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Design of Solar based Multilevel DC to DC Converter for High Voltage DC based Applications

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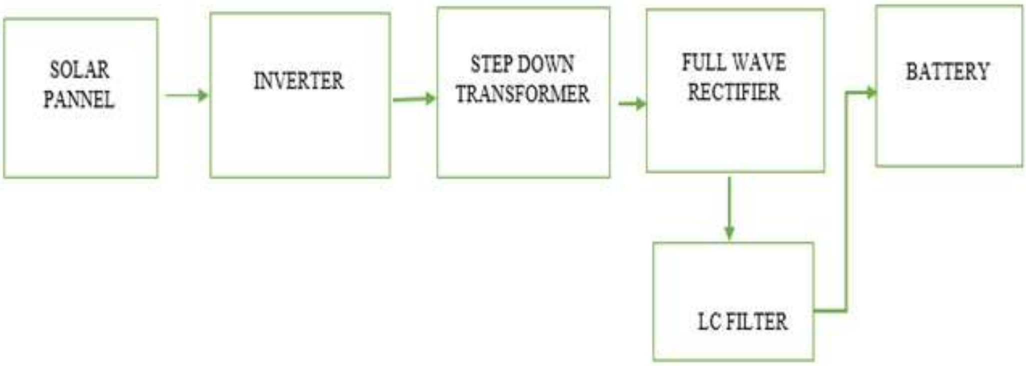
ABSTRACT:
This research paper is described about the designing procedure of charging station for electric vehicles using multilevel dc to dc converter. Multilevel dc to dc converter is precisely used for high power applications.Increasing awareness of global warming, energy shortages and environmental pollution have triggered people's attention in the field of vehicles. Exhaust emissions from traditional internal combustion engine vehicles are one of the main factors contributing to this calamity. The (PHEV -plug-in hybrid electric vehicle) is well-appointed with a large-capacity power battery package. There is aemergent interest in electric-powered transferencefor the reason that of problems such as depletion ofconservational problems and fossil fuel resources triggered by insideincineration engines. The market place for various kinds of small E-mobility devices (EMDs), like aelectric vehicles (EVs), E-bikes, Segways and mini-boards has been mountinghastily. Of these, the distribution of the small electric vehicles called personal mobility devices, which can reportcomplications such as ecological pollution and traffic disputes, is anticipated to gain impetus. Conversely, unlike the widely used charging stations for Electric Vehicles, charging systems forpersonal mobility devices PMDs are unsatisfactory. The paper has a tunnel look into the concept of the multilevel converters with scattered battery energy storage which requires the very high number of largest number of semiconductor devices for a high voltage and high power level; on the other hand, it also provides the better effective, reliability, optimistic and versatile resolution of battery energy-storage integration.
KEYWORDS: Electric vehicle, multilevel dc to dc converters, Charging station, Energy storage, Power conversion.

I. INTRODUCTION

In recent times, since of complications such as exhaustion of fossil fuel possessions and conservationalproblems, the unadventurousapproach to transportation power has been shifting from internal combustion engines to electricity. The 6.26-kV modular multilevel cascade Back To Back system categorized by the use of multiple bidirectional isolated dc/dc converters. Two sets of modular multilevel cascade PWM converters with low-voltage steps make a significant involvement to mitigating supply (line) harmonic currents and electromagnetic interference (EMI) emissions. Moreover, compact and light medium-frequency transformers in the dc/dc converters perform galvanic isolation between the two feeders, thus, resulting in no circulating zero sequence current.

A network of battery energy storage unit and power conversion systems are placed a crucial role in BESS installation. The article gives a full attention towards the Power Conversion System which is one of the component of a (three-phase Battery Energy Storage System),and it is assumed that aadvanced battery designing technology is used, such as, lead acid,sodium sulphuror lithium-ion batteries In a Battery Energy Storage System, energy requisite be transferred obsessed by and out of the battery. Thus, the entire reliability and overall power conversion efficiency of the Battery Energy Storage System–BESS are swooped and eventually this will leads to down in efficiency. For model, the(MMLC) modular multilevel dc to dc converter is figured to get an efficiency of just about 89.3% comparatively to 87.0% of a two-level Voltage Source Converter. Also mostly in the case of multilevel converter the series input series rectifier interleaved forward converter,dual active forward flyback converter and snubber circuits are used to get require voltage across the power converter switches.

As of yet, proper operation of the MMLC with distributed battery energy storage has not been demonstrated; therefore, simulation results are presented. The three converters are then assessed based on their efficiency, cost, module redundancy, and reliability. The main contribution of this paper is the presentation of the proper operation of an MMLC with distributed battery energy storage, and the identification and comparison of PCS topologies



Block diagram of multi-level DC to DC converter

which are modular, efficient, and increase the reliability of a BESS. The ultra-capacitors (UC)stores energy by physically separating positive and negative charges. The charges are stored on two parallel plates divided by an insulator. Since there are no chemical variations on the electrodes, therefore, UCs have a long cycle life but low energy density.

II. SOLAR PANNEL DESIGN

In the today's scenario the population level is extremely high ant it tends to meet peak level usage in fossil fuel vehicles. Because of that the air population becomes major issue across the world. on the other hand we end up meeting lot of health issue and at the same time the purity of the environment is also keep going on in the adverse manner . to mitigate those issues all are interested to use the renewable resource like solar array, thermal , wind power and so on . In this paper fully ponder towards the solar panel. This article has the solar input of 10kW power.

Parallel strings =33

Series strings = 19

$V_{oc} = 32.9$ V

$I_{sc} = 8.21$ A

$\Delta V_{oc} = 0.3699$ %/deg.c

$\Delta I_{sc} = 0.102$%/deg.c

$V_{mp} = 26.4$ A

From this combination of the parallel string and the series string the 600 V input voltage is obtained. This 600 V is directly fed to the input side capacitors namely C_1 and C_2.

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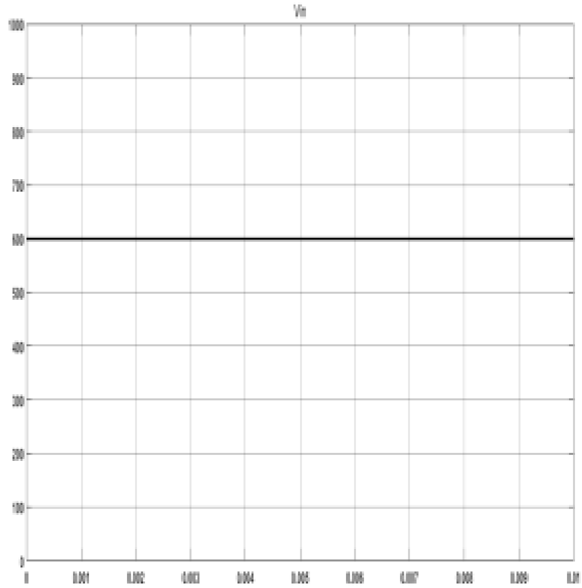
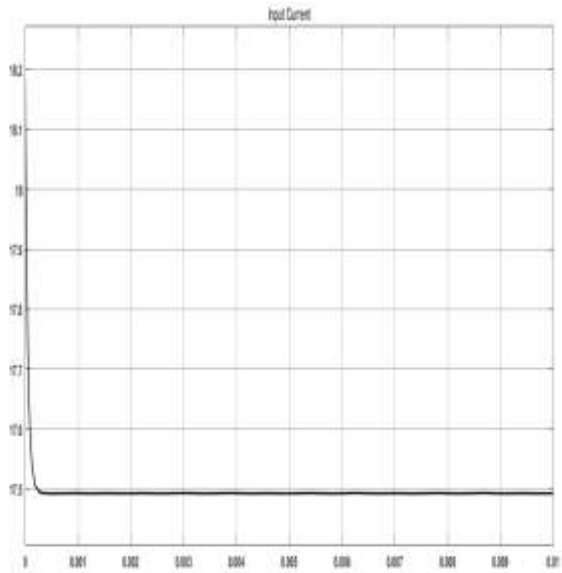


Input voltage waveform from the solar panel

From the solar panel the 600 v is dived equally by the two input side capacitors so the capacitor
C_1 has 300 V and also capacitor C_2 has the 300 V.

But the voltage across the capacitor has some harmonics. To prevent this unperfected issue the flying capacitor is after the two input side capacitor and it can also be connected in upper and lower side switches of the inverter.



Input current waveform from the solar panel

III. NPC-(NEUTRAL POINT CLAMPED) CONVERTER

For the unoriginal Neutral Point Clamping NPC converters with Pulse Width Modulation control, the nonstandard operation situation, such as the mismatch in the gate signals, may cause the some issues like voltage disproportion of the input capacitors. At the end of a result, the capability of the converter is impacted. Moreover, the phase shift control scheme is not suitable for the conventional Neutral Point Clamping converters, which front-runners to reach large switching losses out of neutral point clamping converter. The timing

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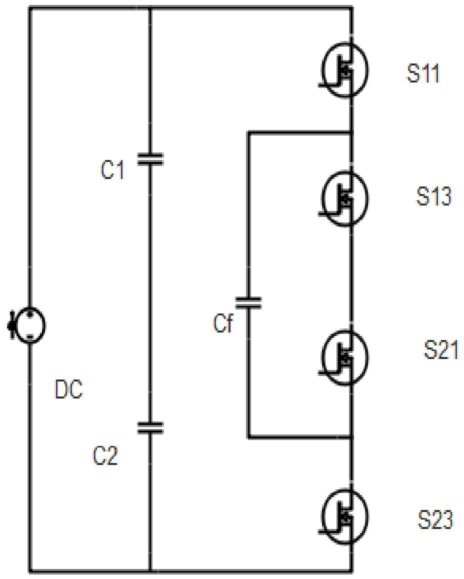
sequences of the leading leg is kept as a constant. Whereas the timing sequences of the lagging leg is altered. The main advantage that is the output voltage is to be regulated only by the shifting the time signal of the lagging bridge.In the cascaded full-bridge converter the lagging legs are still kept unmodified to be responsible for acceptable control freedom to accomplish the fast voltage regulation and also the accurate output voltage regulation. So the conclusion of the neutral point clamping circuit is it can be used along with the multilevel dc to dc cconverter for very high power applications, especially in electric vehicle application.



Providentially, by inserting a small flying capacitor parallel connected with the clamping diodes, the input capacitor voltages are automatically shared because the flying capacitor can be directly parallel with the series input capacitors alternatively.

IV. MULTILEVEL DC TO DC CONVERTER

Conservative modular multilevel converters (MMCs) are gifted converters for high-voltage high-power applications. Unlike DC–AC conversion, DC–DC conversion of MMCs grievesbeginningwell-balanced capacitor voltages owed to the energy implicationbadly-behaved. Modular DC to DC converter comprises of front-end half-bridge Modular Multilevel Converter with half-bridge sub modules monitored by full-bridge MMC with full-bridge replace modules. The(MMLC Modular Multilevel Converter) is gives the better isolation and better protection for the entire circuit. As for the multilevel dc to dc converter can't create any troubles on the voltage source side so it is called as trouble free voltage source.This can also be possible to provide numeral of detached voltage levels .The converter is preparedon or after the series association of Half Bridges. It consumes only one inductor for the entire converter.

That creates the converter as a distinguishing converter, not the series linking of converters as in cascaded converters. MMCs are mainly used in HVDC systems because its modularity allows high voltage levels.

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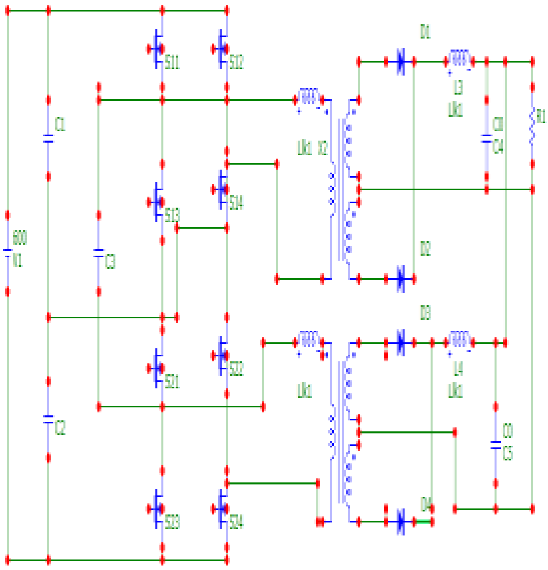


Multilevel dc to dc converter

The realistic application to High Voltage DC systems can be as an energy storage system. Numerous modulation strategies be present for this type of converters. Phase shifting modulation is used because it offers several advantages over others.The simple two stage DC to AC TO DC power conversion system is mostly used for the BESS (Battery Energy Storage System).by an auto-balance mechanism of the multilevel converter the voltage stress across the switch become half compare to other converter. The AC current that only mingles inside of the MMC is used to balance the energy between sub modules (SMs). Conversely, a high voltage conversion ratio will result in a high because of the increasing the value of the AC circulating current of the AC circuit the high rated value of power semiconductor switches are nessary and also this tends to meet a high losses on power.

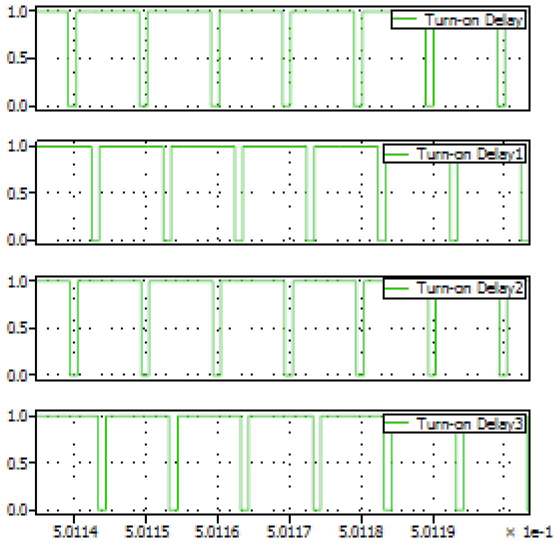
V. WORKING PRINCIPLE OF MMC

In the (MMC modular multilevel dc/dc converter) the secondary side of the transformer can be operated with current type model of full wave rectifier, we can also use the other advanced current type rectifier such as current doubler rectifier. For in this analysis the widespread suitable method of current type full wave rectifier is implemented. In the primary side of transformer three capacitors are implemented namely c_1, c_2 and filter out capacitors. Which are used for the different purposes. The first two capacitors are used to cut down the high level input voltage that may usually fed from a solar panel ,wind power generation, thermal power generation or any other renewable or non- renewable resources. In the multilevel converter two full bridge inverters are connected across the two capacitors c_1 and c_2 respectively. The filter out capacitor is used to reduce the harmonics that can be present in the input inverter side.

A. CONTROL TECHNIQUE

The précising control technique for this multilevel control converter is phase shift control method. In the first leg four switches are connected similar way in the second leg also having four switches. The first leg is called the leading legs and the second leg is called the lagging leg. There is some phase shift between positive and negative switches and this is called phase shift angle of the switches. In first mode switch one and three from upper level converter and switch one and switch three from lower level converters are in on stage. The phase angle between the positive and negative side converter is should be in limit within zero and the value of dead time. The angle difference should not be equal to exact zero in order to maintain the switching losses within the limit. Secondary side two diodes are used to convert the ac into full wave dc rectifier. In addition to that the flying capacitors are connected in each converter which are widely used to control or reduce the interferences that present in the output side of the inverter. The turns ratio of primary and secondary windings are placed a crucial role to attain the required value in the output side of the converter.

pulse sequences for the switches



B. AUTO BALANCE MECHANISIM

The input side voltage is in unsteady. The bitter truth of this multilevel dc to dc converter is unsteady condition of the input side voltage. That is also present in many multi-level converters and input-series output-parallel which is represented as (ISOP) converters, which is mainly caused by the unevenness of the component limitation difference and the divergence of regulator signals.One-stage systems are pretentious, integrating battery energy storage in a straight line on the dc link. so that the inverter can destructively impression system cost, efficiency and reliability. More overly battery voltage dissimilarities occur terminated time as a outcome of the storage systems of the electric vehicle (SOC)state of charge.

In aone-stage systems, the complete collection of voltage deviationshould be provide lodgings only by the grid-tied connected type of the inverter. To guarantee proper operation of the inverter under the condition of low state of charge the converter can also be activated with very high voltage level on the dc bus side. This may affect the output of the inverter so it creates a major issue on LC filter, also the cost will increase due to the additional filter circuit. Likewise, some of the modification are taken inbattery voltage of the string under when chargedand discharged services on the grid to tied inverter to be in the level of the over rated in terms of the output voltage, which definitely further increases the costs.in order to split very high input power from an any sources many no. of converters are connected .the harmonics of the output side is controlled by using LC filter.

VI. MODES OF OPERATIONS

Operation of mode I

The time period for mode I is($t_0$to t_1)

Before enter into t_1, the switches $S_{11}, S_{14}, S_{21}, S_{24}$ are in the turn-on state condition so that the entire power is to be delivered to the secondary side. The output side diodesD_{011} and D_{021} are conducted and the output side diode D_{012} and D_{022} are reverse-biased condition.the primary currents as expressed as below,

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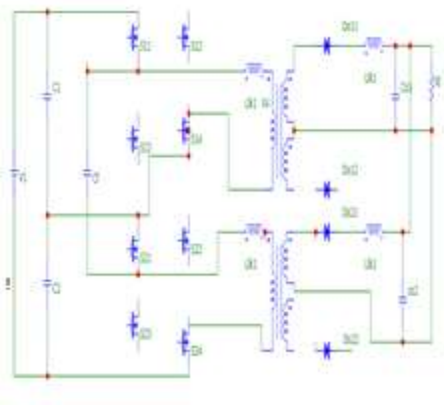
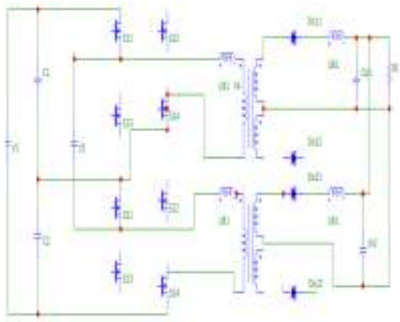


$$i_{p1} = i_{p1} + \frac{(V_{in}/2) - NV_{out}}{L_{lk1} + N^2 L_{f1}}(t - t_0) \quad (1)$$

$$i_{p2} = i_{p2} + \frac{(V_{in}/2) - NV_{out}}{L_{lk2} + N^2 L_{f2}}(t - t_0) \quad (2)$$

Operation of mode II

At the time of t1, the turn-off signals of the switches S_{11} and S_{21} are given. Zero Voltage Switching turn-off for these two switches are accomplished by the capacitors C_{s11} and C_{s21}. In mode II C_{s11} and C_{s21} are charged and C_{s13} and C_{s23} are discharged only by the primary currents.



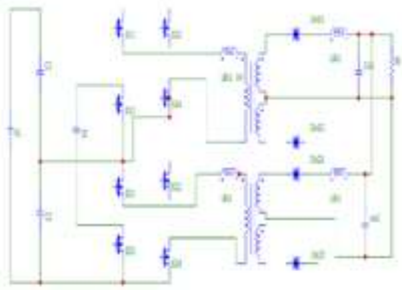
Operation of mode III

At the time period of t_2, the voltages ofacros the C_{s13} and C_{s23} reach to zero and the diodes of S_{13} and S_{23} are conducted, which given that the Zero Voltage Switching turn-on condition for the switches of S_{13} and S_{23}.

The expression for primary carrent is,

$$i_{p1} = \frac{i_{s1}}{N1} \quad (3)$$

$$i_{p2} = \frac{i_{s2}}{N2} \quad (4)$$



Where N is the no. of turns of the transformer windings.

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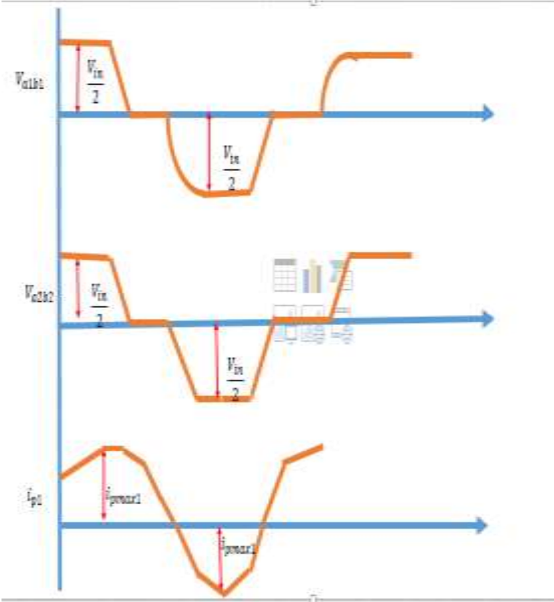
Operation of mode IV

At the time of t_3, switch S_{14} turns off with the condition of ZVS. The capacitor C_{s14} is charged and the capacitor C_{s12} is discharged, prominent to the forward-bias condition ofthe D_{012}, henceforth the secondary side current is flows freely through both the diodes of D_{011} and D_{012}.

$$i_{p1} = i_{p1}(t_3)\cos\omega(t - t_3) \quad (5)$$

$$\omega = \frac{1}{\sqrt{2L_{lk1}C_s}} \quad (6)$$



Voltage and Current Waveforms

The above waveform is illustrate the output voltage at the inverter side of the upper and lower modular multilevel converter. The third wave forms express the primary side current under the all modes of operation.

ADVANTAGES

i)Foremost main advantage is the voltage stresses on the switches on the primary side is only half of the input voltage due to the series structure and the input voltage auto-balance mechanism.

ii) Zero Voltage switching of soft-switching performance is succeeded for each and every power switches without any extra active or passive components due to the phase shift control scheme.

iii) The auto-balance mechanism of the input voltage is achieved only by using the flying capacitor without any secondary circuits or difficult control techniques.

iv) The modular organization of the projected converter make available the opportunity of truly modular system with the possibilities of extended N-stage modules to challenge with higher level of input voltage.

VII. RESULT

I have designed a 10kw charging station which is used to deliver the power to the Battery Energy Storage System. The power from the BESS is fed to the different electric vehicles by using varies type of dc to dc converter such as, buck ,boost ,buck boost, cuck, interleaved converter, dc to dc full bridge dc to dc converter, etc. in different power applications.

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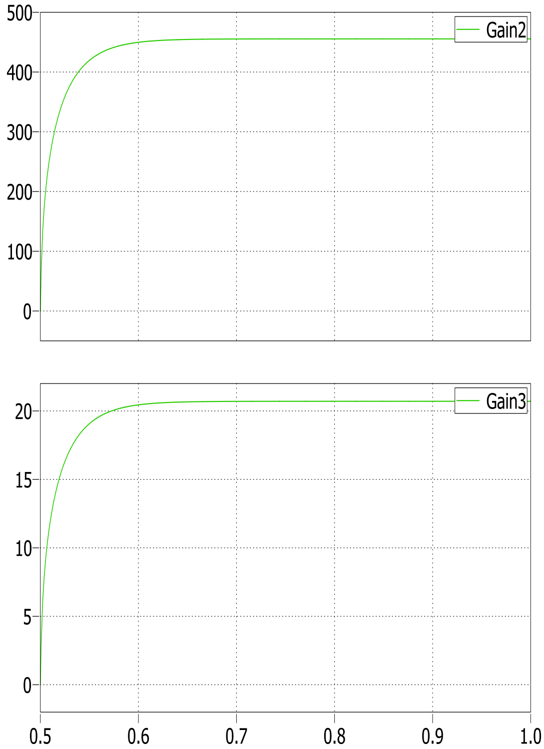

Output voltage and output current waveform of multilevel converter

In this analysis, a multilevel or multiport modular multilevel DC to DC converter performances are analysed, which can have the only one high voltage port but it has more number of low voltage ports on th e output side. As we all known that the power can also flow from the side of the high voltage to the side of the low voltage or else in the opposing direction. Precisely, the circulating current value has very small value specifically in the case of high voltage transformation ratio applications. The very high value of inductor also disregarded, which usually barricades the AC apparatuses from offering at the low voltage on DC side.

VIII. CONCLUSION

Looking into back this project, the overall control techniques for multilevel dc to dc converter is analysed. The operation of multi-level cascaded PV system under different functioning conditions was thoroughly investigated. The modular multilevel DC/DC converter concept can be easily outspread to N-stage converter with stacked full-bridge modules to fulfil extremely high voltage performances with low voltage rated power switches. It is anticipated for putting in place on the 6.3-kV power spreading systems in which the Back To Back system choices from 500 to 1,000 kW. By developing a technology with a structure that shares power by subdividing the power supply, we propose a single charging system with a very wide range of charging voltage that can fulfil the charging inevitabilities such as the current ripple and voltage ripple of various types of E-mobility apparatus batteries, and anbest switching practice to function the system.

REFERENCES

[1]. A. Watson, H. Dang, P. Wheeler, J. Clare, G. Mondal, S. Kenzelmann, A. Rufer, and Y. De Novaes, “Control challenges and solutions for a multicellular converter for use in electricity networks,” EPE J., vol 19, no. 4, pp. 2232–2238, Dec. 2009.

[2]. W. Li, P. Li, H. Yang and X. He, “Three-Level Forward Flyback Phase-Shift ZVS Converter With Integrated Series-Connected Coupled Inductors,” IEEE Trans. Power Electron., vol. 27, No. 6, pp. 2846-2856, Jun 2012.

[3]. L. Maharjan, S. Inoue, and H. Akagi, “The next-generation 6.6-kV BTB (back-to-back) system based on the bidirectional isolated dc–dc converters,” in Proc. IEEJ-IAS Annu. Meeting, 2006, pp. 327–332.

International Journal of Advances in Engineering and Management (IJAEM)
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[4]. A. Emadi and S. S. Williamson, “Fuel cell based vehicles: opportunities and challenges,” IEEE Power Engineering Society General Meeting, pp. 1640-1645, 2004.
[5]. J. Marshall and M. Kazerani, “Design of an efficient fuel cell electric vehicle drive train, featuring a novel boost converter,” IEEE Industrial Electronics Conference, 2005.
[6]. Y. R. de Novaes, A. Rufer, and I. Barbi, “A new quadratic, three-level, dc to dc converter suitable for fuel cell based applications,” IEEE Power Conversion Conference, pp.601-607, 2007.
[7]. M. Winkelnkemper, , and P. Steimer, “A modular multilevel direct converter for transformerless rail intertial applications,” in Proc. IEEE Int. Symp. Ind. Electron., Jul. 2010, pp. 562–567.
[8]. H. Kiyotake, H. Okada, K. Ishizaka, and R. Itoh, “Single-phase voltage-doubler rectifier using a capacitive energy storage/transfer mechanism,” IEE-Electric Power Applications, vol. 150, no. 1, pp. 81-87, Jan. 2003.
[9]. A. Watson, H. Dang, P. Wheeler, J. Clare, G. Mondal, S. Kenzelmann, A. Rufer, and Y. De Novaes, “Control challenges and solutions for a multicellular converter for use in electricity networks,” EPE J., vol 19, no. 4, pp. 2232–2238, Dec. 2009.
[10]. T. T. Sun, H. S. H. Chung and A. Ioinovici, “A High-Voltage DC-DC Converter With Vin/3—Voltage Stress on the Primary Switches,” IEEE Trans. Power Electron., vol. 22, No. 6, pp. 2124-2137, Nov 2007.
[11]. Y. Jang and M. M. Jovanovic, “Interleaved boost converter with intrinsic voltage-doubler characteristic for universal-line PFC front end,” IEEE Trans. Power Electronics, vol. 22, no. 4, pp. 1394-1401. July 2007.
[12]. M. Bragard, N. Soltau, S. Thomas, and R. W. D. Doncker, “The balance of renewable sources and user demands in grids: Power electronics for modular battery energy storage systems,” IEEE Trans. Power Electron., vol. 25, no. 12, pp. 3049–3056, Dec. 2010.
[13]. H. Stemmler, “State of the art and future trends in high power electronics,” in Proc. Int. Power Electron. Conf. (IPEC), vol. 1, Tokyo, Japan, 2000, pp. 4–143.
[14]. L. Maharjan, S. Inoue, H. Akagi, and J. Asakura, “State-of-charge (SOC)- balancing control of a battery energy storage system based on a cascade PWM converter,” IEEE Trans. Power Electron., vol. 26, no. 6, pp. 1628– 1636, Jun. 2009.
[15]. B. R. Lin and C. H. Chao, “Analysis of an Interleaved Three-Level ZVS Converter With Series-Connected Transformers,” IEEE Trans. Power Electron., vol. 28, No. 7, pp. 3088-3099, Jul 2013.
[16]. M. Winkelnkemper, A. Korn, and P. Steimer, “A modular direct converter for transformerless rail interties,” in Proc. IEEE Int. Symp. Ind. Electron., Jul. 2010, pp. 562–567.