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Survey on Multilevel Multi-Output Bidirectional Active Buck PFC Rectifier

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Abstract *– This paper presents new buck type power factor corrector rectifiers that operates in continuous-conduction mode (CCM) and generates a multilevel voltage waveform at the input. The proposed transformer less, reduced filter, and multilevel rectifier topology has been investigated experimentally to validate the good dynamic performance in generating and regulating dual 125-V dc outputs terminals as telecommunication board's feeders or industrial battery chargers under various situation including change in the loads and change in the main grid voltage amplitude. Due to CCM operation, commonly used ac-side capacitive filter and dc-side inductive filter are removed from the proposed modified packed U-cell rectifier structure. High power factor or PFC boost converter is used in model which operates in boost mode. IGBT is used for switching operation and Model works on 50 Hz frequency it uses Less no. of system switches which reduces the system stress and Less number of switches reduces loss in power and also makes circuit simple and cheaper.*

Keywords*: Packed U-Cell, PUC5, HPUC, Buck PFC rectifier, multilevel converter, power quality,*

I. Introduction

Ac–dc conversion of electric power is widely used in several applications such as adjustable-speed drives (ASDs), switch mode power supplies (SMPSs), uninterrupted power supplies (UPSs), and battery energy storage. Conventionally, ac–dc converters, also known as rectifiers, are developed using diodes and thyristors to provide uncontrolled and controlled dc power with unidirectional and bidirectional power flow. Major drawbacks include poor power quality in terms of injected current harmonics; resulting voltage distortion, poor power factor at input ac mains, and slow varying rippled dc output at load end; low efficiency and large size of ac and dc filters. Reduction of harmonic content with the consequent increase of power factor (PF) can be obtained by using either passive or active power factor correction (PFC) techniques. Passive methods include the use of tuned LC filters, what represents a robust solution. However, increased size, weight, and volume result. Besides, the passive filter may not respond adequately if the load power factor comes to vary. On the other hand, active methods come as a more efficient solution by using controlled solid-state switches in association with passive elements such as resistors, inductors, and capacitors.

In fact, the closed-loop operation of the static power converter dedicated to PFC assures satisfactory performance with high input PF and regulated dc output voltage over a wide operating range. Increased complexity and reduced robustness are distinct characteristics of this practice though. In order to meet the requirements in the proposed standards such as IEC 61000-3-2 and IEEE Std 519 on the quality of the input current that can be drawn by low-power equipment, a PFC circuit is typically added as a front end stage.

II. Literature Survey

Hani Vahedi et al. [1] "A Novel Multilevel Multi-Output Bidirectional Active Buck PFC Rectifier", in this paper a 5-level rectifier operating in buck mode has been proposed which is called HPUC as a slight modification to PUC multilevel converter. It has been demonstrated that the proposed rectifier can deceive the grid by generating maximum voltage level of 250V at AC side as boost mode while splitting this voltage value at its two output terminals to provide buck mode of operation with 125V DC useable for battery chargers or telecommunication boards' feeder. Although it has more active switches than other buck rectifier topologies and some limitations on power balance between loads, overall system works in boost mode and CCM which results in removing bulky AC and DC filters that usually used in conventional buck PFC rectifiers. Moreover, generating multilevel waveform leads to reduced harmonic component of the voltage waveform and consequently the line current. It also aims at operating with low switching frequency and small line inductor that all in all characterizes low power losses and high efficiency of the HPUC rectifier. Comprehensive theoretical studies and simulations have been performed on power balancing issue of the HPUC rectifier. Full experimental results in steady state and during load and supply variation have been illustrated to prove the fact that HPUC topology can be a good candidate in a new family of buck bridgeless PFC rectifiers with acceptable performance. Future works can be devoted to developing robust and nonlinear controllers on the proposed rectifier topology.

Julie Metri et al.[2] “Real-Time Implementation of Model Predictive Control on 7-Level Packed U-Cell Inverter”, In this paper, a Model Predictive Control has been designed for the 7-level PUC inverter in grid-connected mode of operation, an excellent candidate for photovoltaic and utility interface application to deliver green power to the utility. MPC is a simple and intuitive method that does not have confusing gains to adjust as well as featuring fast response during any change in the system parameters. Experimental results have been provided to show the fast response of the implemented controller on the grid-connected multilevel PUC inverter. It has been demonstrated that the DC link capacitor voltage has been regulated at desired level and 7-level voltage waveform has been generated at the output of the inverter. The injected current to the grid was successfully controlled to have regulated amplitude and synchronized waveform with the grid voltage to deliver maximum power with unity power factor. Moreover, the PF has been controlled easily to exchange reactive power with the grid while injecting the available active power. Exhaustive experimental results including change in the grid current reference, DC source and AC grid voltages variations, as well as PF have been tested and results have been illustrated which ensured the good dynamic performance of the proposed controller applied on the grid connected PUC inverter.

Hani Vahedi et al.[3] “Sensor-Less Five-Level Packed U-Cell (PUC5) Inverter Operating in Stand-Alone and Grid-Connected Modes”, The PUC5 inverter has been proposed in this paper while the capacitor voltage is balanced without involving any external controller and voltage feedback sensors. The proposed sensor-less voltage controller has been integrated into switching technique to work as open-loop system with reliable results. Moreover, another controller has been designed for the PUC5 inverter to work as unity power factor grid-connected inverter. Low harmonics components in both voltage and current waveforms generated by PUC5, no need to bulky output filters, reliable and good dynamic performance in variable conditions (including change in DC source, load, power amount injected to the grid), requiring no voltage/current sensor in stand-alone mode, low manufacturing costs and miniaturized package due to using less components and etc are interesting advantages of the introduced PUC5 topology which have been proved by experimental results in both stand-alone and grid-connected modes. The presented PUC5 inverter can be a challenging candidate for conventional photovoltaic application inverters.

Mohammad Sharifzadeh et al. [4] “Hybrid SHM-SHE Pulse Amplitude Modulation for High Power Four-Leg Inverter”, The general formulation for hybrid SHM-SHE-PAM technique has been presented in this paper. Consistent with SHM-SHE-PAM principle, both switching angles and DC input voltage have been assumed as degrees of freedom; however, the firing pulses for power switches are unique for all the modulation indexes range. Also, the DC voltage is obtained regarding to the modulation index in order to set the required amplitude of the voltage waveform fundamental component. So, compared to the SHM-SHE-PWM, the quality of output voltage in terms of the harmonic content has been significantly improved. In studied case, all the non-triplen harmonics up to 49th fulfilled the limits specified on grid codes EN50160:2010 and CIGRE WG 36-05 at a very low switching frequency of 400 Hz.. Furthermore, stabilization the voltage THD in specified value and the reduction in time and volume of calculations as well as the possibility of using simple hardware controller like AVR are the prominent advantages of PAM compared to PWM technique. Simulation and experimental tests have been carried out and shown results validate the ability of SHM-SHE-PAM switching strategy in driving the 4-leg inverter and eliminate/mitigate desired harmonics at the output. In addition, results confirmed that the presented modulation technique applied to 4-leg NPC inverter exhibits a good performance in terms of DC bus utilization since the modulation index can be set as high as 1.1. Therefore lower dc bus can be used, and consequently lower capacitor Farads/Volts ratings are requested for the same performance, consequently less costly power unit would be manufactured.

Hani Vahedi et al.[5] “Real-Time Implementation of a Packed U-Cell Seven-Level Inverter with Low Switching Frequency Voltage Regulator”, In this paper a new cascaded nonlinear controller has been designed for 7-level PUC inverter based on the simple model derived by multilevel inverter topology concept. Experimental results showed appropriate dynamic performance of the proposed controller in stand-alone mode as UPS, renewable energy conversion system or motor drive applications. Different changes in the load and DC bus voltage have been made intentionally during the tests to challenge the controller reaction in tracking the voltage and current references. Proposed controller demonstrated satisfying performance in fixing the capacitor voltage of the PUC inverter, generating seven-level voltage with low harmonic content at the output of the PUC inverter and ensures low switching frequency operation of those switches. By applying the designed controller on the 7-level PUC inverter it can be promised to have a multilevel converter with maximum voltage levels while using less active switches and DC sources aims at manufacturing a low-cost converter with high efficiency, low switching frequency, low power losses and also low harmonic contents without using any additional bulky filters.

Hani Vahedi et al.[6] "Five-Level Reduced-Switch-Count Boost PFC Rectifier with Multicarrier PWM", In this paper a reduced switch count 5-level boost PFC rectifier has been presented. A cascaded PI controller has been designed to regulate the output DC voltage and to ensure the unity power factor mode of the input AC voltage and current. Moreover, low harmonic AC current waveform has been achieved by the implemented controller and employing a small inductive filter at the input line. One of the main issues of switching rectifiers is the high switching frequency that has been reduced in this work using PWM technique through adopting multicarrier modulation scheme. Moreover, DC capacitors middle point has not been connected to the load that had required splitting the load to provide a neutral point. Using a single load with no neutral point makes this topology practical in real applications. Comprehensive experimental tests including change in the load, AC voltage fluctuation and generating different DC voltage values have been performed to ensure the good dynamic performance of the rectifier, adopted controller and switching technique. Moreover, the low THD of the input current has been measured to validate the advantage of multilevel waveforms in reducing harmonic contents and consequently diminishing the size of required filters at the input of the converters.

III. Buck PFC Rectifier

Driven by economic reasons and environmental concerns, maintaining high efficiency across the entire load and input voltage range of today's power supplies is in the forefront of customer's performance requirements.

At lower power levels, below 850W, the drawbacks of the universal-line boost PFC front-end may partly be overcome by implementing the PFC front-end with a buck topology. As it has been demonstrated the universal line buck PFC front end with an output voltage in the 80-V range maintains a high efficiency across the entire line range. In addition, a lower input voltage to the dc/dc output stage has beneficial effects on its light-load performance because lower voltage rated semiconductor devices can be used for the dc/dc stage and because lower input voltage reduces the loss and size of the transformer.

The buck PFC converter operation in both DCM and CCM mode whereas additional analysis and circuit refinements. Because the buck PFC converter does not shape the line current around the zero crossing of the line voltage, during the time intervals when the line voltage is lower than the output voltage. It exhibits increased total harmonic distortion (THD) and a lower power factor (PF) compared to its boost counterpart. As a result, in applications where IEC61000-3-2 and corresponding Japanese specifications (JIS-C-61000-3-2) need to be met, the buck converter PFC employment is limited to lower power levels.

A bridgeless buck PFC rectifier that further improves the low-line efficiency of the buck front end by reducing the conduction loss through minimization of the number of simultaneously conducting semiconductor components is introduced. Because the proposed bridgeless buck rectifier also works as a voltage doubler, it can be designed to meet harmonic limit specifications with an output voltage that is twice that of a conventional buck PFC rectifier.

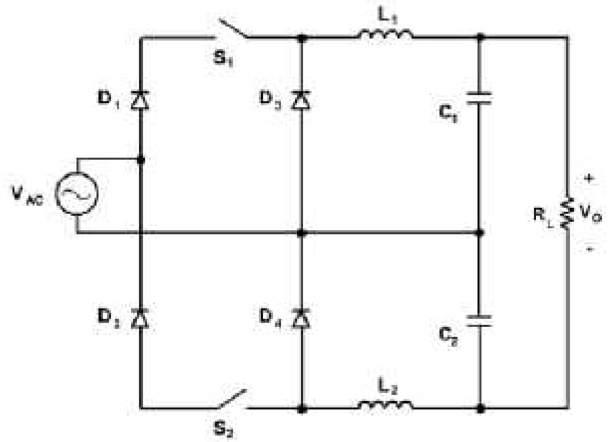

Fig.1 Bridgeless Buck PFC rectifier

IV. Conclusion

In this paper, study or survey of the multilevel multi output bidirectional active buck PFC rectifier. AC-DC conversion is now widely used in many applications like SMPS, ASD's battery charging unit etc. Multilevel converter is now use for producing low harmonics. This survey based on the new topology for AC-DC conversion with reduces number of switch. For completing of work firstly survey the literature of given in this paper. In this paper discuss the buck PFC rectifier. On the basis of this here proposed new topology for power factor correction. Here in this work a reduce number of switch is used for generation of 5 level boost converter. For conversion of AC-DC here required three switches.

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