IMPROVING EFFICIENCY IN ELECTRIC/HYBRID/ FUEL CELL VEHICLES BY USING DTPM BASED 2 STAGE 3 PHASE INVERTER WITH PV ENERGY SYSTEM

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ABSTRACT: *This Paper presents the hybrid modulation technique containing of PV system for front end dc-dc converter and 33% modulation for 3 phase inverter. The dual pulse technique is used to control the fronted dc/dc converter which produces high frequency (HF) pulsating dc voltage waveform; this is relevant to six pulses at 6x line frequency. Where dual pulse line frequency rectified 6-pulse o/p of balanced 3 phase AC wave form. Here the Dc link capacitor is eliminated which retains the modulated information of the inverter device to generate 3 phase voltage waveform resulting in significant saving in switching losses of inverter semiconductor devices. During line cycle only 2 switches are required to switch at HF and remaining switches are maintained at unique state (i.e.) either ON or OFF .This Paper explains operation and analysis of the HF two stage inverter with PV system technique. Analysis has been verified through simulation result using MATLAB.*

Keywords: *Electric vehicle, PV system, High frequency, Six Pulse modulation, three phase inverters.*

I. INTRODUCTION

Solar cell efficiency is the ratio of the electrical output of a solar cell to the incident energy in the form of sunlight. The energy conversion efficiency (η) of a solar cell is the percentage of the solar energy to which the cell is exposed that is converted intoelectrical energy.[1] This is calculated by dividing a cell's power output (in watts) at its maximum power point (Pm) by the irradiance (input light), *G*, in W/m2 and the surface area of the solar cell (*Ac* in m2).

$$\eta = \frac{P_m}{G \times A_c}$$

By convention, solar cell efficiencies are measured under standard test conditions (STC) unless stated otherwise. STC specifies a temperature of 25 °C and irradiance (G) of 1000 W/m2 with an air mass 1.5 (AM1.5) spectrums. These conditions correspond to a clear day with sunlight incident upon a sun-facing 37°-tilted surface with the sun at an angle of 41.81° above the horizon. This represents solar noon near the spring and autumn equinoxes in the continental United States with surface of the cell aimed directly at the sun. Under these test conditions a solar cell of 20% efficiency with a 100 cm2 ((10 cm)2) surface area would produce 2.0 W.

PV system are been tested in countries like U.S, Canada, Germany not only in cars but also in public transportation. The Automotive industries like Honda, Toyota, GM, ford and Kia Ria are designing the FCVs. The architecture of the fuel cell car along with its major components are given in the fig.1.Any device needs a energy storage element and hence based on the characteristics and dynamics of the fuel cell optimal energy storage device like battery or ultra capacitor is selected. A 12-V battery is used to supply power to the auxiliary loads in the vehicle which can also be used with a bi-directional dc/dc converter.

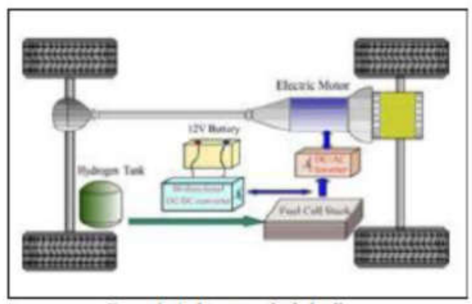

Fig: Architecture of a PV system car

A HF two stage Z-source inverter is employed to convert 100 V into three phase AC voltage, which is used to drive the motor of the vehicle. A voltage fuel cell stack needs a multistage inverter to boost its low voltage to generate three phase voltage signal. HF modulation is adopted to achieve compact, low cost and light weight system. The two stage HF inverter consist of Front end dc-dc converter connected to a standard three phase width modulated (PWM) inverter as shown in fig.2. This paper presents a hybrid modulation technique which has two different modulations for two stages. Single reference six pulse modulation (SRSPM) is done to control the front end dc/dc converter to produce high pulsating dc voltage which produce six pulse information which requires a single reference signal The second modulation is adopted for a three phase Z- source inverter which produces a balanced three phase voltage. In the inverter modulation only one leg is modulated at a time and the other two legs are at the same switching state which reduces the switching frequency and limits the switching losses. Interleaving is done to increase the power transfer capacity. This act of modulating only one bridge at a time adds advantage to the proposed system as even if one bridge fails the other bridge maintains the six pulse information in the pulsating dc – link voltage and the inverter will still be able to produce the balanced three phase voltage.

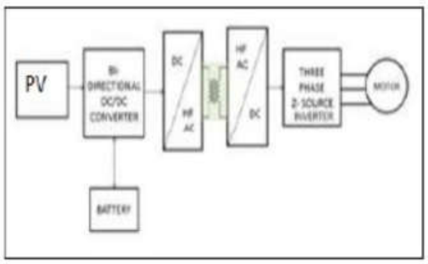

Fig: Functional diagram of a fuel cell propulsion system

The overall merit of the system are (1) Robust. (2) Eliminating dc – link capacitor reduce the volume of system and increases reliability. (3) Reduced switching losses and improved efficiency. (4) Use of the Z-source inverter provides additional advantage such as: (i) produce any desired output ac voltage, even greater than the line voltage, regardless of the input voltage, thus reducing motor ratings; (ii) provide ride-through during voltage sags without any additional circuit (iii) improve power factor and reduce harmonic current and common-mode voltage. The objective of this paper is to explain the operation of the two stages HF Z – source inverter employing proposed modulation scheme, reported in section II.The design of the converter is illustrated in section III. The analysis and design have been verified by simulink MATLAB in section IV.

II. OPERATION

The steady state operation and analysis of the modulation technique have been explained in this section. To increase the power handling capacity full bridge converter are interleaved at front end input series output as shown in fig 4. The full bridges are modulated with six pulse modulation which produces high frequency pulsating dc voltage, which is fed to the three phase z- source inverter. To reduce the switching losses the modulation of the two stages is planned, developed and implemented. To obtain the balanced three phase sine inverter output voltage of required frequency and amplitude the three phase inverter is modulated to shape the high frequency dc voltage of the two bridge converter. The following assumptions are made for easy understanding of the analysis of the converter: 1) All semiconductor devices and components are ideal and lossless. 2) Leakage inductances of the transformers have been neglected. 3) Dc/dc converter cells are switched at higher frequency compared to the inverter. Therefore, current drawn by the inverter, idc remains approximately constant over one HF switching cycle of the dc/dc converter.

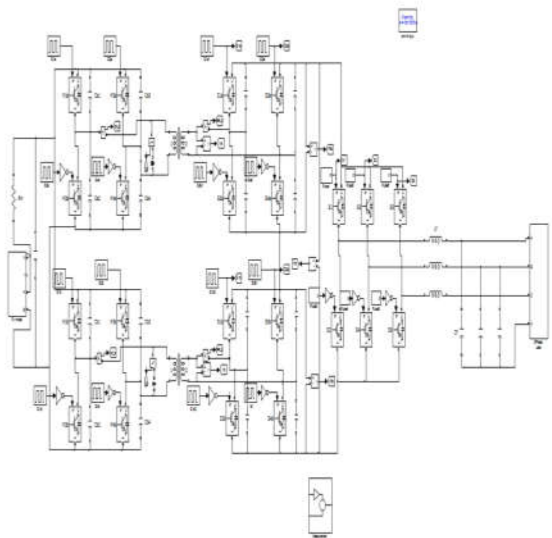

Fig: Schematic of the Proposed PV Inverter System

As already said in a complete line cycle each semiconductor device is switched at high frequency for only one third of the lime cycle,at the same time the device are not commutated when the current is at its peak value.This reduces the switching losses less than 33%. The exact modulating signal are calculated by varying the average dc-link voltage as six pulse modulation.This can be easily implemented by using three phase line-line voltage as shown in fig.

Steady State Operation

Each switch in the full bridge are operated 50 % duty ratio which are complementary to the other switch in same leg. Whenever the diagonal switch pairs are conducting for eg. M1a & M4a, then the input voltage Vin is reflected on the secondary side on other side when the another diagonal pair M2a & M3a are conducting –nVin appears across secondary terminal, where n is the turns ratio of the transformer. Same procedure is applied for bridge B .The bipolar pulsating voltage is converted into unipolar using the full bridge diode rectifier.The duty ratio is obtained from Vref of the six pulse waveform, which varied between maximum value D max and minimum value Dmin for the required three phase output voltage.

Switching Losses

As explained the devices of the three phases inverter switch is operated only for 1/3rd of the line cycle. The switch is kept in the onstate for 1/3rd of the cycle conducting the peak current of the output line current when the output power factor is unity and in the OFF state for rest 1/3rd of the line cycle .When the top switch is in OFF state the line current is at negative peak and is ON state for the bottom switch. When the line current crosses zero the device is switched at high frequency and hence the switching losses in the inverter are reduced.

III. SIMULATION RESULTS

The proposed modulation has been implemented and simulatedfor two-stage inverter usingmatlab.Simulation results are shown in Figs. The results coincideclosely with the predicted operating waveforms.

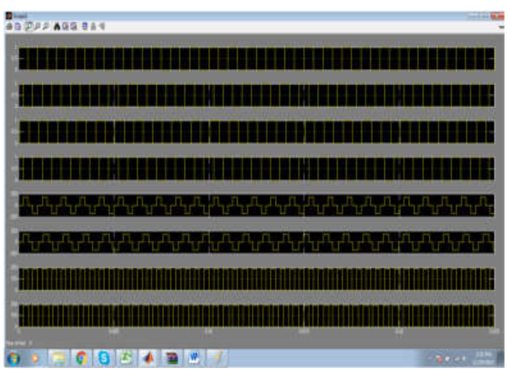

Fig: Simulation output showing voltages VAb, VCD, and Vdc.

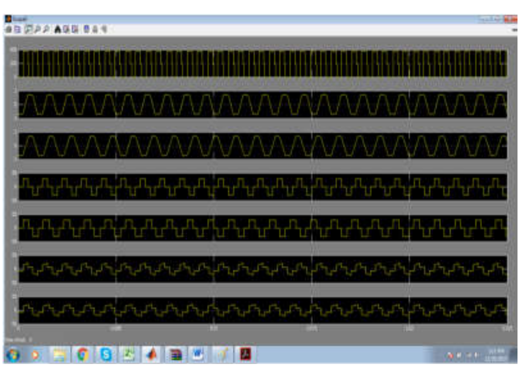

Fig: Simulation waveforms of voltage across primary of the transformerof cells A and B,VAB and VCD (scale: 100 V/div), and voltage input to the inverter Vdc.

IV. SUMMARY AND CONCLUSION

PV system is one of the most important to provide solution toward sustainable low carbon clean mobility owing to zero emission. Volume, cost, efficiency, reliability, and robustness of power electronics are the important features of the power electronics system. This paper proposes a modulation technique named SRSPM to control front-end full-bridge converter to generate HF unipolar pulsating voltage waveform at dc link having six-pulse information if averaged at HF cycle over line frequency. Six-pulse is meant for six-pulse waveform that results after rectification of three-phase balanced ac waveforms at 6× of line frequency. It permits the next three-phase inverter devices to switch at HF during 33.33% (1/3rd) of the line cycle and remains to stay at steady switching state of ON for 33.33% and OFF for rest 33.33% of line cycle. It results in low average switching frequency or 66.66% reduction in switching transition losses and improved efficiency. It is suitable for high-power applications like FCVs and EVs, three-phase uninterruptible power supply (UPS), islanded or standalone micro grid, and solid-state transformer. The proposed modulation technique eliminates the need for dc-link capacitor and feeds directly HF pulsating dc voltage to a threephase inverter. This pulsating waveform is utilized to generate three-phase output voltage at reduced average switching frequency (one third of the inverter switching frequency) or 33% commutations of inverter devices in a line cycle. The steady-state operation and analysis of the two stage HF inverter controlled by the proposed modulation scheme have been discussed. Simulation results using MAT are presented to verify the proposed analysis.

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