# Reduction of Harmonics in Three Phase Solar Power Grid by A Five-Level Voltage Fed Inverter

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**ABSTRACT:** This Paper proposes a system comprises ofcentral five-level voltage-fed inverter (VFI) and a large number of PV modules with module-integrated DC-DC converter. This paper Introduces a system of converters for the integration of a large Photo Voltaic (PV) plant with a utility AC grid. The five-level VFI consists of three three-phase, three-level VFI units connected in parallel on the AC-side. This paper also proposes a new solar power generation system, which is composed of a DC/DC & DC/AC power converter and a new five-level inverter. Five level converts fed with PV modules provide a viable solution to mitigating harmonic related issues caused by diode or thyristor rectifier front-ends. This new five-level inverter is configured using a capacitor selection circuit and a full-bridge power converter, connected in cascade. Five level topology can also produce five voltage levels, which significantly reduces the switching current ripple and the size of passive components. The performance of the proposed power converters system is studied using MATLAB/Simulink.

**Keywords:** Photo Voltaic cell, voltage fed inverter, PWM, Renewable energy, dc-dc converter.

## I. INTRODUCTION

To ADDRESS the ever-increasing demand for energy and the urgent environmental impact issues caused by human activities related to energy production and consumption, one of the most promising solutions is to utilise non-conventional energy sources.With the rapid consumption of fossil energy resources and the deterioration of ecological environment, especially the global climate change caused by greenhouse gas emissions, sustainable development of human society is confronted with serious threats. The development and the use of renewable energy have drawn extensive attention of the international society. Many countries have made definite development goals and carried out policies and regulations for renewable energy. These policies and regulations will guarantee the boost of renewable energy technology and realize the diversification of energy.Solarenergy, as a type of renewable energy, is widely applied in manufacturing and living activities.Mostplants are built this way due to a number of economic, health & safety, logistical, environmental, geographical and geological factors. For example, coal power plants are built away from cities to prevent their heavy air pollution from affecting the populace. In addition, such plants are often built near collieries to minimize the cost of transporting coal. Hydroelectric plants are by their nature limited to operating at sites with sufficient water flow. Most power plants are often considered to be too far away for their waste heat to be used for heating purposes.But these are not the things occurred in case of solar energy consumption.

In recent years, multilevel over traditional two-level converters, especially for high-power and high-voltage applications. In addition to their superior output voltage quality, they can also reduce voltage stress across switching devices. Since the output voltages have multiple levels, lower $dv/dt$ is achieved, which greatly alleviates electromagnetic interference problems due to high-frequency switching.

## II. Principal of operation three-phase three-level Inverter

A three-level inverter to ascertain the differences between it and a conventional two-level inverter [1]. For a three-phase three-level inverter, a structure similar to that used with 12 electronic devices (IGBT) is needed (Fig.2.1). Each phase will switch across three voltage levels ($+V_{dc}/2$, 0, and $-V_{dc}/2$). In a structure such as this the maximum voltage across the IGBT is limited to half the maximum dc link voltage ($V_{dc}/2$). This occurs because the IGBTs are connected to the neutral point (MP) by two fast diodes called neutral clamp diodes.

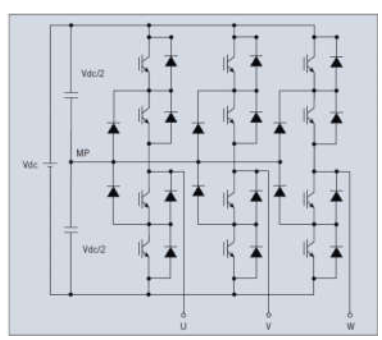


Fig.2.1 Three-phase three-level inverter topology, in which each phase switches across three voltage levels.

Three-phase two-level-inverter (PWM)-generation algorithms can also be applied to multilevel inverters. The algorithms with a triangular carrier waveform produce the best benefits in terms of harmonic distortion reduction, i.e. a three-level inverter needs both a carrier and a reference. In this case the number of triangular carriers is equal to L-1, where L is the number of voltage levels. For a three-phase three-level inverter this means that two triangular carriers and one sinusoidal reference are needed. Three alternative PWM strategies with differing phase relationships can be used for a three-level inverter: Alternative phase-opposition disposition (APOD), where carriers in adjacent bands are phase-shifted by 180°.

## III. Three-Level Inverter Benefits

Phase-opposition dispositions (POD), where the carriers above the reference zero point are 180° out of phase with those below zero. Phase disposition (PD), where all carriers are in phase across all bands. PD strategy is used most frequently because it produces minimum harmonic distortion for the line-to-line output voltage. Triangular carriers and sinusoidal reference profiles, as well as IGBT and NCD current profiles, are shown in Fig.3.1.

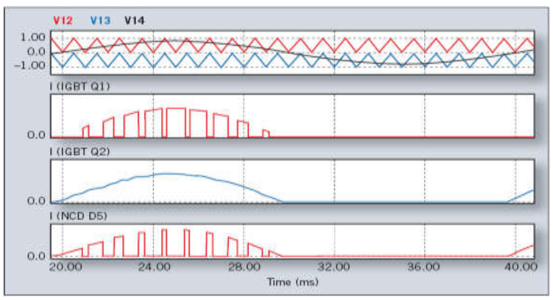


Fig. 3.1- Phase disposition (PD) three-level inverter, where all carriers are in phase across all bands and currents profiles.

A three-level inverter appears to comprise highly complex circuitry compared with a two-level inverter. The resulting technical and economic advantages, however, are the reasons why the use of three-level inverters is strongly recommended.

A three-level inverter features an IGBT with a lower reverse-blocking voltage: 600 V instead of 1,200 V. The 600-V chips are normally faster and thinner than 1,200-V chips. The Silicon in a three-level inverter therefore has lower switching losses and a lower forward-voltage drop; the total losses per single arm of the three-level inverter are 60% lower than those of the two-level inverter. Q2 and Q3 switching losses are negligible. D1 and D4 diodes carry a very low current value since the current of Q1 commutes to D5; the current of Q4 commutes to D6, and the current of Q2 commutes to Q3. Clamp diodes carry the full load current Fig.3.2. As shown below.

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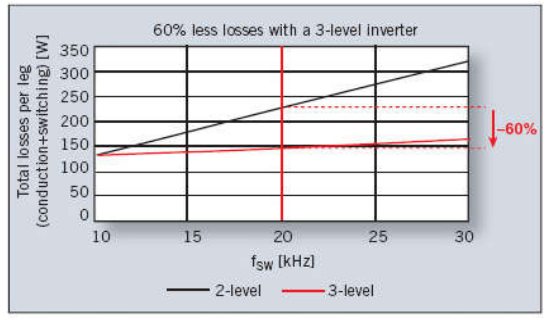


Fig.3 2Overall losses as a function of the switching frequency for a single inverter leg

## IV. Voltage Source Inverter

**IV.1. Single-Phase Voltage Source Inverters :**

Single-phase voltage source inverters (VSIs) can be found as half-bridge and full-bridge topologies. Although the power range they cover is the low one, they are widely used in power supplies, single-phase UPSs, and currently to form elaborate high-power static power topologies, such as for instance, the multi cell configurations . The main features of both approaches are reviewed and presented in the following.

**IV.2. Half-Bridge VSI :**

Figure 4.1shows the power topology of a half-bridge VSI, where two large capacitors are required to provide a neutral point N, such that each capacitor maintains a constant voltage vi=2. Because the current harmonics injected by the operation of the inverter are low-order harmonics, a set of large capacitors (C. and Cÿ) is required. It is clear that both switches S. and Sÿ cannot be on simultaneously because a short circuit across the dc link voltage source vi would be produced. There are two defined (states 1 and 2) and one undefined (state 3) switch state as shown in Table . In order to avoid the short circuit across the dc bus and the undefined ac output voltage condition, the modulating technique should always ensure that at any instant either the top or the bottom switch of the inverter leg is on.

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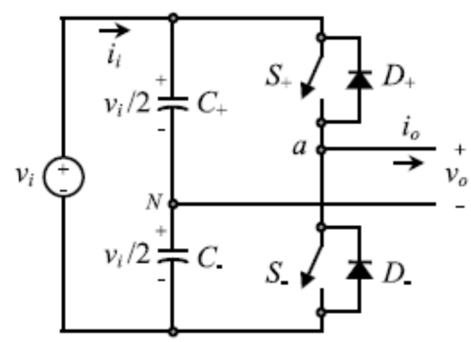


Fig.4.1 Single-phase half-bridge VSI

**TABLE:** Switch states for a half-bridge single-phase VSI

| state | state | $v$ | Components conducting |
|---|---|---|---|
| + is on and – is off | 1 | $v/2$ | + if > 0, + if < 0 |
| - is on and + is off | 2 | $-v/2$ | - if > 0, - if < 0 |
| + and – are all off | 3 | $-v/2, v/2$ | - if > 0, + if < 0 |

## V. SIMULATION & APPLICATION RESULTS

**SIMULATION RESULTS:**

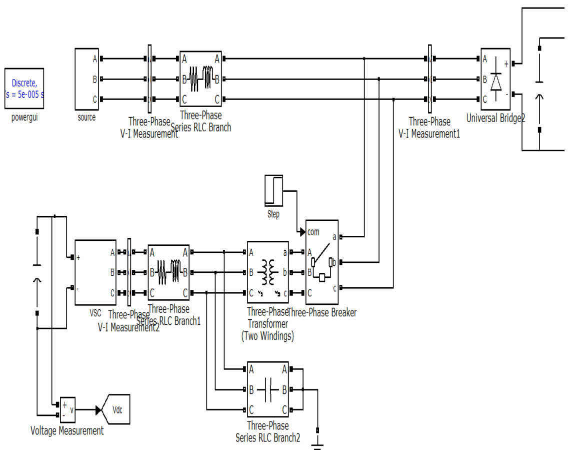


Fig.5.1 Proposed five level Circuit

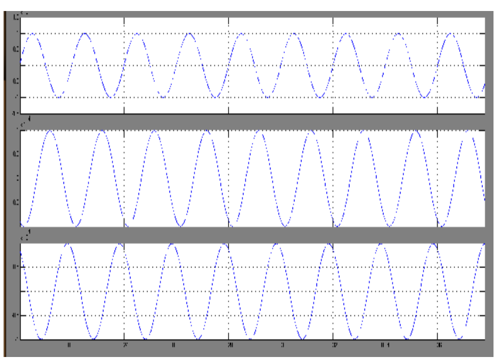

FIG.5.2 Balanced Voltages with Five Level Converter

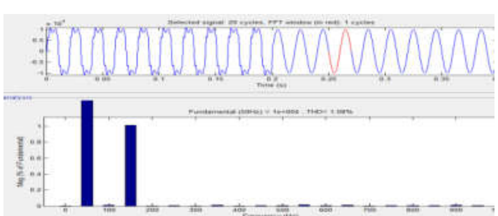

Fig.5.3 THD analysis of balanced voltages with five level converter

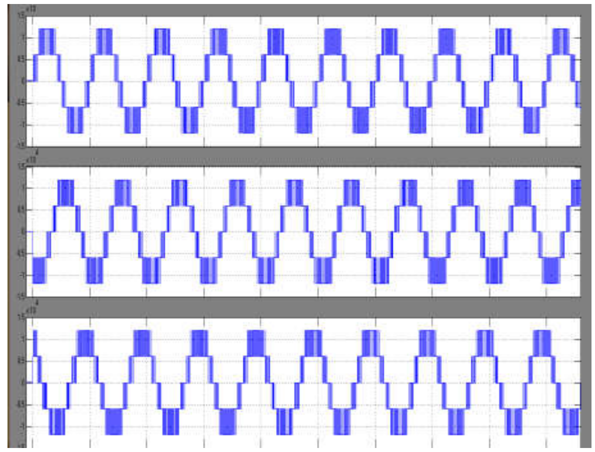

Fig.6 Five Level Voltages of Proposed Converter

## CONCLUSION

This paper has presented "A New topology of Single-Phase [5] Five-Level [6] Inverter with Less Number of Power Elements for Grid [4] Connection". The control technique is pulse generation for switches in the proposed inverter. All switches in proposed inverter operated with fundamental frequency. So, switching losses and THD value are low in the proposed inverter. The future scope is photovoltaic arrays, fuel cells used in this proposed inverter. The details of the high-level control as well as the switching control have been presented. The proposed five level has been validated for a power grid [4] power system using detailed simulation.

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