International Journal of Emerging Innovations in Science and Technology *(ISSN: 2348 – 4403)*
Volume 4– Issue 1, November 2017

Multi-mode operation for the PV power system With SVPWM technique and PI with Fuzzy logic

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Abstract— A multilevel topology with medium-frequency ac link for medium-voltage grid integration of utility photovoltaic (PV) plants is discussed in this paper. In the proposed system we approached perturb and observe (*P&O*) algorithm for MPPT to harvest maximum from the PV panel and to maintain the stability of the system. Each zone employs a medium-frequency transformer with three secondary's, which interface with the three phases of the medium voltage grid. An insulated-gate bipolar transistor full bridge inverter feeds the MF transformer. The voltages at the transformer secondary are then converted to three-phase line frequency ac by three full-bridge ac–ac converters. Cascading several such cells, a high-quality multilevel medium-voltage output is generated. A new control method is proposed for the cascaded multilevel converter during partial shading while minimizing the switch ratings. Here we use Fuzzy controller for quick response time and accuracy in the secondary. The proposed topology eliminates the need for line frequency transformer isolation and reduces the dc bus capacitor size, while improving the power factor and energy yield.

Keywords-component; Maximum power point tracking, Multilevel Inverter, Three phase inverter.

I. INTRODUCTION:

The renewable energy source, such as the Photovoltaic (PV) power system, has been rapidly developed in order to reduce the fossil fuel usage and carbon dioxide emission. However, the unpredictable environmental conditions, such as irradiation or temperature, bring negative impacts to output characteristics of PV arrays. Therefore, developing an effective maximum power point tracking (MPPT) converter to improve the efficiency of PV power system is necessary.

Recently, many countries have announced their own grid codes for the distributed generator to meet the low-voltage ride-through (LVRT) capability in order to increase the quality and stability of the power system.

Different control schemes are proposed to achieve better performance of the power qualities of the PV inverters under unbalanced grid voltage sags [1-5]. Although those control strategies are effective for inverters, the operation of the front-stage boost converter is not considered and the power flow balancing between the MPPT and the inverter is not discussed. The concept of multi-mode operation for PV power system is presented. Therefore, an interleaved boost converter with improved multi-mode operation for the PV power system is proposed in this paper with SVPWM technique and PI with Fuzzy logic. The interleaved boost converter can remain MPPT operation during the slight voltage sag. We have verified the proposed design using MATLAB simulink.

The following are the objectives,

- To improve the system stability.
- To reduce the Total Harmonic Distortion (THD) and to improve the power factor.
- By that the system regulation at the output side is increased.

II. SYSTEM CONFIGURATION:

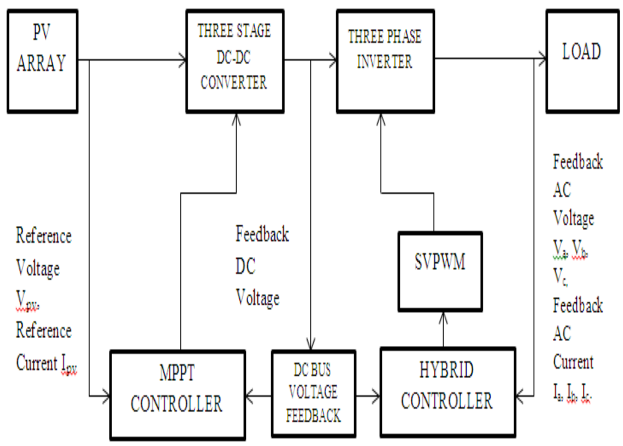

Fig-1. Block Diagram

1.BOOST CONVERTER AND HYBRID CONVERTER

A boost converter (step-up converter) is a DC-to-DC power converter with an output voltage greater than its input voltage. It is a class of switched-mode power supply (SMPS) containing at least two semiconductors (a diode and a transistor) and at least one energy storage element, a capacitor, inductor, or the two in combination. Filters made of capacitors (sometimes in combination with inductors) are normally added to the output of the converter to reduce output voltage ripple in the proposed system we use three stage DC to Dc converter, where the voltage level is boosted much. Then three phase inverter is used to invert the boosted DC voltage to AC and utilized for AC load. The circuit diagram of the three stage boost converter is shown below.

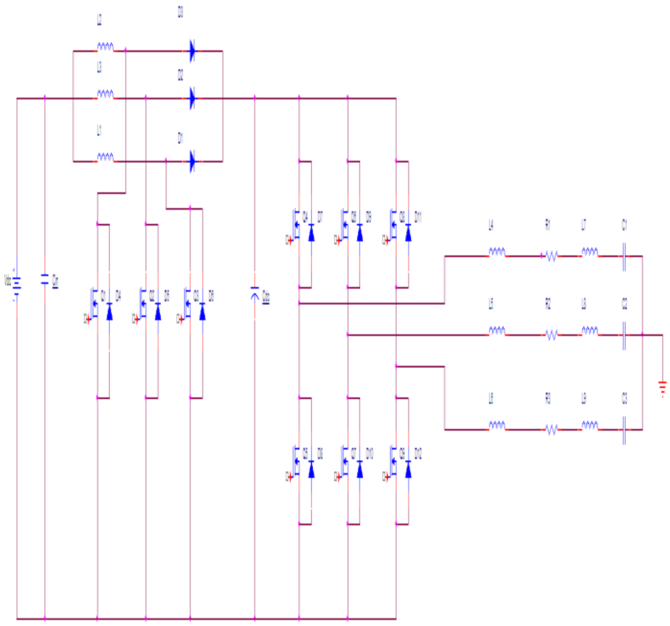

Fig.2.Circuit Diagram of Boost Converter

2.THREE PHASE INVERTER

A power inverter or inverter is an electronic device or circuitry that changes direct current (DC) to alternating current (AC).

The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry.

Here we use MOSFETswitches for three phase inverter. Single-phase VSIs cover low-range power applications and three-phase VSIs cover the medium- to high-power applications.The main purpose of these topologies is to provide a three-phase voltage source, where the amplitude, phase, and frequency of the voltages should always be controllable.

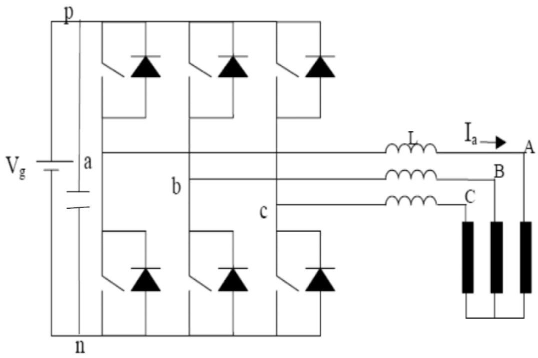

Fig-3. Three Phase inverter

3. SPACE VECTOR MODULATION

Space vector modulation (SVM) is an algorithm for the control of pulse width modulation (PWM). It is used for the creation of alternating current (AC) waveforms; most commonly to drive 3 phase AC powered motors at varying speeds from DC using multiple class-D amplifiers. There are various variations of SVM that result in different quality and computational requirements. One active area of development is in the reduction of total harmonic distortion (THD) created by the rapid switching inherent to these algorithms.

4. P CONTROLLER

P controller is mostly used in first order processes with single energy storage to stabilize the unstable process. The main usage of the P controller is to decrease the steady state error of the system. As the proportional gain factor K increases, the steady state error of the system decreases. However, despite the reduction, P control can never manage to eliminate the steady state error of the system. As we increase the proportional gain, it provides smaller amplitude and phase margin, faster dynamics satisfying wider frequency band and larger sensitivity to the noise. We can use this controller only when our system is tolerable to a constant steady state error. In addition, it can be easily concluded that applying P controller decreases the rise time and after a certain value of reduction on the steady state error, increasing K only leads to overshoot of the system response. P control also causes oscillation if sufficiently aggressive in the presence of lags and/or dead time. The more lags (higher order), the more problem it leads. Plus, it directly amplifies process noise.

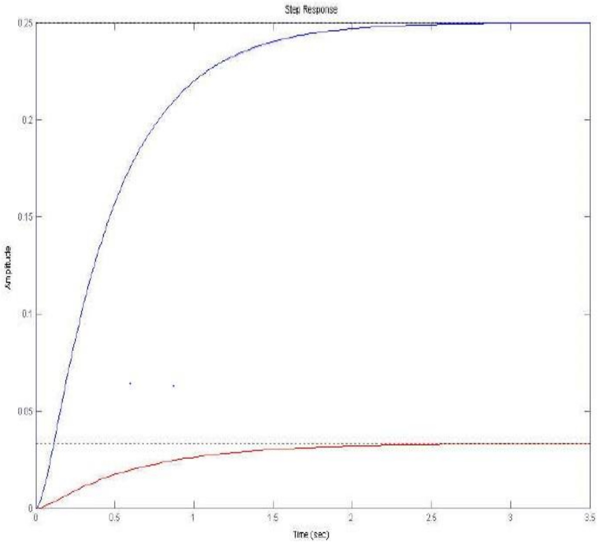

Fig -4.Step response of P controller

5. PI CONTROLLER

P-I controller is mainly used to eliminate the steady state error resulting from P controller. However, in terms of the speed of the response and overall stability of the system, it has a negative impact. This controller is mostly used in areas where speed of the system is not an issue[6-8]. Since P-I controller has no ability to predict the future errors of the system it cannot decrease the rise time and eliminate the oscillations. If applied, any amount of I guarantees set point overshoot.

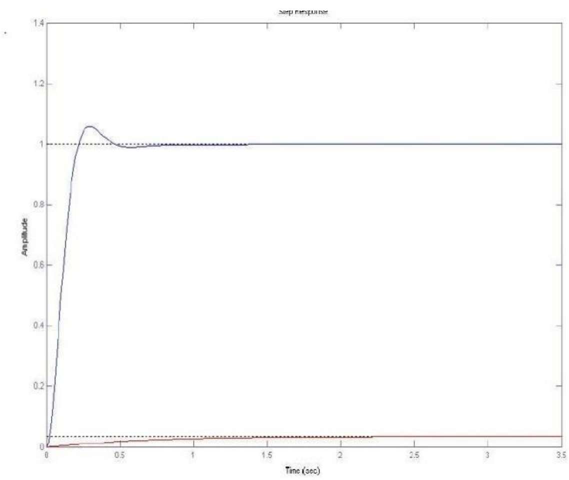

Fig.5. Step Response of PI controller

6. PID CONTROLLER

PID controller has the optimum control dynamics including zero steady state error, fast response (short rise time), no oscillations and higher stability. The necessity of using a derivative gain component in addition to the PI controller is to eliminate the overshoot and the oscillations occurring in the output response of the system [8]. One of the main advantages of the P-I-D controller is that it can be used with higher order processes including more than single energy storage.

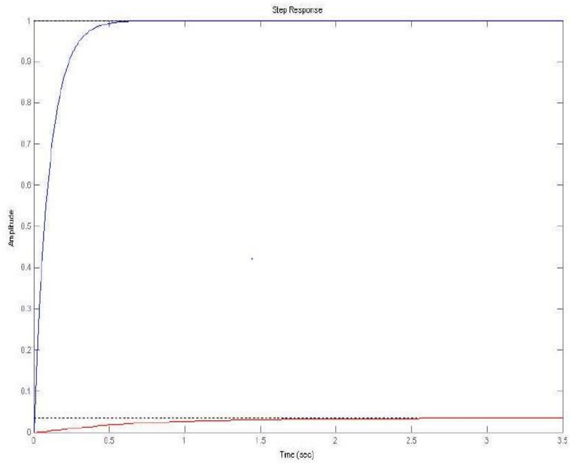

Fig -6. Step response of PID controller

7. FUZZY CONTROLLER

Basically, Fuzzy Logic (FL) is a multivalued logic that allows intermediate values to be defined between conventional evaluations like true/false, yes/no, high/low, etc. Notions like rather tall or very fast can be formulated mathematically and processed by computers, in order to apply a more human−like way of thinking in the programming of computers[9,10].

The internal structure of the fuzzy controller is shown in Figure 7, the error e and change of error (ce) are used numerical variables from the real system. To convert these numerical variables into linguistic variables, the following seven fuzzy levels or sets are chosen as: NB (negative big), NM (negative medium), NS (negative small), ZE (zero), PS (positive small), PM (positive medium), and PB (positive big) as shown in table 1.

The fuzzy controller is characterized as follows:
(i) Seven fuzzy sets for each input and output.
(ii)Fuzzification using continuous universe of discourse.
(iii) Implication using Mamdani's 'min' operator.
(iv) Defuzzification using the 'bisector' method.

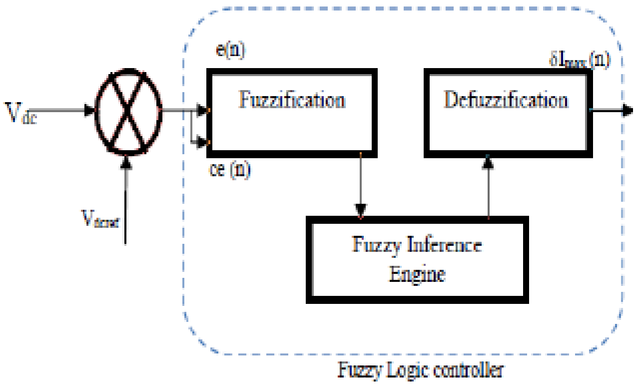

Fig-7. Structure of Fuzzy controller

The elements of rule base table are determined based on the theory that in the transient state, large errors need coarse control, which requires coarse input/output variables; in the steady state, small errors need fine control, which requires fine input/output variables. Based on this the elements of the rule table are obtained as shown in Table 1, with error and change in error as inputs.

ce / e	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	NB	NM	NS	ZE	PS
NB	NB	NB	NM	NS	ZE	PS	PM
ZE	NB	NM	NS	ZE	PS	PM	PB
PS	NM	NS	ZE	PS	PM	PB	PB
PM	NS	ZE	PS	PM	PB	PB	PB
PB	ZE	PS	PM	PB	PB	PB	PB

Table 1 Control rule base

The rule representation and surface view waveform of the fuzzy logic is shown below.

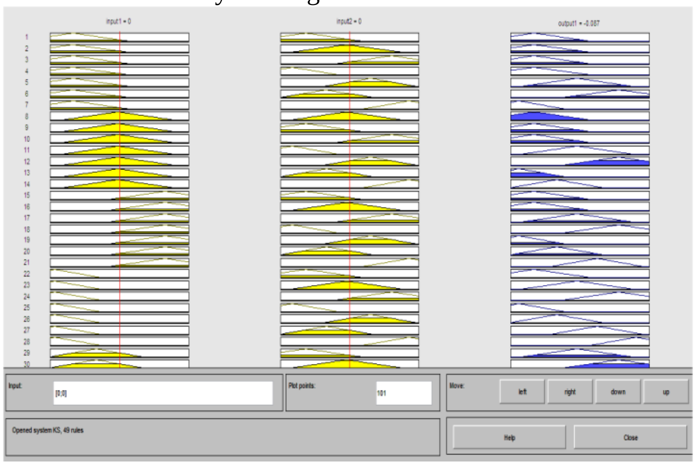

Fig -8. Rule view representation

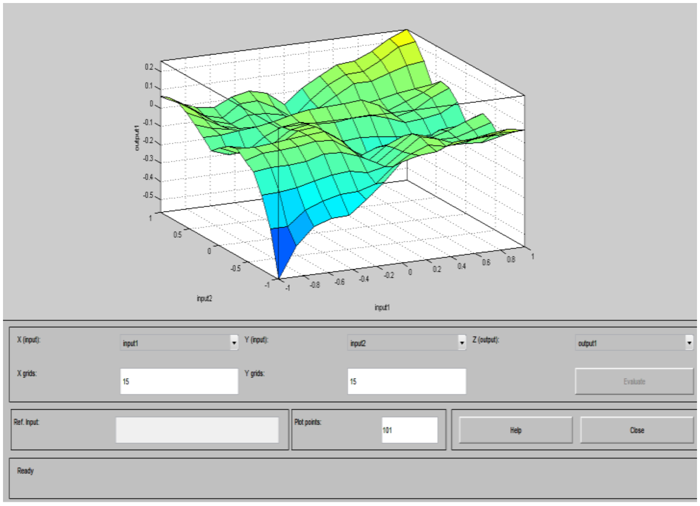

Fig.9- surface view representation

III. RESULTS AND DISCUSSION

This chapter deals with the simulation circuits and results. The circuit has been simulated using MATLAB R2013a software with Simulink toolbox. Simulink is a software package for modeling and analysing dynamic systems.

Hardware results:

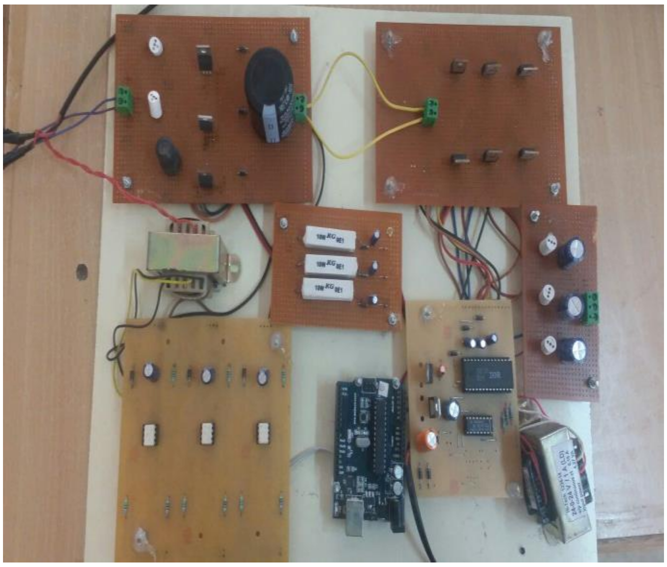

Fig-10. Hardware setup module

PWM PULSES TO THE MOSFET

The following Figure 11 shows the generation of pulses using Gate Driver Circuit to the switches (MOSFET) converter side

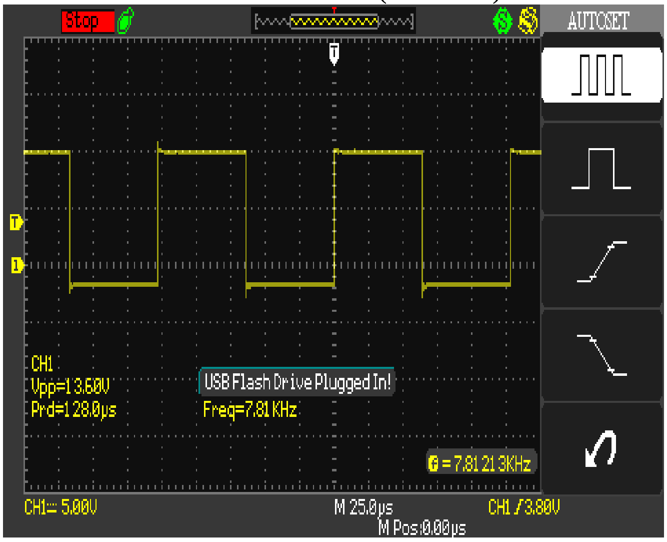

Fig-11.Gate driver waveform

The following Figure shows the dc input to the inverter.

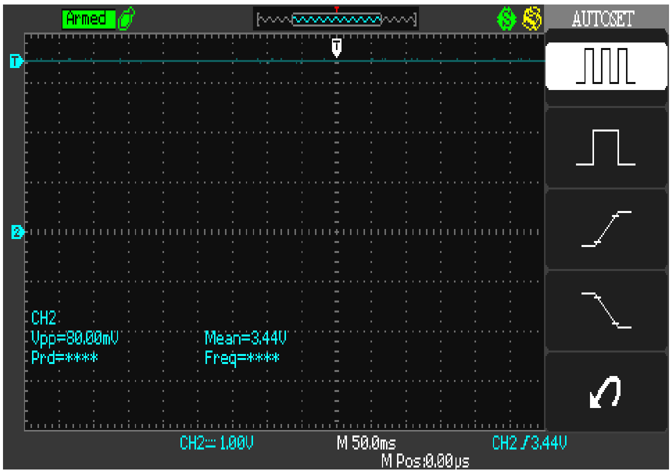

Fig-12. DC Input to the Inverter

IV. CONCLUSION

In this paper we have proposed the three-phase PV power system with low-voltage ride through (LVRT) capability. Here we have designed the system with hybrid controller at the output. We used Fuzzy logic, PI controller and the space vector pulse width modulation (SVPWM) technique to avoid maximum sag and THD in the output. When compared to PWM technique the system PF is high by using SVPWM technique. We tracked maximum power from the solar panel using MPPT controller. Thus the proposed module is designed using MATLAB Simulink and the hardware for the same is done and output is verified.

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