SENSOR LESS BLDC MOTOR CONTROL USING CSC CONVERTOR UNDER VARIABLE VOLTAGE CONDITION

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ABSTRACT: *A power factor correction (PFC) based canonical switching cell (CSC) converter fed brushless DC motor (BLDCM) drive has been proposed. A variable voltage of DC bus has been used for controlling the speed of BLDCM which eventually has given the freedom to operate VSI in low frequency switching mode for reduced switching losses. A front-end CSC converter operating in DICM has been used for dual objectives of DC link voltage control and achieving a unity power factor at AC mains.The BLDCM is electronically commutated for reduced switching losses in VSI due to low frequency switching. By using Matlab/Simulink results, the performance of the proposed drive has been found quite well for its operation at variation of speed over a wide range.*

Keywords*: BLDC , canonical switching cell , voltage source inverter*

INTRODUCTION :

The permanent magnet brushless dc (BLDC) motor is gaining popularity being used in computer, aerospace, military, automotive, industrial and household products because of its high torque, compactness, and high efficiency. The BLDC motor is inherently electronically controlled and requires rotor position information for proper commutations of current.The brushless DC (BLDC) motor has been used in many applications such as computer, automatic office machine, robots for automation , drives of many electronics and miniature machine. The BLDC motor has advantages of the DC motor such as simple control, high torque, high efficiency and compactness. Also, brush maintenance is no longer required, and many problems resulting from mechanical wear of brushes and commutators are improved by changing the position of rotor and stator in DC motor.To alternate the function of brushes and commutator, the BLDC motor requires an inverter and a position sensor that detects rotor position for proper commutation of current.

Some of the common Power Factor Correction Converter topologies are :

Boost Converter Fly Back PFC Forward Converter

Half Bridge Converter Buck- Boost Converter Zeta Converter

SEPIC Converter Cuk Converter

LITERATURE SURVEY:

A single-stage sensor less control of a deep bore well submersible ferrite PM BLDC motor drive is presented(1). Bore well pumps have poor ambience and thus hall effect sensor based control is not reliable in these environments. Further, the PV based water pumps are usually installed in remote rural areas where reliability is a critical factor. A position sensor less control scheme is implemented to eliminate the use of hall-sensors. They are unreliable, pollute the environment and require frequent maintenance .

DC motors require frequent maintenance due to the wear and tear of the brushes and are also inefficient. Induction motor based submersible water pumping systems are reliable due to their ruggedness and low maintenance (2)-(3).

A single stage solar powered speed sensorless vector controlled induction motor drive for water pumping system(4) which is superior to conventional motor drive in terms of reliability and cost. The speed is estimated through estimated stator flux. The proposed system includes solar PV array, a three-phase voltage source inverter and a motor- pump assembly. An incremental and conductance , MPPT algorithm is used to harness maximum power from SPV array. The smooth starting of the motor is attained by vector control of an induction motor.

The dynamic behavior of the brushless direct current motor is analyzed in terms of the parameters such as the speed, current, back electromotive force and torque. For controlling the speed of the brushless direct current motor is utilized the fractional-order proportional–integral–derivative controller for generating the optimal control pulses. With the use of fractional-order proportional– integral–derivative controller, the optimal gain parameters are needed to reduce the torque ripples and control the speed of brushless direct current motor.The proposed strategy(5) is simple in structure and robust to reduce the complexities of the mathematical computations.

In a permanent-magnet (PM) brushless DC motor(6), the waveform of back electromotive force (EMF) is related to the rotor position; hence, the back EMF can be used for position sensorless control. However, in practical implementation, the terminal voltage or phase voltage is used instead, as the back EMF is difficult to be sensed directly.The calculations and analyses on the detection error and the motor commutation angle, and presents an error compensation circuit to ensure proper commutation.

The current sensors of BLDC motor and the voltage sensor at the DC bus of voltage- source inverter (VSI) are eliminated completely. Instead, the speed is controlled by adjusting the DC bus voltage of VSI. The fundamental frequency switching pulses are generated to operate the VSI in order to minimise the switching losses and to enhance the efficiency of proposed system. A DC–DC Cuk converter (7)is utilised to operate the SPV array at its maximum power. The starting current of BLDC motor is bounded by an optimal initialisation and selection of the control parameters, perturbation size and frequency while tracking the peak power of SPV array. The performance of proposed BLDC motor drive is thoroughly evaluated and its potential is demonstrated under realistic operating conditions.

An integrated solution for a photovoltaic (PV)-fed water-pump drive system(8), which uses an open-end winding induction motor (OEWIM). The dual-inverter-fed OEWIM drive achieves the functionality of a three-level inverter and requires low value dc-bus voltage. The proposed control strategy achieves an integration of both maximum power point tracking and V/f control for the efficient utilization of the PV panels and the motor. The proposed control scheme requires the sensing of PV voltage and current

The three-level dual-inverter requires a low PV bus voltage compared with its conventional three-level counterpart. he zero- sequence current is avoided by the SAZE PWM algorithm. Thus, the integrated control algorithm improves the overall performance of the system(9). Furthermore, this also presents the details of system design and analysis of its dynamic behavior during transient environmental conditions.

The position sensorless BLDC drive proposed(10), is based on detection of back electromotive force (back EMF) zero crossing from the terminal voltages. Only three motor terminal voltages need to be measured thus eliminating the need for motor neutral voltage. While starting relies on triggering devices at the zero crossings detected using the proposed algorithm, continuous running is achieved by realizing the correct commutation instants 30◦ delay from the zero crossings.

The neutral point will not be stable during pulse width modulation (PWM) switching(11). Low pass filters have been used to eliminate the higher harmonics and to convert the terminal voltages into triangular waveform signals. Delay is introduced in the sensed signal due to heavy filtering, which also varies with the operating speed. Therefore, this method is well suited only for a narrow speed range

Detecting the free-wheeling diode conduction in the open phase gives the zero- crossing point of the back EMF waveform(12) . This approach of rotor-position sensing works over a wide speed range, especially at lower speed. The main drawback of this scheme is the requirement of six additional power supplies for the comparator circuits to detect current flowing through the free-wheeling diode.

SEPIC converter based control providing output gain stability unbounded region of MPPT, simple gate drive circuit, non-inverting polarity of output voltage with split power supply is presented(13). This eliminates complexity and slows down response of the system. This system cannot be widely used in view of its cost, efficiency and number of energy storage components.

A single switch topology is presented(14). It allows the improved tracking of PV array MPP regardless of temperature, irradiance and the connected load. However, it requires a ripple filter at the input to limit the ripple current and voltage.

A Z-source inverter(15) is used instead of two-stage power conversion thus reducing the switch count. A hysteresis current control loop is used for variable speed operation of the BLDC motor dictated from the available maximum PV power. However, the phase currents of the motor and dc-link capacitor voltage are still to be sensed.

EXISTING SYSTEM

Many topologies of a PFC based BLDCM drives have been developed. A boost PFC converter has been the most popular configuration for feeding BLDCM drive. A constant DC link voltage is maintained at the DC link capacitor and a PWM based VSI is used for the speed control. Hence, the switching losses in VSI are very high due to high switching PWM signals and require huge amount of sensing for its operation. These switching losses are reduced by using a concept of variable DC link voltage for speed control of BLDC motor which has presented in this project.

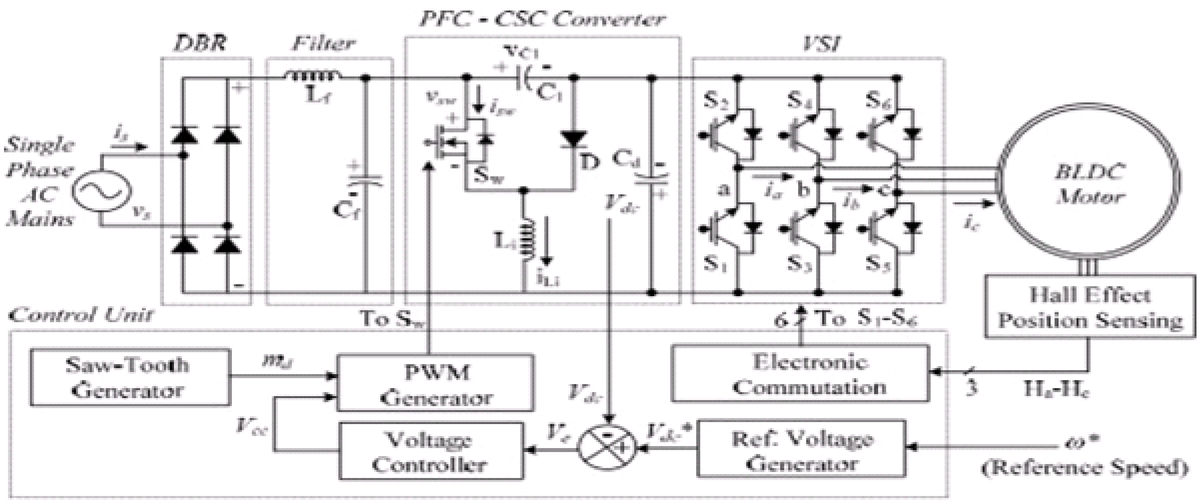
LIMITATIONS:

high starting torque is not achieved. Sensor Cost is high

Complexity of the system Low reliability **PROPOSED SYSTEM**

The proposed BLDCM drive with a front end PFC based Z source (CSC) converter. A CSC converter operating in DICM acts as an inherent power factor pre-regulator for attaining a unity power factor at AC mains. A variable DC bus voltage of the VSI is used for controlling the speed of the BLDCM. The brushless dc (BLDC) motor is receiving much interest in automotive applications on due to its high efficiency, compact size, and lower maintenance when compared to a brush dc motor .The open-loop start-up method named „align and go". The procedure is to excite two phases of the three-phase windings for a preset time. The permanent magnet rotor will then rotate to align to a specific position. With a known initial rotor position and a given commutation logic, an open-loop control scheme is then applied to accelerate the motor from a standstill .Although this technique can be applied to certain automotive applications. Hysteresis comparator of terminal voltage and a potential start-up method with a high starting torque.

BLOCK DIAGRAM OF PROPOSED SYSTEM



PROPOSED SYSTEM DESCRIPTION:

The proposed PFC based CSC Converter operates in DICM. In DICM, the current in inductor Li becomes discontinuous in a switching period (Ts).

1. The performance of the proposed drive has been found quite well for its operation at variation of speed over a wide range.

2. A front-end CSC converter operating in discontinuous inductor current mode (DICM) is used for DC bus voltage control with unity power factor at AC mains.

3. A single sensor for DC bus voltage sensing is used for the development of proposed drive which makes it a cost effective solution.

Among low power servo applications, classical DC motors are very popular because they are reasonably cheap and easy to control. The main disadvantage is the mechanical collector, which has only a limited life period. Also, brush sparking can destroy the rotor coil, generate EMC problems. For a Brushless DC motor, an electronic inverter avoiding mechanical collector does the commutation of the coils. Therefore, BLDC motor is more reliable and as the price of power electronic devices is still decreasing, the brushless dc motor replaces more and more the conventional dc motor.

MODES OF OPERATION:

- Mode I: Figure 3(a)shows the operation of Mode I operation of CSC converter. The switch Sw is turned ON, the energy from the supply and stored energy in the intermediate capacitor C1 are transferred to inductor Li . In this process, the voltage across the intermediate capacitor Vc1 reduces, while inductor current iLi and dc-link voltage Vdc are increased. The designed value of intermediate capacitor is large enough to hold enough energy such that the voltage across it does not become discontinuous.

- Mode II: The switch is turned OFF in this mode of operation. The intermediate capacitor C1 is charged through the supply current while inductor Li starts discharging, hence voltage Vc1 starts increasing, while current iLi decreases in this mode of operation. Figure3(b) shows the operation of Mode II operation of CSC converter. Moreover, the voltage across the dc-link capacitor Vdc continues to increase due to discharging of inductor Li .

- Mode III: This is the discontinuous conduction mode of operation as inductor Li is completely discharged and current iLi becomes zero. Figure 3(c) shows the operation of Mode III operation of CSC converter. The voltage across the intermediate capacitor C1 to increase, while dc-link capacitor supplies the required energy to the load, hence Vdc starts decreasing.

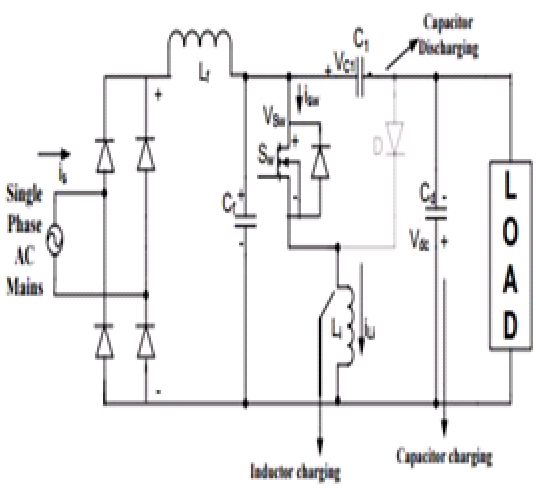


Fig. 3 (a) Mode I

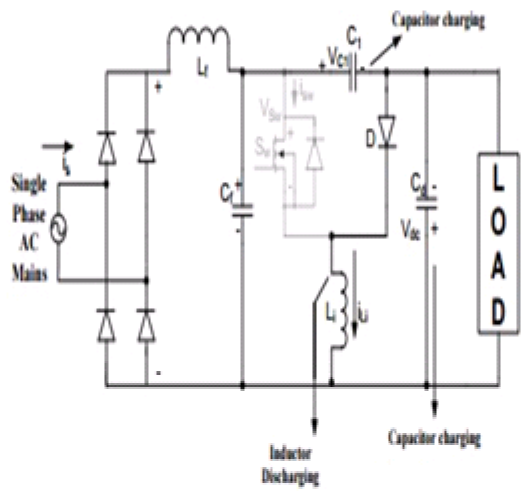


Fig. 3 (b) Mode II

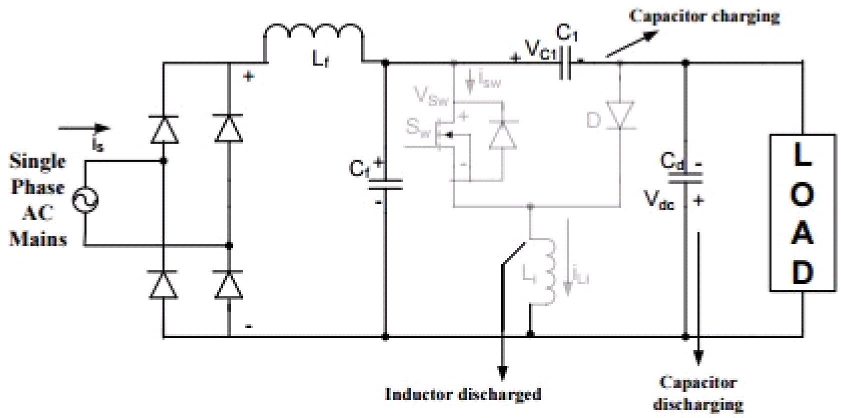
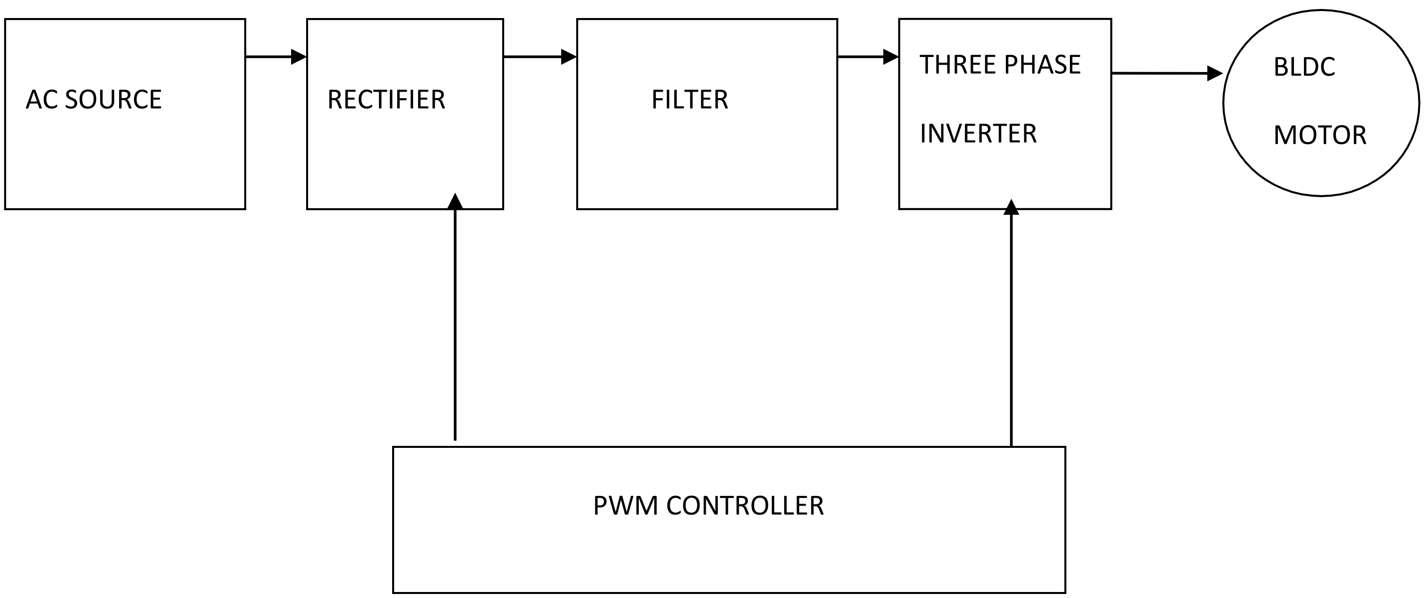


Fig. 3 (c) Mode III

HARDWARE DESCRIPTION



RECTIFIER AND FILTER

A rectifier changes alternating current into direct current. This process is called rectification. The three main types of rectifier are the halfwave, fullwave, and bridge. A rectifier is the opposite of an inverter, which changes direct current into alternating current.

VOLTAGE SOURCE INVERTERS

Traditional inverters are voltage source inverter and current source inverter. Voltage source inverter is the one which the dc source has small or negligible impendance. In other words a voltage source inverter has stiff dc source voltage at its input terminals.

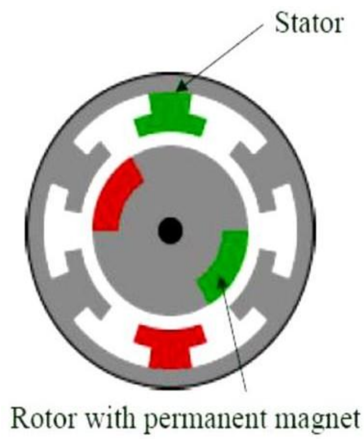
INVERTERS

They two types of inverters,

- **Voltage source inverters**
- **Current- source inverters**

BLDC MOTOR

Brushless dc motors use an electronic control to sequentially energize the stator poles. The motor consists of permanent magnet rotor and the distributed stator windings are wound such that electromotive force is trapezoidal. Permanent magnet motors are usually small because of permanent magnet rotor. Brushless dc motors provide less maintenance, longer life, lower EMI and quieter operation than wound rotor DC motor due to elimination of brushes. They have better speed torque characteristics and inertia, which improves their dynamic performance when compared to a dc motor.



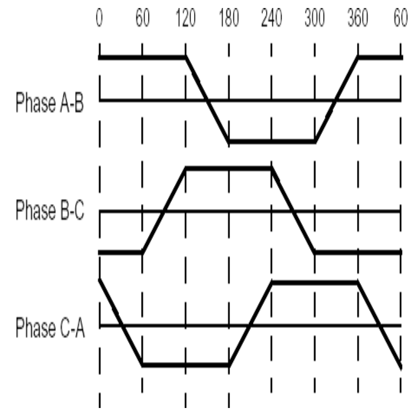
Cross sectional view of a BLDC motor

RESULT AND DISCUSSION

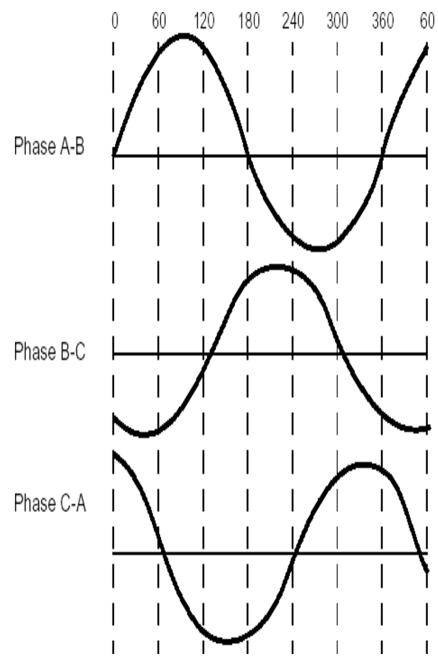
The stator of a BLDC motor consists of stacked steel laminations with windings placed in the slots that are axially cut along the inner periphery traditionally, the stator resembles that of an induction motor; however, the windings are distributed in a different manner . Most BLDC motors have three stator windings connected in star fashion. 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. There are two types of stator windings variants: trapezoidal and sinusoidal motors. This differentiation is made on the basis of the interconnection of coils in the stator windings to give the different types of back Electromotive Force (EMF).

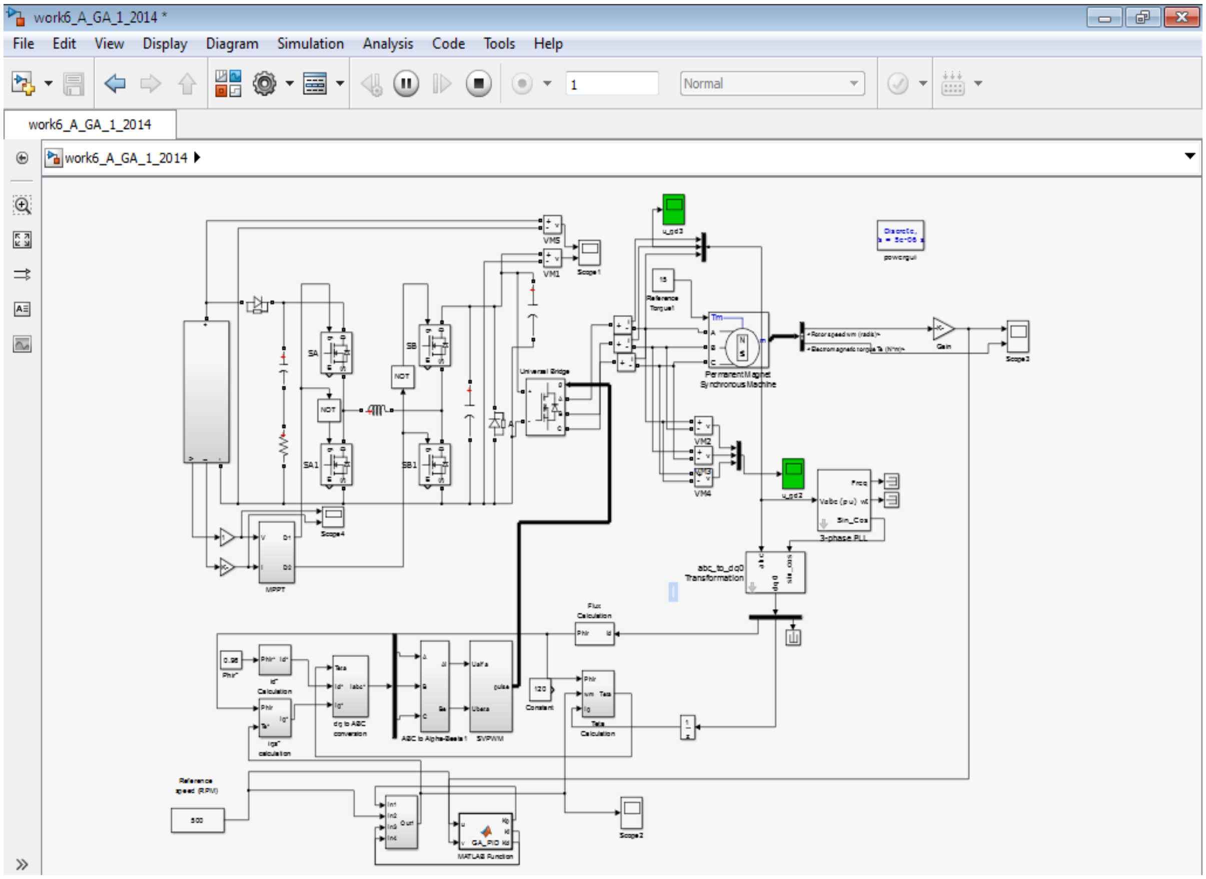
TRAPEZOIDAL BACK EMF



SINUSOIDAL BACK EMF



BLDC MOTOR CONTROL USING SIMULINK CIRCUIT



BLDC MOTOR CONTROL USING SIMULINK CIRCUIT

CONCLUSION

Matlab software is designed to provide a debugging, diagnostic and demonstration tool for the development of algorithms and applications in electric drives. The modeling and analysis of BLDC is done for Matlab. The simulation results of this paper has proposed the use of a commercially available software package to study the performance of BLDC motor. The MATLAB simulation provides good soft computing technique.The results of simulation model gives help in building hardware with expected results. The simulation saves time and manpower in making hardware models at initial stages and reduces the costing of the research work.This paper presents systematically a comparative study of a bridgeless PFC boost rectifier fed BLDC with VSI fed BLDC motor. With the bridgeless boost converter it is possible to save energy, to suppress harmonics current and to improve drive performance. Simulation results of VSI fed BLDC motor are compared with those of the bridgeless boost converter fed BLDC motor. It is found that THD can be reduced to 6.7% by using bridgeless PFC boost.

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