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Improvement of Power Quality by Hybridized Seven Level Inverter

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ABSTRACT

Distributed generation (DG) with converter interface to the grid is found in many of the green power resources applications. This paper presents a novel single phase seven level inverter to reduce harmonic content in output voltage and load current. Level shifted multi carrier pulse width modulation (LS-PWM) is used as the switching scheme for the proposed inverter. The validity of proposed inverter is verified through simulation for RL load.

KEYWORDS: *Distributed power generation, multilevel inverter, LS-PWM, modulation index*

I. INTRODUCTION

A renewable energy application such as photovoltaic (PV) system has been widely used for a few decades since PV energy is free, abundant and distributed throughout the earth. The focus of the Engineers is to make use of abundantly available PV energy and so to design and control an inverter suitable for photo voltaic applications. Power electronic circuits with pulse width modulation (PWM) are mostly used in energy conversion systems to achieve closed loop control. But even updated pulse width modulation (PWM) techniques do not produce perfect response which strongly depends on the semiconductors switching frequency. Also, it is well known that distorted voltages and currents waveforms produce harmonic contamination, additional power losses, and high frequency noise that can affect not only the load power but also the associated controller. The conventional single-phase inverter topologies for driving induction motor include half bridge and full bridge [1]. They are transformer less configuration.

The half-bridge inverter is configured by one capacitor arm and one power electronic arm. The output ac voltage of the half-bridge inverter is two levels. The full- bridge inverter is configured by two power electronic arms. The popular modulation strategies for the full-bridge inverter are bipolar modulation and uni-polar modulation [2]. The output ac voltage of the full-bridge inverter is two levels if the bipolar modulation is used and three levels if the uni-polar modulation is used. Bipolar modulation has less leakage current, but causes more harmonics and more losses.

In order to reduce the losses, uni-polar PWM (Pulse width modulation) is commonly used. All power electronic switches operate in high switching frequency in both half -bridge and full bridge inverters. The switching operation will result in switching loss. The loss of power electronic switch includes the switching loss and the conduction loss. The conduction loss depends on the handling power of power electronic switch. The switching loss is proportional to the switching frequency, and the current of the power electronic switches. The power efficiency can be advanced if the switching

loss of the dc ac inverter is reduced. On the other hand, the power converter technology is continuously developing, and cascaded multilevel inverters have become a very attractive solution for EV applications, due to its modular structure, higher voltage capability, reduced common mode voltages, near sinusoidal outputs, and smaller or even no output filter [8]. In general, cascaded multilevel inverter may be classified in two groups. The first one refers to the amplitude of isolated DC sources devoted to supply each H-bridge cell. If the amplitude of all sources is equal, then the inverter is called symmetrical, otherwise, if at least one of the sources present different amplitude, then it will be called asymmetrical. The second classification label the multilevel inverter whether hybrid or not. If the converter is implemented with different technologies of semiconductor devices (IGBTs, SCRs, GTOs, IGCTs), different nature of DC sources (fuel cells, batteries and super capacitors) and/or if it presents a hybrid modulation strategy, then it is classified as hybrid [9-10].

II. PROPOSED SEVEN LEVEL TOPOLOGY

Proposed seven level inverter is shown in Fig. 1. It consist of two dc bus of magnitudes E & 2E, six unidirectional switches (SI, S2, S3, S4, Sb and Sc) and one bidirectional switch (Sa). Each unidirectional switch consists of an IGBT and a fast recovery freewheeling diode. Fig. 2 shows different structure of bidirectional switch [12].

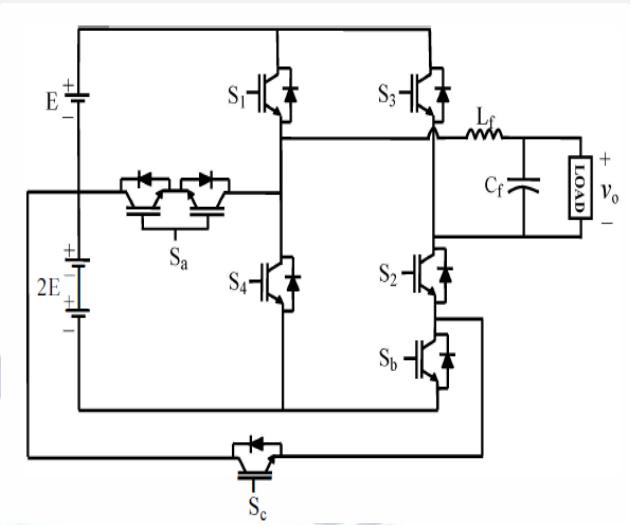

Fig.l: Proposed seven level inverter topology.

Fig. 2(a) requires only one switch and is easy to control, but its voltage drop is high which results in increased power loss. Voltage drop get reduced in Fig. 2(b), but it requires two gate driver circuits. Fig. 2(c) shows common emitter bidirectional switch which require only one gate driver and having reduced voltage drop. Therefore, bidirectional switch in Fig. 2(c) is selected for the proposed inverter. Since the voltage sources are of different magnitude, proposed inverter belongs to hybrid category. By proper switching it is able to generate voltages levels of 0, E, 2E, 3E, -E, -2E and -3E. Output voltage levels and corresponding status of switches are shown in Table I. The complete operation of proposed inverter can be divided into seven states as shown in Fig. 3. Current path corresponding to seven output voltage levels is also indicated in Fig. 3.

TABLE I
SWITCHING PATTERN FOR PROPOSED INVERTER

S1	S2	S3	S4	Sa	Sb	Sc	Voltage level
1	1	0	0	0	0	1	E
0	1	0	0	1	1	0	2E
1	1	0	0	0	1	0	3E
1	0	1	0	0	0	0	0
1	0	1	0	1	0	0	-E
1	1	0	1	0	0	1	-2E
1	0	1	1	0	0	0	-3E

Even though proposed topology requires two different dc voltage sources of magnitude E and 2E, it may be easily realized by suitably arranging dc sources. There is no issue of voltage balancing as no capacitors are used in it. Table 2 shows comparison of proposed topology with other well known symmetrical 7-level topologies like neutral point clamped (NPC) [1], flying capacitor (FC) [2], cascade H bridge (CHB) [3] and reverse voltage topology [4] in terms of number of components. It is evident from Table II that proposed topology

require less number of components and hence will have reduced switching losses.

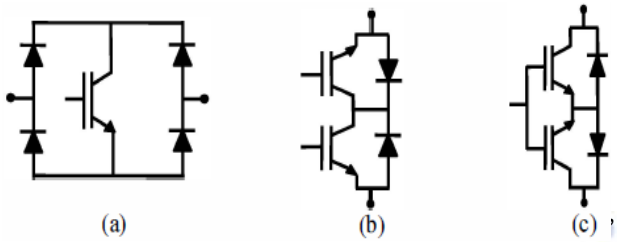

Fig. 2 Bidirectional switch configurations

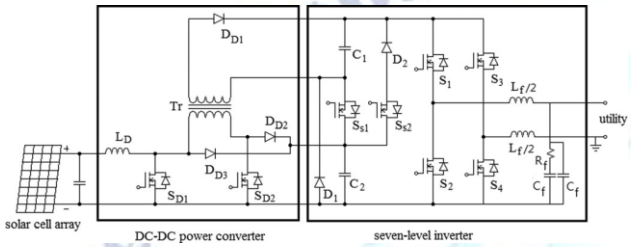

Fig.3: Configuration of the proposed solar power generation system for suppressing the leakage current.

As seen in Fig. 3, the DC–DC power converter incorporates a boost converter and a current-fed forward converter. The boost converter is composed of an inductor *LD*, a power electronic switch *SD*1, and a diode, *DD*3. The boost converter charges capacitor *C*2 of the seven-level inverter. The current-fed forward converter is composed of an inductor *LD*, power electronic switches *SD*1 and *SD*2, a transformer, and diodes *DD*1 and *DD*2. The current-fed forward converter charges capacitor *C*1 of the seven-level inverter. The inductor *LD* and the power electronic switch *SD*1 of the current-fed forward converter are also used in the boost converter.

III. SIMULINK/MATLAB MODEL OF SEVEN LEVEL INVERTER WITH DC-DC CONVERTER

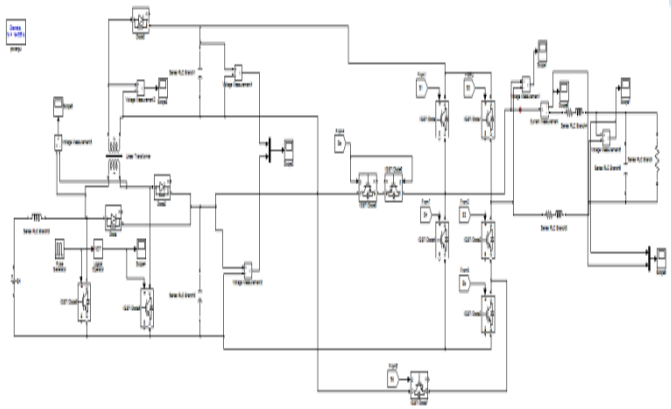

Fig.4: simulink model for proposed seven level inverter with DC-DC connverter.

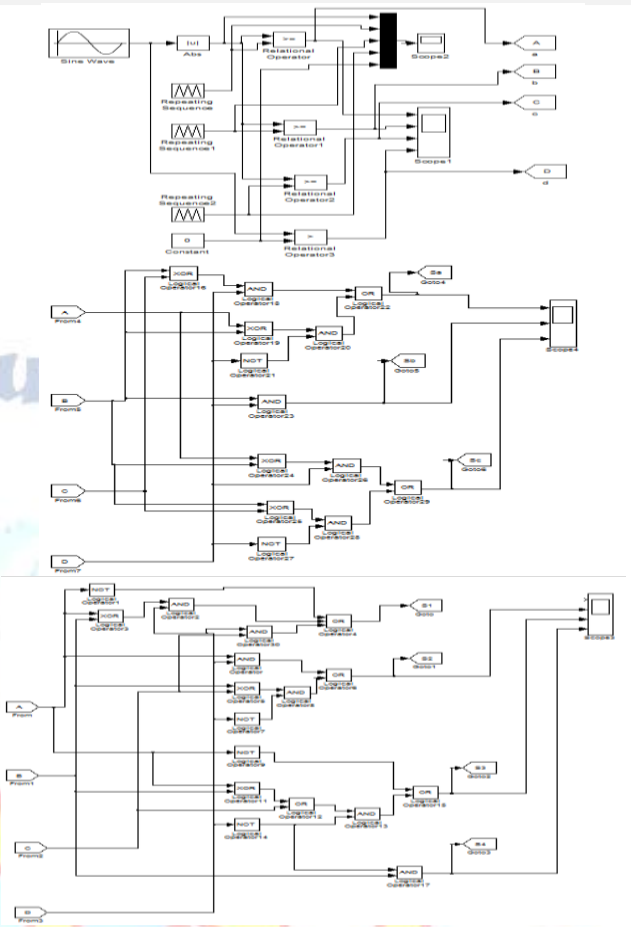

Fig.5: control strategy used to generate the switching pulses.

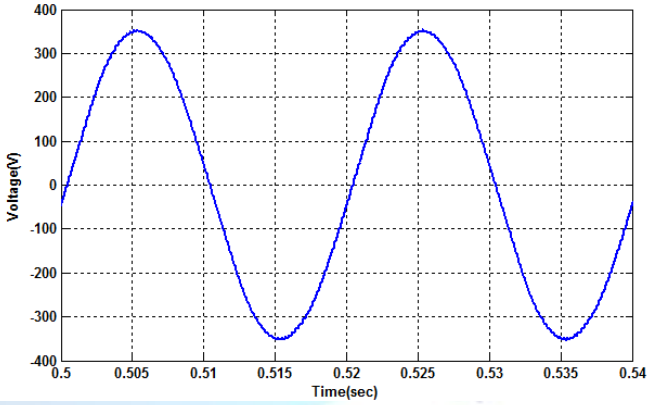

Fig.6: Voltage response in load center.

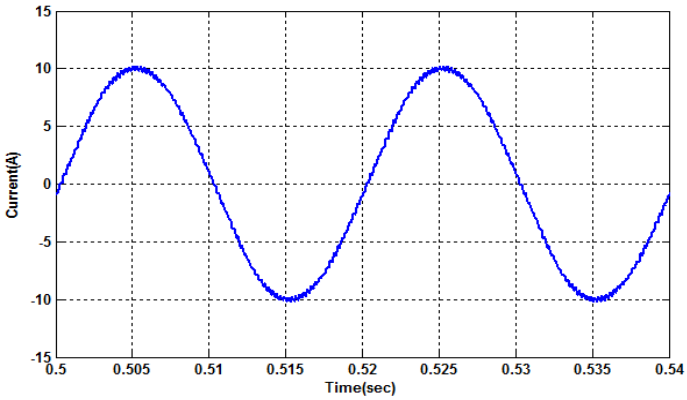

Fig.7: Current response in load center.

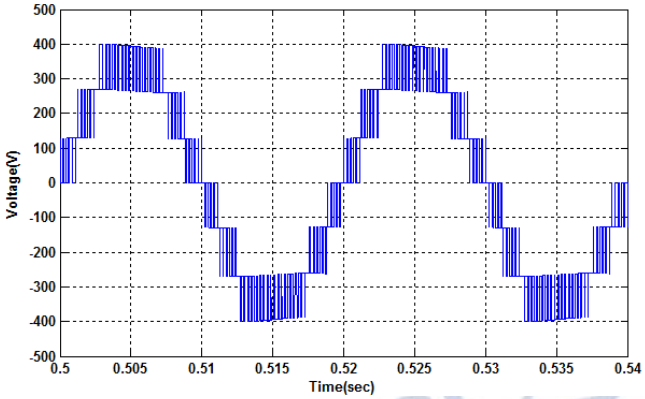

Fig.8: output voltage response of the proposed seven level inverter.

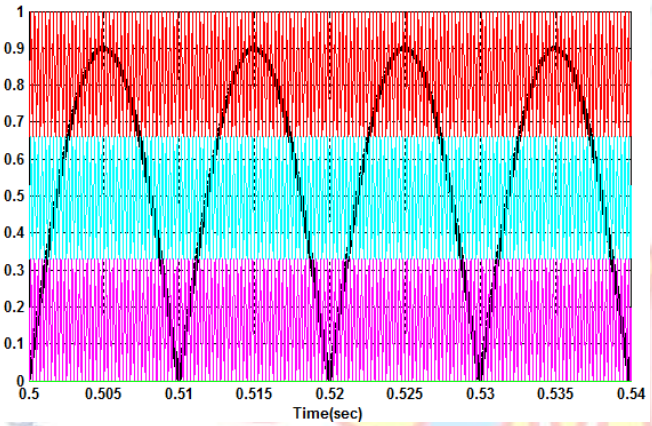

Fig.9 : Response of PWM modulation for Ma = 0.9.

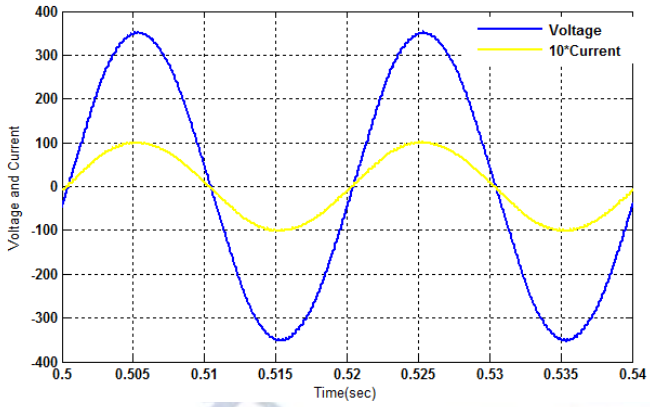

Fig 10: Voltage and current response at the load center.

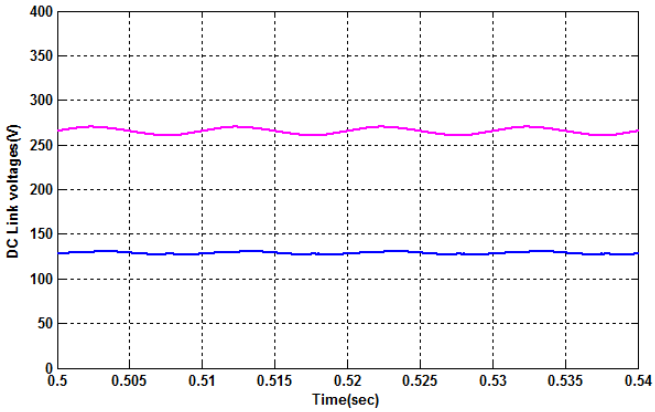

Fig 11: Response of DC link voltage

IV. Conclusion

With the help of proposed inverter topology good power quality is achieved and it can verify by MATLAB software.

Proposed inverter can give yield voltage of good quality with lessened consonant substance. Inverter requires less number of switches which in turn reduces cost and power losses. LS-PWM system is utilized as the tweak conspires for producing pulse signals. It utilizes three carrier signs and one reference flag. Sensible articulations for creating pulse signals from PWM are determined. Execution of proposed inverter system is confirmed through reproduction in MA TLABI SIMULINK.

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Bibliography

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