PERFORMANCE ANALYSIS OF GRID-CONNECTED PV INVERTER USING CURRENT CONTROL TECHNIQUES

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ABSTRACT

Solar photovoltaic (PV) is one of the most promising renewable energy resources that converts solar energy into electricity with environment friendly manner. However, it has low efficiency and high relative costs. In order to overcome these drawbacks, a grid-connected PV energy system should be required to satisfy the load demand.

In this paper , the analysis and simulation of grid connected single stage PV system using hybrid inverter and its control methods for implementation of DC to AC power conversion is presented.The design of grid connected single stage PV- system using hybrid inverter modeling and simulation is carried in MATLAB - simulink environment. A fixed D.C. i/p voltage is given by the help of P-V module to the hybrid inverter and a controlled A.C. o/p power is obtained by adjusting the value of Id and Iq ,hence varying the on/off periods of the inverter components. The hybrid inverter used in this thesis presents a single-phase version of SSI with improvements in inverter topology as well as the pulse width modulation (PWM) technique. An inductor is connected to two MOSFETs operating at fundamental frequency to boost the voltage from input source to dc-link voltage. In this inverter, one of the full-bridge legs undergoes constant duty cycle switching while the other one undergoes sinusoidally varying duty cycle switching, with the former is accountable for charging and discharging of inductor while the latter is accountable for producing ac output. The duty cycle variation is achieved by using pulse width modulation [PWM] generator block .

*   Hence by varying the value of Id and Iq the active and reactive o/p power can be controlled by using decoupled current control method in hybrid inverter.*

KEYWORDS: *Photovoltaic(PV),MOSFETS,PWM,Hybrid Inverter.*

I. INTRODUCTION
1. The need for Renewable Energy
The wellsprings of sustainable power source are tides, daylight, rain, warm vitality and wind. This assets might be normally refilled and never leave stock. Normally the prime supplies of vitality these days come directly or in a roundabout way from petroleum derivatives which are gradually getting depleted from the earth stockpiling dissimilar to these sustainable assets which are limitless in nature. With time and advancement people around the world have been searching for non customary hotspots for long run satisfaction of their fundamental vitality request. With rapidly developing populace and fuel utilization, the contamination caused to the surroundings also will

increment, hence there is a basic need of Clean and unpracticed Mechanisms which are currently prominently received by countries all through the world. The clean and no contamination utilization of these sustainable power source is what pulled in the present globe and hence a gigantic capital venture is being improved the situation reaping these assets.

1.2 Solar power

The rising force request of everyday life can't exclusively be kept up by exploitation average vitality recourses because of its detachment. Together with standard frameworks the interest for inexhaustible sources has collected to satisfy the vitality request. Inexhaustible sources like elective vitality and wind vitality are the prime vitality sources that are being utilized amid this respect. The persistent utilization of non-renewable energy sources has radically influenced the air draining the part and exacting warming. Collect sunlight based power is achievable because of It's excessively comfort. The present vitality emergency might be handled by enhancing power with productivity and might be separated from the approaching radiation. The office transformation procedures are for the most part restricted inside the past couple of years. to look up to the powerful interest the occasion in power material science and material science has helped specialists to return up horribly transient anyway intense frameworks. The expanded power thickness is that the significant con of those frameworks. Pattern has set certain the usage of multi-input convertor units which will viably control the potential anomalies. Anyway on account of staggering expense and furthermore the low intensity of those frameworks they'll scarcely strive inside the aggressive markets as an essential power age source[7].

1.3 Installation of PV system:-

The establishment of PV is finished with regards to their task and needs of activity named as:
1. Stand alone PV framework.
2. Grid associated PV framework

Remote zones are furnished by exploitation remain solitary framework with the use of convertor and vitality memory gadget, on the contrary turn in matrix framework the capacity created is specifically sustained to link and dispersed.

A.Stand alone PV framework:

Remain solitary universes the sun oriented boards don't appear to be associated with a matrix anyway rather are acclimated charge a bank of batteries. These batteries store the limit made by the sun arranged sheets then your electrical weights draw their capacity from these batteries. Stay lone sun based essentialness systems are used for a broadened time in zones wherever no open grid is promoted. Regardless, the basic improvement in sun

situated essentialness structures inside the latest five years has been in grid Connect systems[1].

B.Grid associated PV framework:

The present pattern is to utilize the sun oriented power for creating power with the help of lattice associated framework. A lattice associate framework is one that works in with the local utility network so once your sun based boards make extra sun powered power than your house is utilizing the overabundance control is nourished into the matrix. With a lattice interface elective vitality framework once your home needs extra power than what your star boards are producing then the parity of your power is given by the utility matrix. To incorporate the PV framework with matrix the basic needs are -

(I) The PV framework should confront rise and fall in voltage for a concise time.
(ii) Desired control plot should be there to synchronize it with the network.
(iii) There ought to be less symphonious mutilation.

Network associated PV framework cause a few issues due to discontinuous nature of sun oriented power and interminably factor matrix conditions. Goliath exertion is made worldwide to plot benchmarks for lattice associated PV framework. IEEE1547, IEC61727 and ENC61000-3-2 manages issues like quality recognition of islanding activity, amount of infused current into the matrix, Total Harmonic Distortion (THD) and so forth.

1.4 Basic Grid Connected Photovoltaic System:-
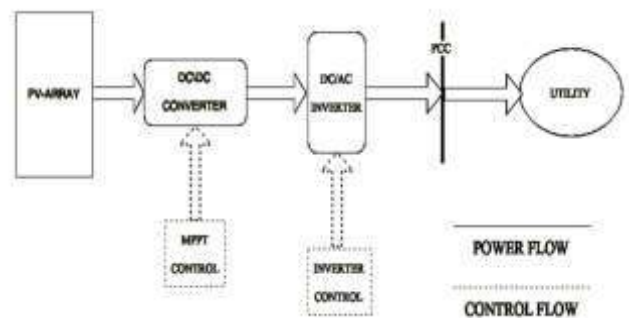
Fig.1.1 Basic grid connected PV system

- **PV Array:-**
PV exhibit might be a bunch of arrangement associated sunlight based cell that is nonlinear supply of vitality. Its most power age ability is extremely dependent on irradiance and temperature, while its moment control age specifically dependent on its yield ohm obstruction[1].
- **DC-DC CONVERTER:-**
The DC-DC converters are most broadly misled in PV producing frameworks as an interfacing between PV

module and the heap. These converters ought to be been prepared to coordinate the most power focuses (MPP) of PV module once climatic condition change with very surprising resistive load esteems. In this way DC-DC converters ought to be utilized with MPPT controller to decrease misfortunes inside the worldwide PV framework.

- **DC - AC INVERTER:-**

Inverters are imperative in any sun based power framework and are ordinarily considered as to be the brain of a task, regardless of whether it's a 2-kW framework or a 5-MW control substation. An inverter's basic role is to "convert" the DC yield into AC. Air conditioning is that the typical used by every single modern apparatus, that is the reason a few view inverters in light of the fact that the "entryway" between the photovoltaic (PV) framework and furthermore the vitality off-taker. Inverters controls are utilized to control the dynamic and receptive forces and to synchronize it with lattice appropriately[11][13].

## 2. METHODOLOGY
2.1 PROPOSED SYSTEM:
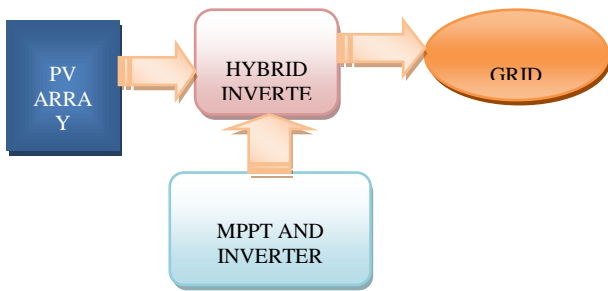
Fig. 2.1 Proposed System

2.1.1 Photovoltaic System Components:-
- ### *Photovoltaic cell :-*

In photovoltaic cell "Photograph" essentially implies that light, and "voltaic" alludes to voltage, that could be a unit of potential power. when you blend these 2 terms, the word photovoltaic incorporates the change of light vitality to AN electrical flow. For straightforwardness, you'll take a seat with electrical marvel cells as star cells. A sun based cell or identifier may likewise be delineated as the semiconductor unit basically a p-n intersection diode that proselytes light to power by photovoltaic impact. When photon particles of light having vitality greater than the band hole of the valence electron is shelled to the intersection electron gap sets are created that once followed up on by inside field end in a photocurrent. PV cell is basically a current supply wherever current is made by the variety of photons not the voltage.
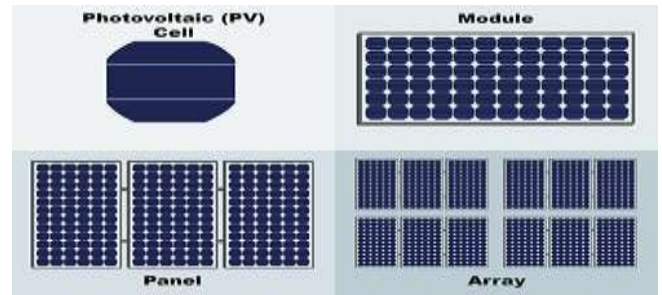
Fig .2.2 Photovoltaic cells, modules, panels and arrays.
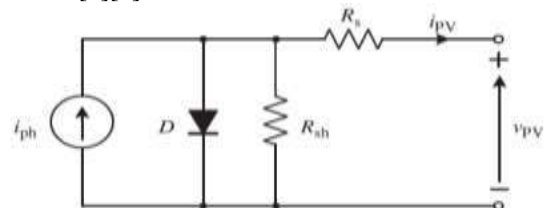
• *PV module :-*
It comprises of an outsized assortment of PV cells composed in arrangement or parallel or a mix of both to fulfill the utilization request. PV modules of grouped materials and expanded efficiencies and of wanted size are accessible inside the market.

• *PV exhibit :-*
A photovoltaic exhibit is that the whole power-producing unit, comprising of any choice of PV modules and boards. The execution of PV modules and clusters are by and large appraised to keep with their most DC control yield (watts) beneath typical test Conditions.

• *PV demonstrating:-*
Normally a cell is displayed by a current supply and a diode in turn around one-sided associated in parallel to it. The PV cell has its very own arrangement and parallel opposition. Arrangement opposition is on account of the diode obstruction (of the mass material) and obstruction of metal contacts while parallel opposition speaks to the electron gap recombination before itcomes to theload[1][7].

fig.2.3 -Single diode model of a PV cell

Following equation is used to model PV cell, PV Module and PV array.

PV Module output current (Ipv) can be given by:-

$$ipv = iph - i0[\exp\{(Vpv + ipv*Rs)/a\} - 1] - (Vpv + ipv*Rs)/Rsh \dots \dots (1)$$

Where,

iPV- Output current (A),

$i0$- Leakage current of the diode (A),

Vpv-Voltage at MPP (V),

ipv- Current at MPP (A),

Rs- Series resistance (Ω),

Rsh- shunt resistance (Ω),

a – Modified ideality factor.

Photo current (iph) which is depend on irradiance and temperature is given by,

$$iph= \qquad (iph,+\mu sc*\Delta T) \ldots \ldots (2)$$

Where, G - Irradiance $W/m2$, $Gref$ - Irradiance at STC (1000$W/m2$),

μsc- Temperature coefficient of short circuit current(A/k),

ΔT- Difference between actual Temperature(Tc) and Temperature at STC ($Tc,ref-298K$).

Leakage current of diode $i0$ can be evaluated by,

$$i0 = i0,*(Tc/Tc,ref)^3*\exp[(q\varepsilon g/Ak)(\qquad - \qquad)]$$
$$\ldots \ldots (3)$$

Where, q- Electron charge (1.6×10−19C), εg- Band gap energy (eV),

A – Diode ideality factor, k - Boltzmann constant (1.381×10−23J/K).

In which leakage current at STC ($I0,$)can be given as,

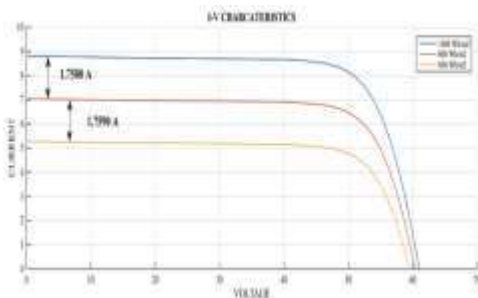$$i0,=isc,ref[\exp(Voc/a)−1] \ldots \ldots (4)$$

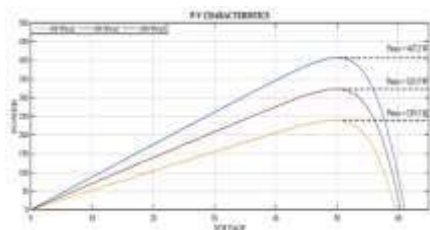**Fig.2.4 I-V Characteristics**

Fig. 2.5 P-V Characteristics

2.1.2 CONVERTERS:-

In electrical building, control transformation includes an extra particular importance, especially changing over electrical power from one sort to an alternate. Power change frameworks regularly fuse repetition and voltage direction.

One method for arranging power transformation framework is as per regardless of whether the info and yield are exchanging current (AC) or direct current (DC).

2.1.3 INVERTER:-

In electrical building, control change incorporates an additional specific significance, particularly changing over electrical power from one sort to a substitute. Power change structures consistently combine redundancy and voltage heading.

One technique for orchestrating power change structure is according to paying little respect to whether the information and yield are trading current (AC) or direct current(DC)[3].
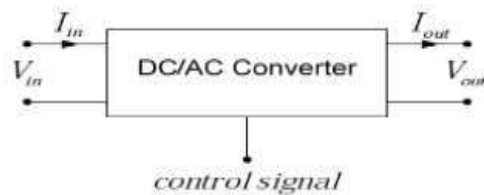

fig.2.6 DC/AC Converter block

A regular DC/AC convertor framework is appeared in figure. Information is from DC supply and yield is wanted to be a sinusoidal voltage or current with zero DC component. The heap can be a uninvolved RLC organize, an AC voltage sink or an AC current sink . Control parameters is a point, a heartbeat expansiveness, a voltage or current flag.

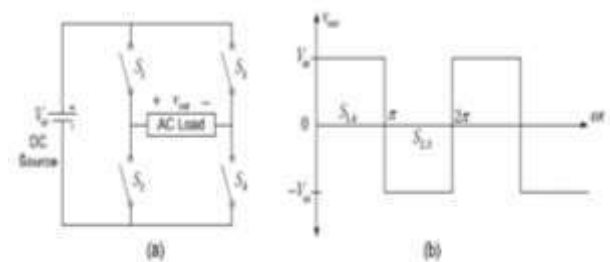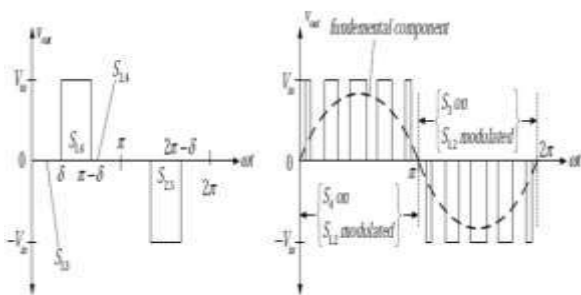**Fig. 2.7(a) Single phase bridge inverter (b)Output wave of AC voltage**

A 1-φ connect which is the least complex assortment of DC to AC convertor is appeared in graph. By as an elective opening and closing the diagonals switch combines that is S1 and S4 or s2 and s3 individually we can get the single stage DC to AC change basically. The yield voltage wave is appeared in

figure.

Fig.2.8 output AC Voltage (a) with zero state (b) With PWM control

For variable the AC voltage parameters normal technique is to present third express that is known as zero state. This might be gotten either by shutting the upper switches (S1and S3) or by shutting lower leg switches (S2 and S4) and you may get the required AC voltage parameters.

PWM inverters are for the most part utilized in power electronic hardware in physical applications. These can create air conditioning voltages of variable plentifulness and recurrence. The nature of the yield voltage of PWM inverter is the best when contrasted with the square wave inverters.

There should be direct connection between connected voltage and recurrence. The PWM inverters may be upheld to be utilized in single stage and 3 stage assortments. There are very surprising Kind of PWM systems, contingent upon the techniques of execution. In any case, by and large these strategies, the produced yield voltage once sifting, procure a conventional quality sinusoidal voltage waveform having wanted recurrence and abundancy individually. PWM inverters are utilized to control the voltage and to decrease the symphonious substance inside the yield voltage. Just if there should arise an occurrence of PWM inverters, the broadness of the yield beats is regulated to accomplish the coveted voltage control[9].

2.2 GRID TIES INVERTER:-

Inverters assume an indispensable job in any sun oriented vitality framework and are typically contemplated to be the brains of a task, regardless of whether it's a 2-kW framework or a 5-MW utility power substation. An inverter's fundamental activity is to "reverse" the DC yield into exchanging current (AC). Air conditioning is that the typical used by every single mechanical machine, that is the reason many view inverters in light of the fact that the "passage" between the photovoltaic (PV) framework and in this way the vitality off-taker. Inverters controls are utilized to control the

dynamic and responsive forces and to synchronize it with network appropriately.

Some Single Stage Inverters:-

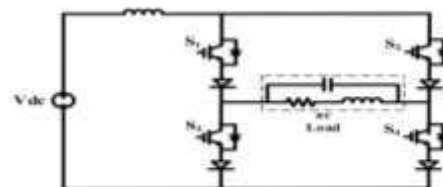### 1. Voltage Source Inverter (VSI):

Voltage source inverters are the preeminent basic inverter topology. A VSI contains a voltage source and a current sink, and it's basically a stage down (buck) inverter. Along these lines, with the end goal to venture up the voltage when a VSI is utilized, we'd jump at the chance to include another stage, i.e. a dc-dc convertor, to the inverter or utilize a low-recurrence electrical gadget. Including another power procedure arrange needs decoupling the dc-dc convertor and furthermore the inverter through gigantic capacitors. On the off chance that electrolytic capacitors are utilized, the inverter effectiveness will turn out to be continuously more regrettable. Utilization of low recurrence transformers lessens the power thickness, since low recurrence transformers are extensive and noteworthy. Figure 1.6 demonstrates the schematic of this topology[16].
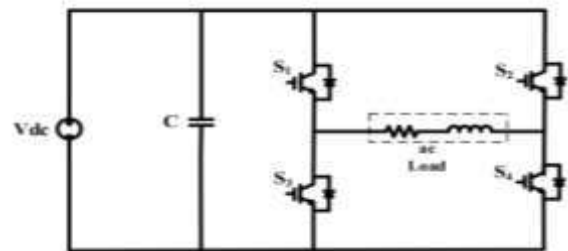
fig.2.9 Voltage source inverter

2. Current Source Inverter (CSI):

Current source inverters, appeared in Figure 4.10, are formed by a current source and a voltage sink, and are venture up (help) inverters. Current source is made by embeddings an inductor in arrangement with a voltage source. As found in Figure 4.10 amid this topology turn around blocking switches are required, and this will build conductivity misfortunes. CSI are just equipped for venturing up the voltage; in this way, much the same as VSIs they require limited voltage gain. Just in the event that disengagement is required a low recurrence transformer is required to be utilized.

fig. 2.10 Current source inverter

3. CONCLUSION

In this paper, a control scheme of Single stage Photovoltaic hybrid inverter for a grid connected PV system has been presented. Individual MPPT control is realized to maximize the solar energy extraction of each PV string and improve the efficiency of the PV system. Decoupled current control gives the steady state result. Simulation and experimental verified the proposed system.

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