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A Single Phase Grid Connected Five-Level Converter for Renewable Distribution System with Reactive Power control

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ABSTRACT:Single phase converters are the popular choice in low-power grid connected systems. However, these converters invariably use a power transformer on the output side, which increases the system losses, cost and size. This paper discusses a five-level single phase converter topology that does not require a transformer on the output side, thereby removing the disadvantages associated with it. The converter architecture is based on a full bridge topology, with an addition of two more power switches and two diodes. The diodes are connected to the midpoint of the dc link. Since the discharging of the two capacitors is responsible for the addition of the added levels, the balancing of the midpoint voltage of the capacitors has been considered Simulation results will be used to show the effectiveness of the proposed solution..

KEYWORDS: Multilevel systems, photovoltaic(PV) systems,Voltage source inverter,Common mode leakage current, five level converter, pulse width modulation(PWM), PLL, DClink.

I.INTRODUCTION

Recently, solutions employing high frequency transformers, or making no use of transformer at all, have been investigated in order to reduce size, weight and cost[1] . In low power applications, international standards allow the use of grid connected power converter without any galvanic isolation, thus allowing the so-called ‘transformer less architectures[7].

The standard solution for single phase converters is the three level (unipolar) full bridge architecture. As the number of output voltage levels increases, the harmonic distortion of the injected grid current decreases, allowing the use of smaller and cheaper output filters. Moreover, multilevel topologies are usually characterized by a strong reduction of the switching voltages across the power switches, allowing the reduction of switching power losses and EM[1][7]I. This work uses a novel five-level converter based on a full bridge topology with two added power switches and two diodes connected to the mid-point of the dc link. In order to balance the mid-point voltage, a suitable PWM modulation strategy is employed[4][8].

Another important issue of grid-tied transformer less PV inverter is the ability of injecting reactive power into the utility grid[3]. Recently almost every international regulation has imposed that a definite amount of reactive power should be handled by the grid-tied PV inverter. This is due to the problems of grid voltage instability.

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II.LITERATURE SURVEY

Multilevel voltage source inverters synthesize the AC output terminal voltage from several levels of voltages, eliminates the need of transformer thus reduce harmonic distortion, losses, costs, size and filter requirements Galvanic connection of the grid and the DC sources in transformerless systems introduce additional leakage currents due to the earth capacitance. Amplitude and spectrum of leakage current depends on converter topology, switching strategy, resonant circuit formed by the ground capacitance, converter, AC filter and the grid. Regarding only to ground current the half bridge neutral point clamp is the best choice. Leakage current in cascaded converter is expected to decrease when the number of levels increases. In Half bridge topology the ground voltage is constant and thus, eliminates

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ground current. In low-power grid connected systems (renewable or traditional energy sources) a single phase converter is usually adopted. Converter architecture is based on a full bridge topology with two more power switches and two diodes connected to the midpoint of the DC link[1]. Since the two added levels are obtained by the discharge of two capacitors, the balancing of the midpoint voltage is taken into account.
A least complex grid synchronization Approach can be used for the generation of orthogonal and parallel components of the grid voltage using various computing techniques to generate a Synchronized current reference value in the current control Loop. Converter topology can be developed to minimize ground leakage current using unipolar PWM without increasing size of common mode filter and increasing efficiency. Grid voltage estimator produces two components. Parallel components multiplexed with the grid voltage and orthogonal component leads the grid voltage by 90 degree, the resulting current component thus, control the active power flow similarly orthogonal component of current controls reactive power through to the Grid[2].Notch filter eliminates ripples in dc link voltages such that output grid current free from ripple component[3].

III. KEY FEATURES OF THE SYSTEM

Benefits of using transformerless PV system:

1. Usually much lighter in weight than inverters with transformers.
2. Have higher efficiency ratings.
3. Capable of dual MPPT inputs, depending on manufacturer
4. Lower cost and size,higher efficiency
5. Embodied energy.
6. They can generate output voltages with extremely low distortion and lower dv/dt.
7. They draw input current with very less distortion.
8. They generate smaller common mode (CM) voltage, thus reducing the stress in motor bearings
9. They can operate with a lower switching frequency.

PHASE LOCKED LOOP

- It can be used control the reactive power of the grid
- For synchronization of grid output voltage with that of grid and monitoring grid voltage parameters as amplitude and frequency.
- It provides unitary power factor operation.

Unipolar PWM method can be used to control the mid point voltage of the dc link.

Research objective has been decided

i. Grid synchronization and control
ii. Grid-side controller, which can have the following tasks:

- active power generated to the grid should be controlled;
- reactive power transfer between the DPGS and the grid should be taken care of;
- dc-link voltage needs to be controlled;
- high quality of the injected power should be ensured

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IV. RESEARCH PROBLEM STATEMENT

BLOCK DIAGRAM

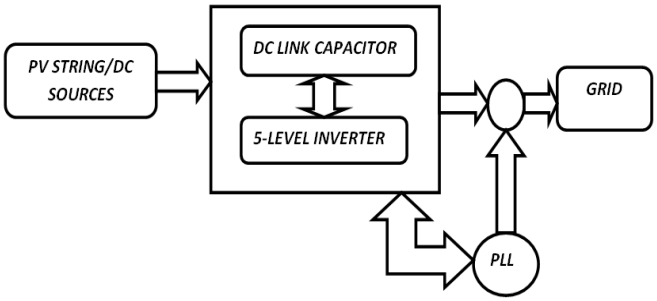

Fig:(1)

Utilization of a custom five-level inverter for interfacing a renewable energy source with the grid. The five-level converter provides an output with less harmonic distortion, minimizes the common- mode leakage current and improves the efficiency[7]

- To **synchronize** the inverter output **voltage** with that of the grid.
- To **Balance** the input side dc link capacitors, responsible for synthesizing the five-level output voltage
- To handle the output **reactive power** of the converter so as to control the reactive power of the Grid

PROJECT DEISGN STRUCTURE

- Step 1: Simulation of circuit with dc sources(without capacitors)using sinusoidal PWM level shifted method without grid connection
- Step 2 : Replacing DC sources with capacitors and ensure voltage balancing of capacitors
- Step 3 : Connecting Grid and ensure synchronization of inverter output with grid voltage
- Step 4 : Observation of waveforms after simulation

V. SYSTEM SETUP AND PROPOSED METHODOLOGY

Five-level single-phase topology

As shown in Fig(2)[7], the main work is to utilize a custom five-level inverter for interfacing a renewable energy source with the grid. The five-level converter provides an output with less harmonic distortion; minimizes the common-mode leakage current and improves the efficiency.

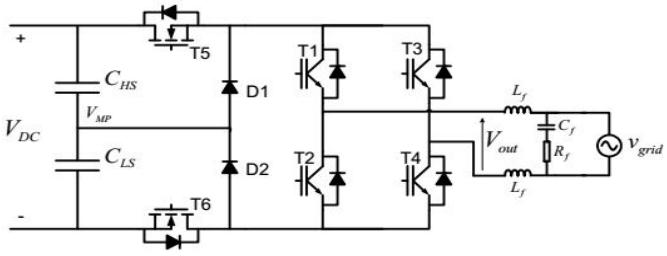

Fig: (2)

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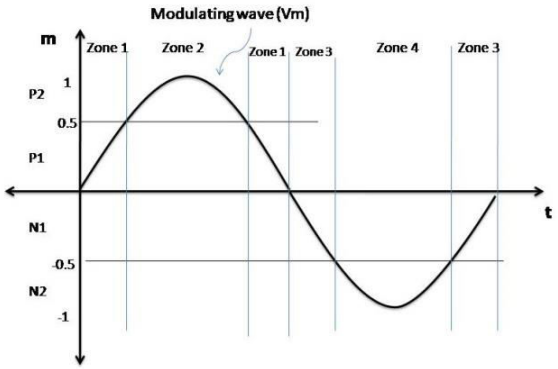
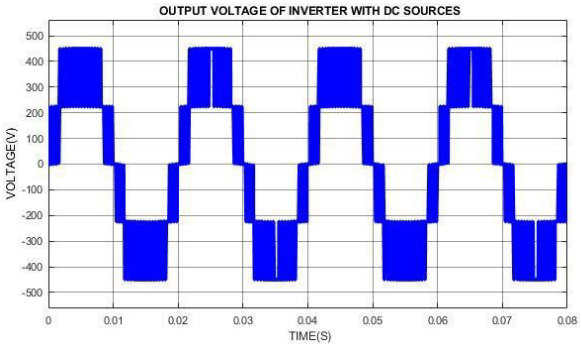
Fig. (3)[7] shows the output voltage waveform of the inverter over a full cycle corresponding to the grid voltage period. Fig. 3 shows the modulation index waveform in steady state conditions, along with definition of the four different PWM zones. The definitions of the PWM zones, depending on the modulation index m, are also listed in Table I.

Table 1

ZONE	M	Output Voltages
1	0<m<0.5	+Vmp and 0
2	0.5<m<1	+Vmp and +Vdc
3	-0.5<m<0	0 and –Vmp
4	-0.5<m<-1	-Vmp and –Vdc





During the positive half-cycle, 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, while in Zone 2 T5 commutates at the switching frequency and T6 is ON. During the negative half-cycle, 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.

FIVE LEVELS

Table 2

Sr No	Range	Voltage	Switch
1	P2>Vm>P1	+Vmp	T6 ON
2	Vm>P2	+Vdc	T5,T6 ON
3	N1<Vm<P1	0	T5,T6 OFF
4	N2<Vm<N1	-Vmp	T5 ON
5	Vm<N2	-Vdc	T5,T6 ON

MODULATION STRATEGY

A level shifted sinusoidal PWM technique is being used for the thyristor switches.. The advantage of this strategy is that only two transistors commutate at high frequency, while the four transistors of the full bridge commutate at line frequency[7].For obtaining five levels in the output, four carrier waves have been used viz.,P1,P2,N1,N2 as mentioned in figure(3)

Mid-point Voltage Balancing

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The mid-point voltage balancing can be obtained by ensuring that the discharge times of the high-side and low-side capacitors are the same[7]. A suitable control scheme will be utilized to ensure that the voltages on the two capacitors are kept equal. This will be ensured, in turn, by maintaining the discharge times of the two capacitors same over a complete grid-cycle.

A PLL will be used to synchronize the inverter output voltage with the grid-voltage[5][9].It enables both the inverter output voltage and grid voltage to have the same phase angle.By connecting filter circuit the output voltage can be made sinusoidal as shown in fig

Reactive Power Control

By changing the angle of modulating wave Vm, the reactive power fed to the grid is controlled. For this, the input to the modulating wave sine wave is changed. A phase shift is introduced deliberately, resulting in a change in the reactive power fed to the grid.

VI. RESULT AND CONCLUSION

The proposed work deals with a novel five-level topology for single-phase grid connected converters[7]. The PWM modulation strategy for the converter was chosen in order to obtain the minimum number of commutations to maximize efficiency[4][8]. The converter topology uses the mid-point voltage of the dc link to provide two more output voltage levels, decreasing switching power losses and EMI. The balancing of the mid-point voltage will be taken into account and a suitable control scheme, able to compensate system asymmetries, will be developed.[4][6].

The five level inverter is connected to the grid through PLL offering several advantages over transformer. The different five levels of inverter are shown in fig(6).Capacitor balancing is achieved and verified by its simulation results as shown in fig (4).Output voltage of inverter and grid is synchronised with the help of PLL block.

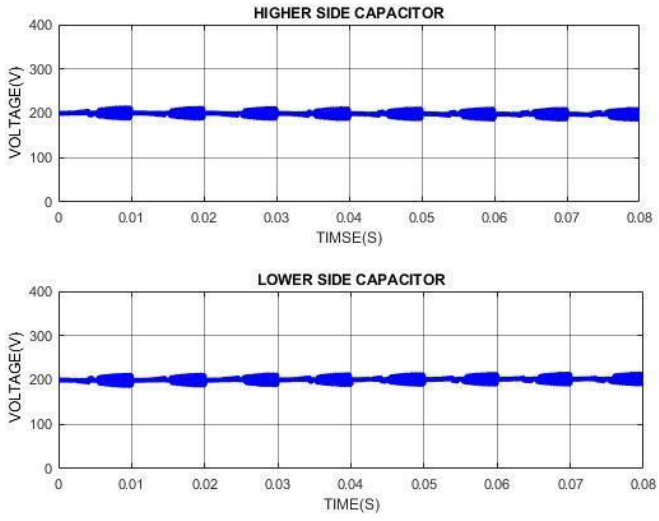

Fig 4 : Capacitor Balancing

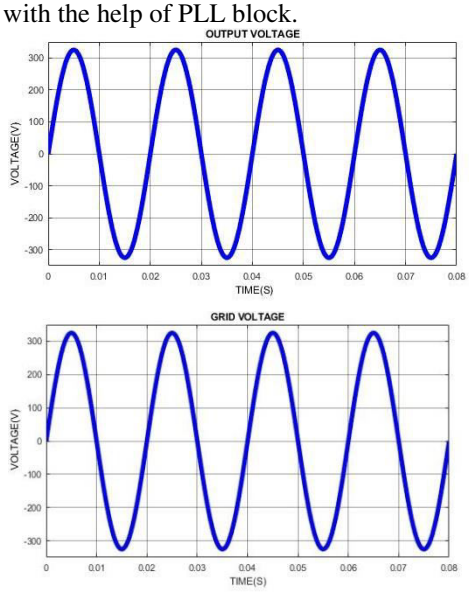

Fig 5 : Synchronisation

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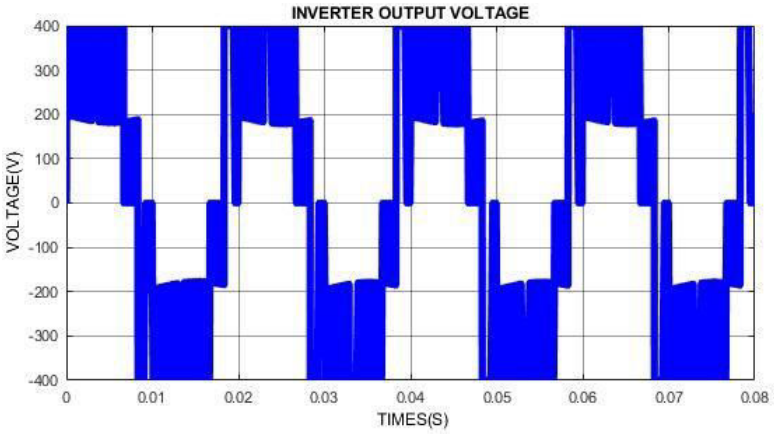

Fig(6):Five levels of inverter

It can be concluded that it is possible to replace transformer with the multilevel inverter for having its several advantages over bulky and costly transformer. The system designed thus, enables renewable system generating dc output, to be connected with the grid directly without involving transformers. This is possible with multilevel inverter configuration. Further, synchronisation and smooth operation is done by phase locked loop. The proposed system can be further be developed with control scheme to control the reactive power injected into the grid by changing the modulating wave so as to maintain the power factor at the grid as close to unity as possible[5][9].

REFERENCES

[1] Lopez, Oscar; Teodorescu, Remus; Doval-Gandoy, Jesus; "Multilevel transformerless topologies for single-phase grid-connected converters", IECON 2006 - 32nd Annual Conference on Nov. 2006 pp.5191 – 5196.

[2] Bhvik Brahmbhatt and HinaChandwani, "Single phase transformerless photovoltaic inverter with reactive power control",IEEE(ICPEICES-2016),pp.1-5

[3] Xiangdong Zong,PeterW.Lehn, "Reactive power control of single phase grid tied voltage source inverters for residential application",IECON-2012,38th annual conference IEEE industrial electronics society,2012,Pages:696-701

[4] Barater, D; Buticchi G.; Crinto A. S.; Franceschini G.; Lorenzani E.;"A new proposal for ground leakage current reduction in Transformerless Grid-Connected Converters for Photovoltaic Plants", in Proc. of IEEE IECON 2009, November 3-5 2009 pp. 4567-4572, Porto (Portugal).

[5] Monirul Islam,Nadia Afirm,SaadMekhilef, "Efficient single phase transformerless inverter for grid-tied PVG system with reactive power control",IEEE transaction on sustainable energy,2016,pp.1-11

[6] Gimpaolo Buticchi, Giovanni I Franceschini, "A Novel five level Single Phase Grid Connected Converter for Renewable Distributed systems",IEEE,2010,pp.3535-3540

[7] Selvaraj, J.; Rahim, N.A., "Multilevel Inverter For Grid-Connected PV System Employing Digital PI Controller," Industrial Electronics, IEEE Transactions on , vol.56, no.1, Jan. 2009, pp.149-158

[8] Mihai Ciobotaru, Remus Teodorescu and Frede Blaabjerg **"**A New Single-Phase PLL Structure Based on Second Order Generalized Integrator**"**,IEEE transaction

[9] Infield, D.G.; Onions, P.; Simmons, A.D.; Smith, G.A., "Power quality from multiple grid-connected single-phase inverters" Power Delivery, IEEE Transactions on , vol.19, no.4, Oct. 2004 pp. 1983-1989,

[10] Rong Zeng, Zhiqiang (Jack) Wang, and Madhu Sudhan Chinthavali "Coordinated Reactive Power Control of Single-Phase Grid-Connected Converter for Distributed Energy Resources Integration Considering Multiple Functionality Conflicts"Power Electronics and Electric Machinery Group, Oak Ridge National Laboratory , IEEE Transportatio Electricfication Conference and Expo,2017

[11] Pedram Sotoodeh**;** Ruth Douglas Miller **"**Design and control of a new single-phase inverter for grid-connected renewable energy systems"4th IEEE International Symposium on Power Electronics for Distributed Generation Systems,2013

[12] Kerekes, T.; Teodorescu, R.; Borup, U.; "Transformerless Photovoltaic Inverters Connected to the Grid" Applied Power Electronics Conference, APEC 2007 - Twenty Second Annual IEEE Feb. 25 2007-March 1 2007 Page(s):1733 – 1737.