IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676,p-ISSN: 2320-3331
PP 66-71
www.iosrjournals.org

A Novel Grid Connected PV Micro Inverter

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Abstract: *The ordinary grid connected PV micro inverters are faced with limitations on the performance properties. In this paper a novel approach with good performance properties is proposed. The proposed inverter includes a quadrupler, having high efficiency and less voltage stress across the diodes. The proposed converter has considerably less stress that come across the diodes that use in the inverter section and, also the protection scheme provided is to eliminate the chances of the error due to fault. The backbone in the proposed converter is implemented using perturb and observe algorithm so that the fluctuation in the voltage can be reduce and can attain maximum power point. This paper includes simulation and experimental results are also presented to demonstrate the effectiveness of the proposed converter.*

I. Introduction

The renewable energy is the alternate source of energy that is available abundantly. The renewable energy is also cheap. India is one among the countries that utilizes this energy efficiently. The renewable energy includes wind energy, biomass, sunlight, tidal etc in this paper we are dealing with the efficient utilization of the solar energy. The solar energy can be converted to electrical energy by means of PV cell. The problem in this is the cost. The material used to construct the PV cell is silicon, a costly material. The initial investment is considerably very high for the PV panel. So, this is not so popular among the domestic application.The output that can be obtained from the PV panel is very low (approx~24 V). The interconnection of a solar cell in both parallel and series can improve the output to our required value. This arrangement is called the PV array. The proposed inverter consists of a PV array, a converter (DC-DC converter or Quadrupler), and an inverter, MPPT controller protection scheme (relay and circuit breaker unit). The proposed converter checks the output of both the DC-DC converter as well as quadrupler. The highest value and efficiency is being chosen. The inverter that we connected is an H-Bridge inverter with four diodes two of the will be n and the rest will be on commutation. The next stage will be controller to provide MPP. And stable output.

The protection scheme that we used here is a relay with a circuit breaker. The proposed converter is able to handle the stress across the diodes, and the chances of fault. Whenever a fault occurs in the grid section it will actuate the relay thereby the circuit breaker. Hence the entire system is protected. The inverter proposed here has enough advantages as compared with the conventional inverter section. The entire efficiency anis improved to a greater extent and also the voltage stress across the diodes is being reduced to minimum. And the remarkable feature is its protection schemes and MPPT provided.

II. Circuit Diagram

The grid connected PV Micro inverter utilizes a DC-DC Converter, inverter a MPPT controller and a protection schemes. The output from the PV panel is provided to the DC-DC converter section, which converter converts the small value of input to the desired value by adjusting the duty ratio. The third stage is a DC-AC inverter stage that converts the dc value to an n ac value.

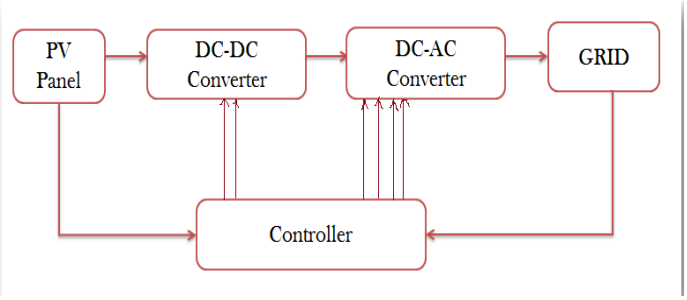


Fig 1: Block diagram of grid connected PV micro inverter

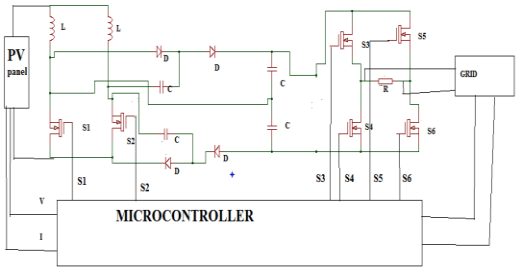


Fig.2. circuit diagram of micro inverter

The PV panel of specification of 24V is being used. Photovoltaic systems use cells to convert solar radiation into electricity. The Solar cell consists of one or two layers of a semiconducting material. When light shines on the cell it creates an electric field across the layers, causing electricity to flow. Greater the intensity of the light, greater will be the flow of electricity. The most common semiconductor material used in photovoltaic cells is silicon. Silicon is the second most abundant material in the earth's mass.. It can also generate electricity on cloudy days. The voltage obtained from the PV is 24V. In order to generate a large value we need to boost the voltage output of PV. So we go for a converter it may be either a DC-DC converter or a quadrupler. The convention system utilizes a DC-DC converter. The conventional DC-DC converter can generate a voltage of 170 from a 24V input.As it is low to drive our power requirement. High step up DC-DC converter with switched capacitor is being used. The coupled inductor along with switched capacitor can achieve a high step up duty ratio. The voltage stress across the diodes remains as such.

Quadrupler circuits are used to multiply the voltage values. The quadrupler output will be four times as compared to the DC-DC converter. It consists of two multiplier circuits. The quadrupler has enough advantages it includes high voltage gain and automatic current sharing capability. The overall conversion efficiency is high. The quadrupler consists of two multiplier diodes. And two inductors with which it will be storing energy. The DC-AC inverter is used to convert the DC value to AC. The inverter consist of four switches in which two of them will be on simultaneously and others will be off and having frequency equal to grid frequency. The SPWM signal is used to fire the MOSFETs. The SPWM signal is the compared output of the sinusoidal and the repeating sequence. The sinusoidal pulse is from the grid, it is compared with the repeating sequence. The output of the DC-AC- inverter will be an AC value. Also an islanding protection and abnormal state detection is also provided in this stage

III. Design And Analysis Of Micro Inverter

The DC-AC inverter consists of a full bridge inverter comprises of four switches and with a low pass filter. The hybrid pulse width modulation (HPWM) is used for switch driven [7]. The HPWM method uses two different switching frequency signals to drive switches respectively. There are only two of four switches commuted at lower frequency which is equal to grid frequency. Other two switches are driven by the pulse width modulation signals came from the compared result of sinusoid amplitude signal and triangle carrier. Fig. shows the HPWM switch driving signals of the full bridge inverter

Mode I:

During positive half cycle, switches S1 and S4 are active; other switches including S2 and S3 are turned off. The switch S4 is subject to duty cycle modulation control.

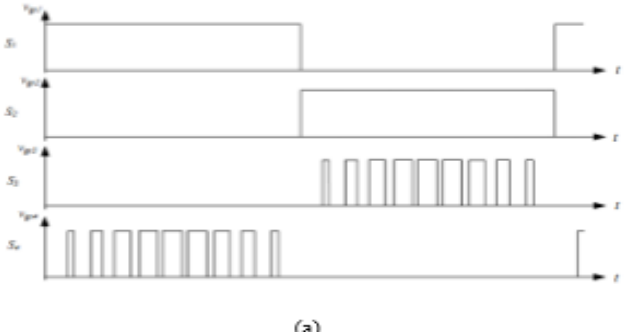


Fig: 3 The HPWM signals on the switches of the full-bridge inverter.

Mode II

In this mode the other two switches S2 and S3 is turn on. The gate signal used here is SPWM itself with a delay as compared to the other.

The output is taken across the resister.

Output across point ab will be,

V_{ab}=-DV_{Bus} (2)

The duty ratio of the inverter is being adjusted to get a desired value output. . Upper switches S1 and S2 are commutated at low frequency, therefore switching losses will be reduced than others as result efficiency will be improved.

Quadrupler

The basics quadrupler used here consist of two capacitor and two diodes. In which first inductor discharges through the one diode and the other with stored energy of capacitor 1 is discharged to the next capacitor so the voltage value and gain will be increased. As a result net output doubled. The complete working can be explained in three modes. In order to explain the working initially, some assumptions are taken they are as follows.

1) All components used are ideal

2) The capacitor value being large enough, so that the voltage across it to be constant

3) It is working in the continuous mode and under steady state condition.

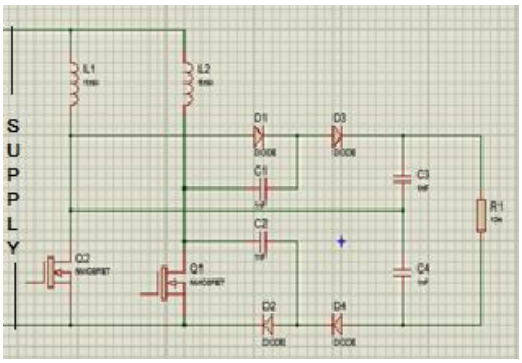


Fig 4 : Quadrupler circuit

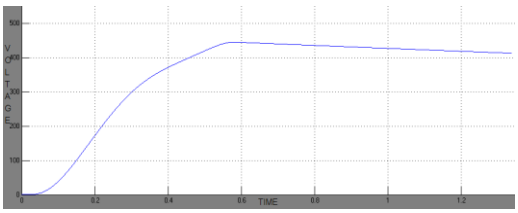


Fig.5: simulation output of quadrupler

Modes I&III

In this mode both the switches are ON. And all the diodes are under OFF condition. The inductors are being charged and store energy according to current flow through it. The voltage across the diodes is clamped to capacitors. The voltages across the diodes DA1 and D_{A2} are V_{CA} and V_{CB} respectively. The voltages across the diodes D_{1B} and D_{2B} are V_{C2}-V_{CB} and V_{C1}– V_{CA} respectively. The capacitors on load side discharges through the load

Mode II

In the second mode of operation one of the switches are on and the other is off. The switch S_1 is ON and S_2 is OFF. The diodes D_{2A} and D_{2B} are ON. The capacitor C_A and inductor L_2 discharges to C_1 and the energy of L_2 stored to C_B. The current through L_1 is increasing and L_2 is decreasing.

Mode IV

Here S_2 is conducting and S_1 is turned OFF. D_{1A} and D_{1B} is conducting L_1 and CB discharges to the capacitor C2 and load. The energy of L1 is stored to CA. The capacitor voltage V_{C2} is equal to V_{CB}+V_{CA}. The iL2 is increasing and i_{L1} is decreasing

IV. Design And Setting Of Microinverter

The major control programs of micro inverter include starting check, abnormal state detection, MPPT technique, islanding detection. These are discussed in this section.

A. Maximum power point tracking program:

Maximum power point tracking technique is used to improve the efficiency of the solar panel. According to Maximum Power Transfer theorem, the power output of a circuit is maximum when the Thevenin impedance of the circuit (source impedance) matches with the load impedance. Hence our problem of tracking the maximum power point reduces to an impedance matching problem. In this paper deals with petrub and observe method.This technique use only one sensor that is voltage sensor. The time complexity of this algorithm is very less for calculating the maximum power but on reaching very close to the Maximum Power Point Tracking (MPPT) it doesn't stop at the MPP and keeps on perturbing on both the directions so for that reason it have multiple local maximum at the very same point. In certain situations like changing atmospheric conditions and change in irradiance the maximum power point shifts from its normal operating point. P&O algorithm shown in Fig 6

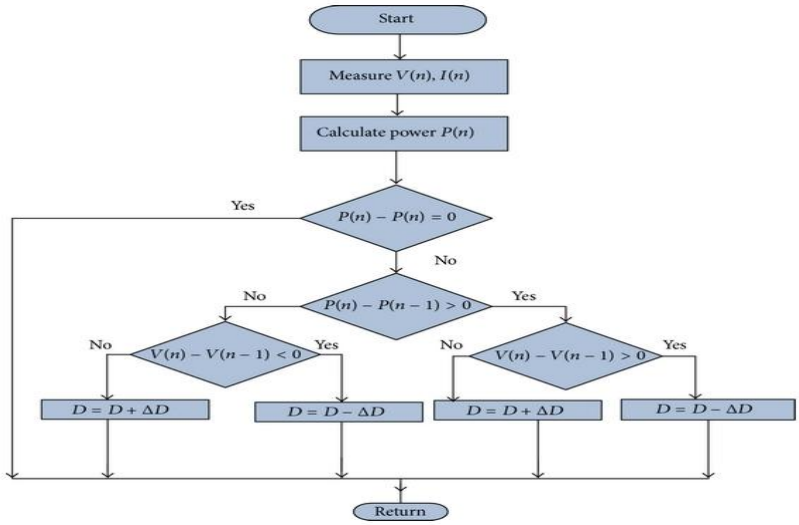


Fig 6.P&O Algorithm

B. Abnormal State detection program

In abnormal state detection program detect the problem in the system i.e. Over voltage, over current etc. According to IEEE Std.929, the grid voltage range is 88%-100% of 230V (196Vrms-242Vrms) and grid frequency range is49.3Hz-50.5Hz. In abnormal state condition the system voltage can withstand constantly out of settling range for more than 330ms and the frequency constantly out of setting range for more than 100ms then only the system will shutdown.Fig.6(b) shows the abnormal state detection program.

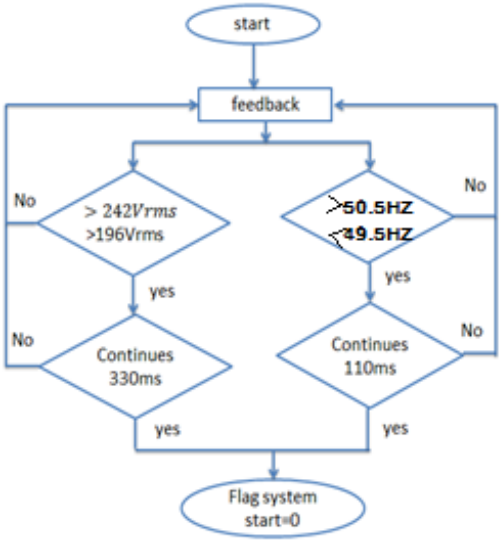
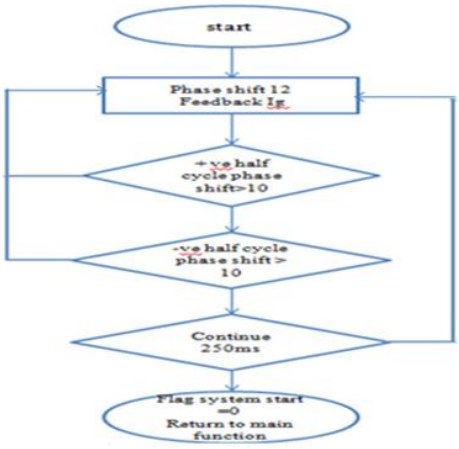


Fig. 7(a) abnormal state detection



(b) Islanding detection program

C. Islanding detection program

Islanding detection provide in the system for the continues operation ,when the grid power malfunction and photovoltaic generation system does not detect the malfunction or promptly disconnect .Two methods are for the islanding detection ,they are active and passive. In abnormal condition passive methods will detects within the setting range of frequency and voltage, it will not detect abnormal condition.So active method is preferable. In this method frequency shift algorithm is used. Islanding is triggered when frequency shift is greater than 10^0 in positive and negative half cycle. According to IEEE std 929, the total current distortion should be less than 5% and the time period will within 2s.Fig.7 flowchart of islanding detection program.

V. Results

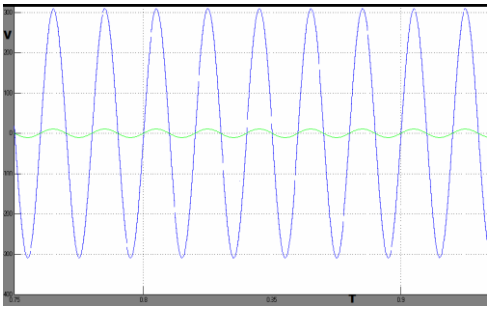


Fig 9: micro inverter output

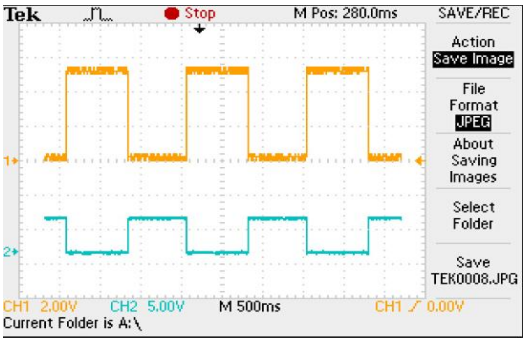


Fig 8: inverter pulses

VI. Conclusion

A PV micro inverter is being implemented in this paper. The PV inverter that we proposed has enough functionality as compared to the conventional inverter. A conventional inverter has a converter section inverter as well as a controller. The voltage stress across the diodes is very high and the low efficiency is remarkable disadvantage. The one more problem that we are dealing is the fault. So in this converter we are using the quadrupler to multiply the output and boost it. Also a coupled inductor with switched capacitor can reduce the voltage stress across the diodes. The overall efficiency of the proposed system is high. In this we are also

providing an anti-islanding as well as the abnormal state protection. In this any chances of the fault can be detected in it and will isolate the overall circuit from the grid. In all these ways the proposed PV inverter can counter the disadvantage of conventional converter and we mould it as a new inverter with better features.

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