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Review on Brushless DC Motor Drive Operated By Four Switch Three Phase Inverter

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ABSTRACT*:* This is a review paper on brushless DC motor driven by four switch three phase inverter. This paper describes the comparison and design of a low cost three phase inverter brushless dc motor (BLDC) drive. For effective use of the developed system, a direct current controlled Pulse width modulation scheme is designed and implemented. Operation of the four-switch three phase inverter BLDC motor drive and the developed control scheme are theoretically analysed .

KEYWORDS: Brushless DC (BLDC) motor drive, four-switch three phase inverter, six switch three phase inverter, Pulse width modulation.

I.INTRODUCTION

Brushless DC (BLDC) motor finds variety of uses and applications in almost all industries such as aerospace, military, household products and automobile industry etc. BLDC motor has higher efficiency high torque, increased power density and ease of control and maintenance. Torque developed by BLDC motor is almost constant. Previously a conventional BLDC motor is driven by a six switch three phase inverter. Conventional method of six switch three phase inverter has more cost and losses. In this review paper four switch three phase technique is use to reduce cost and losses by reducing the no of power switches, switching driver circuit.

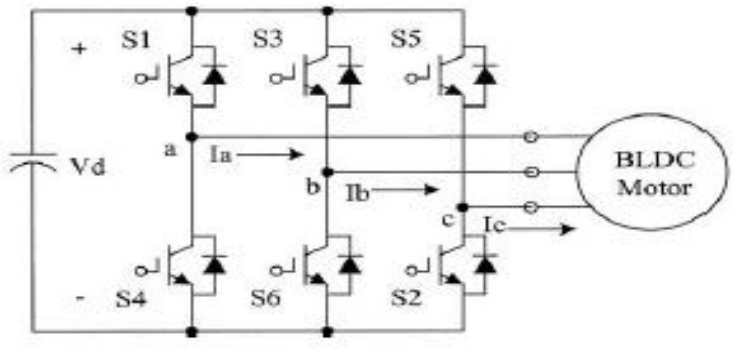

Figure 1. Six switch three phase inverter circuit

Figure 1.shows the conventional method of BLDC motor drive which has four switch three phase inverter. The literature survey, theoretical analysis and simulations on MATLAB / SIMULINK were conducted to check the feasibility of above proposed method.

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II.LITURATURE SURVEY

Changliang Xia, Senior Member, IEEE, Dan Wu, Tingna Shi, Member, IEEE, and Wei Chen, Member, IEEE "A Current Control Scheme of Brushless DC Motors Driven by Four-Switch Three-Phase Inverters"In this paper brushless DC motors (BLDCM) driven by four-switch three-phase inverter (FSTPI), a current control scheme is proposed to reduce the current ripple of both normal conduction region and commutation region. Assuming c-phase winding is connected to the middle point of DC-link capacitor.
B. K. Lee, Student Member, IEEE and M. Ehsani, Fellow, IEEE "Advanced BLDC Motor Drive for Low Cost and High Performance Propulsion System in Electric and Hybrid Vehicles"In this paper, there is an advanced brushless dc motor drive for low cost and high performance electric propulsion system in electric vehicles (EV's) and hybrid electric vehicles (HEV's). It includes reduced parts power converter topologies and an optimal PWM control strategy to produce the desired dynamic and static speed and torque characteristics. The theory and operational principle are explained in detail.

Thang Nguyen Trong , Minh Nguyen Duc "The speed control system of BLDC using PID controller with PWM modulation technique" In this paper presents that how to control the speed of BLDC motor using Proportional Integral Controller with the PWM technique. The output values of the PI controller given to the power switches for controlling the duty cycle of high frequency control signal ang adjusting the motor speed. Finally, the simulation have been performed using software MATLAB/SIMULINK, the simulation results show that the proposed method is effective.

Sathish Kumar Shanmugam, Meenakumari Ramachandran, Krishna Kumar Kanagaraj, and AnbarasuLoganathan "Sensor less Control of Four-Switch Inverter for Brushless DC Motor Drive and Its Simulation" In this paperthe research is to control the speed of the BLDC motor with sensor less control for FSTPI. This proposed system is easily described the topological structure of the conventional six-switch three phase inverter. In this proposed method, a new structure of four-switch three phase inverterwith reduced number of switches for system is introduced.

M .S. Aspalli, Farhat Mubeen Munshi, Savitri.L.Medegar "Speed control of BLDC Motor with Four Switch Three Phase Inverter using Digital Signal Controller" The main purpose of this paper is to develop a low costdrive system for BLDC motor with reduced switches and minimum hardware. Due to the characteristics of the Brushless DC motor such as high efficiency, high power factor, high torque, low maintenance and ease of control, it is widely used in variablespeed drives and industrial applications.

III. PROPOSED SYSTEM DEVELOPMENT

Four switch three phase inverter is shown in Figure 2, it is derived from six switch inverter circuit scheme by replacing the power switches with twocapacitors at the one leg. Phases A and B are each connected to any one bridge of the inverter, Phase C of the motor is connected to mid-point of the voltage divider capacitors and it is uncontrolled but, supplying the full dc link voltage equally between the voltage divider capacitors.

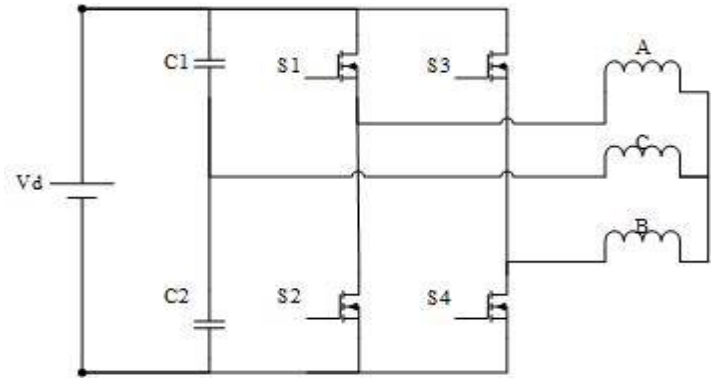

Figure 2. Four Switch Three Phase Inverter Topology

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According to Hall-signals that are obtained from rotor position there are total six commutation modes are generated. PWM signals are created with different duty ratios for each mode. Then, voltages of phases A and B are controlled by controlling power switchesTable I shows which phase or phases will be energized and which switches are controlled.

Mode	Rotor Position	Active Phases	Silent Phases	Switches
I	$330^0 < \theta_r < 0^0$ $0^0 < \theta_r < 30^0$	B and C $I_b + I_c = 0$	A $I_a = 0$	S_4
II	$30^0 < \theta_r < 90^0$	A and B $I_a + I_b = 0$	C $I_c = 0$	S_1 and S_4
III	$90^0 < \theta_r < 150^0$	A and C $I_a + I_c = 0$	B $I_b = 0$	S_1
IV	$150^0 < \theta_r < 210^0$	B and C $I_b + I_c = 0$	A $I_a = 0$	S_3
V	$210^0 < \theta_r < 270^0$	A and B $I_a + I_b = 0$	C $I_c = 0$	S_2 and S_3
VI	$270^0 < \theta_r < 330^0$	A and C $I_a + I_c = 0$	B $I_b = 0$	S_2

Table 1.Rotor Position, Active Phases and Active Switches.

All six modes of operation are given in Figure 3. The major complication of four switch inverter that it is not able to supply the full dc link voltage for some commutation modes like , mode a , mode c, mode d and mode f . On the other hand, mode b and mode e are the ones that circuit is supplied with full dc-link voltage(Vd) , the two switches are operated together.

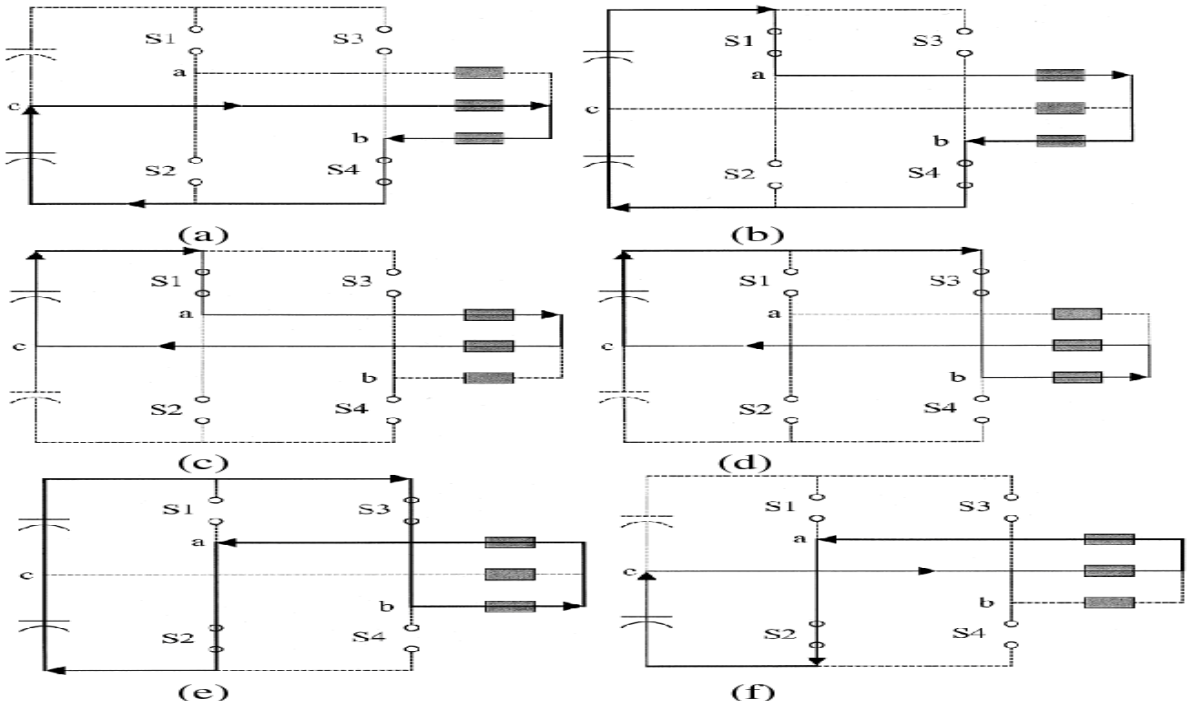

Figure 3. Six Commutation Modes

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For mode b and mode e one of the switch is operated at DTs while the other one operating for Ts because the currentmust complete the circuit as seen on Figure 4(A) for mode b and Figure 4(B) for mode e.

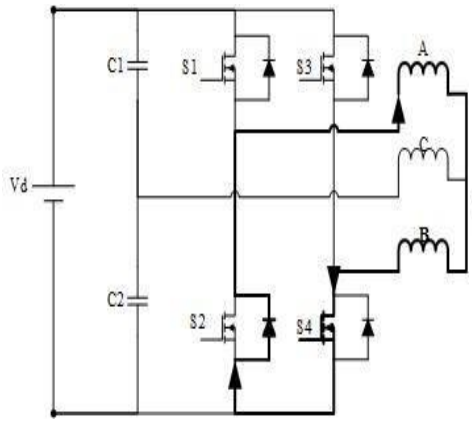

Fig. 4A

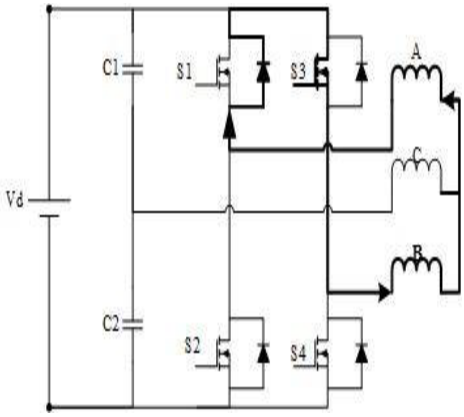

Fig. 4B

A procedure should be performed to balance the phase voltages in mode a , mode c, mode d and mode f due to unbalance supply voltage . So, the duty ratio in mode a, mode c, mode d and mode f is twice than duty ratio in mode band mode e to equate all phase mean voltage. This switching sequence is presented in Figure 5.

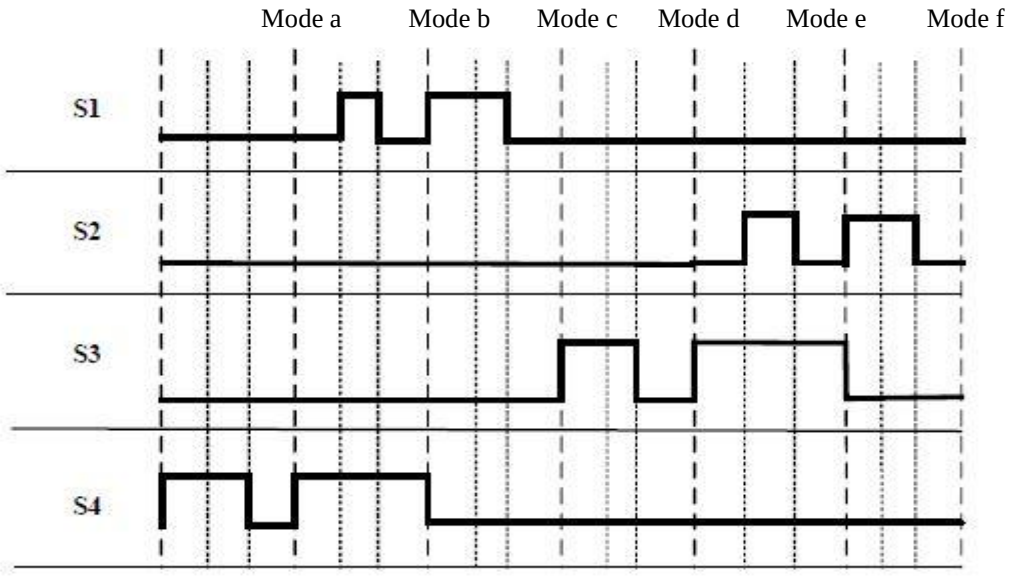

Figure 5. Switching Sequence

Supply voltage should be equally distributed between voltage divider capacitors in order to obtain balance. This is provided by equally using the top and bottoms half of the inverter. While the switching sequence algorithm is defined the procedure is briefly that the duty ratio is calculated by using PI controller for mode b and mode e. After that, the duty ratio for other modes is found by multiplying the duty ratio for mode b and mode e by 2. Proposed system block diagram is shown in figure 6.

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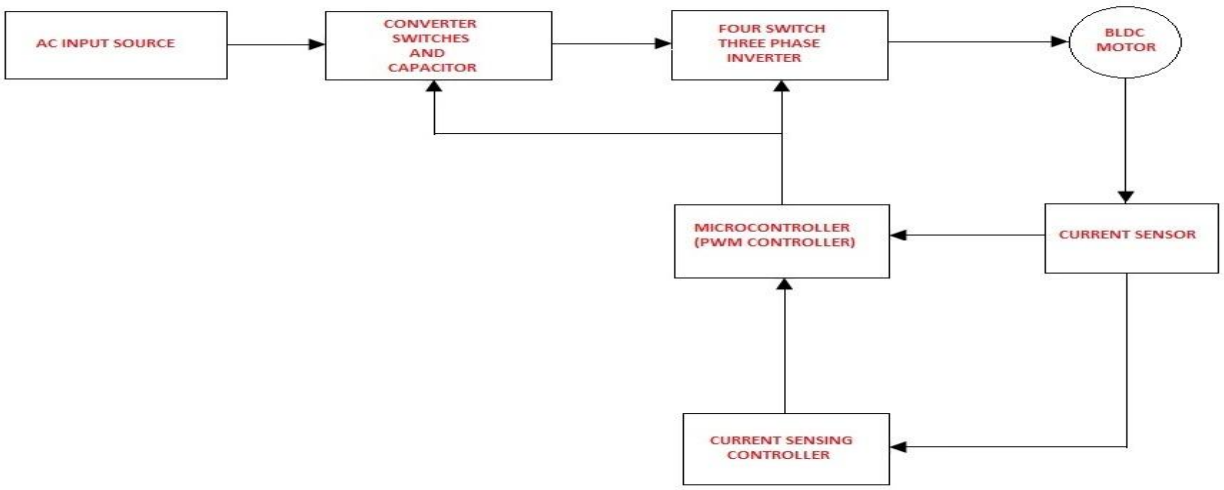

Figure 6. Proposed System Block Diagram

VI. CONCLUSION

The main cause of this FSTPI topology is to develop a low cost drive system for BLDC motor with reduced switches andminimum hardware. Due to the major characteristics of the Brushless DC motor such as high efficiency, high power factor, high torque, low maintenance and ease of control, it can be widely use in variable speed drives and various industrial applications.

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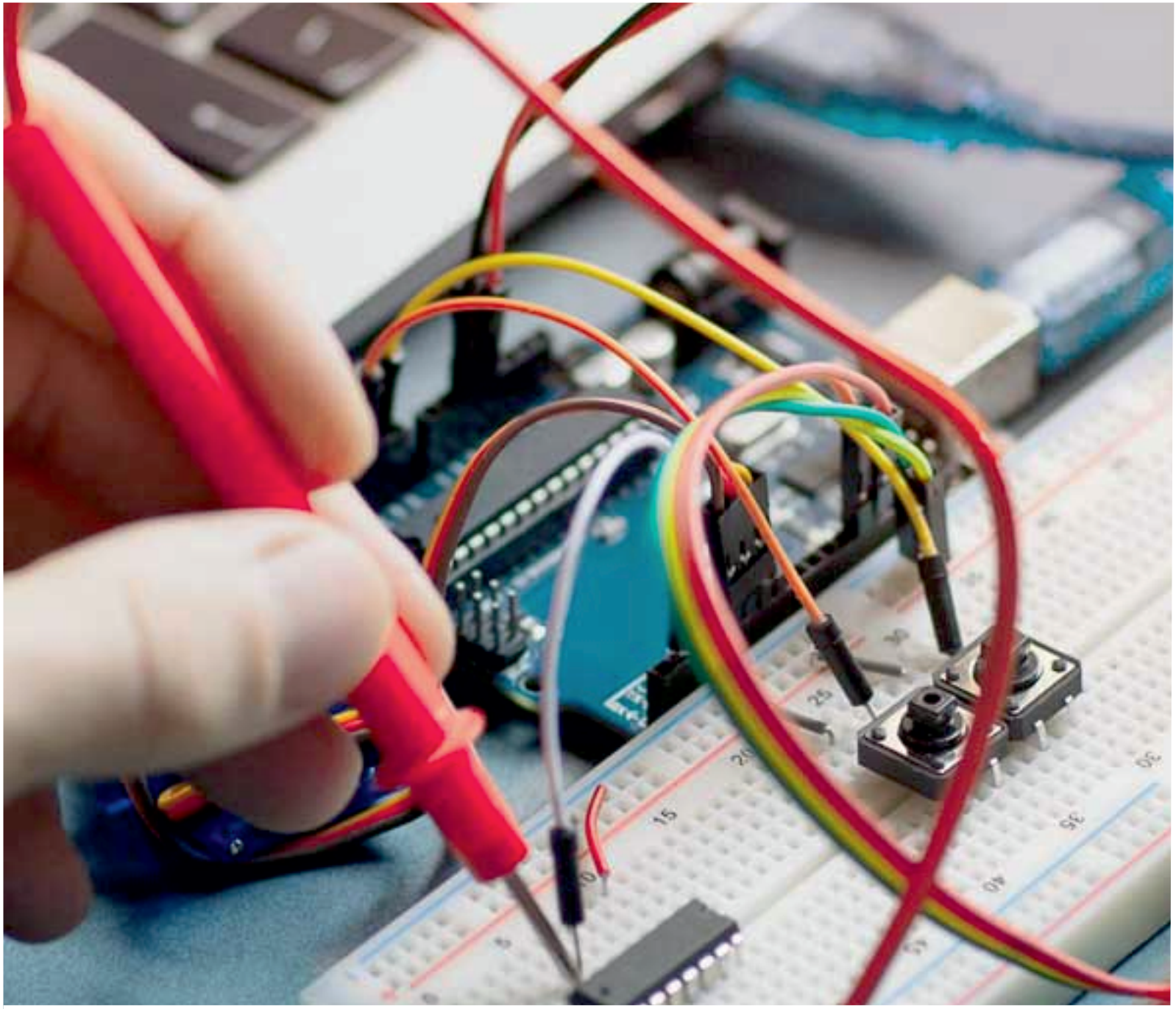

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