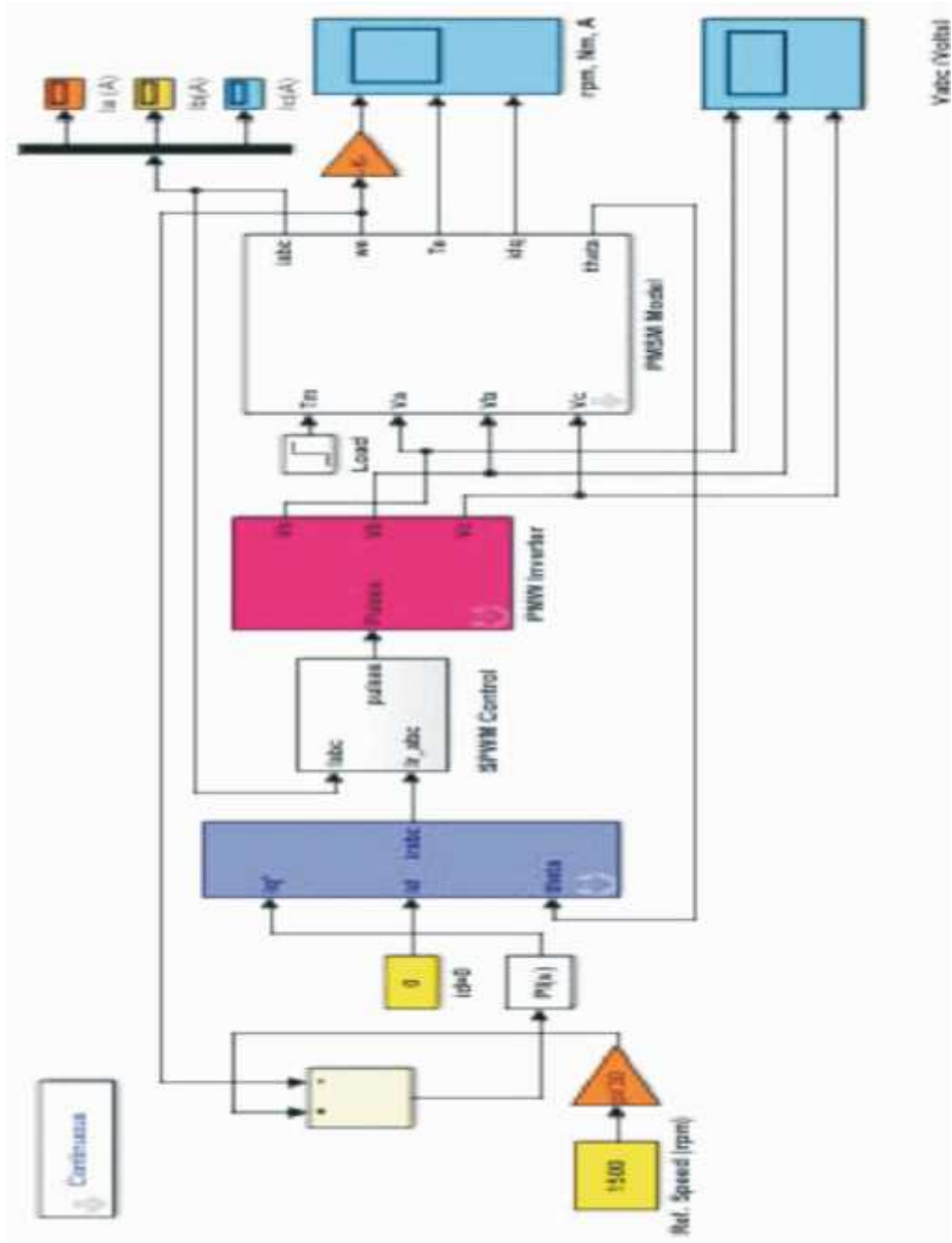
When firing angles are changed such that $90^\circ \leq \alpha < 180^\circ$ and $0 \leq \alpha < 90^\circ$, the load side converter operates as a rectifier and the source side as an inverter. Consequently, the power flow reverses and machine operates in regenerative braking. The magnitude of torque depends on $(V_{ds} - V_{dl})$. Speed can be changed by control of line side converter firing angles.

When working as an inverter, the firing angle has to be less than 180° to take care of commutation overlap and turn-off of thyristors. It is common to define a commutation lead angle for load side converter as

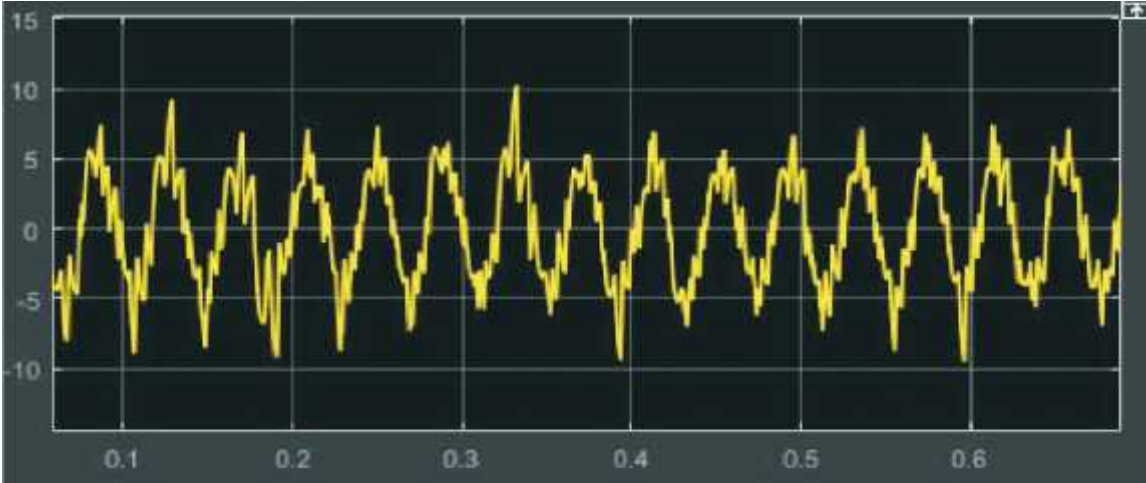
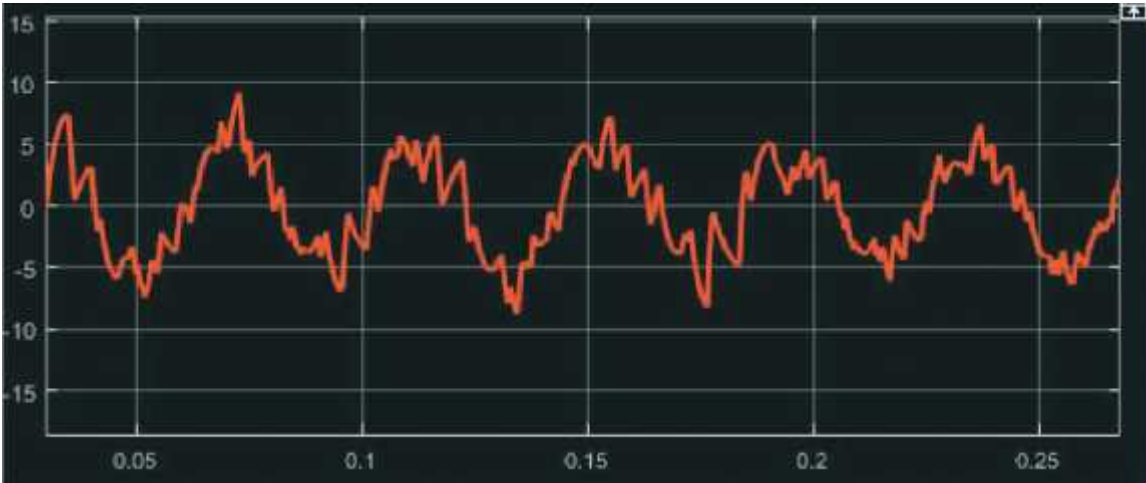
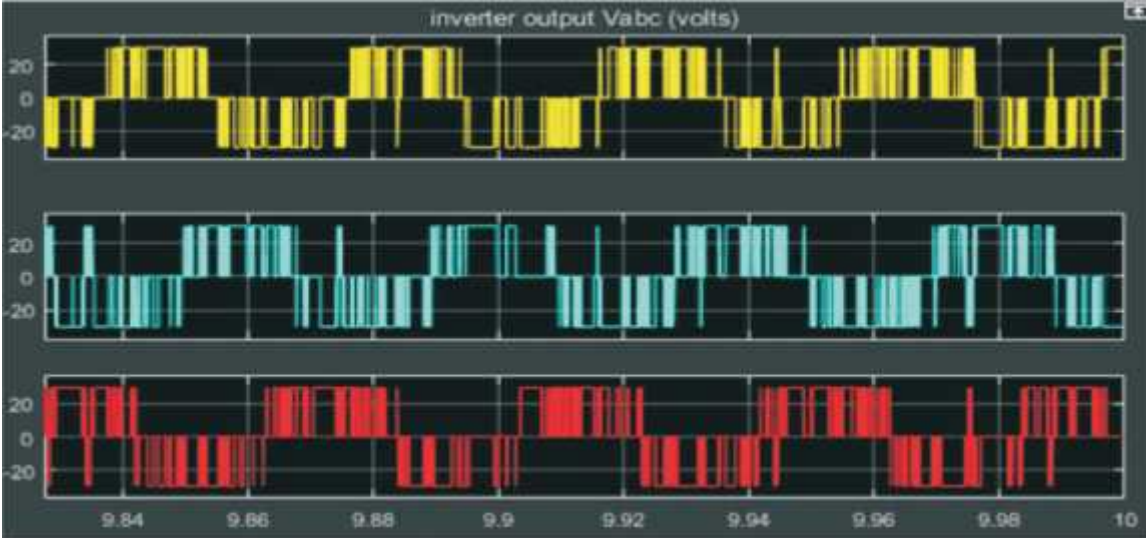
$$\beta_1 = 180^\circ - \alpha_1$$

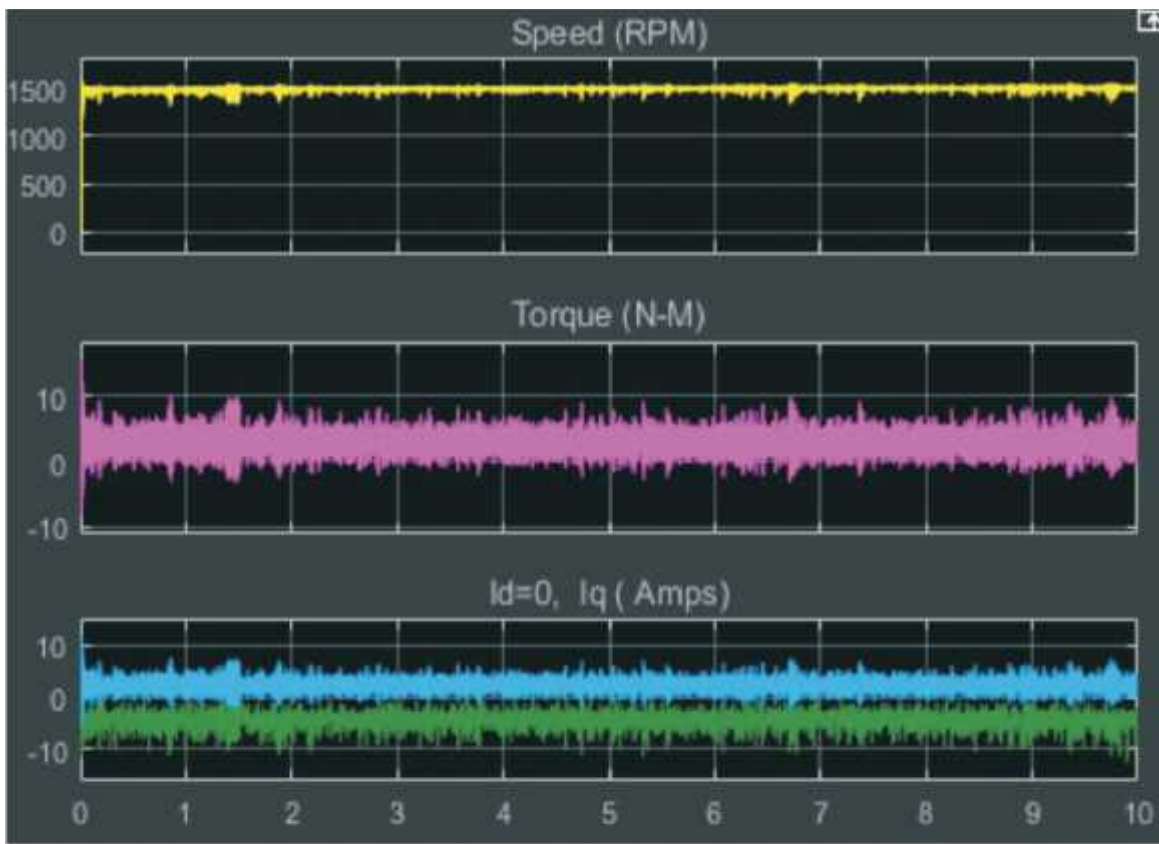
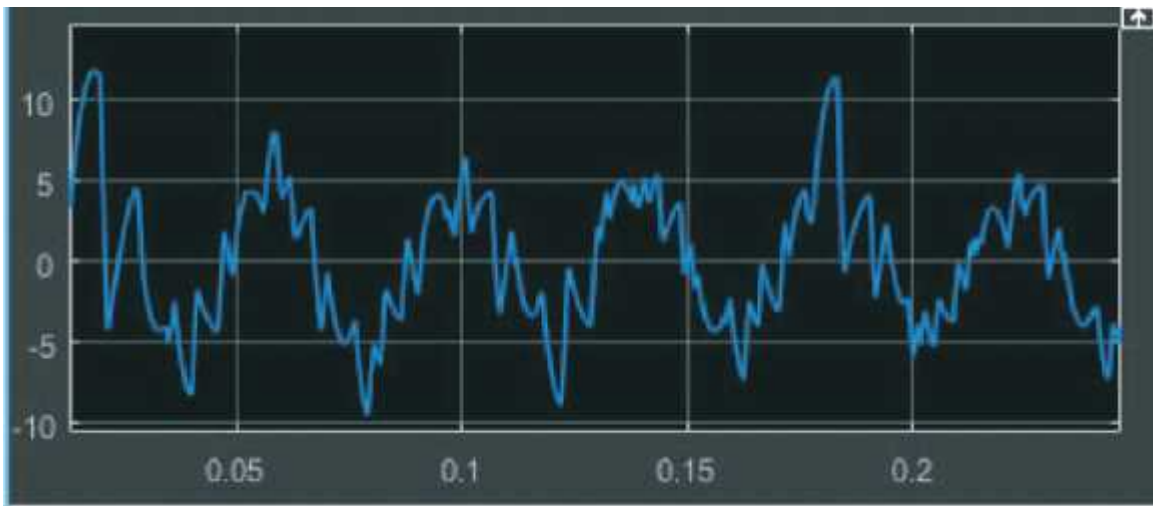
If commutation overlap is ignored, the input ac current of the converter will lag behind input ac voltage by angle α . Since motor input current has an opposite phase to converter input current, the motor current will lead its terminal voltage by an angle α . Therefore, the motor operates at a leading power factor.

SIMULINK DIAGRAM



OUTPUT WAVEFORMS:





Ready

Offset=0 T=10.000

PROCEDURE:

1. A model is created by using the component available in the simulink browser
2. Go to the voltage measurements block & set the magnitude as 100 V and frequency as 50 Hz
3. Next go to the thyristor gate of pulse generator block and set the firing angle as 15°, 90°, etc.
4. Then go to the load block and enter the value as for stator current, rotor current & angular speed and electromagnetic torque
5. Verify all the model parameters values & re-enter for the various firing angle for the required rating of the parameter block.
6. Then run the program by clicking the arrow in the top box (Or) Go to the simulink parameter and click the start.
7. Double click the scope to see the output waveform.
8. Then output is printed for result analysis.

RESULT:

Thus, the dynamic characteristics of Permanent Magnet Synchronous Motor using MATLAB Simulink was simulated.