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DC-AC Converter for Grid Connected Electric Vehicles

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ABSTRACT: Electric transportation has gained a great deal of interest within the transport sector because of its great potential to become a low-carbon substitute for conventional combustion engine vehicles. But the widespread use of this form of transportation, such as plug-in electric vehicles (PEVs), will cause a significant draw on power grids, especially when connected with uncontrolled charging schemes. In fact, electric utilities are not able to control individual PEVs so as to manage their charging and avoid negative consequences for distribution lines. Motivated by this background, hybrid type converter that can be used for electric vehicle. PV output is efficiently boost using a Flying Capacitor Converter (FCC) is supplying the DC voltage to the charging station in a renewable source, AC voltage to the inverter should be reduced THD also have to be constant and not affected by any voltage fluctuations. The proposed system mainly aims in this area due to any undesirable changes in grid can affect the whole system to be damaged. Dynamic Voltage Restorer DVR in the proposed system keep inverter voltage controlled. Moreover the converter reduces the Total Harmonic Distortion (THD) also the switching losses. A simulation of the proposed system is modelled and evaluated with desirable results in MATLAB/Simulink.

KEYWORDS: Flying Capacitor converter FCC, Plug in electric vehicle, Total Harmonic Distortion (THD), Dynamic Voltage Restorer (DVR).

I. INTRODUCTION

With the aim of creating a sustainable society, vehicle fuel economy standards are becoming progressively tighter every year in order to reduce carbon dioxide (CO₂) emissions. It is expected that the proportion of the total market accounted for by electric vehicles (EVs) and hybrid electric vehicles (HEVs) will grow significantly by 2020. HEVs have great commercial aspect in a variety of forms. There has been demand in recent years to increase the output and reduce the size of inverters so that they can fit into the limited space available in vehicles.

Recent years, photovoltaic (PV) systems have been actively researched as a sustainable power solution. As a result, the world global market installation reached a record high of 277 GW in 2015. In order to use the generated power by PV panels, power converter systems (PCSs) are used to connect the PV system to the single-phase AC grid. These PCSs require the following capabilities: (1) high efficiency power conversion, (2) “plug and play” operation, (3) maintenance free, and (4) small packaging design.

On the other hand, double-line-frequency power ripple occurs in the DC side due to the single-phase AC grid. This power ripple leads to a decrease in a performance of the maximum power point tracking (MPPT). Therefore, a bulky electrolytic capacitor is usually required in the DC link in order to absorb the power ripple i.e., a passive power decoupling method is used. However, the electrolytic capacitor limits the life-time of the power converter according to the Arrhenius law. This paper proposes a novel active power decoupling method based on the FCC. The original contribution of the present paper is that active power.

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De-coupling control is achieved using a typical DC/DC converter without any additional components in order to reduce the volume, cost, and converter loss. In the paper, a multi-level DC/DC converter that has capacitive storage is focused. Originally, the FCC has a small flying capacitor in order to achieve a high boost ratio. The proposed control uses this capacitor for both boost operation and double-line- frequency power ripple compensation. Voltage source inverter fed with DC gives synchronized AC voltage with grid system using Dynamic voltage restorer.

An electric vehicle consist of a battery bank which stores energy. Charging stations are used to charge the electric vehicles namely ac charging stations and dc charging stations. The 'on board' chargers are charged using alternating current which is used in most electric vehicles, and they are transformed into DC and stored in the battery bank. AC can be transformed into DC, which then bypasses the onboard charger of electric vehicle and send this direct current directly, is used in DC charging stations. Automotive inverters are able to accelerate or decelerate the vehicle by converting the DC power from the batteries to alternating current (AC) at the frequency required for vehicle speed and other systems control the electric motor speed, drive torque, and power. The performance requirements for these electric drive systems for HEVs and EVs are small size (important for ensuring that the system can be installed in the vehicle), high efficiency to extend EV range, high output to provide suitable acceleration performance, and reliability to operate in the harsh environment inside a vehicle.

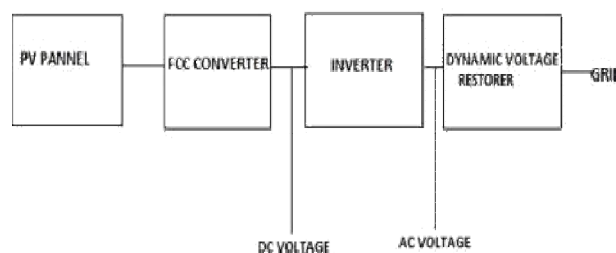


Fig. 1 Block diagram of proposed system

II. SYSTEM DESCRIPTION

The proposed configuration consist of three sections, a dc-dc converter, a voltage source half bridge inverter and Dynamic Voltage Restorer connected to the AC grid system. Flying Capacitor Converter in the system gives high boost voltage of PV voltage with reduced ripples. Half bridge inverter gives stabilized AC voltage for any voltage sag or swell conditions on the grid voltage with aid of DVR.

1. Flying Capacitor Converter

Fig. 2(a) describes the DC to single-phase AC grid-connected converter with the FCC, which is used in the proposed active power decoupling. In the proposed method, the small flying capacitor C_{fc} is used for both the boost operation of the PV input voltage V_{in} and the active power decoupling. The FCC has many advantages compared to the typical boost converter. First, the low voltage rating devices, which have low on- resistance, can be used because the drain-source voltage of each MOSFET can be reduced due to the increase in the number of levels, i.e., the characteristic of the multi-level topology. Therefore, low conduction loss can be achieved. In addition, the volume of the boost inductor L_{fc} is small compared to that of the typical boost converter. In the typical boost converter, the inductor voltage alternates between zero voltage and the DC link voltage. On the other hand, the maximum inductor voltage of FCC converter can be reduced in comparison with typical boost converter because the inductor voltage is clamped to the flying capacitor voltage and the difference value between the DC link voltage and the flying capacitor voltage. In other words, in the typical boost converter, the boost operation is achieved by only the boost inductor whereas in the FCC converters (even when the proposed method is applied) the boost operation is achieved by both the boost inductor and the flying capacitor. As a result, the inductor current ripple in the FCC converters becomes low in comparison with the typical boost converter.

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2. Voltage Source Inverter

Half-bridge VSI, requires two large capacitors to provide a neutral point N, such that each capacitor maintains a constant voltage $/2$. Lower order current harmonics are induced because of the operation of the inverter, a set of large capacitors (C+ and C-) is required. It requires a two controllable switch like, MOSFET. The commonly used switching frequency is in the range of 100 kHz. The input to the inverter is boosted dc voltage with triggered gate pulses from feed backed DVR.

3. Dynamic Voltage Restorer

The primary function of a DVR is preventing the effect of voltage sags/swells on sensitive loads connected to the network. Therefore as shown in the Fig. 2(c), the DVR is located near the sensitive loads. If a voltage disturbance occurs in the line, DVR injects a series voltage V_{DVR} thus compensating load voltage to a reference value. The three injected phase voltages momentary amplitudes are controlled to eliminate detrimental effects of actual voltage to the load voltage V_L . This ensures that any differential voltages caused by transient disturbances in the ac feeder will be compensated by an equivalent voltage injected through the injection transformer, generated by the converter.

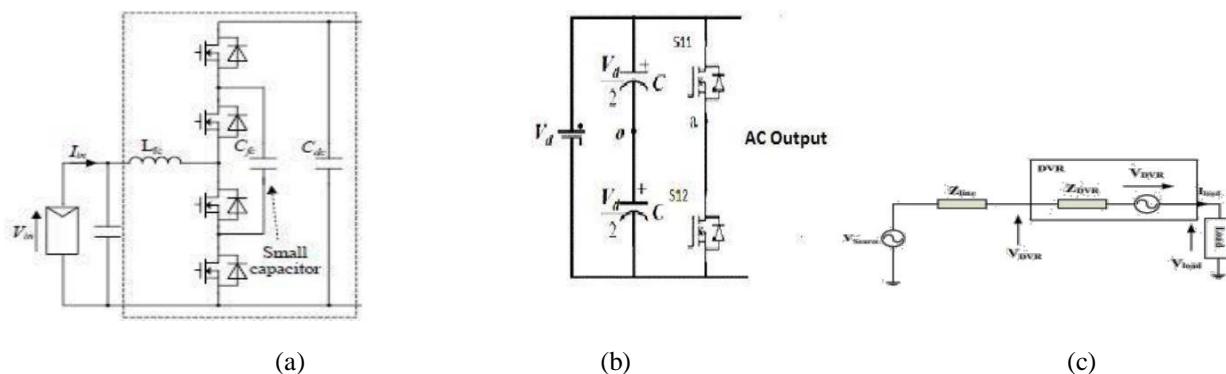


Fig. 2. System description (a) Flying Capacitor Converter (b) Voltage Source Inverter (c) Dynamic Voltage Restorer

III. PROPOSED SYSTEM

The figure shows the Flying Capacitor Converter (FCC). The FCC have more advantage than the normal type of converters, because using a switched capacitor arrangement with negligible inductance value. The boosted DC output voltage is linked to a capacitor in order to filter out and pass to next stage of conversion. DC voltage can be supplied to electric vehicle charging board. Next stage is the DC to AC conversion using the Half Bridge Voltage Source Inverter. The number of switches is reduced from a normal inverter in sense of using DVR. The VSI connected to a grid system with DVR. In any voltage fluctuation condition on the grid system, the VSI supplying a constant and stable AC voltage to the load of inverter. This reduces harmonic voltage from the grid connected inverter can supplied to the electric vehicle plug in stage. FCC and VSI are controlled through the controlling algorithm shown in Fig.3. A single infrastructure can be used in plug in electric vehicle with AC and DC charging conditions.

IV. CONTROL OF THE PROPOSED SYSTEM

1. FCC Control Strategy

Fig. 3(a) shows the control of the FCC. In proposed control an automatic voltage regulator (AVR) and automatic current regulator (ACR) is used to control the active power decoupling.

2. DVR Control Strategy

The functions of a DVR are: detection of voltage sag/swell conditions in the system and the correcting voltage. It is done by generating gate pulses to the sinusoidal PWM generator. Also the correction of any voltage change make in the series voltage injection and cancellation of gate pulses when the difference has done. It may also be used to shift the DC-AC inverter to rectifier operation to charge the capacitors. The control is based on the dq0 transformation. This method gives length of the sag and phase shift starting and sending times the disturbance. The obtained parameters are expressed as instantaneous space vectors Firstly convert the voltage from a- b-c reference to d-q-0 reference. For simpler zero phase sequence components are negated. Fig. 6 shows the block diagram of transformation for voltage sags/swells detection. The detection is carried out in every three phase's .The control scheme for system based by comparing of reference and the actual voltages from the load side of the system. Voltage sag of the system is detected when actual voltage dip below 90% of the reference value and swell condition is detected when voltage increases 25%. Error signal between actual and reference voltage is used for the modulation signal, to make a commutation for the switches (IGBT's) which makes voltage source converter (VSC). Sinusoidal Pulse Width Modulation (SPWM) employs the switching pattern in the system. The voltage magnitude and angle are controlled through this modulation. The PLL circuit is shown in Fig. 3(b) is used to generate sinusoidal wave.

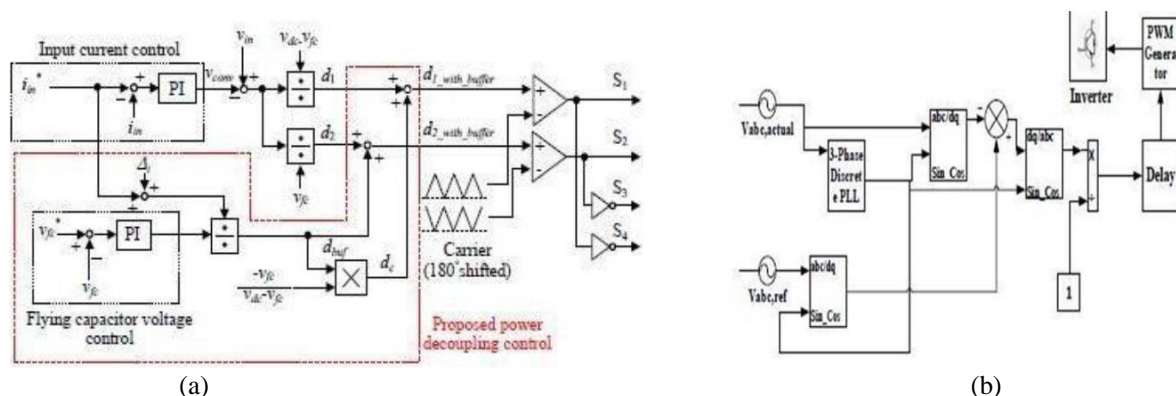


Fig. 3. Control of the proposed system (a) FCC Control Strategy (b) DVR Control

V. SIMULATION RESULTS

The system is modelled and evaluated in MATLAB/Simulink. The proposed system has been simulated for PV input of 200V and the system is obtained a boost voltage of double the input voltage. An RL load (load resistance and inductance $R_L = 100 \, \Omega$ and $L_L = 30 \, \mu H$, respectively) is used. Three transformers supplying three different grid voltages are used to produce the voltage fluctuation at a phase delay 0.006 seconds. The switching is done at 25KHz. A sinusoidal voltage 300 volts is obtained with THD less than 5 percentage. Fig. 4(a) shows the inverter source voltage and the grid system

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fluctuations for a sag and swell Condition. Fig. 4(b) shows the Boosted DC voltage of the FCC for an input of 200V from the PV panel. It is obtaining a sinusoidal stabilized voltage of 300V.

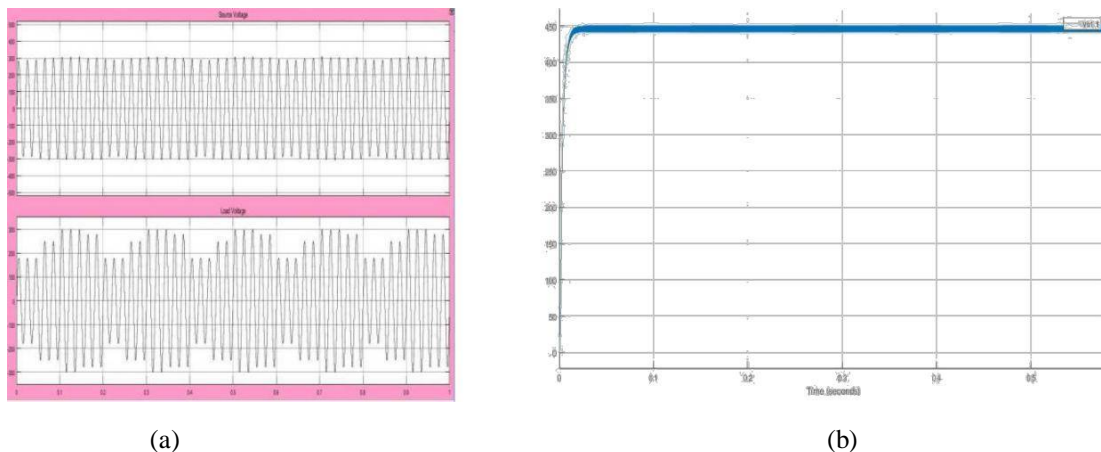


Fig. 4. Simulation results (a) Voltage comparison (b) Simulation result of boosted DC voltage of the FCC

VI. CONCLUSION

The proposed dc to ac converter topology generates a stabilized ac output voltage with reduced voltage harmonics and a high boost output DC voltage for charging. The Flying Capacitor Converter utilizes solar energy from PV to generate stabilized dc output voltage with ripple free. The ac voltage stabilization is performed by the Dynamic Voltage Restorer stage which inject a sinusoidal voltage corresponds to the sag and swell in AC grid. The proposed topology can be employed to dc charging station from the view of utilization of renewable source as well as the plug in for electric vehicle into a unified charging infrastructure which makes the proposed system cost-effective and life time. The proposed topology reduces the THD less than 5% of the ac output voltage. The proposed system is simulated for different conditions.

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