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Solar based switched quasi ZSI fed induction motor drives

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Abstract*— This paper deals with the integration of switched quasi impedance source inverter with capacitor start induction motor. A 200W solar panel with battery is designed to supply power to induction motor. MPPT is used to track maximum power delivered by solar panel by using P&O algorithm. Switched quasi ZSI provide single stage conversion as it has the ability to boost the voltage with less duty ratio. The two states of impedance network are shoot-through and non-shoot-through mode. These states are employed through a semiconductor switch (MOSFET). It also has continuous input current and the voltage stress of the active switch is reduced. The semiconductor switch used in inverter is IGBT. The gate pulse to the inverter switches is given through SPWM controller using sinusoidal pulse width modulation technique. The harmonics is also reduced when compared with single phase H-Bridge inverter. The simulation is performed on the MATLAB/Simulink environment.*

Index Terms*— ZSI, solar, induction motor, single stage conversion, quasi ZSI, MPPT, Harmonic reduction.*

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I. INTRODUCTION

Solar energy is the conversion of light energy into electrical energy using photovoltaic cells. It is renewable and clean form of energy. The power delivered by a solar cell is the product of current and voltage. The point at which the cell generates maximum electrical power is the maximum power point which can be tracked by maximum power point tracking controller using any one of its algorithm. Battery is used to store the DC power generated by solar panel. Normally, lead acid battery is used. But in upcoming days lithium-ion batteries are used widely.

Converters play major role in converting solar generated DC power into AC power. Usually, the DC is boosted using DC-DC converter and then it is converted into AC using DC-AC converter (inverter). This is a two stage conversion which increases the cost and power loss. These issues can be overcome using single stage conversion in which the DC-DC converter is eliminated.

The control unit performs the control actions of the converter. Usually, Sinusoidal PWM controller is used. The PWM signal is generated by the combination of carrier signal and modulating signal. The carrier signal will be a triangular wave and modulating signal will be a sine wave. The PWM signal is controlled by varying modulation index. Modulation index is the ratio of the peak of modulating waveform to the peak of carrier waveform. The capacitor start induction motor is used where high starting torque is required like pumps, refrigerator compressor and conveyors.

II. EXISTING SYSTEM

The switched-inductor quasi-Z-source has higher booster multiple, lower capacitance stress, and higher conversion efficiency. Therefore, it is very suitable for grid-connected photovoltaic power generation system [1]. The power inverters play a significant role in many areas such as AC motor control, uninterruptible power supplies, variable speed drives and renewable energy sources. The proposed quasi ZSI eliminates main drawbacks such as discontinuous constant DC current from the input source and higher component ratings [2]. Recently, new topologies of quasi Z-source inverter obtained from Z-source inverter are offered in. One of these is voltage fed quasi Z-source inverter that has some privileges compared to conventional Z-source inverter like Power ratings of required components are reduced and Current drawn from DC supply is continuous [3]. Quasi Z-Source Inverter in the Fuel Cell Battery Based power generation system. It connects the Fuel Cell Stack and outputs three phase 50 Hz, 330 V ac to resistive loads, which is the standard utility level [5]. Multi-level inverters (MLIs) are preferred due to their attractive features compared with two-level voltage source inverters (VSIs) such as better AC voltage quality, low voltage stress on semiconductors, possibility to produce significantly higher voltages than a single-switch voltage rating[7].

III. PROPOSED SYSTEM

Fig 1 is the block diagram of the proposed system. The circuit diagram of switched quasi ZSI is represented in Fig 2.

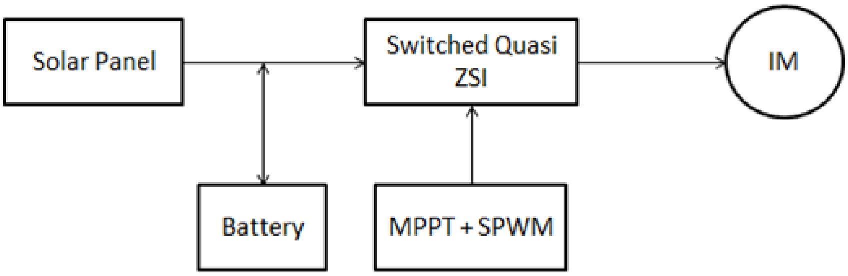
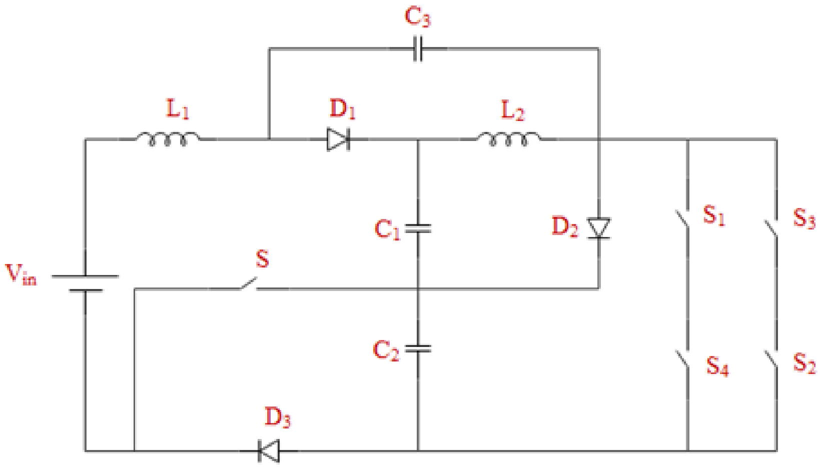


FIG. 1 BLOCK DIAGRAM

The output power from a 200W solar panel is given to a switched quasi-ZSI which provides single stage conversion. It converts DC to AC. The output power from inverter is fed to a capacitor start induction motor. The voltage from solar panel is boosted by the impedance network by controlling the shoot through duty ratio. Here, the duty ratio is 0.45. The gate pulse for inverter is given by SPWM technique. This pulse width can be adjusted through modulation index which is the ratio of

Fig. 2 Circuit diagram of switched quasi ZSI



amplitude of reference wave (sine wave) to amplitude of carrier wave (triangular wave). Here, the modulation index is 0.7.

The boosting ability of the Switched quasi ZSI can be achieved by utilizing the shoot-through state of the inverter in which the inverter leg is short-circuited by turning on two switches simultaneously. Therefore, the operation modes of the proposed Switched quasi ZSI can be considered as shoot-through mode and non-shoot-through mode. In order to simplify the analysis, the capacitors or inductors in the topology are identical.

The inductors L1 and L2 can be obtained by,

$D(VC1 + VC3 + Vin) + (1D)(Vin+VC3 - V p dc) = 0$ (1)

$D(VC1 - VC2) - (1D) VC2 = 0$ (2)

The capacitor voltages can be derived as

$VC1 = 1/ 1 - 3D Vin$ (3)

$VC2 = VC3= D/ 1 - 3D Vin$

Boost factor B can be obtained as

B = Output Voltage / Input Voltage (4)

The voltage gain G in respect to the modulation index M can be expressed as

$G = M/ 3M - 2$ (5)

IV. SIMULATION RESULTS

The SIMULINK model of switched quasi ZSI with single phase induction motor drive is shown in Fig 3. The power from solar panel is fed to induction motor through switched quasi ZSI. The specifications of solar panel are represented in table 1. The voltage across PV is shown in Fig 4. The gate pulse for quasi impedance network is provided by MPPT using P & O algorithm. The voltage across switched quasi ZSI is represented in Fig 5. The parameters of switched quasi ZSI are shown in table 2. The gate pulse for inverter is given using sinusoidal pulse width modulation technique. The speed of induction motor is depicted in Fig 8 and the motor torque is shown in Fig 9. The voltage across motor load is represented in Fig 6. The current through motor load is shown in Fig 7. The current THD of the H-Bridge inverter is shown in Fig 10. And, the current THD of switched quasi ZSI is shown in Fig 11.

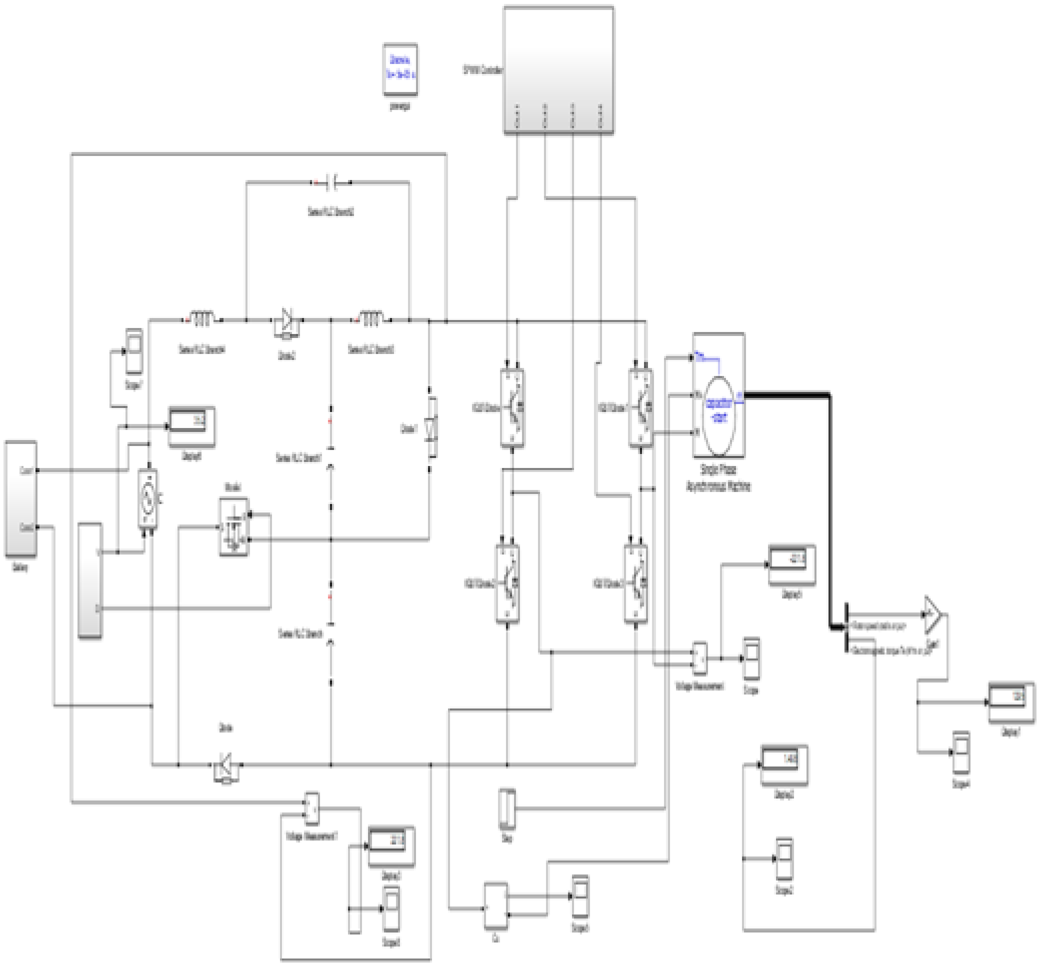


Fig. 3 Simulation diagram

Table 1 Parameters of Solar Panel

Particular	Description
Power Max(P_m)	200W
Short Circuit Current	6.10A
Max Power Current	5.70A
Maximum Voltage	35.20V
Open Circuit Voltage	44.40V
Maximum System Voltage	1000V DC

Table 2 Parameters of switched quasi ZSI

Parameters	Values
Frequency	50HZ
Boost Factor(B)	6
Voltage Gain(G)	7
Modulation Index(M)	0.7
Duty Ratio(D)	0.45
Inductance(L)	3mH
Capacitance(C)	1800μF
Switching Frequency(fs)	1.5KHz

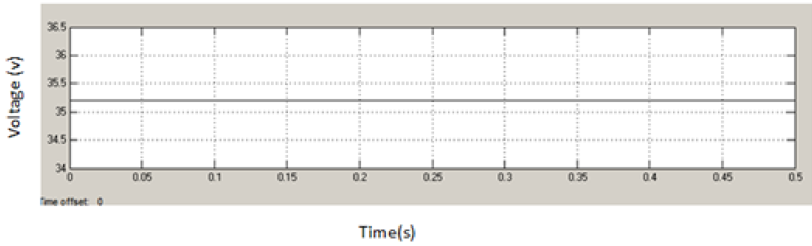


Fig. 4 Voltage across PV panel

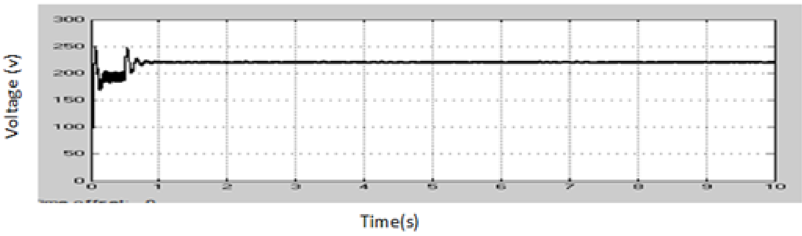


Fig. 5 Voltage across impedance network

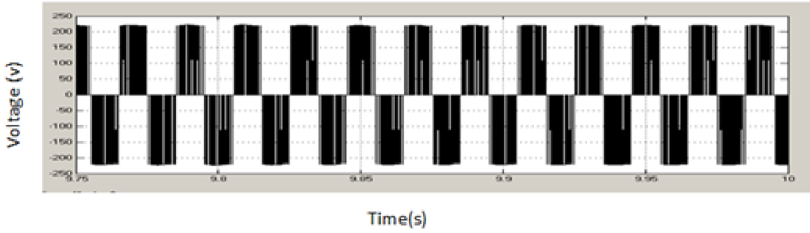


Fig. 6 Voltage across motor load

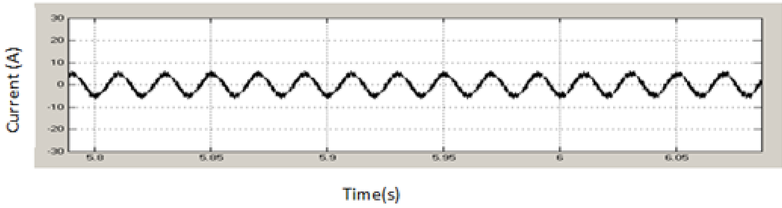


Fig. 7 Current through motor load

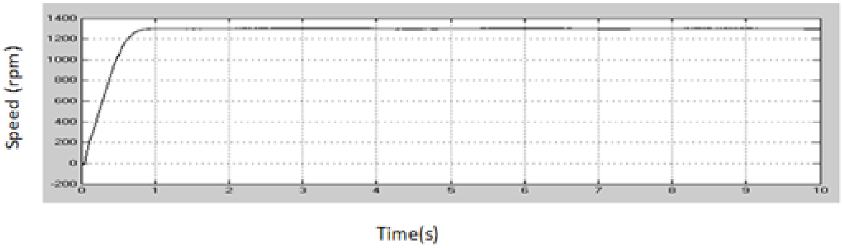


Fig. 8 Speed of induction motor

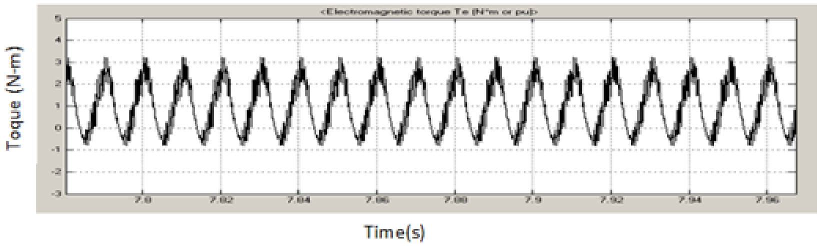


Fig. 9 Torque of induction motor

A comparison for output voltage, motor speed, motor torque and output current THD is done for capacitor start single phase induction motor and is tabulated in table .3. The comparison for H-bridge inverter and ZSI is represented in table 4.

Table 3 Parameters of Single Phase induction motor drive with Switched quasi ZSI

Vo	N	T	THD
221V	1295rpm	1.5N-m	6.75%

Table 4 Comparison of THD of inverters

THD of H-Bridge Inverter	THD od Switched quasi ZSI
11.88%	6.75%

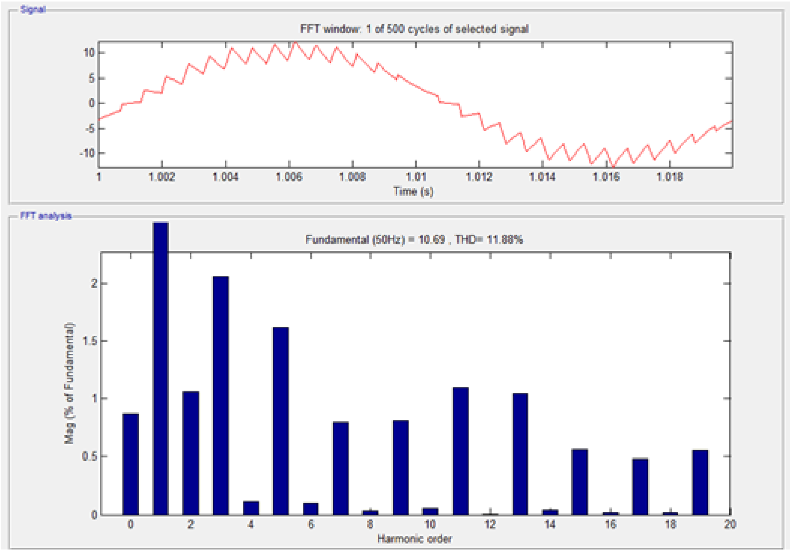


Fig. 10 Current THD of H-Bridge inverter

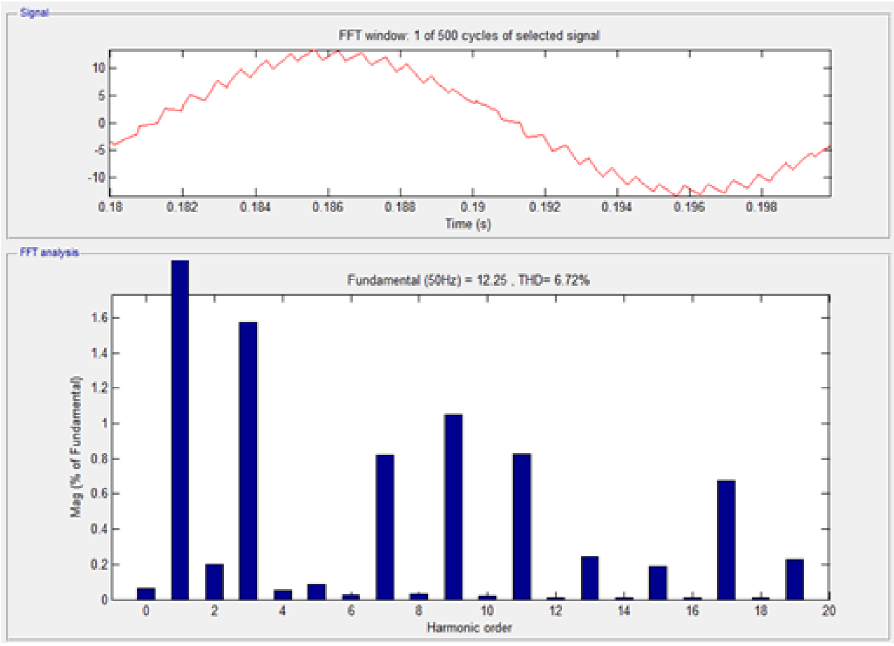


Fig. 11 Current THD of switched quasi ZSI

V. FUTURE SCOPE

In future, Power Groups (PG), a thyristor augmented multilevel structure will be designed to reduce power loss. Here, thyristor is used to build MMC sub-module circuitry where an auxiliary Full-Bridge Chain-Link (FBCL) is adopted for controlled transition and forced commutation of main thyristor bridge which forms active forced commutated (AFC) thyristor cell. A suitable LC filter will be designed to reduce harmonics. And this stand-alone system can be connected to grid with proper synchronisation.

VI. CONCLUSION

In this project, a 200W solar panel with battery is designed for a ¼ HP capacitor start induction motor. A switched quasi ZSI is designed to increase efficiency and to reduce harmonics. It performs single stage conversion with continuous input current which makes it suitable for renewable energy applications. Finally, the simulation and experimental results shows the performance in terms of high boost capability, lower voltage stress of switches and capacitors.

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