QUASI Z-SOURCE NETWORK BASEDCONTROL SCHEME FOR FSTP BLDC MOTOR

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ABSTRACT:

The paper proposes a novel four switch three phase BLDC motor control scheme which boosts the voltage level, extends the range of speed as well as reduces output torque ripple. The additionally partial circuits of quasi Z-source network and the bridge arm of four-switch inverter constitute the quasi Z-source converter. During the operation of motor, shoot through states are inserted. Then the input voltage of inverter increases and the performance of motor can be markedly improved. The dynamic performance of current is influenced and the speed is limited, for the irregular dc-link voltage utilization in the control of four-switch three-phase (FSTP) BLDC motor. This project presents a novel topology, which combines quasi Z-source converter and FSTP drive circuit. The drawbacks of FSTP BLDC motor are analyzed, the control methods of each mode in quasi Z-source four-switch three-phase (QZFSTP) topology are illustrated. Simulations for QZFSTP BLDC motor were constructed in MATLAB/Simulink circumstance. We can provide an alternate strategy to control BLDC motor by using Four Switch Three Phase inverter. FSTPI helps reduction in switching losses, gate drive requirements, circuit cost and computational time. At low power application, FSTPI fed BLDC motor drives are more suitable than SSTPI (Six Switch Three Phase Inverter). Also reconfiguration of these three leg inverter to FSTPI, in case of switch or leg failure can be done. In proposed system losses are minimizing due to FSTPI because there is reduction in switching losses and also due to Quasi Z-source Inverter output voltage is boosting hence output results were better. To overcome the ripple in torque and distortion in current the QZFSTP BLDC motor control scheme is proposed.

KEYWORDS: QZFSTP, BLDC motor, PWM, and Shoot-through state.

1. INTRODUCTION:

Brushless DC motor is widely applied in various fields, because of its high power density, large output torque and quickly dynamic response, etc. Four-switch three-phase brushless dc motor is developed based on the driving circuit that is composed of conventional six-switch inverter. It has the advantages of low-driven cost and less switching loss. Therefore, it is of great significance to research on performance enhancements of four-switch three-phase brushless dc motor.

According to the deficiency of FSTP brushless dc motor, many scholars at home or abroad put forward a series of improved strategy. In full dc-link voltage period, the distortion of phase current will happen for existence of C phase back-EMF. Consequently, the current control based voltage vector is adopted in paper[2]. It can make the C phase current converge to zero through inserting adjusting vectors. The strategy is easy to implement and has merits of fixed frequency, high stability and rapid dynamic response. In paper[2] the double closed-loop control that contains speed and current hysteresis is restrained effectively. To further reduce controlling costs, a novel control scheme of four-switch three-phase brushless dc motor without current sensor is presented in paper [1]. The commutation time of motor can be determined through the zero-crossing detection for terminal voltage. Meanwhile, the phase error is significantly decreased for no need of delaying 30 or 90 electrical angles. The paper [2] introduces a novel topology of five-switch three-phase brushless dc motor to extend the range of speed and improve the load capacity when supply voltage is low or battery. It combines four-switch three-phase inverter with the boost circuit to increase the input voltage of inverter by three effective- vector current control. Furthermore, it features the compact structure and simple arithmetic.

1.1 QUASI Z-SOURCE:

A network that consists of a split-inductor and capacitors are connected in X shape is employed to provide an impedance source (Z-source) coupling the inverter.

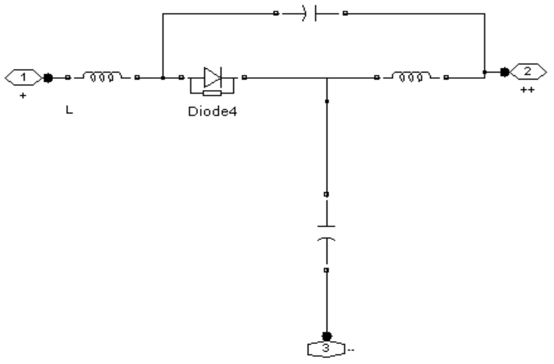

Fig-1: Quasi Z-source Network

The dc source/or load can be either a voltage or a current source/or load. Therefore, the dc source can be a battery, diode rectifier, thyristor converter, fuel cell, an inductor, a capacitor, or a combination of those. The inductance can be provided through a split inductor or two separate inductors.

1.2 BLDC MOTOR:

The BLDC motor is an AC synchronous motor with permanent magnets on the rotor (moving part) and windings on the stator (fixed part). Permanent magnets create the rotor flux and the energized stator windings create electromagnet poles. The rotor (equivalent to a bar magnet) is attracted by the energized stator phase. By using the appropriate sequence to supply the stator phases, a rotating field on the stator is created and maintained. This action of the rotor, chasing after the electromagnet poles on the stator, is the fundamental action used in synchronous permanent magnet motors. The lead between the rotor and the rotating field must be controlled to produce torque and this synchronization implies knowledge of the rotor position.

Conventional dc motors have many attractive properties such as high efficiency and linear torque-speed characteristics. The control of dc motors is also simple and does not require complex hardware however main drawback of the dc motor is to need periodic maintenance. The brushes of the mechanical commutator have other undesirable effects such as sparks. Despite the name, BLDC motors are actually a type of permanent magnet synchronous motors. They are driven by DC voltage.

- High efficiency
- Better speed versus torque characteristics
- Noiseless operation
- Higher speed range

1.3MERITSOF QZSI OVER ZSI:

- Two capacitors in ZSI sustain same high voltage, while the voltage in capacitor C_2 inQZSL is lower, which require lower capacitor rating.
- For QZSI there is common dc rail between source and inverter which is easier two assemble and causes less EMF problem
- QZSI draws continuous constant dc current due to inductor L_1 which reduce input stress from the source, while in ZSI draws discontinuous current and voltage on capacitor C_2 is greatly reduce.

2. METHODOLOGY:

2.1 INTRODUCTION:

In Proposed system, we are using Z-Source inverter and hence due to that output voltage is boosting and will become equal or greater than input voltage. Applied input voltage is same as applied to existing system also the PI controller is used in this proposed system to control the speed and torque ripple. The Hall sensor which works on Hall Effect gives signal to PWM generator and it generates pulses which are used to turn ON and OFF switches. Also as explained in Quasi Z-source network, there are two major working modes which are Shoot Through mode and Non-shoot through mode. In shoot through mode supply is cutting off and fifth switch is working as auxiliary switch which supply the voltage to inverter by discharging capacitor.

Only half of DC bus voltage participate in work on account of FSTP inverter notwithstanding, brushless DC motor operates under lower than rated voltage. The Quasi Z-Source network works in boosting status in mode I&VI.Then DC voltage of FSTP inverter increases and normal operation of motor would not be disturbed. At the moment, the power U_{dc} and capacitor C_3 recharge inductance L_1 and L_1 stored energy. Also capacitor C_4 recharges inductance L_2 and L_2 stored energy.

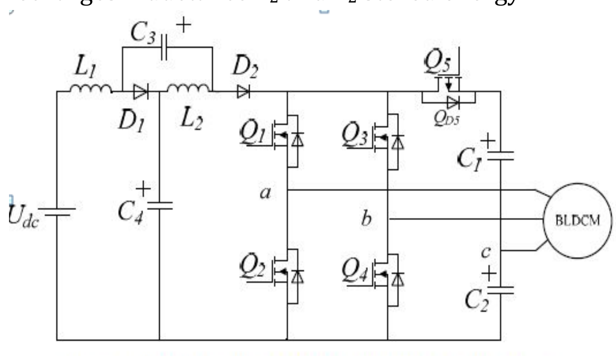

Fig.-2: Circuit topology of FSTP brushless drive

The BLDC motor is fed by the power of capacitor C_2. The reverse bias voltage across diode D_1 blocks itself from working. Q_5 is used because of preventing the capacitor C_1 & C_2 from being short circuited. In mode II & IV there exist current distribution in C phase back-EMF is not zero .There is relationship among A, B, C, phase current would happen if the switches Q_1& Q_4 are gated by control signal. To solve this problem, two switch of one bridge arm should be controlled independent theoretically, the

$$Vo = \frac{1}{1-2D} Vin.$$

Where,

V_{in}= Input voltage,

D =shoot through duty.

2.2 SIMULINK MODEL:

In Proposed system, we are using Z-Source inverter and hence due to that output voltage is boosting and will become equal or greater than input voltage as shown in Fig.21. Applied input voltage is same as applied to existing system also the PI controller is used in this proposed system to control the speed and torque ripple. As explained in PWM, the Hall sensor which works on Hall Effect gives signal to PWM generator and it generates pulses which are used to turn ON and OFF switches. Also as explained in Quasi Z-source network, there are two major working modes which are Shoot Through mode and Non-shoot through mode. In shoot through mode supply is cutting off and fifth switch is working as auxiliary switch which supply the voltage to inverter by discharging capacitor.

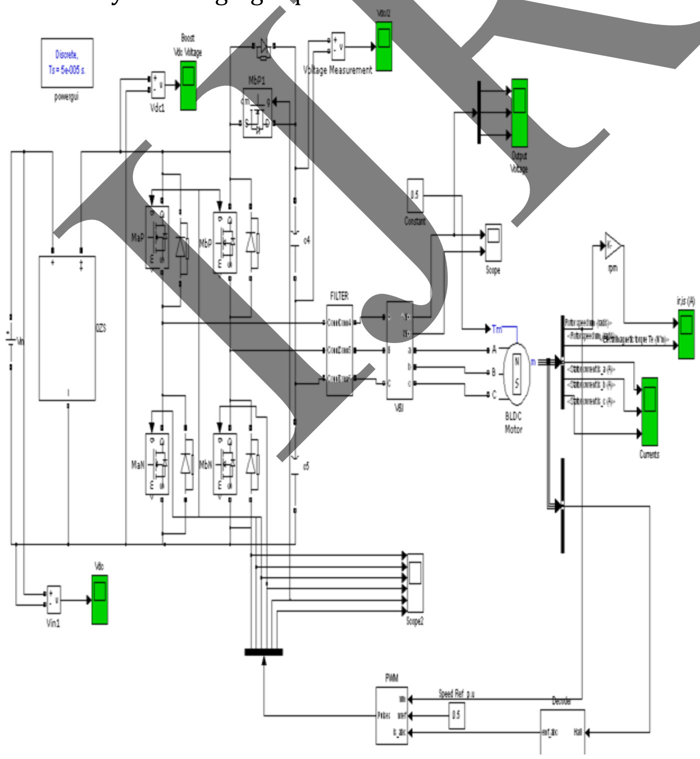

Fig.-3 Simulink Model for Proposed system with QZS

2.3 MODES OF OPERATION:

The modes of operations of QZSI are:

- **NON-SHOOT THROUGH MODE:**

In the non-shoot through mode, the switching sequence for the QZSI is similar to that of VSI. Equivalent circuit of QZSI in non- shoot through mode,

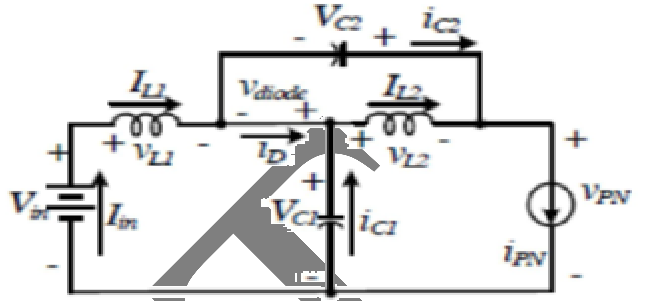

Fig.-4 Non-shoot through Mode

The inverter bridge is equivalent to current source if we viewed from the DC side. The DC link voltage is available, as DC link voltage input to the inverter, which makes the QZSI behave similar to a VSI.

During one switching cycle T interval of shoot through is T_0 and interval of non- shoot through is T_1.

$T=T_0+T_1$

From fig.-4,

Appling KVL we get

$V_{L\,i} = V_{in} - V_{C1}$ & $V_{L\,2} = -V_{C2}$

$V_{PN} = V_{C1} - V_{L\,2} = V_{C1}+V_{C2}$

Therefore, $V_{diode} = 0$

- **SHOOT THROUGH MODE:**

In the shoot through mode, switches of the inverter bridge on the same phase are switched ON simultaneously for a very short ration, the source then do not get short circuited because of LC network.

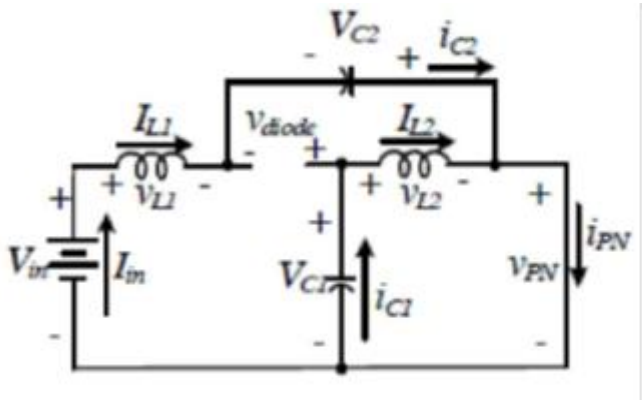

Fig.-5 Shoot through Mode

While boosting the output voltage, the DC link voltage during the shoot through state is boosting by boosting factor, whose value depends upon shoot through duty ratio. Quasi z-source is renewable and attractive converter for attractive energy source, voltage double in rectifier side. it is characterized by high current low voltage values.Hence QZSI inherits all the advantages of the ZSI. It can buck or boost a voltage with a given boost factor. It is able to handle a shoot through state and therefore it is more reliable than the traditional VSI.

From fig.-5,

$V_{L1}=V_{C2}+V_{in}, \quad V_{L2}=-V_{C1}$

$V_{PN}=0, \quad V_{diode}=V_{C1}+V_{C2}$

At steady state average voltage of inductors over one switching cycle is zero.

$Vc1 = \frac{T1}{T1-T0} Vin$, $\quad Vc2 = \frac{T0}{T1-T0} Vin$

Therefore,

$V_{PN} = V_{C1}+V_{C2} = \frac{T}{T1-T0} V_{in} = \frac{1}{1-2\frac{T0}{T}} Vin = B.Vin$

Where, B= Boost Factor.

2.4. SIMULINK RESULT:

As Shown in Fig.-3, input voltage is applied to the Z-source Network then following results are obtained.

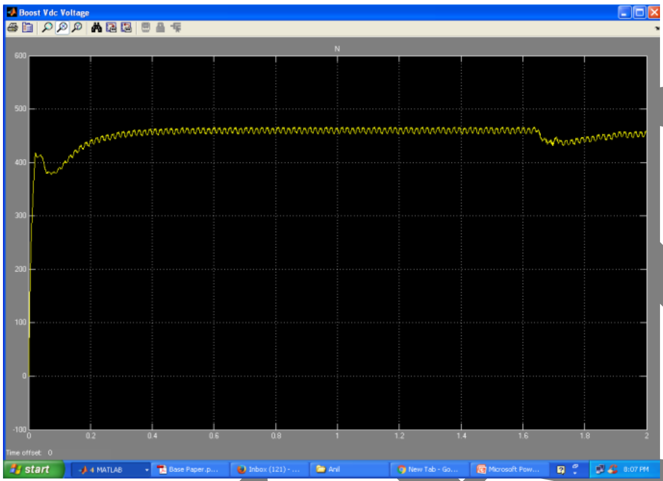

Fig.-6 Boost V_{dc} Voltage

The Network containing capacitor and inductor in cross X-shaped which having input voltage of 311V, which boosts that voltage beyond the input voltage which is nothing but 400V where shoot through mode and Non-shoot through mode takes place which is discussed earlier in previous section.

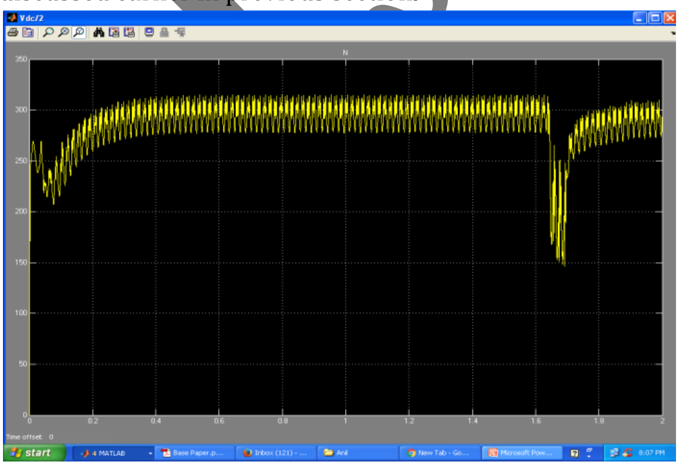

Fig.7 DC link Voltage

DC link voltage is a voltage that appears across the capacitor C_1 at C-phase, which is obtained when auxiliary switch Q_5 is at ON state.

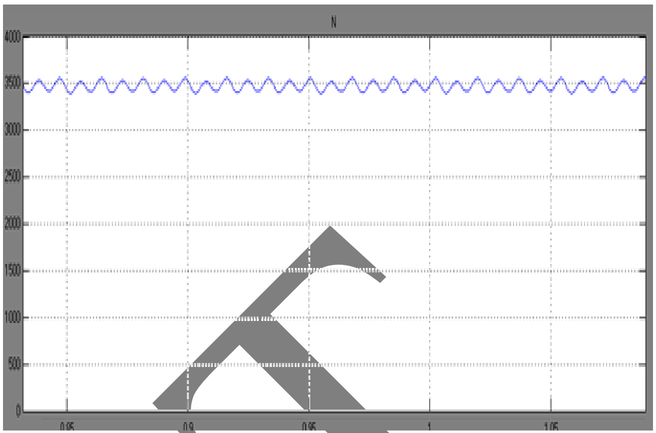

Fig.8 Speed

In existing system speed is 3000rpm, while speed is increase in QZSI system is 3500 rpm.

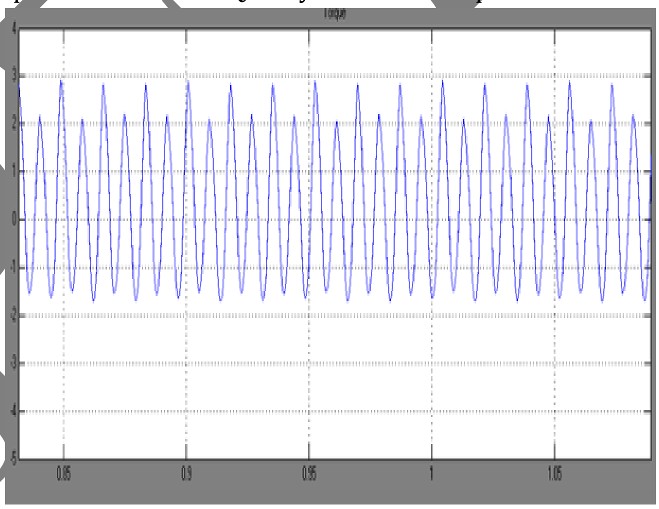

Fig.9 Torque

Torque in existing system is 3.9 N-M, while in QZSI system it is decrease upto 2.9N-M due to increase in speed.

2.5 COMPARISONOF EXISTING AND PROPOSED SYSTEM:

Table No.1 Comparison of existing and proposed system

Sr.no	Parameters	Existing System	Proposed System
1	Input Voltage	311.2 V	311.2 V
2	Output Voltage	320 V	400 V
3	Speed	3000 RPM	3500 RPM
4	Torque	3.9 N-M	2.9 N-M

3. CONCLUSIONS:

The presented paper is an outline of the worked novel four-switch three-phase brushless dc motor control scheme based on quasi Z-source network, which combines FSTP BLDC motor and quasi Z-source network. The input voltage of FSTP inverter will be boosted to enlarge the range of speed and will be enhance the ability with load when quasi Z-source converter works. The quasi Z-source network is employed to boost the DC voltage, and the problem that the speed of motor restricted to solved under the condition of low DC voltage. The QZFSTP motor circuit is simulated; the new topology having some advantages such as boosting DC voltage, rapid response and extending the range.

REFERENCES:

1) Tuopu Na, Qianfan Zhang, Chaowei Zhou (2015) *"Modelling and Design of Quasi-Z- Source Inverter for PMSM Drive System."*

2) Kun Xia (2015)" *Research of Four-Switch Three-Phase BLDC Motor Control Scheme Based on Quasi Z-Source Converter".*

3) Farshad Khosravi1,2, Naziha Ahmad Azli1, Avin Kaykhosravi1 (2014)" *Design of a reduced component count single-phase to three-phase quasi-Z-source converter."*

4) Shaikh Moinoddin, Haitham Abu-Rub, Atif Iqbal (2013)" *Carrier-Based PWM of Voltage Fed Five-Phase QZSI with Coupled Inductors."*

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