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QUASI Z-SOURCE INVERTER OF INDUCTION MOTOR CONTROL

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Abstract:

In this paper a new induction motor drive is designed, which provides a single phase to three phase conversion as well as acts as motor drive. Using effective 4 switch structure and a quasi z-source inverter, voltage boost even greater than the supply voltage can be achieved. The use of input capacitor in the traditional Z source inverters is not present in the proposed topology and also the shoot through duty ratio effectively establishes soft switching of the semiconductor devices. The proposed circuit could also be operated in the bi-directional mode by replacing the input diode with a bi-directional switch. Since 4 switches instead of the traditional 6 switches are used, the costs of the circuit along with switching losses are reduced and the control method for this circuit is much simpler than the traditional 6 pulse circuit.

Keywords: Induction Motor Drives , Quazi Z- Source Inverter, Shoot Through Duty Ratio.

1. INTRODUCTION

Three-phase induction motors have been the main consideration in industries more than single phase induction motors due to certain parameters such as; efficiency, torque ripples and power factor. In places like rural areas to be use of rolling mills, machine tools and in low power industrial application for robotics, where by a three-phase utility may not be available, high performance converters must be used to run three-phase induction motor. Low losses and cost-effectiveness of these converters are very important. The voltage sags is defined as the sudden reduction in the supply voltage followed by a recovery after a short interval. The voltage swell is defined as the sudden increment of the supply voltage from the nominal value. To increase the reliability of the power system many techniques have been proposed in literature based upon inverter system and power switches. Some of them are also based upon dynamic voltage restorer (DVR) and uninterrupted power supply (UPS) .These techniques are able to compensate the power quality problem like voltage sags and swells [2]. But some of these techniques are based upon use of large energy storage components like capacitors and batteries bank, as the power level increases the size of these energy storage devices also increases which increase the cost of the system and also the system become bulky [3]. In this paper a feedback control technique is presented which has a capability to compensate the voltage sags and swells. The impedance source inverters i.e. Z-Source inverter, quasi-Z-Source inverter were proposed as an alternate power Conversion concept and they have capability to both voltage buck and boost [4]. Among these two the quasi-Z-Source inverter has an advantage of continuous input current. During voltage sags and swells the control system regulates the load voltage and maintained a constant rated voltage at motor terminals so as the motor operation is not interrupted.

2. PROPOSED METHOD

The proposed system is shown in fig. 1. The whole system consists of mainly eight blocks- the three phase ac supply, rectifier, quasi-Z-Source impedance network, traditional three phase inverter, 3-phase induction motor, RPM to Hz gain constant, V/Hz gain constant and control block. The purpose of the control system is to vary the speed of the induction motor by varying the frequency of the stator voltage while keeping the V/f ratio constant. Besides this it also keeps the stator voltage at reference value during voltage sags or swells in the three phase supply voltage.

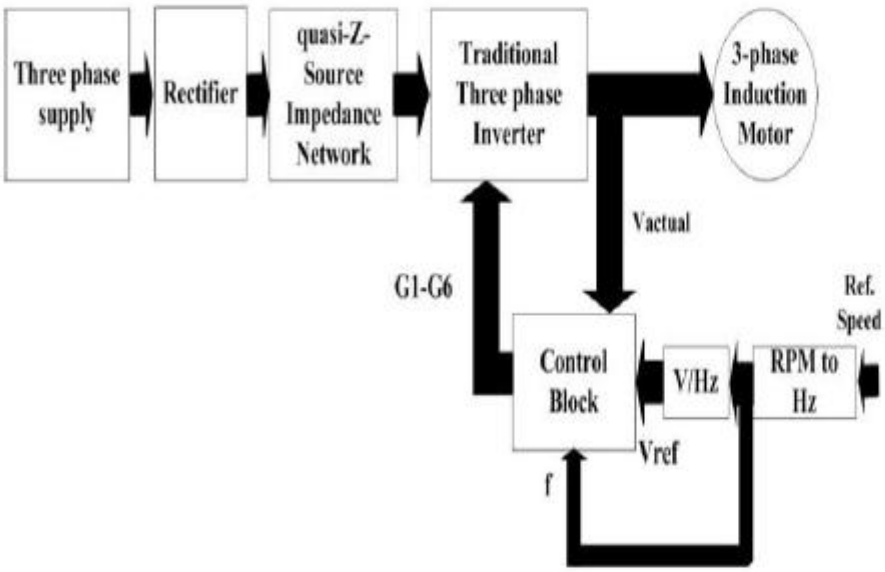

Fig.1. The scheme of the proposed system

The base speed of the induction motor is directly proportional to the supply frequency and indirectly proportional to the number of poles (1). The voltage applied to the stator is directly proportional to the

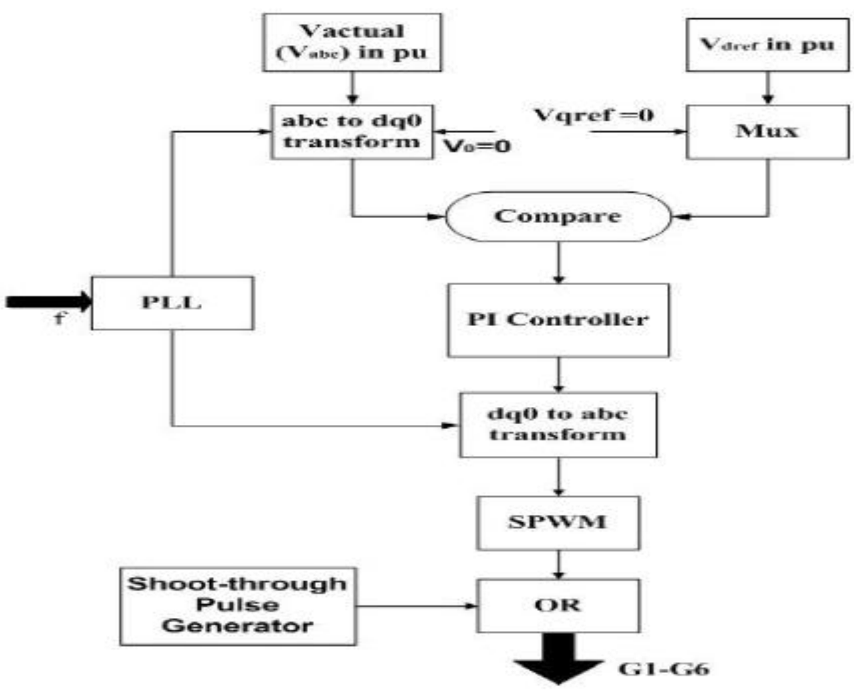

Fig.2. Flow chart of feedback control technique based upon dq0 transform

product of the stator flux and angular velocity (2) and the torque developed by the motor is directly proportional to the magnetic field produced by the stator. This makes the flux produced by the stator proportional to the ratio of applied voltage and frequency of supply. The flow chart of the control block is shown in fig. 2. The basic function of the controller in the proposed system is to detect voltage sag/swell in the system, computation of correcting voltage and generation of trigger pulses for the three phase quasi-Z-Source DC-AC inverter [5][6]. The dq0 transformation or Park's transformation (4), (5) & (6) has been used in the system [7]. First it converts the actual stator voltage from abc-frame to dq0-frame.For the sake of simplicity the zero sequence component is made zero. The error signal is generated by comparing this transformed actual voltage with the reference value of stator voltage. Further this error is minimized using PI controller the output signal from the PI controller is converted into abc-frame by using inverse Park's transform (7), (8) & (9) [7]. This signal is used as a reference signal to generate the gate pulses for the inverter. Before applying these pulses to the inverter the shoot through pulses are inserted using OR logic. The PLL circuit is used to generate the unit sinusoidal signal of frequency equal to frequency calculated from the V/Hz gain constant block.

3. OPERATION PRINCIPLE

From this derivation, we can see that in the improved topology, when the shoot-through duty ratio Do is zero, the Z- source capacitor voltage Vc is equal to zero. When the converter is in the soft-starting state, Vc is zero naturally, so if we control the Do increase from zero gradually, Vc can also increase from zero gradually and soft start can be achieved. But this is not the case in traditional topology is the boost factor determined by D and M is the modulation ratio. As can be seen from, the output voltage is boosted by a factor B ($B \geq 1$), which is the same as the traditional topology.

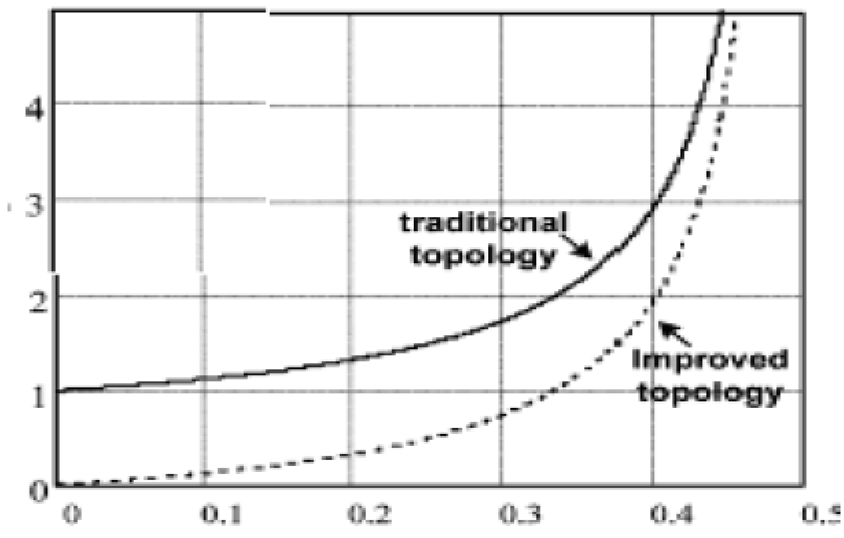

Fig.3. Vc/Vo versus Do of two topologies

All the power switches and diodes used in improved and traditional topologies are exactly the same. A comparison is given on the Z-source capacitor, Z-source inductor, and input current ripple. Consider, for example, the input voltage is 150–300V. In traditional topology, the capacitor voltage stress is decided by the maximum input voltage, so VC is no less than 300V. However, in the improved topology, VC is decided by the minimum input voltage to achieve the maximum voltage boost, the capacitor voltage stress is only 75V to get the required voltage boost under 150V input voltage; thus, low-voltage capacitors can be used. During shoot-through time, the condition for previous and improved Z-source inverters is the same, the Z-source inductor current discharges the capacitors.

4. RESULT ANALYSIS

To confirm the above analysis of impedance source inverter simulation is performed using MATLAB shows the open loop main circuit configuration of impedance source inverter for photovoltaic applications. The impedance network parameters are L1=L2=1000mH and C1=C2=C=2200mF, switching frequency: 10 kHz. The purpose of the system is to boost the input voltage and rotor speed characteristics. The main circuit configuration of impedance source inverter.

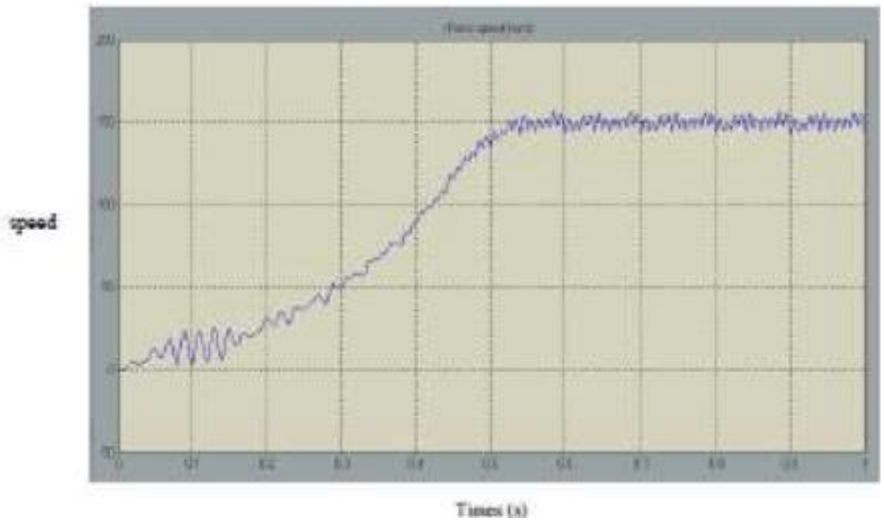

Fig.4. Output waveform

The impedance network parameters are L1=L2=1000 microHenry and C1=C2=C= 2200microFarad, switching frequency: 10 kHz. The purpose of the system is to boost the input voltage. The simulation model consists of two parts. One is main system and the other one is subsystem. Main system is used to produce PWM wave by comparing sine wave and oscillatory wave and is given to the subsystem. PI controller is used for the closed loop control of the quasi Z-source inverter reference speed is given to the controller and the actual speed is given using the speed sensing unit. The pulse triggers are generated from the above controller using the pi controller. The output pulses are given to the four MOSFET switches. The rotor speed relationship with time.

CONCLUSION

A 220v to 50 volt transformer is used in the input side. A tachometer is used for check in the speed of the motor. A half hp squirrel cage induction motor is used for verification of the result. A multi meter is used for checking the output voltage. The input voltage is found to be 50V AC while the output is 3 phase 58V. This is sufficient to drive a 3 phase induction motor with a speed of 900 rpm. The future scope of this paper can be extended for the use in rural areas where 3 phase supply is in high demand. Closed loop of this paper is simulated which can be implemented in places where constant speed is required. It can also be used with DC supply by directly connecting it to the z-source omitting the rectifier circuit.

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