A Review on MPPT Control Schemes for Large Generation Single Phase Grid Connected PV Systems

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ABSTRACT- On increased demand of energy for residential sectors, solar energy considered as best alternative for generation. For production of such large power plants PV cells need to be grid connected. With increased capacity, nonlinearity introduced in the system could not be ignored. This paper reviews some existing techniques to reduce harmonics & controlling power level of inverter.. It also focus on the design of inverters with PV cell characteristics, its MPPT tracking point & current control schemes used in single phase grid connected systems.

Keywords:- Harmonic distortion, MPPT Nonlinearity, Grid integrated PV generation,

1. INTRODUCTION

Indian government has taken initiation towards development of solar power generation. World's largest capacity solar power plant in Tamil Nadu is the one of example. They are not hazardous to environment & pollution free. It also covers large residential powered area. Due to this some state governments localized energy on roof tops of commercial sector. For development of such large power plants photovoltaic solar cells need to be integrated together & connected in grid. [1]

Grid connected PV cells produces harmonics & nonlinearity in power systems. Harmonics in current produces voltage distortion & power system stability reduces. Hence distortion or harmonics compensated power system need to be designed. The design can be implemented by proper understanding of basic PV cell characteristics, its inverter & MPPT design. [2] It is shown in basic configuration diagram.

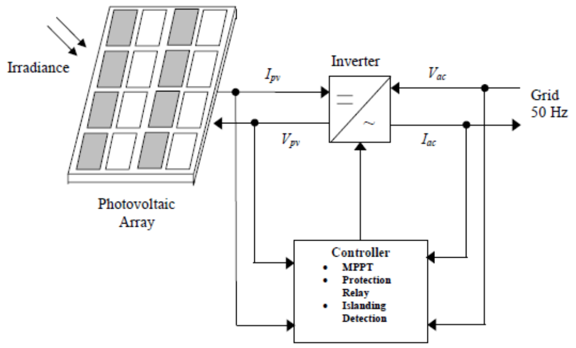

Fig1. Basic configuration of grid connected PV system.

1.1 A single PV cell characteristic

A PV cell current depends on its photocurrent, diode current & shunt current. PV characteristic shows that specific power rating can be obtained by joining specific voltage solar cells in series or parallel. Hence an operating point of the system depends on its open circuit voltage Voc, short circuit current Isc. Maximum power point tracked with respect to its solar irradiance & solar temperature & load resistance. Load joint with a cellar cell shifts tracked point which is shown in fig. 2

Photovoltaic cell current is given by equation [1.1]. Open circuit voltage represented in equation [1.2]

$$Ipv = Ip - Io\left[e^{\frac{q(Vpv+RsIpv)}{NkT}} - 1\right] - \frac{Vpv+RsIpv}{Rsh} \qquad [1.1]$$

Here middle term indicates diode current whereas last term denotes shunt current.

$$Voc = \frac{nkT}{q}\ln[\frac{Ip+Io}{Io}] \qquad [1.2]$$

When short circuited load maximum photovoltaic current $Isc = Ip$.

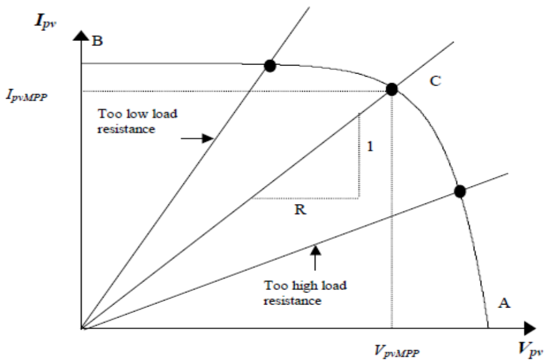

Fig.2.Shifting of MPPT point in accordance with load.

For increased irradiance MPP line shifts towards left reducing voltage & increasing current. Thermal stability of photovoltaic cell depends on its temperature rating. Commercial loads varied in temperature range of -40^{0}C to 60^{0}C. [3]

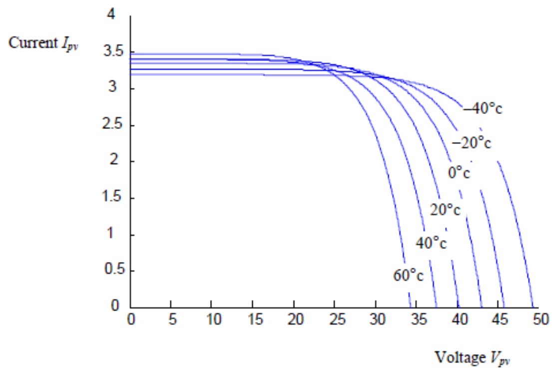

Fig.3. Effect of temperature on PV cell

Increase in temperature increases PV cell current reducing operating photovoltaic cell voltage as shown in fig 3 & 4.

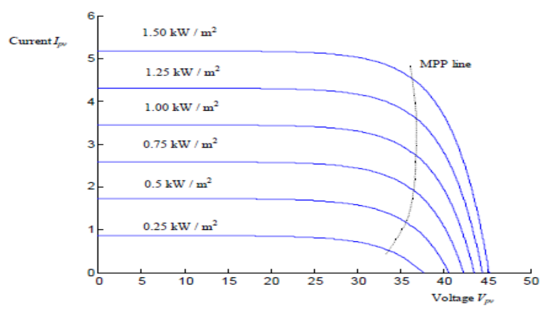

Fig.4. Effect of irradience on MPP line

1.2 Inverter considerations

Output obtained from PV cell is DC. For residential purpose conversion performed in AC using inverter. TLCI inverters & PWM inverters are the two best choices to obtain AC scheme. [4]

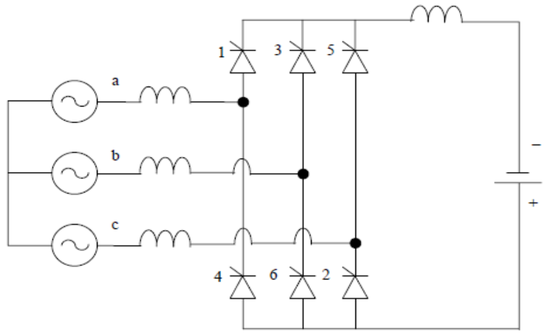

Fig.5. TLCI inverter

TLCI inverters have advantage of modest cost & availability for required power level. For considerable higher power rating PWM inverters are preferred. This IGBT or MOSFET based design is easy to control. Output frequency & voltage controlled by switching characteristics. [4,5]

Firing angle control controls load current, when these inverters directly connected to PV cell. It is possible to control both voltage & frequency simultaneously using PWM scheme.

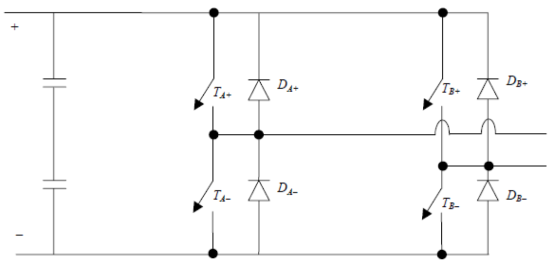

Fig.6. PWM VSI Inverter

1.3. Controller selection

Due to variation in track of MPPT point with change in load a charge controller designed has load matching characteristic. Selection of controller depends on its load matching, reference voltage & power to be handled at load side. Fallowing methods briefely describes relation in MPPT & power.

1.3.1 Simple Panel load matching

Simple panel load matching technique helps to operate a PV cell near to maximum power point.

Average operating conditions can be considered in series management for corresponding values of I_{PV} & V_{PV}. This technique requires no additional circuitry hence significant reduction in cost of system. Drawback of using such system does not take considerations of environmental conditions such as irradiance, temperature, dust etc. [6]

1.3.2 Voltage feedback method

Voltage feedback method used also has same drawbacks as in simple load matching technique. For implementation voltage kept at constant reference level to monitor & compare with load change. Process for measurement of V_{PV} & Voc has fallowing steps.

1. Shutdown of inverter.

2. Measure panel open circuit voltage.

3. Calculate new operating voltage taking 70% of open circuit voltage.

4. Turn on inverter & operate it with new photovoltaic cell voltage

5. Repeat these steps continuously.

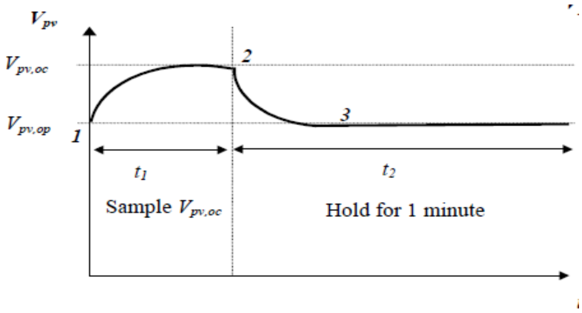

Fig.7. Sampling time of inversion

Switching of inverter load produces low order harmonics. Only 70% of power can be utilized instead of full utilization of power. Hence a sub-optimum performance can be achieved by operating maximum power voltage.[7] For fast sampling response load resistance & capacitance of cell should be kept low. Method is suitable for obtaining constant power.

1.3.3 Power feedback method

For finding actual MPP, knowledge of extracted actual power from PV array must be known. For $Ppv = Vpv \times Ipv$ .These values can be tracked by fallowing methods.

2. REVIWE METHODS

Perturbation & observation method & Incremental conductance method are mostly used in literature as power feedback method.[8] Algorithm discussion implemented discussed below.

2.1 Perturbation and Observation (P&O) Method

MPP operating point can be tracked with respect to irradiance & temperature by using P & O method. Perturbation represents observation in impact of power changes. Fallowing major steps are taken in algorithm designing of P & O method.

1. P_{PV} (k) compared with P_{PV} (k-1).
2. If it is found to be increased then refer same direction of V_{PV} on MPP line whereas for decreased value change direction in opposite manner.
3. Perturb ate value of V_{PV} at every MPPT cycle
4. For maximum power point V_{PV} oscillates with optimum value.

Increase in step size of perturbation can cause power loss. If temperature & irradiance changes suddenly, P & O method fails to response quickly. A moving cloud suddenly comes on solar way is example of such case. But generally such cases are rare to happen. Use of microcontroller base MPPT controllers is best solution for such problems. It reduces response time & has fast response. MPP controller makes step changes for $V_{PV.}$ [9]. Algorithm generally searches I_{PV} instead of V_{PV} on MPP line. It is because V_{PV} has quick changes in accordance with atmospheric noise & matched conditions. Limitations of P & O method can be reduced in incremental conductance method.

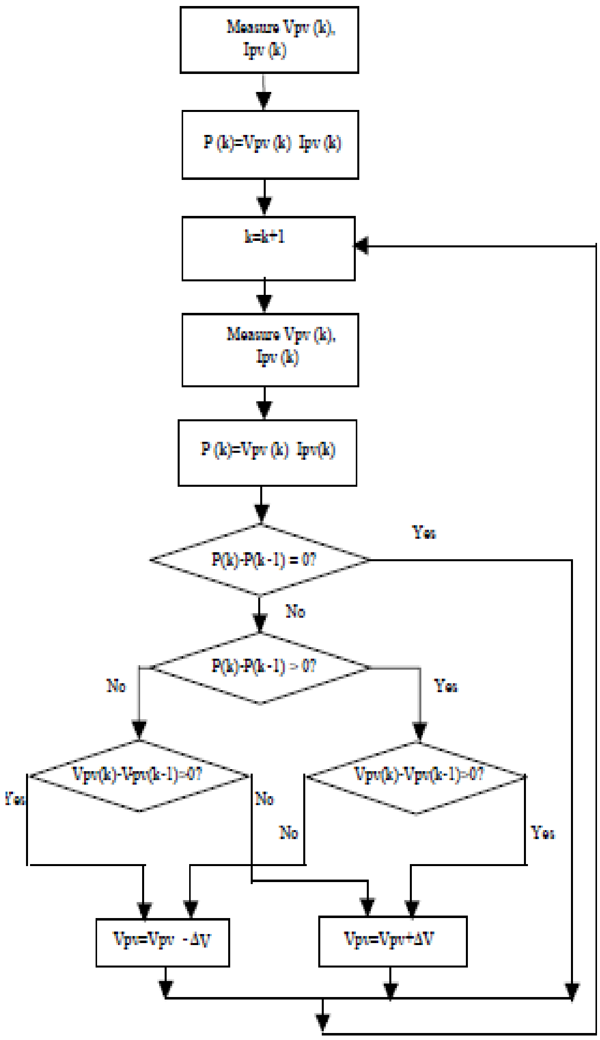

Fig.8. Flowchart for P & O method

2.2 Incremental Conductance Method

This method tracks deviation of conductance on MPP line. Algorithm presented here control inverter operating point by measurement of incremental & instantaneous conductance. The equations can be written as

$$\frac{dIpv}{dVpv} = -\frac{Ipv}{Vpv} \quad at\ MPP \quad [2.1]$$

$$\frac{dIpv}{dVpv} > -\frac{Ipv}{Vpv} \quad to\ left\ of\ MPP \quad [2.2]$$

$$\frac{dIpv}{dVpv} < -\frac{Ipv}{Vpv} \quad to\ right\ of\ MPP \quad [2.3]$$

This method is difficult to implement because division of denominator may be equate to zero & MPPT point approaches to infinity.

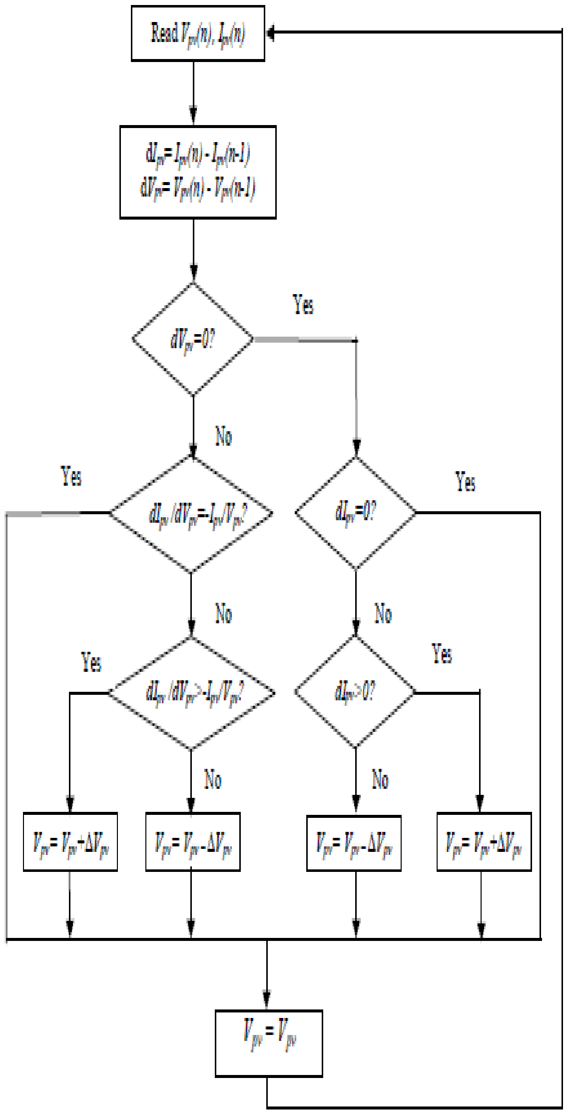

Fig.9. Flowchart for incremental conductance method

3. PROBLEM IDENTIFICATION

Grid connected networks looks as an infinite energy sink. Power quality, operation on grid & its protection are some of requirements for grid connection.

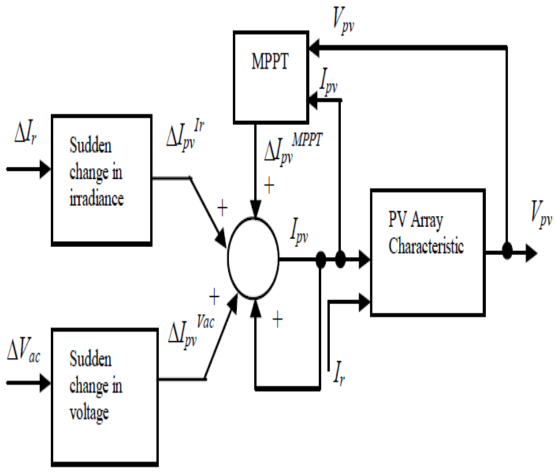

Fig.10. Existing model of PV generation

Before installation of such large PV systems, it is necessary to build up a model which will capable of simulating response to irradiance & grid voltages. Model development can be done on its empirical or analytical basis. Experimental work carried out in this direction shows that MPPT controllers are not included in these models. Existing PV model for generation system represents non-linear characteristics of PV array.

3.1 Grid connection & its protection

When utility of inverter disconnected it is not protective because of potential lack in earthing. In grid connection main power supply should be isolated with grid section. This gives rise to new values of voltages & frequency. Under or over voltage protection is necessary. Frequency compensation must also be provided in islanding protection. The shutdown response time is to be taken in limit of 0.1S. Stability & its protection criteria considered while studying the effect of large penetration on PV generators.

In case of power match of local loads voltage & frequency remains constant. It can produce sustained oscillations. In case of microcontrollers active frequency drift (AFD) method is used in switching. But this method introduces harmonics.

4. PROPOSED SIMULATION MODEL

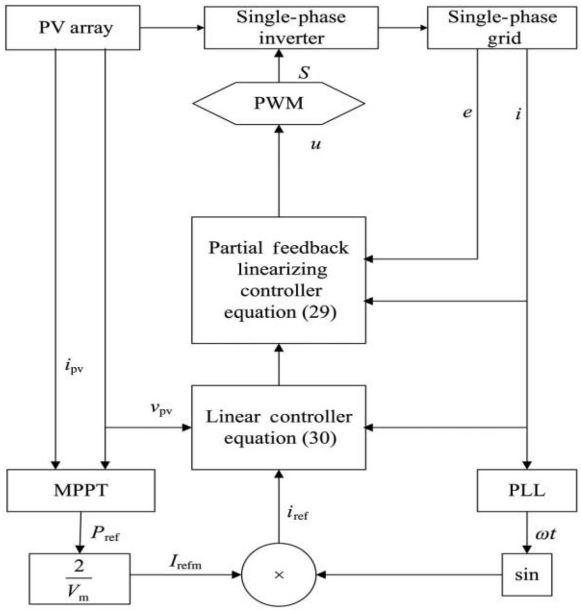

Fig.11. Partial feedback linearized control model for single phase grid connection PV array

Here we built up & simulate proposed model which will accurately reflect dynamic behavior of the system with respect to irradiance as well as grid voltage. It is also capable of representing complex dynamic & nonlinear behavior. Designed MPPT controller is capable of compensating effect of temperature on PV characteristic.

5. CONCLUSION

MPPT controller plays important role in study of dynamic behavior of grid connected PV system. Stability of large generation PV arrays gets affected by irradiance & temperature. Existing model has nonlinear characteristics in PV models. Its inverter design produces harmonics. Proposed model uses partial feedback linearization technique to basically control current in MPPT. It is much stable than previous existing model because of partial functions & PWM scheme.

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