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**CHARGE SYSTEM ON ENERGY-SAVING CONFIGURATION BY SMART  
CHARGE MANAGEMENT USING PHOTOVOLTAIC BURP : A STUDY**

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**ABSTRACT**

To achieve pulse charge using direct photovoltaic (PV) energy, it is necessary to keep the energy supply from PV module continuous and optimum, especially to prevent energy supply from interrupting during the pulse break period. To perform the mentioned idea, a PV burp charge system (PV-BCS) proposed is to make PV energy pump continuous with optimum maximum power point tracking (MPPT), which increases the PV utilization, and to dispatch the remaining PV energy for further storage in the pulse break period. A smart charging management (CM) presents three kinds of charge statuses, a burp pulse (BP) charge and two pulse charges, which charges three batteries, Bm, B1, and B2 concurrently and individually. The two pulse charges provided are for accompanying the BP charge in order to keep the PV energy supply continuous and cherish the remaining energy for further storage. The BP charge for Bm is composed of a positive pulse (PP) charge in a positive burp pulse (PBP) period and negative pulse (NP) charge in non-PBP period. The other two batteries B1 and B2 are always with PP charge in the non-PBP period, in which B1 charges the remaining PV energy to keep the PV energy supply continuous, realizing the energy treasuring concept; B2 charges the discharge amount from Bm by intensely discharging, which indeed is equivalent to the NP charge, achieving the energy recovery concept. A laboratory prototype, 250-W PV-BCS, with elaborated simulation and experiment demonstrates the proposed concurrent charging idea, which is feasible for conceiving an energy-saving concept, especially applicable in a large-scale energy management for such as battery exchange station to electric vehicle service. In addition, the PV-BCS can be further as a hybrid charger for renewable energy application if additional renewable energy is mixed with the PV energy, such as wind energy.

**Keywords:** Photovoltaic Burp Charge System (PV-BCS), Maximum Power Point Tracking (MPPT), Pulse Charging, Smart Charging Management, Energy Recovery

**INTRODUCTION**

The ever-increasing energy consumption, fossil fuels' soaring costs and exhaustible nature, and worsening global environment have created a booming interest in renewable energy generation systems, one of which is photovoltaic. Such a system generates electricity by converting the Sun's energy directly into electricity. Photovoltaic-generated energy can be delivered to power system networks through grid-connected inverters. A single-phase grid-connected inverter is usually used for residential or low-power

applications of power ranges that are less than 10 kW. Types of single-phase grid-connected inverters have been investigated. A common topology of this inverter is full-bridge three-level.

The three-level inverter can satisfy specifications through its very high switching, but it could also unfortunately increase switching losses, acoustic noise, and level of interference to other equipment.

Improving its output waveform reduces its harmonic content and, hence, also the size of the filter used and the level of electromagnetic interference (EMI) generated by the inverter's switching operation. Multilevel inverters are promising; they have nearly sinusoidal output-voltage waveforms, output current with better harmonic profile, less stressing of electronic components owing to decreased voltages, switching losses that are lower than those of conventional two-level inverters, a smaller filter size, and lower EMI, all of which make them cheaper, lighter, and more compact. Various topologies for multilevel inverters have been proposed over the years.

Common ones are diode-clamped, flying capacitor or multicellular, cascaded H-bridge, and modified H-bridge multilevel. This paper recounts the development of a novel modified H-bridge single-phase multilevel inverter that has two diode embedded bidirectional switches and a novel pulse width modulated (PWM) technique.

### **Photovoltaic technology**

Photovoltaic is the field of technology and research related to the devices which directly convert sunlight into electricity using semiconductors that exhibit the photovoltaic effect. Photovoltaic effect involves the creation of voltage in a material upon exposure to electromagnetic radiation.

The photovoltaic effect was first noted by a French physicist, Edmund Becquerel, in 1839, who found that certain materials would produce small amounts of electric current when exposed to light. In 1905, Albert Einstein described the nature of light and the photoelectric effect on which photovoltaic technology is based, for which he later won a Nobel Prize in physics. The first photovoltaic module was built by Bell Laboratories in 1954. It was billed as a solar battery and was mostly just a curiosity as it was too expensive to gain widespread use. In the 1960s, the space industry began to make the first serious use of the technology to provide power aboard spacecraft. Through the space programs, the technology advanced, its reliability was established, and the cost began to decline. During the energy crisis in the 1970s, photovoltaic technology gained recognition as a source of power for non-space applications.

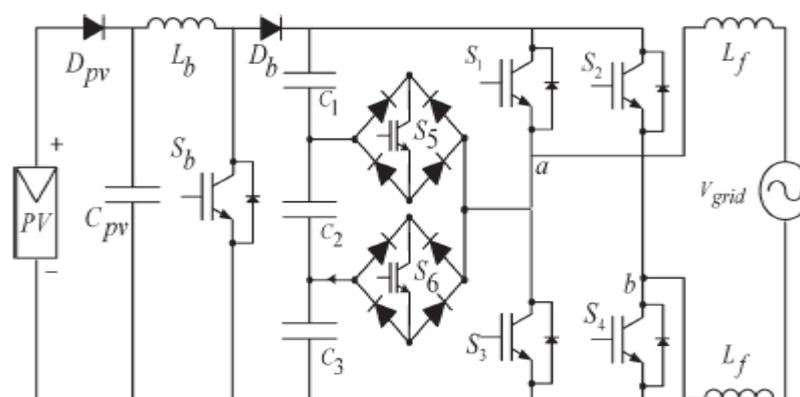
The solar cell is the elementary building block of the photovoltaic technology. Solar cells are made of semiconductor materials, such as silicon. One of the properties of semiconductors that makes them most useful is that their conductivity may easily be modified by introducing impurities into their crystal lattice. For instance, in the fabrication of a photovoltaic solar cell, silicon, which has four valence electrons, is treated to increase its conductivity. On one side of the cell, the impurities, which are phosphorus atoms with five valence electrons (n-donor), donate weakly bound valence electrons to the silicon material, creating excess negative charge carriers.

### **Inverter classification:**

Solar inverters may be classified into three broad types:

- Stand-alone inverters, used in isolated systems where the inverter draws its DC energy from batteries charged by photovoltaic arrays and/or other sources, such as wind turbines, hydro turbines, or engine generators.
- Many stand-alone inverters also incorporate integral battery chargers to replenish the battery from an AC source, when available. Normally these do not interface in any way with the utility grid, and as such, are not required to have anti-islanding protection.
- Grid tie inverters, which match phase with a utility-supplied sine wave. Grid-tie inverters are designed to shut down automatically upon loss of utility supply, for safety reasons. They do not provide backup power during utility outages.

### PROPOSED MULTILEVEL INVERTER TOPOLOGY

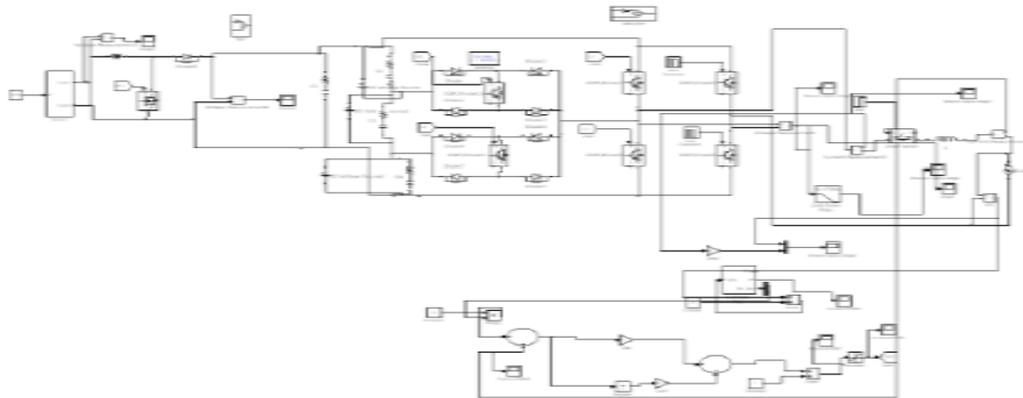


#### Proposed single phase seven-level grid connected inverter for photovoltaic systems.

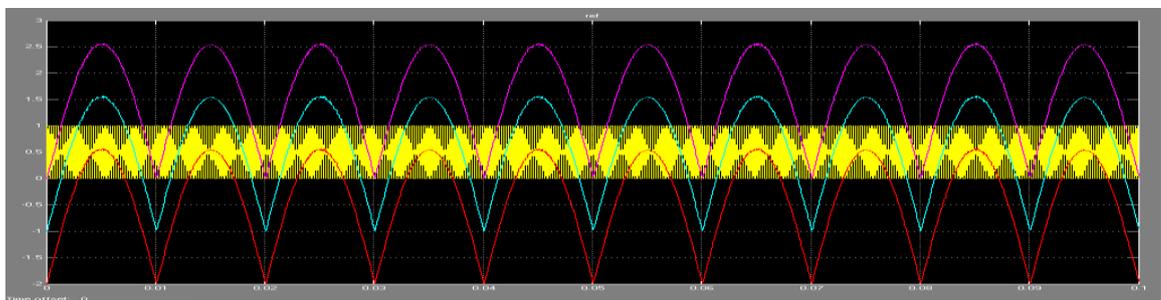
- The proposed single-phase seven-level inverter was developed from the five-level inverter. It comprises a single-phase conventional H-bridge inverter, two bidirectional switches, and a capacitor voltage divider formed by  $C_1$ ,  $C_2$ , and  $C_3$ , as shown in Fig. 1. The modified H-bridge topology is significantly advantageous over other topologies, i.e., less power switch, power diodes, and less capacitor for inverters of the same number of levels. Photovoltaic (PV) arrays were connected to the inverter via a dc–dc boost converter. The power generated by the inverter is to be delivered to the power network, so the utility grid, rather than a load, was used. The dc–dc boost converter was required because the PV arrays had a voltage that was lower than the grid voltage. High dc bus voltages are necessary to ensure that power flows from the PV arrays to the grid. A filtering inductance  $L_f$  was used to filter the current injected into the grid.
- Proper switching of the inverter can produce seven output-voltage levels ( $V_{dc}$ ,  $2V_{dc}/3$ ,  $V_{dc}/3$ ,  $0$ ,  $-V_{dc}/3$ ,  $-2V_{dc}/3$ ,  $-V_{dc}$ ) from the dc supply voltage. The proposed inverter's operation can be divided into seven switching states, as shown in Fig. 5.3(a)–(g). Fig. 5.3(a), (d), and (g) shows a conventional inverter's operational states in sequence, while Fig. 5.3(b), (c), (e), and (f) shows additional states in the proposed inverter synthesizing one- and two-third levels of the dc-bus voltage.

### MATLAB CASE STUDY & SIMULATION RESULTS

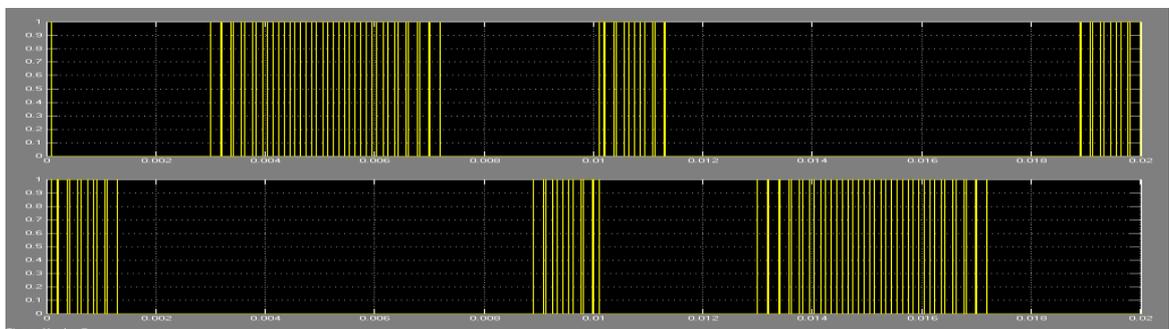
MATLAB SIMULINK simulated the proposed configuration before it was physically implemented in a prototype. The PWM switching patterns were generated by comparing three reference signals ( $V_{ref1}$ ,  $V_{ref2}$ , and  $V_{ref3}$ ) against a triangular carrier signal (see Fig. 7.1).



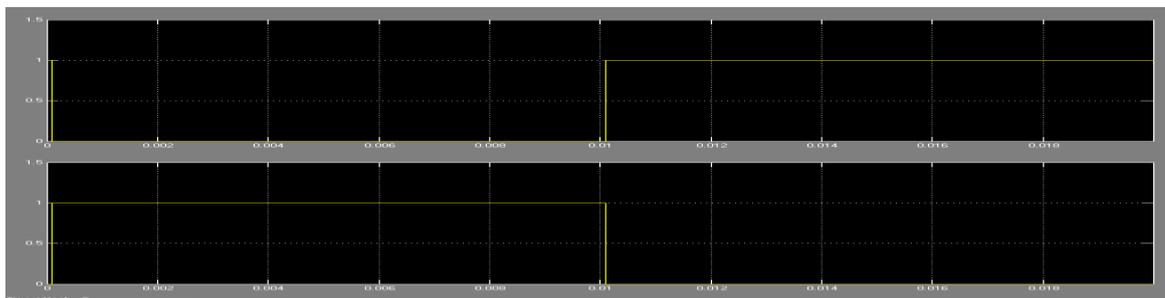
Matlab/Simulink model of Grid connected PV system



PWM switching signal generation.



PWM signals for S1 and S3.

**PWM signals for S2 and S4.**

## CONCLUSION

Multilevel inverters offer improved output waveforms and lower THD. This paper has presented a novel PWM switching scheme for the proposed multilevel inverter. It utilizes three reference signals and a triangular carrier signal to generate PWM switching signals. The behavior of the proposed multilevel inverter was analyzed in detail. By controlling the modulation index, the desired number of levels of the inverter's output voltage can be achieved. The less THD in the seven-level inverter compared with that in the five- and three-level inverters is an attractive solution for grid-connected PV inverters.

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