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Efficient Implementation Of PFC Based Hybrid Reverberation PWM To BLDC Drive

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ABSTRACT

A power factor correction (PFC) based Hybrid Resonance Pulse Width Modulation (HRPWM) fed brushless DC motor (BLDC) drive is proposed, analyzed and tested. In this regard, small signal and circuit analysis of HRPWM are calculated in resonance frequency, aboveand below resonance frequency.control method for regulating DC link voltage is also presented. The limitations are eliminated in this project by adding two auxiliary switches (one for buck operation and another one for boost operation) and two auxiliary diodes. In this project buck PFC converter performance is improved by implementing constant ON-time control which is utilized to force it to operate in critical conduction mode (CCM).

INTRODUCTION

In the modern society, electricity is the most popular secondary energy source. The application of motors has spread to all kinds of fields in national economy and our daily life as the main mechanic-electronic energy-conversion device for more than a century. In order to adapt to different practical applications, various types of motors, from several milliwatts to millions of kilowatts, including synchronous motors, induction motors, DC motors, switched reluctance motors and so on, emerge as the times require.

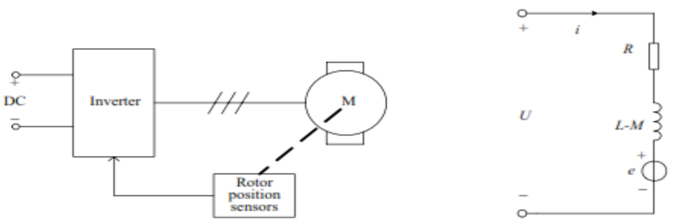
Although the synchronous motor has advantages of large torque, hard mechanical characteristic, high precision and efficiency, it has difficulties in speed regulation, which limits the range of its application. An induction motor has the advantages of simple structure, easy fabrication, reliable work and low price, but it is uneconomical to regulate the speed smoothly over a wide range and it is not easy to start up. Also, it is necessary to absorb the lagging field current from the power system resulting in the decrease of grid power factor. Moreover, its mechanical characteristic is soft, and the power factor is small. Without windings or a permanent magnet on its rotor, a switched reluctance motor has a simple structure and low price. It can produce high torque at low speed. However, the noise and torque ripples limit its popularization and applications.

DC motors are still widely used in electric power drive systems that have demands for startup and speed regulation, such as electric traction, rolling mill and hoisting equipment, because this type of motors have high efficiency and good speed-regulation performance. Nowadays, DC motors of small capacity are still widely used in automation and control systems. But in traditional DC motors, mechanical commutation is implemented by using brushes, which will result in problems like mechanical friction that would shorten the lifetime, and create noise, electric sparks, and radio interference, etc. In this condition, considering the disadvantages of high production cost and inconvenient maintenance 6-10, the range of applications in particular areashave been limited. Therefore, applications of small and medium size are in urgent need of novel high-performance motors.

The BLDC motor is developed based on brushed DC motors. The modern machine theory was established when Faraday discovered the electromagnetism induction phenomenon in 1831. The first DC motor was born in the 1840s. Confined by the development of power electronic devices and permanent magnet materials, BLDC motor was designed successfully until more than one century later. In 1915, an American, Langmuir, invented the mercury rectifier to control grid electrode and made the DC/AC converter. Contraposing the disadvantages of traditional motors, in the 1930s, some scholars started developing brushless motors in which electronic commutation was implemented, which prepare for the BLDC motor. However, at that time, power electronic devices were still in the early stage of development, scholars could not find an appropriate commutation device. This type of motor, with less reliable work and low efficiency, was only used in the lab instead of being popularized. In 1955, Harrison and Rye made the first patent claim for a thyristor commutator circuit to take the place of mechanical commutation equipment.

This is exactly the rudiment of the BLDC motor 11. The principles of operation are as follows, when the rotor rotates, periodic electromotive force (EMF) is induced in the signal winding, which leads to the conduction of related thyristors. Hence, power windings feed by turns to achieve commutation. However, the problems are, first, when the rotor stops rotating, induced EMF cannot be produced in the signal windings and the thyristor is not biased, so the power winding cannot feed the current and this type of brushless motor has no starting torque. Furthermore, power consumption is large because the gradient of the electric potential’s sloping part is small. To overcome these problems, researchers introduced the commutators with centrifugal plant or put an accessory steel magnet to ensure the motor started reliably. But the former solution is more complex, while the latter needs an additional starting pulse. After that, by numerous experiments and practices, the electronic commutation brushless motor was developed with the help of Hall elements in 1962, which inaugurated a new era in productionization of BLDC motors.

In the 1970s, a magnet sensing diode, whose sensitivity is almost thousands of times greater than that of the Hall element, was used successfully for the control of BLDC motor. Later, as the electrical and electronics industry was developing, many high-performance power semiconductors and permanent magnet materials like samarium cobalt and Neodymium Magnet emerged, which established a solid ground for widespread use of BLDC motors.



(a) Topology (b) Equivalent circuit

Figure 1:TOPOLOGY OF BLDC WITH ROTOR POSITION SENSORS AND ITS EQUIVALENT CIRCUIT

EXISTINGSYSTEM

PFC converters are widely used in AC/DC converters in order to control output voltage and attain a unity power factor. Various topologies have been proposed for PFC converters in literature which have high efficiency and low stress on active switches and simple circuit structure. In BLDC motor, PFC converters are widely used to optimize power quality. In, a Cuk converter and diode bridge are used to feed the BLDC motor. Motor speed is controlled through varying DC link voltage. Other different converter topologies as Buck-boost, Sepic and Zeta are proposed for PFC respectively, which all suffer from excessive circuit components; considering diode bridge rectifier, measured THD is relatively high and PF is low.

In 1978, the Indramat branch of Mannesmann Corporation of the Federal Republic of Germany officially launched the MAC brushless DC motor and its drive system on Trade Shows in Hanover, which indicates that the BLDC motor had enter the practical stage. Since then, worldwide further research has proceeded. Trapezoid-wave/square-wave and sinewave BLDC motors were developed successively. The sine-wave brushless DC motor is the so-called permanent magnet synchronous motor. Generally, it has the same topology shown in. It can be considered as a PMSMwhere rotor-position detection is used to control the commutation in order to ensure self-synchronization operation without starting windings. Meantime, these two kinds of motors have the same equivalent circuit as shown in Figure 1 in which L–M is the equivalent inductance of each phase. With the development of permanent magnet materials, microelectronics, power electronics, detection techniques, automation and control technology, especially the power-switched devices like insulated gate bipolar transistor (IGBT), integrated gatecommutated thyristor (IGCT) and so on, the BLDC motors in which electronic commutation is used are growing towards the intelligent, high-frequency and integrated directions. In the late 1990s, computer techniques and control theories developed rapidly. Microprocessors such as microcontroller units (MCU), digital signal processors (DSP), field programmable gate arrays (FPGA), complex programmable logic devices (CPLD) made unprecedented development, while a qualitative leap was taken in instruction speed and storage space, which further promoted the evolution of BLDC motor. Moreover, a series of control strategies and methods, such as sliding-mode variable structure control, neural-network control, fuzzy control, active disturbance rejection control (ADRC), adaptive control and so on 6,12-20, are constantly used in BLDCmotor drive systems.

These methods can improve the performance of BLDC motor drive systems on torque-ripple minimization, dynamic and steady-state speed response and system anti-disturbance ability to some extent, as well as enlarge the application range and enrich the control theory.

PROPOSED SYSTEM

Active PFC method is suitable for DC drives fed from the AC supply. In active PFC method, the buck and boost converters are most popularly used. Both are having their own limitations. Proposed system has two control loops; one for DC link voltage regulation and the other for BLDC motor operation. To control DC link voltage, sensed DC link voltage is compared to reference voltage.

Error voltage is given to voltage controller to produce required signal for PWM generation. Voltage controller is designed using MATLAB/Sisotool.

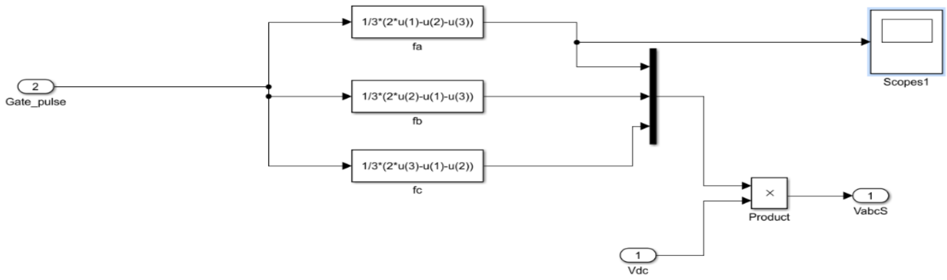


Fig 2 three phase vsc

The limitations are eliminated in this project by adding two auxiliary switches (one for buck operation and another one for boost operation) and two auxiliary diodes. In this project buck PFC converter performance is improved by implementing constant ON-time control which is utilized to force it to operate in critical conduction mode (CCM). By selecting suitable control parameters, nearly unity power factor can be achieved within the nominal input voltage range.

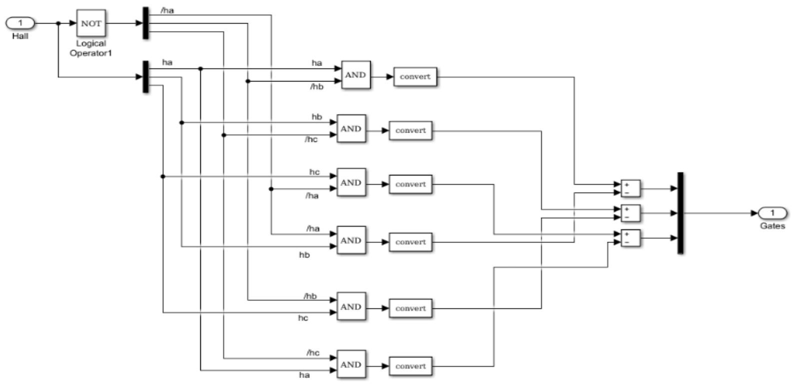


Fig 3 control logic

SIMULATION ANALYSIS

There are two typical circuits of these converters. Its basic circuit is a PWM-based current-source inverter with self-commutating devices. Since MOSFETs, BJTs, and IGBTs do not have reverse voltage blocking capability, a series diode is required to provide reverse voltage blocking capability. However, if a GTO is used, it does not require this additional diode but cannot operate at high PWM frequency, which is a prime factor to reduce the size of the filter and energy storage elements. It can be considered as a replacement of a single-phase thyristor bridge rectifier. Similarly, to that, it has unidirectional dc current with controllable bidirectional dc-link voltage to provide bidirectional power flow. It provides much faster response compared to a conventional dual converter. Output dc ripple compensation is also made using a third leg and it needs a reduced size filter with improved performance at input ac mains and output dc load.

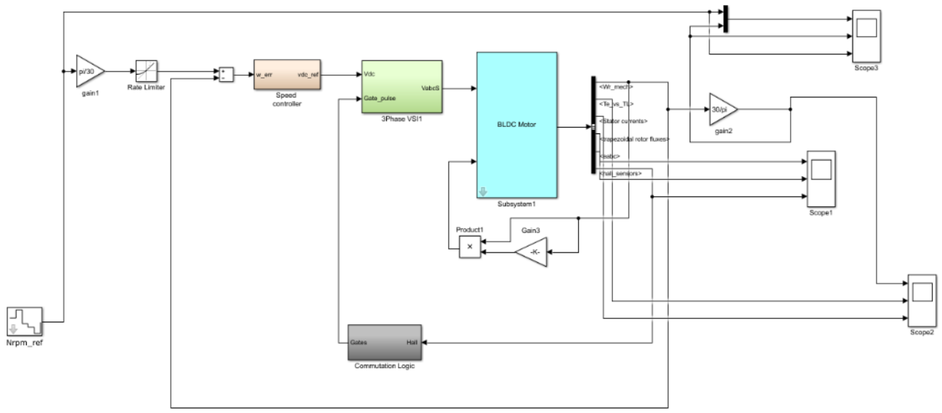


Fig 4 Power factor improvement circuit

With the double bridge connection in antiparallel, it provides performance similar to that of a conventional thyristor dual converter. In a large power rating such as in traction, it is used with several series converters with transformers for an isolated single-phase system with GTO to improve power quality at the input ac mains and at dc output. It may also be used in dc motor drives, battery charging, and to provide an ideal dc current source to feed current-source-inverter-based ac motor drivesvarying configurations to fulfill the very close and exact requirement in varietyUnidirectional Buck-Boost Converters

These converters are developed in both nonisolated and isolated circuit configurations. A few circuits of these converters. It is a combination of diode rectifier with buck-boost dc-dc converters. Since buck-boost converters are developed in non-isolated and isolated topologies, many configurations is also reported, such as a combination of buck and boost or vice versa, buck-boost, fly back, SEPIC, Zeta, Cuk, etc. These are now cascaded with a diode rectifier to improve power quality at the ac mains with required variable controllable output dc voltage to meet the need of specific applications. High-frequency transformer isolation provides voltage adjustment for better control, safety on load equipment, compactness, reduced as a current-source or a voltage-source rectifier and inverter with reduced energy storage elements for fast response.

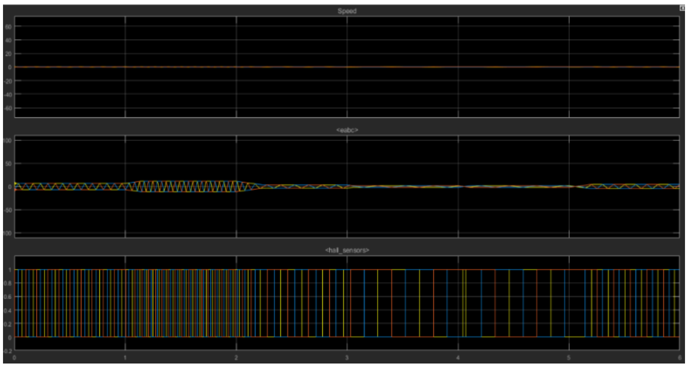


Fig 5 speed, voltage, hall signal

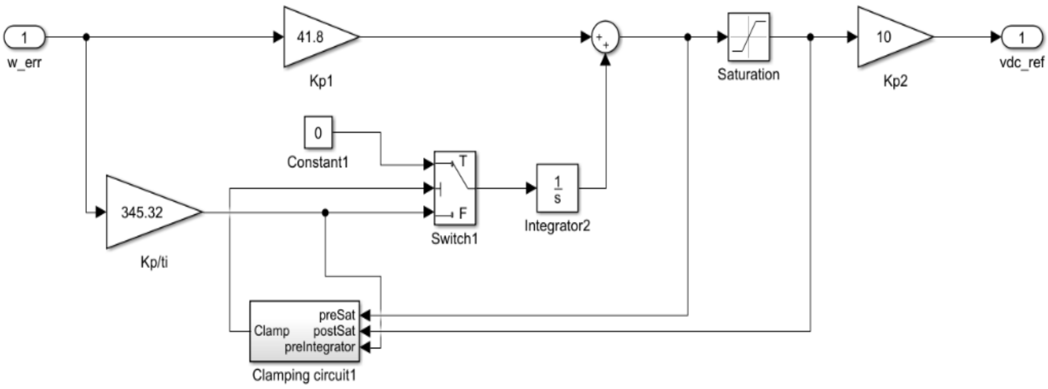


Fig 6 speed controller

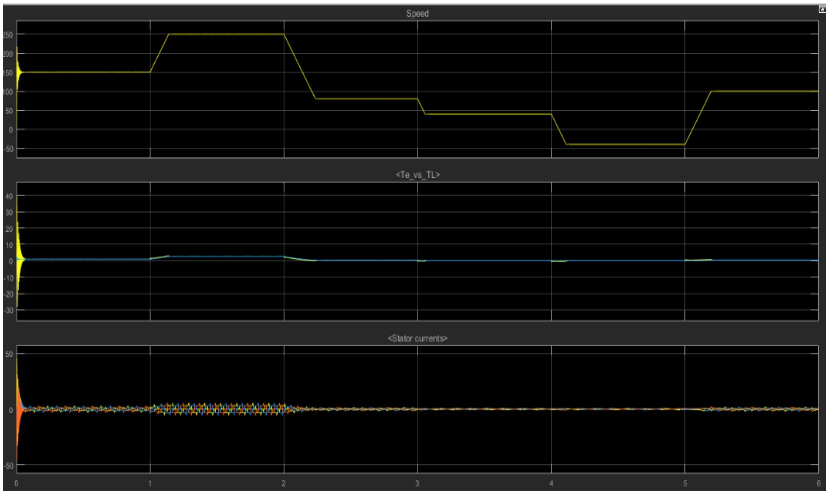


Fig 6 speed, torque, stator current

It is a most interesting converter, which operates as a four-quadrant converter and has the capability of operating in buck as well as boost mode. Here, increasing its switching frequency can further reduce the size of input and output filters. However, for a high-power rating, it can be implemented using a GTO which also avoids the series diode normally used with IGBTs to provide reverse voltage blocking capability.

CONCLUSION

Active PFC method is suitable for DC drives fed from the AC supply. In active PFC method, the buck and boost converters are most popularly used. Both are having their own limitations. Proposed system has two control loops; one for DC link voltage regulation and the other for BLDC motor operation. To control DC link voltage, sensed DC link voltage is compared to reference voltage. Error voltage is given to voltage controller to produce required signal for PWM generation. Voltage controller is designed using MATLAB.

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