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# Multi-Level Single Phase Grid Connected Converter for Renewable Distributed System

**Nilesh Budukhale[1], Prof.P.R.Jawale[2], Prof.A.V.Mohod[3]**

PLITMS, Buldana[1,2]

Prof. Ram Meghe College of Engineering and Management, Badnera, Amravati[3]

**Abstract:** a single phase grid-connected converter is usually adopted In low power renewable distributed systems. This paper deals with a A review of the multi level topologies , a theoretical power loss comparison with the proposed solution is realized. The proposed converter is full-bridge architecture with two extra power switches and to the midpoint of the dc link two diodes are connected . Since the two more levels are obtained when two capacitor of dc link is discharge, the balancing of the midpoint voltage is achieved with pulse width modulation (PWM) strategy, Multilevel converters have been under research and development for found successful industrial application. This is still a technology under development and many new commercial topologies have been reported in the last few years advances made in modulation and control of multilevel converters are also mention. A great part of this paper is to show non traditional applications powered by multilevel converters and how multilevel converters are becoming an enabling technology in more industrial areas.This technology developed for renewable energy scheme where unity power factor required . a variation of the proposed topology which allows four-quadrant operations.

**Keywords:** Cascaded Full-Bridge, Hybrid Five-Level Topologies, SPWM, THD, DC to AC Conversion Distributed power Generation, grid- connected converters, Single – phase system multilevel converters. *Multilevel power conversion; Power quality; Harmonic reduction*

## INTRODUCTION

This converter topologies employing a high-frequency transformer instead of a line frequency one have been developed in order to reduce size and weight. Power Electronics is the art of converting electrical energy from one form to another form in an efficient, compact manner for convenient used. It is the technology associated with efficient conversion, control and conditioning of electric power from its available input into the desired output form. With regard to harmonic distortion content, power factors, and dc components, the output current of grid connected power converters must comply with the requirements of electricity supply companies

It has observed that an important place in modern technology being core of power and energy control . The trade offs between high efficiency and low cost are a hard task for these architectures because they require many power stages. Low-power applications, international standards allow the use of grid-connected power converters without any galvanic isolation, so permited to the so called transformer less architectures. This paper concerns the use of multilevel technic for single-phase converters.

The field of high power devices has been one of the most active area in research and development of power electronics in the last decades. Several industrial processes have increased their power level needs, triggering the development of new power semiconductors, converter topologies, and control methods. series connection of power switches is the solution for dealing with large voltages in order in order to meet the industrial demand, to remain linked to a practical implementation, the unipolar PWM applied to a full bridge topology is taken as reference. It is important to note that, in this paper, the term unipolar PWM refers to a three-level output voltage, whose first switching harmonic resides at twice the switching frequency concept of a multilevel converter to achieve high power is to use a series of power semiconductor switches with several low voltage sources to perform the conversion by synthesizing a staircase voltage waveforms.

## SINGLE-PHASE MULTI-LEVEL TECHNICQUE

Multilevel converters are nowadays widely adopted; the basic idea is that the dc-link voltage can be split between different capacitors, which can provide intermediate voltage levels between the reference potential and the dc-link voltage [4]. Numerous solutions regarding milti-level single-phase topologies are reported in literature, and they will be described in the following.

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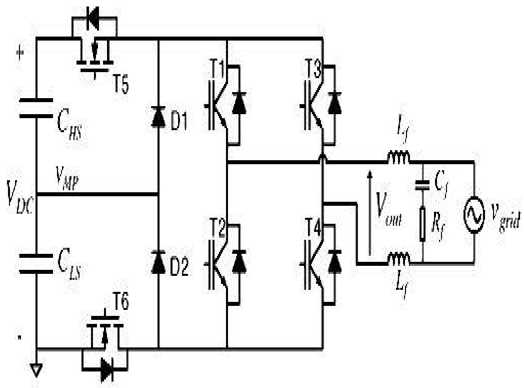
### A. Cascaded Full-Bridge

Another possibility to provide a multilevel output voltage is to connect in series multiple full-bridge structures. This solution needs several independent dc sources, i.e., multiple PV strings transformers with multiple secondaries and rectifiers. This requirement limits the adoption of this topology. A different approach, employing a transformer, allowed to connect in series various full-bridge structures using a single dc supply. The cascaded full-bridge allows multiple PWM strategies, i.e., carrier-based modulations or space-vector approaches. In the field of carrier-based PWM, unipolar and hybrid modulations can be applied. A modulation scheme, where each full-bridge is driven by a unipolar modulator and a 90◦ phase shift exists between the modulators‘ carriers, allows to minimize the harmonic distortion (the current ripple is at four times the switching frequency). Instead, with a hybrid modulation scheme, one of the full-bridges commutates at high frequency (unipolar PWM), whereas the other at line frequency. This subdivision allows to optimize the conduction power losses because low-frequency devices can be chosen for one full-bridge structure. In this case, the output current ripple is at
twice the switching frequency. Anyway, eight devices are needed, and there are always four devices conducting.




### B.combined multi Level system

A variation on the NPC full-bridge was recently presented in [6]: it consists of an NPC three-level leg (four devices), whereas the other leg consists only of two devices switch at low frequency A flying capacitor is employed to provide the additional voltage levels. An advantage of this architecture compared with the NPC full-bridge is that only three devices are conducting; however, these devices must have a breakdown voltage equal to the dc-link voltage. The voltage control of the flying capacitor was also realized. where four low frequency devices (instead of the two employed in) were employed in a full-bridge configuration. An alternative way to provide five voltage levels with a full bridge topology was presented in (see Fig. 2) and employed in a photovoltaic application in and. In this latter proposal, the converter is constituted by a full bridge with an additional bidirectional switch (realized with an IGBT and four diodes), employed to connect the midpoint of the dc link to the converter output. The energy efficiency of this solution is potentially very high; however, the capacitor_s voltage balancing is not taken into account. A different solution was proposed in, where the positive rail of a full-bridge can be connected either to the dc link or to the midpoint of the dc-link capacitors. Only six devices are needed, and the maximum number of conducting devices is three. However, the balancing of the dc-link capacitors is a serious issue and limits the field of application to a reactive compensator. The difference between these hybrid five-level topologies in Section II-A–C) is that the number of conducting devices is reduced, but the breakdown voltage increases because the dc-link voltage is not divided in a uniform way along the power semiconductors.

### PROPOSED Multi -LEVEL SINGLE-PHASE SOLUTION

This converter architecture, known as the H6 Bridge, was originally developed in, in combination with a suitable PWM strategy, in order to keep constant the output common-mode voltage in case of a transformer less inverter for photovoltaic applications. With the same purpose, another PWM strategy for the H6 bridge was developed in and. In this paper, this converter structure is used to obtain a multi-level grid-connected converter for single-phase applications. **Fig.** Multilevel converter allow to reduces the harmonic content of the converter output voltage, allowing the use of smaller and cheaper output filters. Moreover, these converters are usually characterized by a strong reduction of the switching voltages across the power switches, allowing the reduction of switching power losses and

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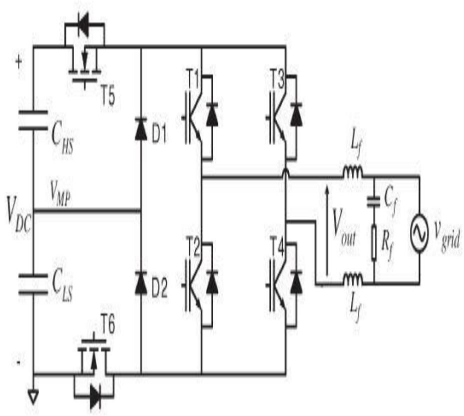
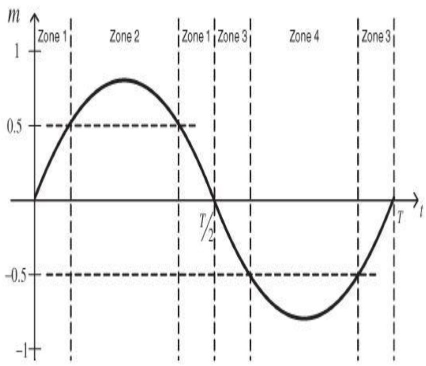
electromagnetic interference. The cascaded full-bridge allows multiple PWM strategies, i.e., carrier-based modulations or space-vector approaches. In the field of carrier-based PWM




The proposed converter is shown in Fig. 3. This converter architecture, known as the H6 Bridge, was originally developed in, in combination with a suitable PWM strategy, in order to keep constant the output common-mode voltage in case of a transformer less inverter for photovoltaic applications. With the same purpose, another PWM strategy for the H6 bridge was developed in and. In this paper, this converter structure is used to obtain a five-level grid-connected converter for single-phase applicationIn steady-state conditions, due to the low voltage drop across the inductance Lf of the output filter, the output voltage of the converter has a fundamental component very close to the grid voltage. The frequencies of these two voltages are identical, whereas the amplitude and their phase displacement are only slightly different. As a consequence, the shape of the modulation index m of the power converter is very similar to the grid voltage waveform. The output voltage of the converter can be written as Vout = m Vdc. Depending on the modulation index value, the power converter will be driven by different PWM strategies. As a matter of fact, it is possible to identify four operating zones (see Fig. 4), and for each zone, the output voltage levels of the power converter will be different, as shown in Table I. With reference to the schematic in Fig. 3, the behaviour of the proposed solution is shown for a whole period of the grid voltage, i.e., of the modulation index. During the positive semi period the transistors T1 and T4 are ON and T2 and T3 are OFF. In Zone 1, T5 is OFF and T6 commutates at the switching frequency, whereas in Zone 2 T5 commutates at the switching frequency and T6 is ON. During the negative semi period the full-bridge changes configuration, with T1 and T4 OFF and T2 and T3 ON. With similarity to Zone 1 and 2, in Zone 3 T5 commutates while T6 is OFF, and in Zone 4 T5 in ON and T6 commutates

**Modulation index waveform in steady-state conditions and definition of the four different PWM zones.**



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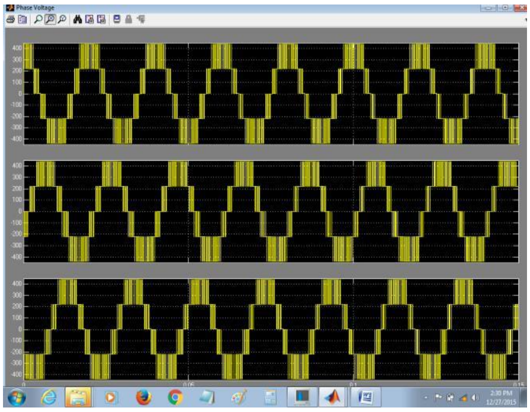
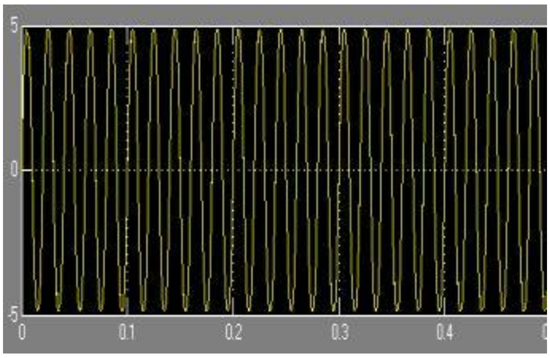
**SIMULATION RESULT**



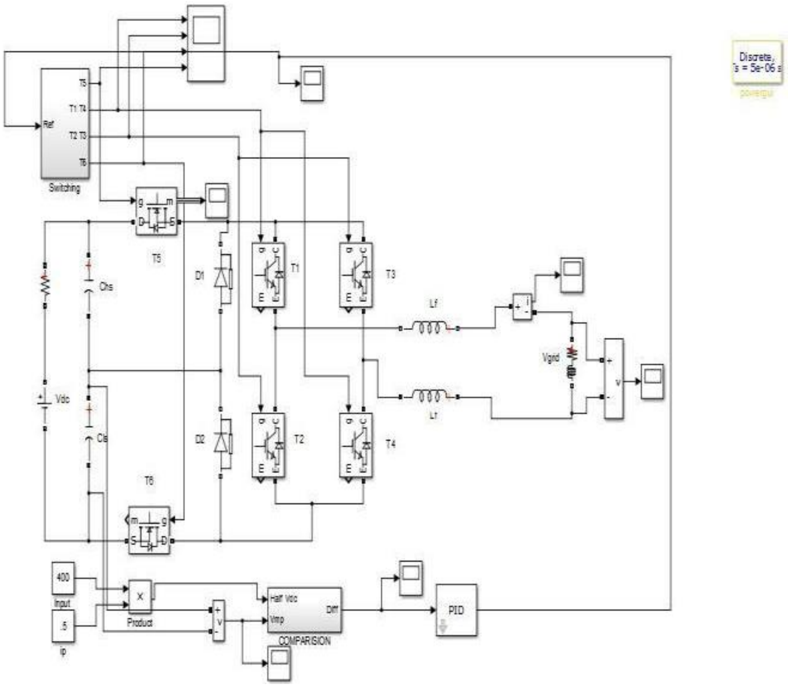
**OUTPUT WAVEFORM OF MULTI LEVEL CONVERTER**




**CURRENT WAVEFORM OF MULTI LEVEL CONVERTER**

**SIMULATION MODEL DESIGN OF PROPOSED CIRCUIT**

Grid-tie inverters are also designed to quickly disconnect from the grid if the utility grid goes down. This is an NEC requirement that ensures that in the event of a blackout, the grid tie inverter will shut down to prevent the energy it transfers from harming any line workers who are sent to fix the power grid.



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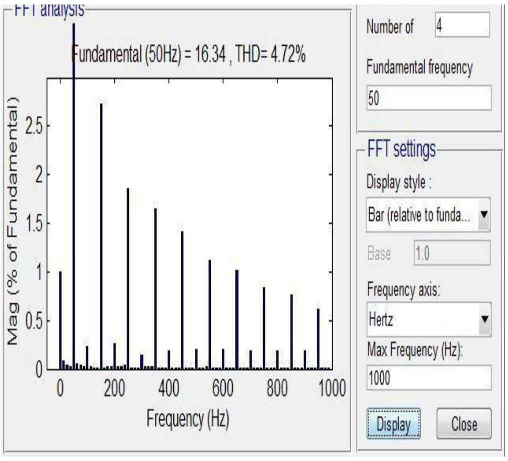
Properly configured, a grid tie inverter enables a home owner to use an alternative power generation system like solar or wind power without extensive rewiring and without batteries. If the alternative power being produced is insufficient, the deficit will be sourced from the electricity grid. The simulation design of proposed converter connected to grid is shown below in fig The closed loop system with proposed unipolar PWM gate signal generation is provided.

**proposed system in Matlab Simulink model design**

The main advantage of the proposed system is with the balancing of the split capacitor voltage according to the requirement of the active power need is like demand verses supply with available power quantity check. The figure is the gate pulse generation using uni-polar pulse width modulation way of pulse generation i.e. reference wave verses carrier pulse of 10 kHz frequency comparison. The output voltage of the proposed five-level converter based on a full-bridge converter with two added power switches and two diodes connected to the midpoint of the dc link obtained in the Simulink model is ±400 peak-peak and the output waveformsThe THD analysis is also compared for the simulation which is shown in Fig. 4.5. The total harmonic distortion in grid currents is 4.72% for the selected signals of five obtained using the FFT analysis




**Merits of this system**

1.Reduced harmonic.
2. Less EMI.
3. Smaller & Cheaper filter.
4. Reduced switching power losses.
5. Power factor improvement
6.Vdc=12V RPS
7.Vac=24Vac pk to pk

## CONCLUSION

This paper has dealt with MULTI -level solution for single-phase grid-connected converters. To order to obtain the minimum number of commutations to maximize efficiency.hence we choose pwm strategy The converter topology uses the midpoint voltage of the dc link to provide two or more output voltage levels, decreasing switching power losses and EMI. The proposed solution was compared with the state of the art of multi-level topologies in terms of theoretical semiconductor power losses. As a matter of fact, the PWM strategy developed allows the use of MOSFETs as active devices, making it possible to reduce the conduction power losses. Moreover, an effective balancing control (i.e., MVC) was implemented. It is important to note that the multi level output voltage is guaranteed only with a unity power factor operations; otherwise, the converter can output only three voltage levels, thus increasing THD and switching loss Simulations results showed the feasibility of the proposed converter architecture and the ability of the MVC to compensate for system asymmetries.Experimental results showed the effectiveness of the proposed solution in terms of output current quality and efficiency multi level full bridge MC for single-phase grid connected converters. the feasibility of the proposed converter architecture and the ability of the MVC to compensate for system asymmetries. Experimental results showed that the effectiveness of the proposed solution in terms of THD is good about 4.7% only.

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**Demand in future of this technique**

The system can be developed to high level that can further reduce the distortion. As the structure of this project itself implies that it can be very simple and very efficient one. Solar power plant is emerging trend to extract the electrical power. In future this design may more help to invert the power and directly fed to the grid. This solution is designed for renewable energy systems, where unity power factor operations are generally required. Nevertheless, a variation of the proposed topology, which allows four-quadrant operations

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