THREE PHASE DELTA INVERTER INTEGRATED WITH FORWARD CONVERTER FOR PV APPLICATION

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Abstract—This paper presents to develop a new delta inverter system integrated with forward converter for pv application. It achieves DC to three phase AC inversion by using only three switches instead of six devices as in a conventional full bridge three phase inverter. The reduction in the number of switching devices contributes higher power density for PV energy conversion system. In the proposed configuration PV field connected to a DC voltage block, that connected to a forward converter which is connected to a 3-switch DIS.It only require one isolated DC source to produce three phase output. This topology have advantages over centralized full bridge PV inverters, such as reduced component and higher energy yield.

Keywords—Photovoltaic,Delta inverter system

I. INTRODUCTION

Less than 1% of the global electrical energy consumption comes from photon-to-electron conversion. Renewable energy sources such as photovoltaic energy are available in both clean and economical due to new advancement in technology and use of good and efficient cells. Solar energy is advantageous compared to any other renewable energy sources available. The efficient and fast growth in the field of solar energy result in Photovoltaic(PV) system design for various application with reliable operation and application for more reliable and efficient operation. PV module represents the fundamental power conversion unit of a PV generator system. The output characteristics of PV module depends on the solar insolation, the cell temperature and output voltage of PV module. Since PV module has nonlinear characteristics, it is necessary to model it for the design and simulation of PV system applications. But the installation of photovoltaic (PV) power stations has been increasing tremendously both on the residential scale and at the commercial / utility scale . Solar PV, at the time of publication, still has a long way to go in terms of financially competing successfully with conventional electricity. It has been established that reducing the inverter equipment and maintenance costs is essential to make solar energy more cost competitive . To achieve this goal, new methods to efficiently convert DC power to AC with low cost and high reliability are required. Different topologies and techniques to interface large scale PV plants to the utility grid have been studied.

Reduced semiconductor devices and components count reduce failure rates and maintenance costs over the lifetime of a PV inverter . The architecture proposed in this paper is a delta inverter based system which utilizes three DC voltage sources and three semiconductor devices to produce a three phase output.The delta inverter was first introduced primarily for adjustable speed drives. Pulse width modulation (PWM) techniques for control of the delta inverter were developed. The delta inverter did not find acceptance in practice primarily due to the limitation of requiring three separate DC sources. But the need for more efficient PV topologies opens new possibilities for the delta inverter. The proposed delta inverter system (DIS) architectures for PV applications have the following advantages:

- DIS employs three switching devices which results in fewer components in the overall system (gate drive circuitry, heat sinks, busbars, fuses, etc.). This leads to higher reliability due to reduced number of power switching semiconductor devices which in turn results in higher lifetime of inverter and lower maintenance costs.
- Advanced PWM techniques proposed in this paper enable operation of DIS even while the insolation levels are unbalanced for the three PV sources.

However, the DIS suffers from some disadvantages such as the requirement for higher switch voltage ratings up to 3·Vdc; and the requirement for three isolated DC voltage sources. This paper proposes two DIS architectures within the context of PV applications, since isolated PV arrays could produce isolated DC voltage sources, overcoming the latter of the above two disadvantages.

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II BLOCK DIAGRAM OF THE PROPOSED SYSTEM

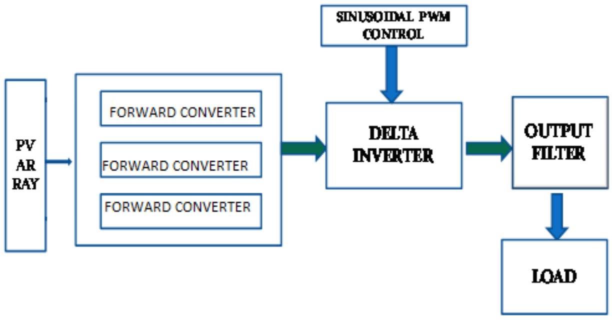

Fig 1: Block diagram of proposed system

In this figure 1 shows the block diagram of proposed system. Here PV array is connected to the forward converter and output of the forward converter is fed to the delta inverter. And output of the delta inverter is ac which is connected to the load through output filter.

III. PROPOSED SYSTEM

In the proposed configuration of DIS a large scale PV field of a DC voltage blocks, pv block connected to a forward converter which is connected to a 3-switch DIS interfaced to the load. The DIS with forward Converter configuration proposed for PV grid integration utilizes a forward converter for each phase which performs maximum power point tracking (MPPT). The proposed architecture, shown in above fig employs a DC voltage sources which consist of a series-parallel combination of solar PV modules. The three power semiconductor devices (Sab, Sbc, Sca) are controlled by sinusoidal PWM.. The output of the forward converters serve as the DC voltage sources for the delta inverter. The inverter output is connected to an LC filter tuned at half of the switching frequency. The filtered output of the delta inverter is then connected to the load. Here figure 2 shows proposed delta inverter system.

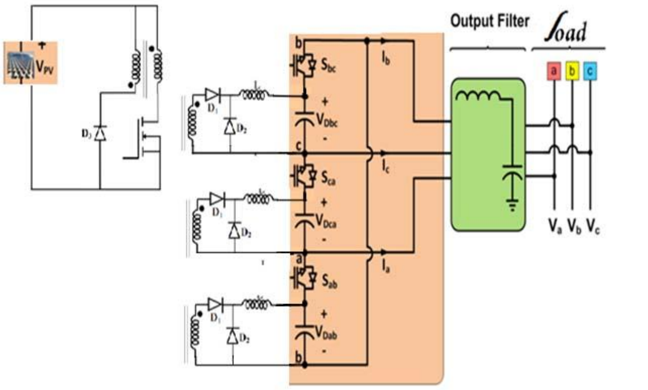

Figure 2: Proposed Delta Inverter System (DIS)

IV ADVANCED PWM TECHNIQUE UNDER UNBALANCED OPERATION

When the insolation levels of the three PV arrays connected to a delta inverter change and become asymmetric the controller uses advanced PWM techniques to produce balanced three phase output voltages from thee unequal DC voltage sources during the transition period.

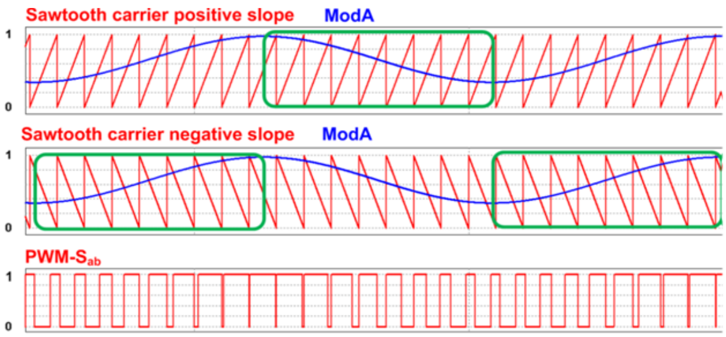

Figure 3: . Generation of gating signals for Delta Inverter System (DIS).

Positive slope sawtooth carrier is chosen during negative slope of modulating function and vice- versa. PWM-Sab is the sum of ModA-produced-PWM and the NAND logic of PWMs produced by ModB and ModC. This is done to ensure that only two switches are ON at any time.

The modulation index associated with the lowest DC voltage source must first be calculated so that the DC offset is eliminated. This is done by decreasing the negative peak value by adjusting the modulation depth and position of the sinusoidal reference signal. Accordingly, the modulating signals of the other two DC sources must also be adjusted, since three phase balanced output voltages need to be produced. Hence the peak line-to-line output is limited by the lowest DC voltage source.

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The corrected modulation indices are given by

$$\alpha_{\min} = \frac{2*|V_{DC\min}|}{|V_{DC2}|+|V_{DC3}|}$$

$$\alpha_2 = \frac{.33}{2}\left[\frac{|V_{DC\min}|}{|V_{DC2}|} + \frac{2*|V_{DC\min}|}{|V_{DC3}|+|V_{DC\min}|}\right]$$

$$\alpha_3 = .\frac{.33}{2}\left[\frac{|V_{DC\min}|}{|V_{DC3}|} + \frac{2*|V_{DC\min}|}{|V_{DC\min}|+|V_{DC2}|}\right]$$

where amin is the modulation index with the lowest DC source; a2 is the amplitude of the modulating function associated with VDC,2 and a3 is the amplitude of the modulating function associated with VDC,3. Similarly, the corrected offset of the modulating functions with respect to the carrier signals are given by:

$$P_{\min} = 0.66 + 0.33(1-\alpha_{\min})$$

$$P_2 = 0.66 - 0.66\frac{|V_{DC\min}|}{|V_{DC3}|+|V_{DC\min}|} + \alpha_3$$

$$P_3 = 0.66 - 0.66\frac{|V_{DC\min}|}{|V_{DC2}|+|V_{DC\min}|} + \alpha_3$$

V. SIMULATION RESULTS

The semiconductor devices used were commercial IGBT modules. A single isolated DC power supplies were used as three DC voltage sources in the delta inverter. DC voltage source is rated at 150 V. The controller was implemented using Texas Instruments TMS320F28335. The control system implemented was the advanced pulse width modulation scheme discussed in section IV.

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1.OUTPUT VOLTAGE WAVEFORMS OF FORWARD CONVERTERS

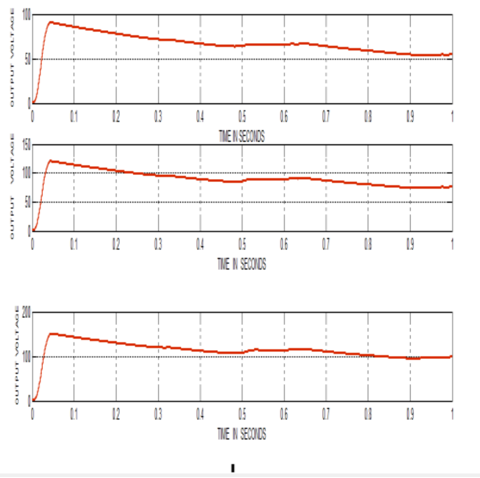

Figure: 4

2.OUTPUT PHASE VOLTAGE WAVEFORM OF DIS

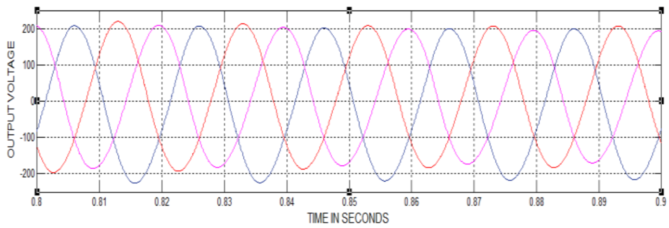

Figure 5

VI CON CLUSION

A new DIS for large scale solar photovoltaic power systems was introduced..This DIS topologies have advantages over centralized full bridge PV inverters, such as reduced component count and higher energy yield.The delta inverter based system utilizes one DC voltage sources and three semiconductor devices to produce a three phase output. It leads to higher reliability due to reduced number of power switching semiconductor devices which in turn results in higher lifetime of inverter and lower maintenance costs.

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