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Solar Inverter with a Battery on a Standard Power Electronic Cell for Micro Grid Applications

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ABSTRACT*:*There is a strong to increase energy security which means having assured across to reliable supplies of energy and the ability to protect and deliver sufficient energy to meet operational needs. The aim of this project is to develop a solar photovoltaic generation system with a battery for micro grid applications. Here, a hybrid solar system is used with lithium-ion battery for input power generation. The proposed system is capable to provide security of supply by providing uninterrupted power to critical loads and transition consistently. We have used hysteresis control technique for the inverter to generate pulses. In the proposed micro grid system, simulation results are presented and analyzed.

KEYWORDS: PhotoVoltaic (PV) Generation System, DC-DC Converter, Inverter, Isolated Transformer, Battery.

I.INTRODUCTION

Solar PV and energy storage have been extensively used for standalone operation of pumps, telecommunication systems and houses in remote areas. Typically energy storage elements used in those applications are lead acid batteries. Grid-tie PV inverters are batteries have used to smooth power injected to the grid. Recently grid-tie battery energy storage using Lithium-ion have been demonstrated for single phase systems.

The aim of this paper is to development of 80KW solar photovoltaic micro source with lithium-ion battery. The proposed system as oppose to the ones reported in the literature, is able to operate in standalone and grid connected mode and seamlessly transition from grid connected to grid disconnected mode of operation. The implementation is based on a standard power electronics cell concept for micro grid applications. Figure shows the connection diagram of the system.

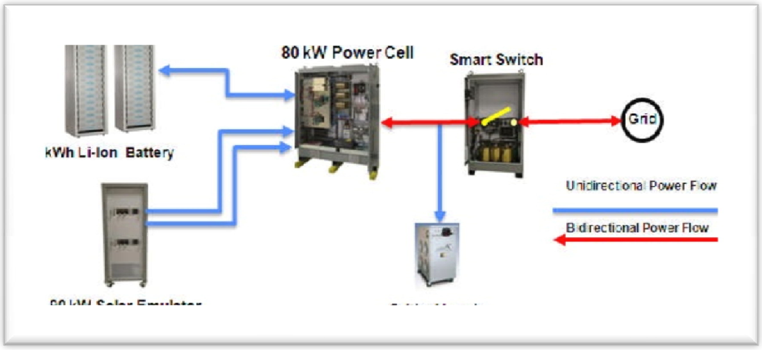

Fig 1 standalone and grid connected PV micro-source

Using these configuration critical loads will be powered either from the grid or the hybrid inverter. Also if the grid conditions are not up to the power quality standards required by the load it is possible to create an intentional islanding

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until the grid conditions return to normal. The worst case scenario is a sudden loss of the grid power; in this case the system should automatically transition to a standalone mode of operation and continue supplying energy to the critical loads. These and other possible operating conditions present a challenge to the local controller that needs to address all of them without human intervention or changing the control structure. The paper will present a description of the system and various components as well as simulation and experimental results. The outcome of this work will provide a solution that will help DoD to meet his ambitious clean energy programs.

United States dependence on fossil fuels has been identified as a major issue that is detrimentally affecting its economic growth and jeopardizing its national security. Also this dependence is putting US to compete for conventional fossil fuels with the emerging economies. The Department of Defence (DoD) consumes about 60 percent of all energy used at federal government facilities. To address this problem the federal government through the Department of Energy (DoE) and Department of Defence (DoD) is strongly supporting the use of renewable energy sources by setting very challenging goals through the Energy Policy Act of 2005. This policy directs DOD to consume at least 3% of its total electricity needs from renewable sources through Fiscal Year (FY) 2009, 5% through FY 2012, and not less than 7.5 % beginning FY 2013.

II.CIRCUIT TOPOLOGY

The proposed inter connecting block diagram is shown in fig 2 It consists of PV array a battery as inputs. This is connected to the Dc-Dc converter which will boost the voltage and then it is connected to inverter via dc link capacitor. The filters are used to reduce the ripple content. A Smart switch is used to trip the circuit in case of over voltages.

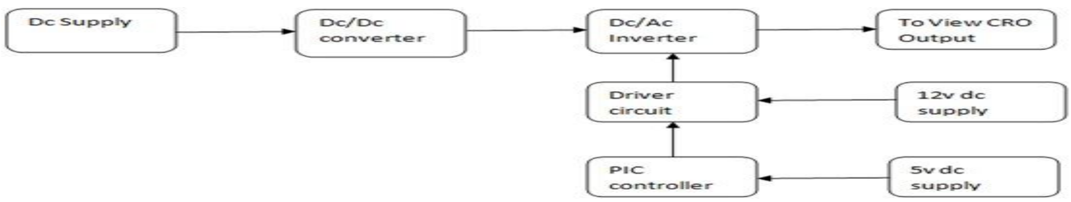

Figure 2. Block diagram of system interconnected diagram

A. DC-DC converters:

The DC-DC converter is an electronic circuit which converts a source of direct current (DC) from one voltage level to another voltage level and also it is a class of power converter. DC-DC converters are important in portable electronic devices such as cellular phones and laptops and also computers which are supplied power from batteries. Then such electronic devices often contain several sub-circuits with each sub-circuit requiring a unique voltage level different than that supplied by the battery conversion methods.

B. Bidirectional converter:

The bi-directional converter along with energy storage has become a promising option for many power related system, including hybrid vehicle, fuel cell, renewable energy system and so forth. It is not only reduces the cost and improves efficiency, but also improves the performance of the system.

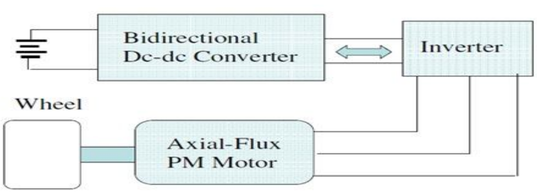

Figure 3 Bidirectional DC-DC converters in energy regenerative system

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III.OPERATIONAL OF PROPOSED CONVERTER

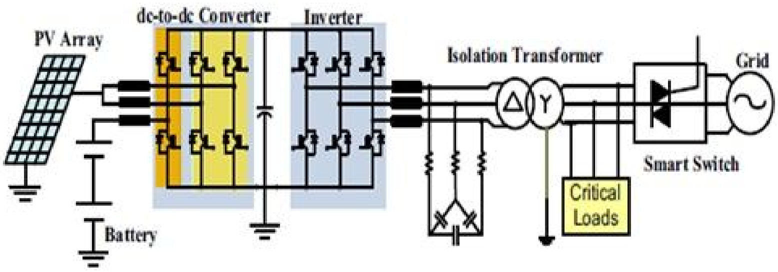

Fig 4 shows system interconnected diagram

The above fig 4 shows the connection of the circuit voltage of 360V with a maximum voltage of 420V and a minimum voltage of 315V. This battery will be able to provide up to 40KW of power for half an hour. The power conditioning unit is an 80KW standard cell at the DC side each leg is able to process 40KW at a minimum input voltage of 300V. Two legs are configured as unidirectional interleaved boost converter to interface the PV array and one leg is configured as a bidirectional dc-dc converter to interface the battery.

A.HYSTERESIS CONTROL:

Among various PWM techniques, the hysteresis band current control is used very often because of its simplicity of implementation and also besides fast response current loop and the method does not need any knowledge of load parameters and however the current control with a fixed hysteresis band has the disadvantage that the PWM frequency various with in a band because peak-to-peak current ripple is required to be controlled at all points of the fundamental frequency wave. Then the method of adaptive Hysteresis-band current control PWM technique where the band can be programmed as a function of load to optimize the PWM performance is described.

The basic implementation of Hysteresis current control is based on deriving the switching signals from the comparison of the current error with a fixed tolerance band. Then this control is based on the comparison of the current error with a fixed tolerance band around the reference current associated with that phase. On the other hand, this type of band control is negatively affected by the phase current interactions which is typical in three-phase system. This is mainly due to the interfaces between the commutations of the three phases and since each phase current not only depends on the corresponding phase voltage but is also affected by the voltage of the other two phases. Depending on the load conditions switching frequency may vary during the fundamental period and resulting in irregular inverter operation. To minimize the effect of interferences between phases while maintaining the advantages of the Hysteresis methods by using phase-locked loop (PLL) technique to constrain the inverter switching at a fixed predetermined frequency. In this project, the current control of PWM-VSI has been implemented in the stationary (α,β) reference frames.

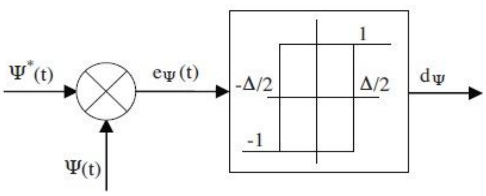

Figure 5 Two Level Hysteresis Band Control

A two level Hysteresis comparator is used to compare the actual value of stator flux to the internal reference value produced by stator flux reference controller.

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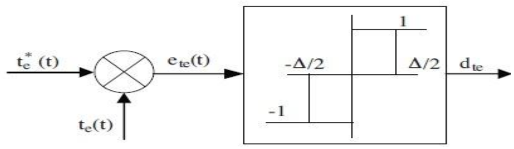

Figure 6 Three Level Hysteresis Band Control

A Three level Hysteresis comparator as shown in figure 6 and it is used to compare the actual value of the torque to the internal reference value produced by the speed torque reference controller. The outputs of these comparators update every sampling time and they indicate whether the flux or torque must be varied.There are two Hysteresis current control methods 1. Square Hysteresis based control, 2. Hexagon Hysteresis based controlboth controllers work with current components represented in stationary (α,β) coordinate system. In this project we are using Hexagon Hysteresis based control.

IV.SIMULATION RESULTS

In the simulation we are giving solar and battery as inputs. This DC voltage is given to the bidirectional DC-DC boost converter and this is connected to 3 phase inverter through a DC link capacitor shown in the figure. For the DC-DC boost converter the first leg pulses are given by a closed loop configuration by PI controller. The other 2 leg pulses are given by normal PWM technique. The switching technique which we are using here is HYSTERISIS CURRENT CONTROL. By using this technique the pulses are given to the inverter. This is a closed loop configuration. Then the output of the inverter is connected to filters which will reduce the ripple content. Finally we will get 3 phase AC voltage at the output.

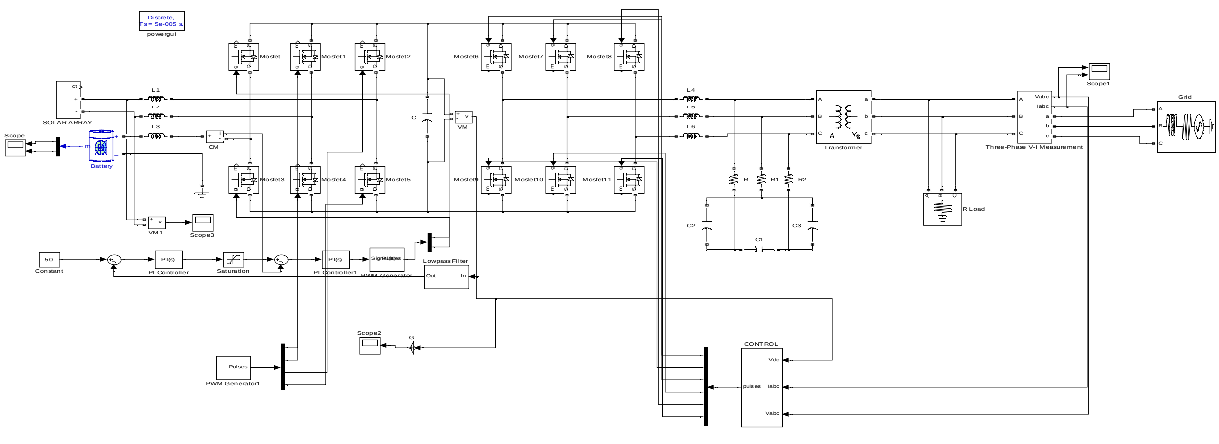

Figure 7 Simulink diagram

The above fig 7 shows for the design of the system very important system level objectives for the operation of the system needs to define.

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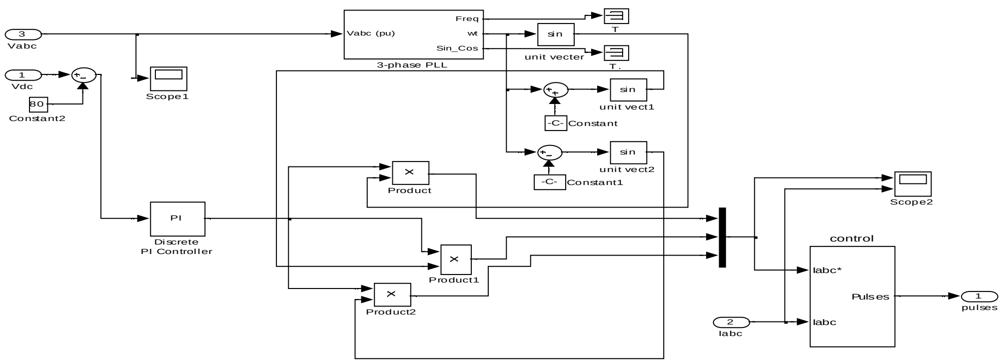

Figure 8Control logic for pulses

The above fig 8 shows the operation to control the voltage and current and giving the input pulses for the switch operation.

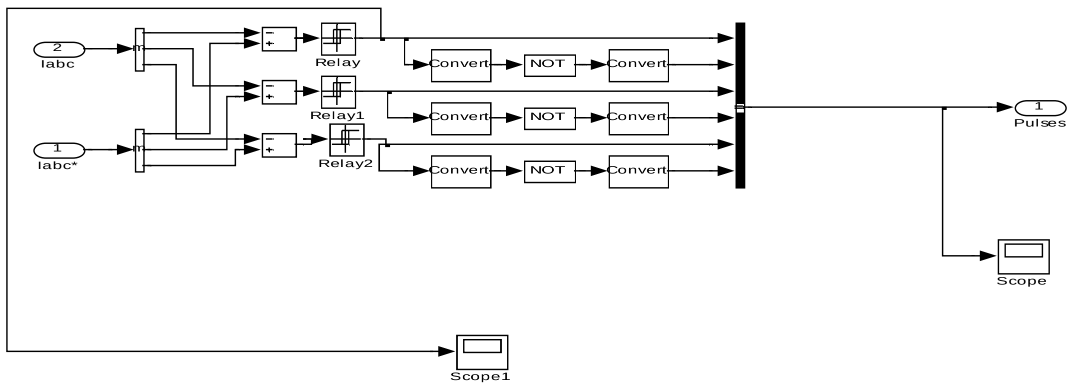

Figure 9 Hysteresis control logic block

The current difference is should be move back towards the middle of the hysteresis hexagon as slowly as possible to achieve a low switching frequency. And the tip of the current error i.e. is outside of the hexagon it should be returned in hexagon as fast as possible the operation shown in above fig 9.

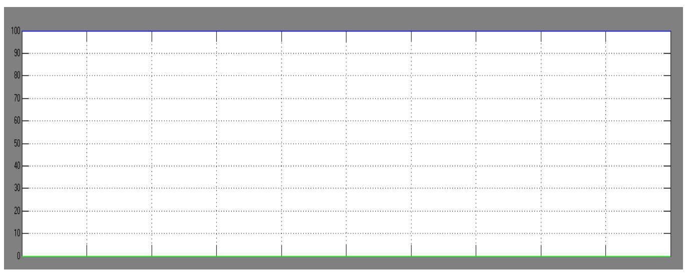

Figure: 10 PV voltages [V (vs) T]

The above fig10 shows the input voltage at dc side of the solar PV array is 100V.

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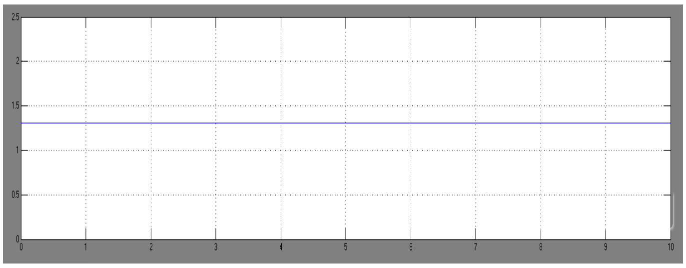

Figure 11 battery voltages [V (vs) T]

The above figure11 shows the input of the battery. The voltage is setting at 100V and battery current is 1.25A

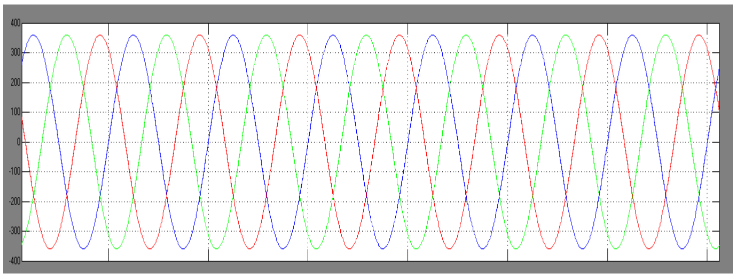

Figure 12 output voltages [V (vs) T]

The above figure 12 shows the operation of output voltages getting 380v in output side in three-phase. In single phase the input voltage is 100V and output side the voltage is 380V.

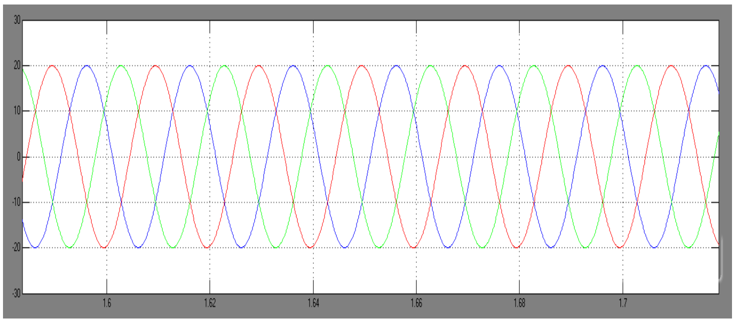

Figure 13 output current [V (vs) T]

The above figure 13 shows the out current in three phase system is 20A. The input side is 1.25A and outside of the three phases is 100A.

V. CONCLUSION

In this project, a solar panel and lithium ion battery is used as inputs for the power generation. The concept of Hysteresis band current control is introduced here to generate pulses for the inverter. This method does not need any knowledge of load parameters. Because of the multiple advantages that lithium ion battery offers compared to the other battery technologies, it is a very promising technology that can be successfully used to mitigate the effect of variability of the generation and load demand. Furthermore, the proposed integration of the DC-DC converters and the control schemes demonstrate the capability of stable and fast dynamic operation under various modes operation of PV array and the Battery. The software tool used in this project is MATLAB 2012.

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