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Performance Investigation on Grid Connected Solar PV System with Different MPPT Techniques

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ABSTRACT

In modern era the development of any village, city, or country depends on electrical energy. Although fossil fuels provides energy to an extent but it leads to major cause of pollution, as well as efficiency is reduced due to losses. Moreover they are limited. An alternative to this being clean, noiseless, economical, and never ending energy is present in the nature like Sun, Wind , ,hydro etc ; are now playing an active role for supplying electrical energy. In this paper Solar PV cell system is modeled; and Perturb & observe /Incremental Conductance based MPPT techniques are used, so as to keep the output of Solar PV system constant, so that energy can be harnessed for various application. The performance of proposed system is judged under varying solar insolation and with impacts of loads.

KEYWORDS

Solar Photovoltaic, Maximum Power Point Tracker, Insolation, Irradiance, Perturb and Observation, Incremental conductance

1. INTRODUCTION

The highly increased demand of energy whose cost is less and concern for environmental issues, which leads to various problems like health hazards, acid rains etc. has shown interest in utilization of renewable sources of energy like solar energy. The non- ending, freely available as well as abundantly presence of solar energy can be easily converted into electrical energy. A PV structure with various benefits such as cost of maintenance is less, no moving or rotating parts, and a pollution-free energy conversion process. However, the demerits found in the PV source about its ineffectiveness at nights or when isolation is low and also during partial shading condition.

The initial high capital cost is another hurdle at the time of installation, of PV systems. The above demerits are not withstanding. The emergence of PV systems is very popular alternatives to conventional energy, thanks to the advancement in technology and favorable government policies in several countries.The challenging condition in application of PV as shown by P-V non linear Current–voltage [I–V] characteristics. Furthermore since its characteristics totally depends on various changing weather condition because of which a change in Insolation, temperature and partial shading. As the above parameters vary continuously thus variation occurs faster, so the MPP does the same, maintaining power at its maximum value Including cost of installation is high in case of PV source and low value of energy conversion and thus the efficiency is also reduced, it is suitable to operate, the PV system at its MPP value so that highest power is achieved

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2. MAXIMUM POWER POINT TRACKER

Solar radiation when directly changed into electrical energy, obtained from cells of PV has a number of merits. A photo-voltaic [PV] module has non linear characteristics and its [P–V] quality study,makes clear that there is only one point, [P max] at which it delivers the maximum power. Depending on load variation, highest value of power is obtained and accordingly efficiency is optimized for transferring energy.

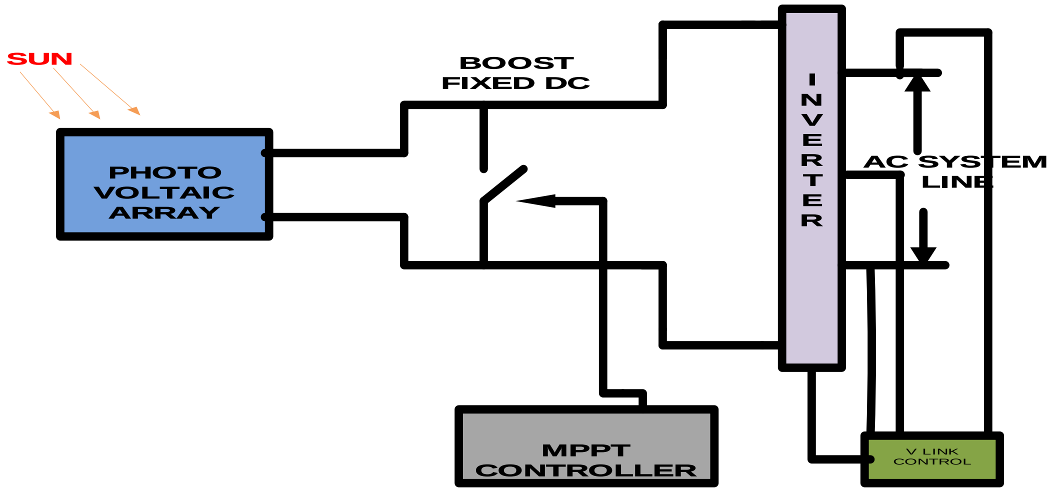

Fig 1: Maximum power point tracker system

Tracking of highest power point [MPP] of a Solar PV array is usually an important for the PV system. There are various classic algorithms so that maximum power can be tracked they are constant voltage method, Hill climbing, Constant current ,Incremental conductance ,Perturb and observation etc specifically used is Inc and Perturb-and-observation [P&O] .The algorithms are dependent on technology, which regulates PV array's voltage by maintaining optimal set point. Various methods have been developed & implemented. The above methods varies in its complexity, the kind of sensors, its working speed, its cost, to the range at which it efficiently, implementation of hardware, its popularity, and various other respect. Various other tracking schemes is brought. Among which the better option can be Perturb and observation [P&O] and Incremental conductance.

This paper Solar PV system is modeled; and Perturb & observe /Incremental Conductance based MPPT techniques are used so as to output obtained from solar system remains constant, so that it can be harnessed for various application. The performance of proposed system is judged under varying solar insolation and with impacts of loads. This analysis is so designed so that MPPT can achieve an optimal algorithm. This analysis is so designed to find out the most suitable method for MPPT in order achieve an optimal algorithm.

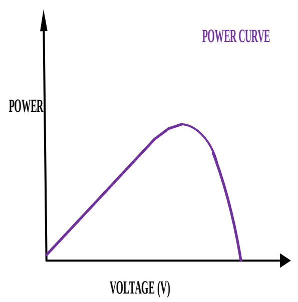

Fig 2: Current-Voltage and Power-Voltage Characteristics in PV cell

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The above curve has shown three parameters they are as follows, open circuit voltage[Voc] ,short circuit current [I-sc], and the maximum/highest power point i.e MPP.

3. REQUIREMENT OF MPPT

The nature of MPPT is mostly influenced by three factors of environmental changes. The quality of each cells of solar are chiefly influenced by –a)Insolation b)Temperature c) Partial criteria of shading.

Their impacts like that of an environmental affects various factor which are shown under:

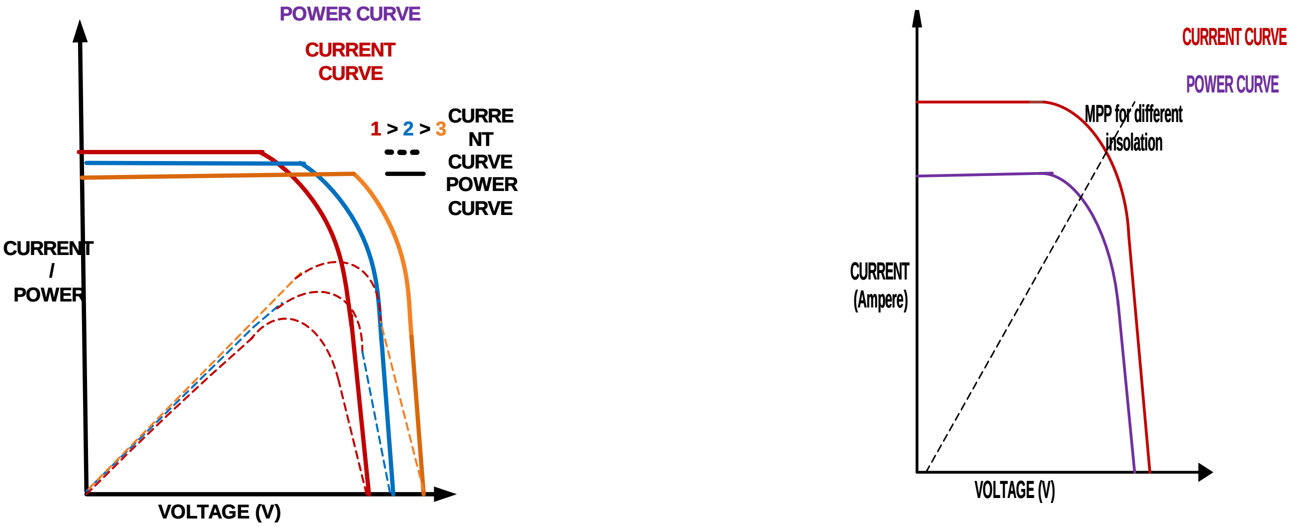

Fig 3: Solar I–V and P–V curve (a) with different temperature insolation and (b) MPP for different Insolatio

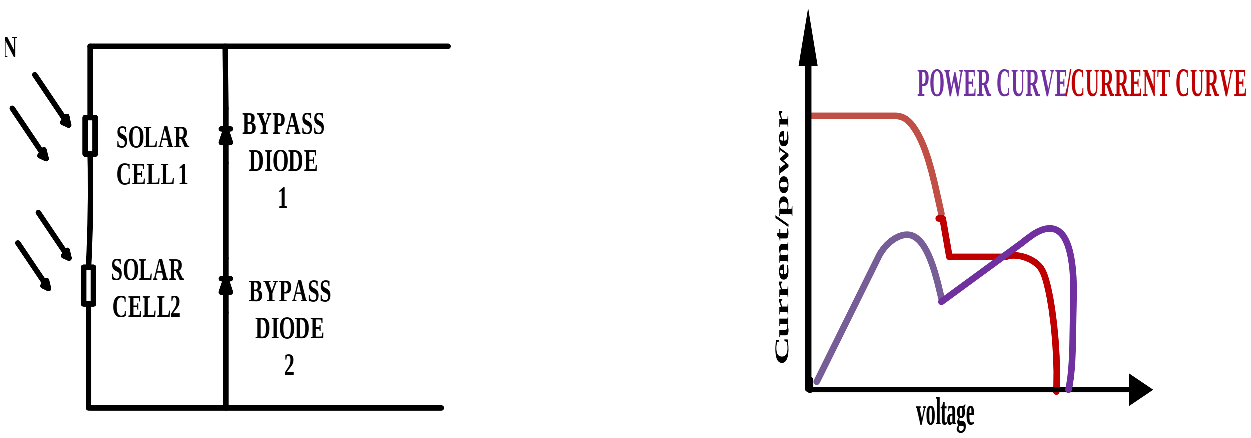

Fig 4(c) Operation of solar P-V under partial shading condition, (d) P–V graph under same partial shading criteria

From fig 4(c) : Connected solar cell with its terminal V: V1 andV2, overall power P and total V Thus it is seen that all these time variant and environmental dependent factors shows a major contribution in the adjustments of the operation point or highest or maximum power point tracker [MPP] throughout the whole day. Its behavior i.e. high power point tracker is there to make a shift in the continuously varying operating point [P max] here PV module delivers highest power.

Photons energy is defined on the wavelength and the frequency; also calculate it from the Einstein's law, which is:

E = hυ (1)

E - energy of photon

h -Plank's constant = 6.626×10^{-34} *Js*

υ -Photon frequency

Photon frequency Released electrons obtained by such process of a photo electric effect is known as photo electron. The amount of energy required for the releasing the valence electron, from the atom on which photon are collided is known a work out Wi and it defines on the kind of material on which all such process of "photo electric effect", is being done. The process is as follow:

hv = Wi + Ekin Where, (2)

hv - Photon energy

Wi, - work out

Ekin - kinetic energy of emitted

4. CHARACTERISTIC OF PHOTO-VOLTAIC CELL

The basic circuit diagram represents overall working of the MPPT method. It contains a current source which represents the photocurrent (I-ph) i.e. the current when solar radiation falls on the panel and current in diode,(I-d) which represents the saturation current in diode. It is that value of a current when solar radiation is absent on the solar panel. The load current value is kept at zero and output current flowing through the panel (I) and output voltage across the panel (Voc)is given as feedback signal to the MPPT.

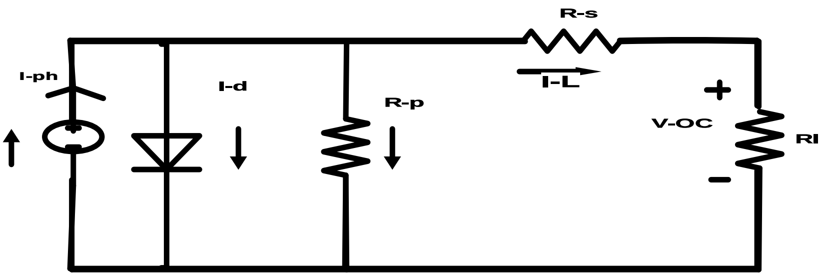

Fig 5: Equivalent circuit of photo-voltaic cell

$$I = I_{ph} - I_s\left(e^{\frac{q(V+I\;\;)}{N}-1}\right) - (V + IR_s)/R_{sh} \quad \textbf{(3)}$$

$$I = n_p I_{ph} - n_p I_s\left(e^{\frac{q(V+I\;\;)}{(N\;\;)n_s}-1}\right) \quad \textbf{(4)}$$

$$I_d = I_s\left(e^{\frac{q(V+I\ \ )}{N}}-1\right) \qquad (5)$$

R_S = intrinsic sequence resistance, value is highly small, Rp = shunt/parallel resistance having high value, Iph = Isolation I, I = Cell I, Io = Reverse saturation I,V = Cell's voltage, V_t is the Thermal voltage [KT/q] K =Boltzmann constant, T = Temperature (Kelvin), q = electron charge.

5. PERTURB & OBSERVE [P&O] ALGORITHM

Solar cell power module changes continuously, in case of power increment, the perturbation will be continued in (same) as previous direction.

TABLE 1: FOR PERTURB & OBSERVATION METHOD

Sign of dv	Sign of dp	Direction of next step.
Positive	Positive	+C
Negative	Negative	+C
Negative	Positive	-C
Positive	Negative	-C

The power will then at next step will decrease as soon as maximum power is attained, and after this perturbation will reverse. The algorithm starts oscillating around its highest point as soon as the steady value is reached. Size of perturbation is kept very small, thus power variation small. Even then this algorithm is important in mega service as it is simple. The algorithm can be understood from study of flow chart, which is shown below:

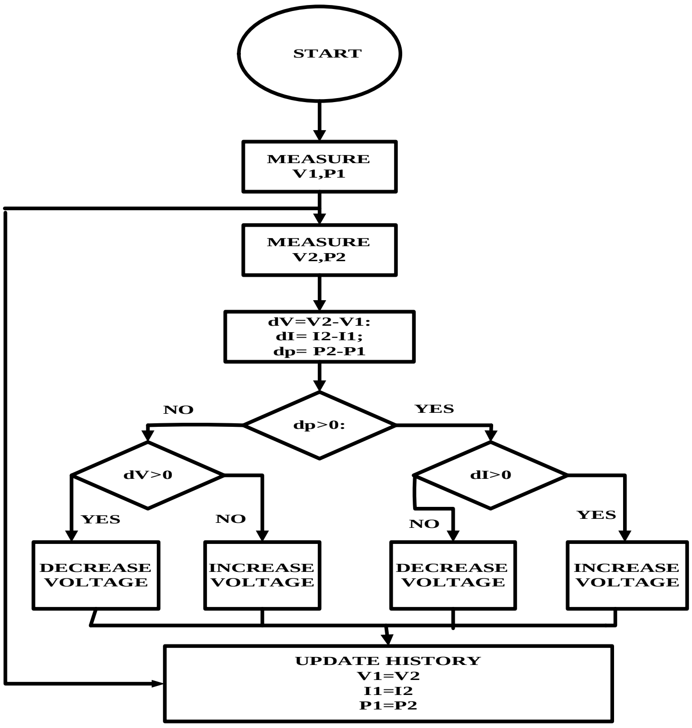

Fig 6 : Flow chart of Perturbation and observation

6. ALGORITHM FOR INCREMENTAL CONDUCTANCE (Inc)

The demerits of Perturb & observation [P&O] method for tracking highest power under fast changing atmospheric weather condition ,and its oscillation at its maximum value ,is removed by using Incremental Conductance method.

The Inc method determines if MPPT reached highest value and thus perturbation at operating point is stopped. In case the condition fails, then the direction of operating point of MPPT is to be perturbed this is then calculated as shown dl/dv and –I/V.

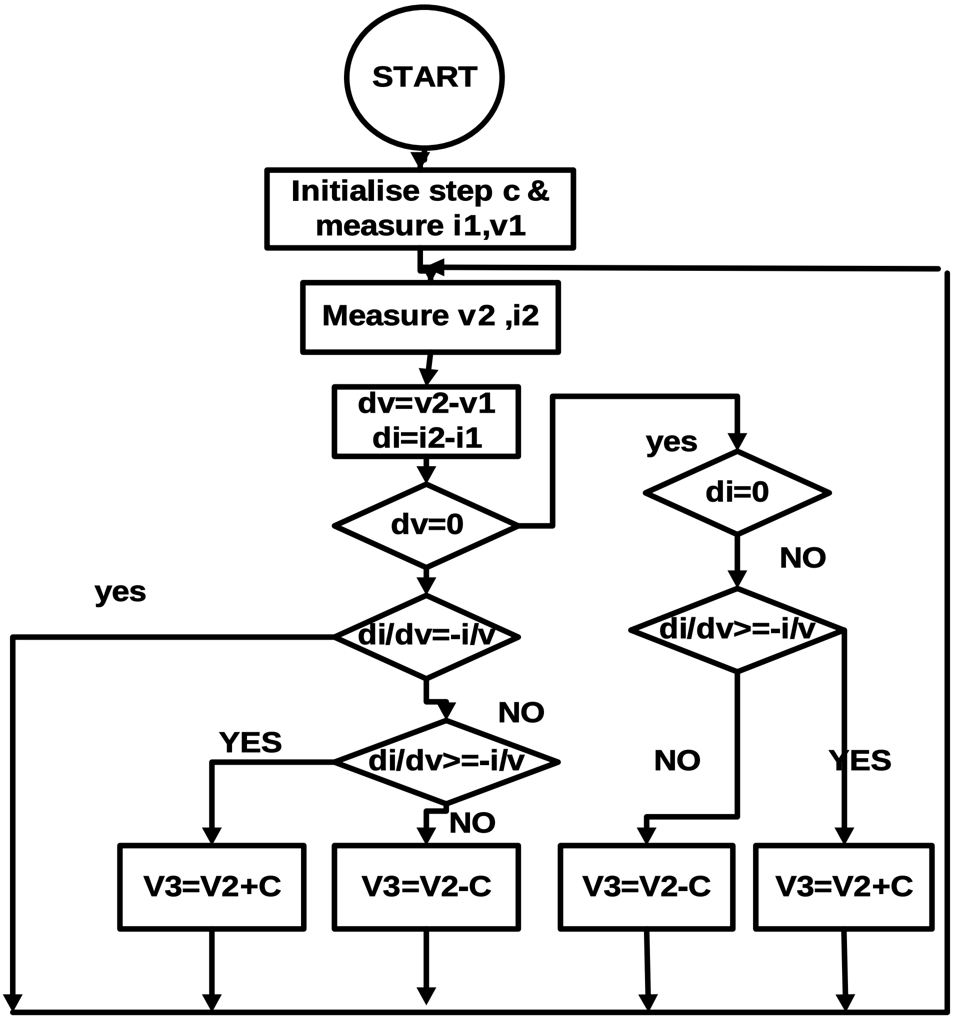

Fig7: Flow chart for Incremental conductance method

$dp/dv \geq 0$	left of MPP	(6)
$dp/dv \leq 0$	right of MPP	(7)
$dp/dv = 0$	at MPP	(8)

Since,

dp/dv=d(iv)/dv	=I +Vdi/dv	(9)
di/dv≥-i/v	left of MPP	10
di/dv≤-i/v	right of MPP	(11)
di/dv=0	at MPP	(12)

The Inc depends on a particular condition that the given slope of a PV array graph is 0, when its MPP, positive at its left of a MPP, and is negative on its right as given

7. SIMULATIONS AND RESULTS

The PV array simulation model shown below in fig 1,Since the Irradiance effect is not constant all the time but do changes,therefore different Irradinace value is taken at 1000 w/m^2,800 w/m^2,600 w/m^2 and again at 1000 w/m^2.and the teperature constant is 25.

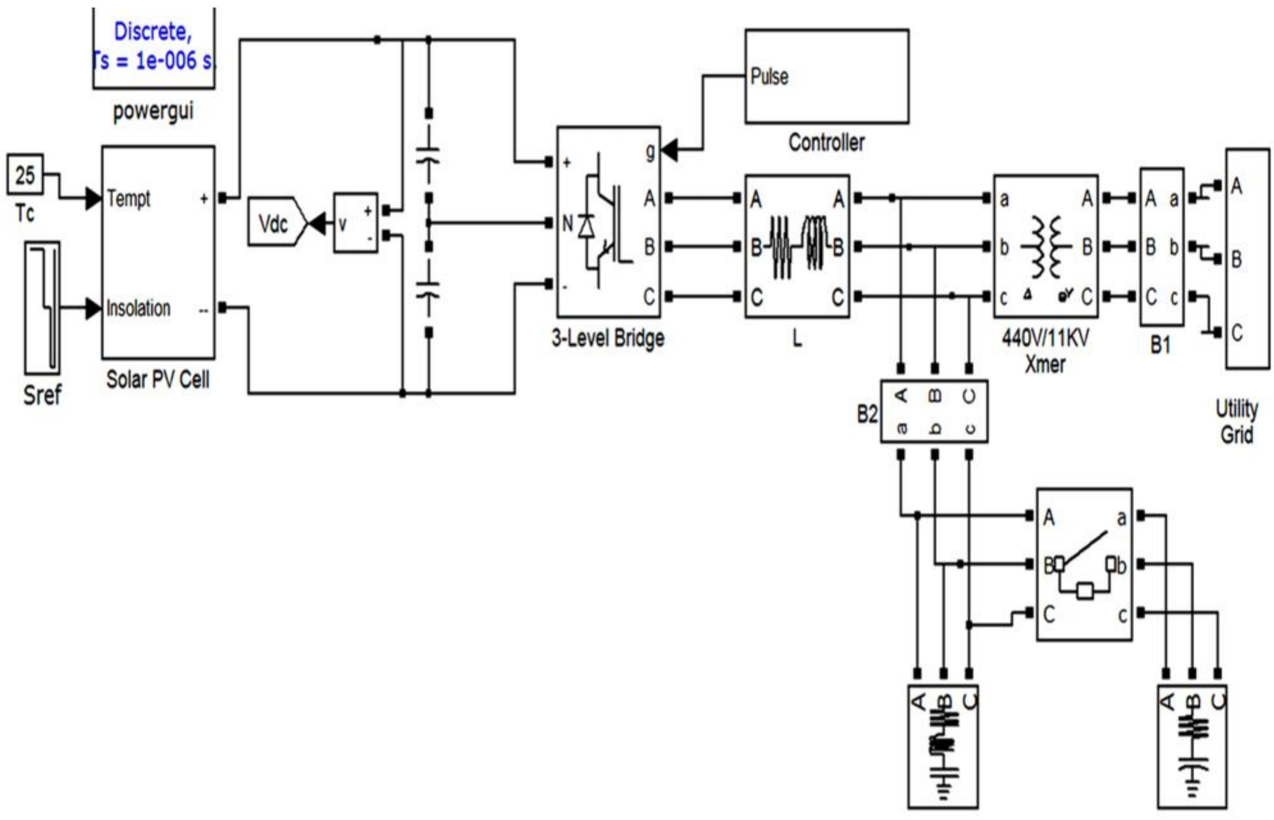

Fig 8: Simulink model of Grid connected Solar PV system

The output obtained from Solar PV cell is fed into Inverter which then changes the Solar PV cell outut voltage into suitable AC voltage and frequency.A 33/11kv grid which is connected in parallel to the solar PV model, then 11kv voltage is stepped down to suitable voltage i.e 440 V .A load of 2kv connected intially and an additional load of 5kv is also connected by three phase circuit breaker.

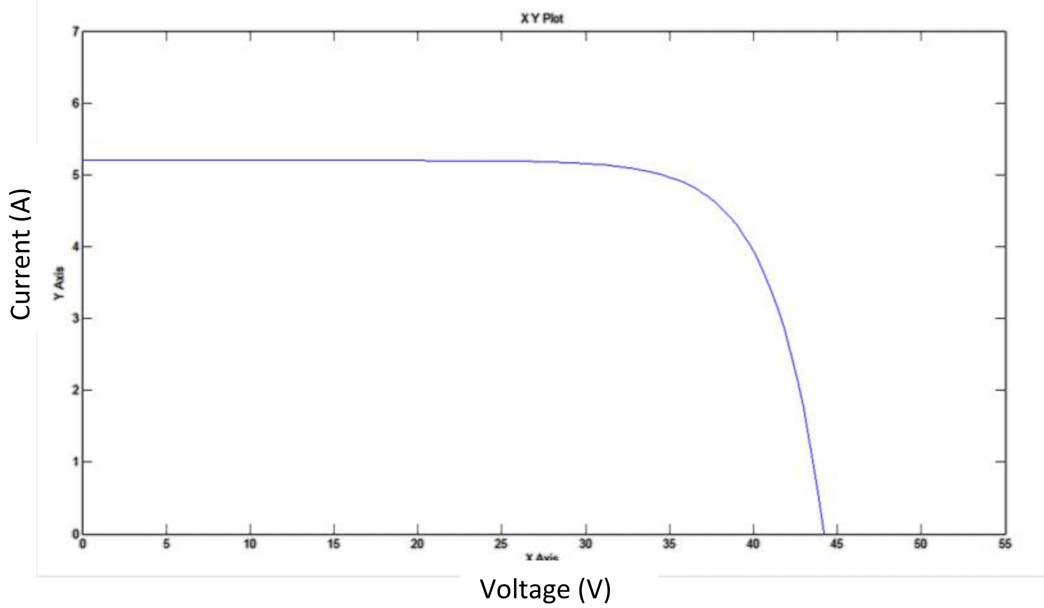

Fig:9 P-V curve

Above shown PV curve shows that, MPPT always tracks maximum current though the voltage varies. The maximum voltage i.e $V_{OC=}$44V. However the current is maintained at its maximum value i.e I_{SC} =5.2A.

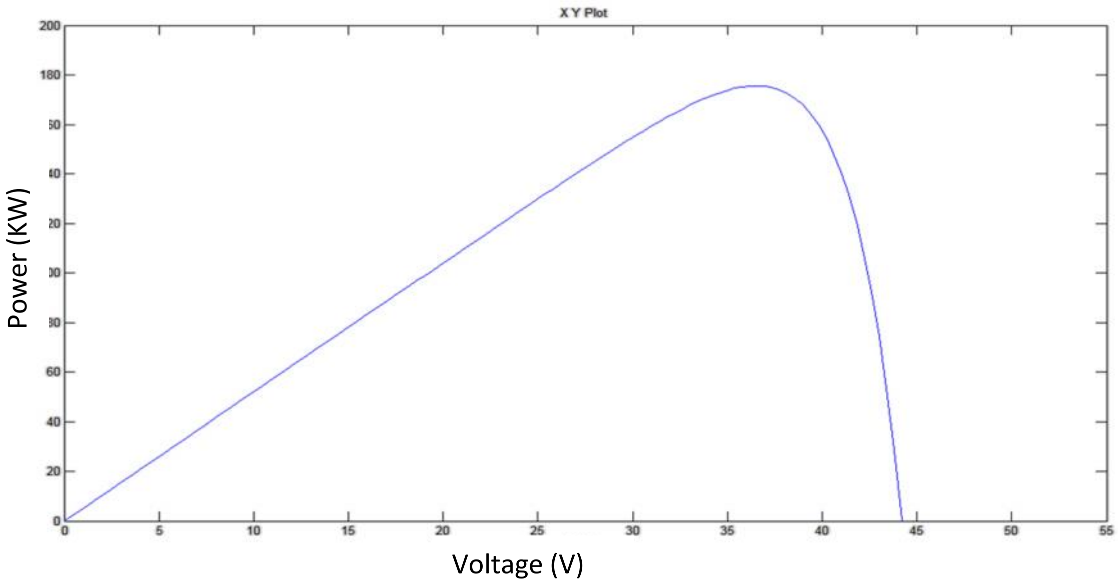

Fig 10: I-V curve

Above figures shows that MPPT maintains maximum Power i.e (short circuit current) $I_{SC=}$ 170A, and V_{OC} =44V. And power obtained is 5.2 KW

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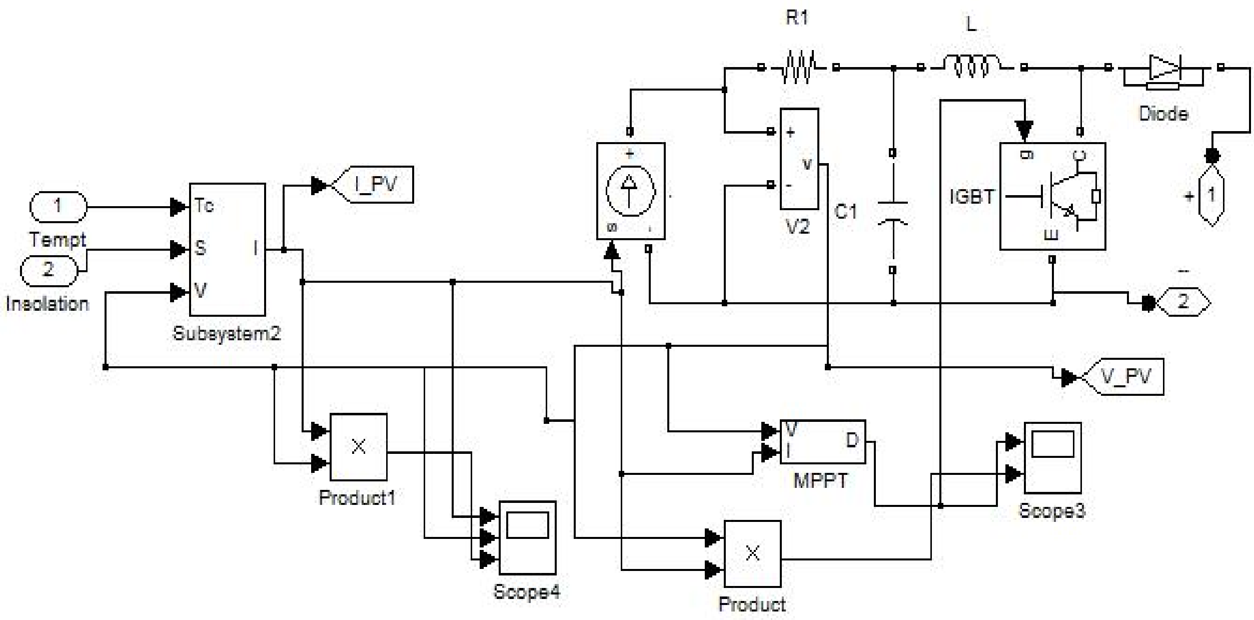

Fig11: Simullink model for Solar PV cell

Simulation model for Solar PV cell shown in fig 2, An input with Irradinace 1000 w/m^2,800 w/m^2,600 w/m^2 and again at 1000 w/m^2.and the temperature constant is 25.

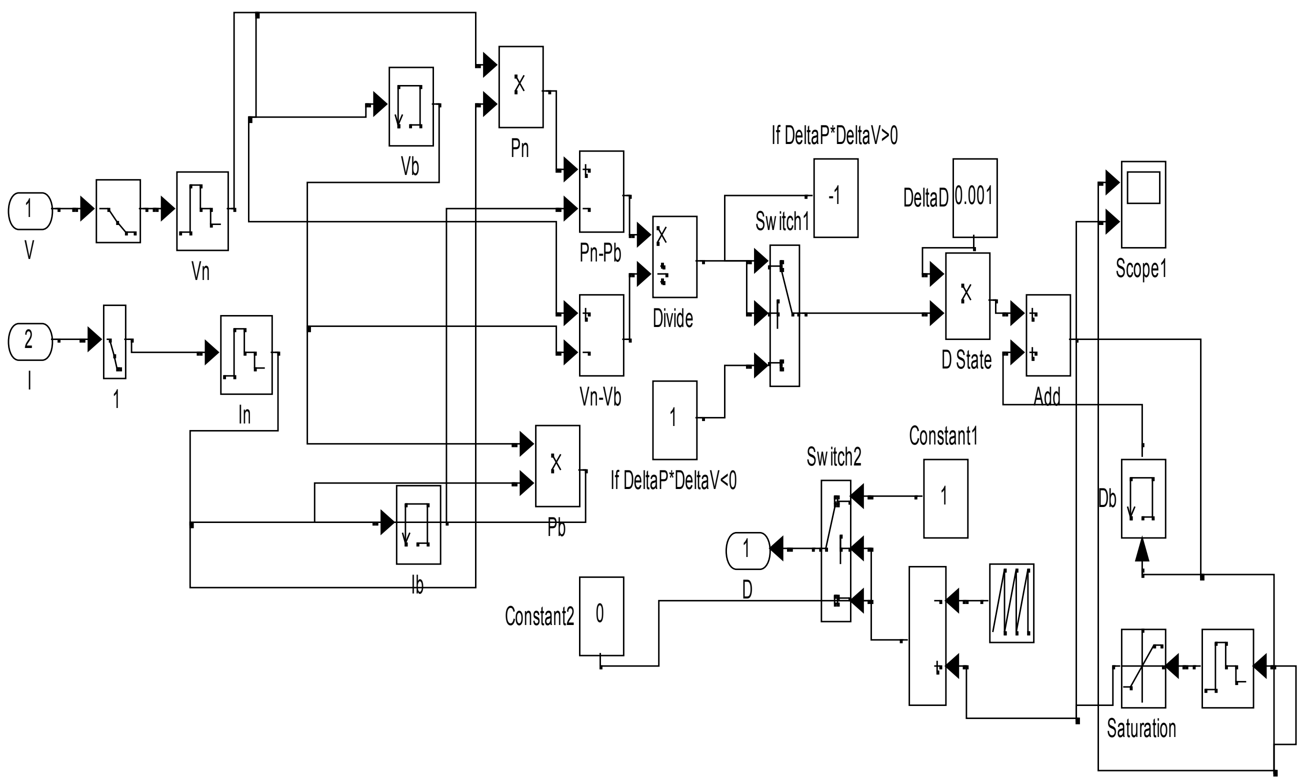

Fig 12: Simulink model for Perturb and observation

As explained above since the parameters do not remains constant but changes with time.And therefore simulation results for Incremental conductance are shown below.

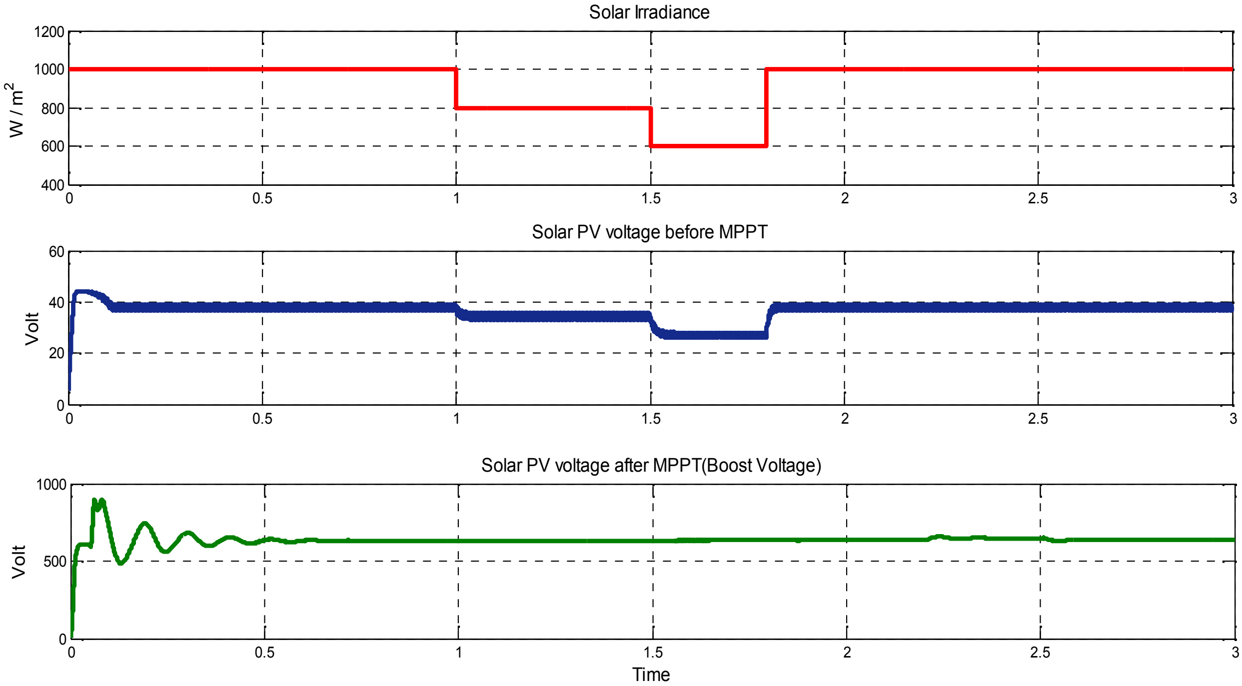

Fig:13 Effect of solar Irradinace on the PV cell voltage before and after MPPT

When Irradinace = 1000 w/m^2,from 0 to1second PV voltage before MPPT is 40 V,and after MPPT it variates about550 V.As irradince drops to 800 w/m^{2,} (t)=1 to 1.5sec. Voltage also goes down by 38 V and and after MPPT 600V.Further whenIrradince reduced to 600 w/m^2 from t=1.5 to 1.8 sec,Voltage before MPPT goes more down to 22V.But clearly Voltage after MPPT is still 600V.And as Irradince increased to 1000 w/m^2 from 1.8 to 3 sec,Voltage before MPPT is increased with it and becomes 40 v again.but after MPPT it is still maintained to 600V.

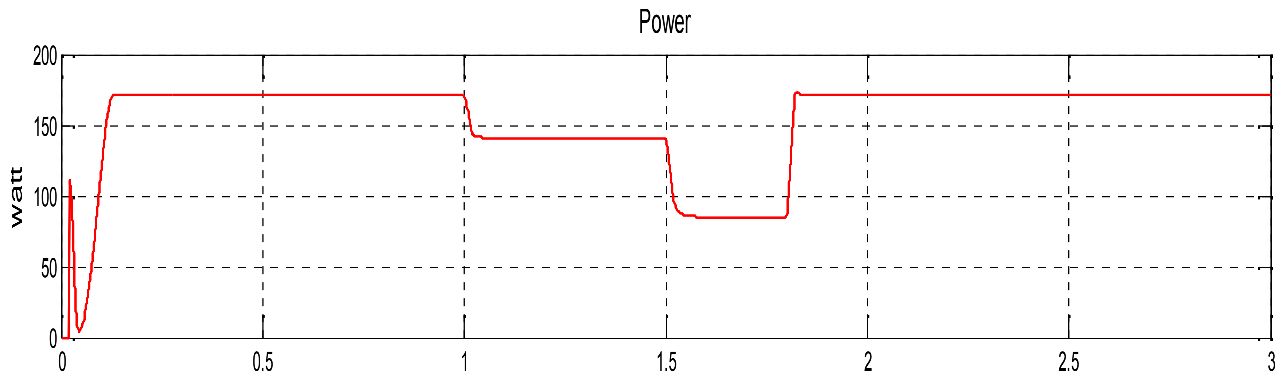

Fig 14:Power obtained from PV cell

Since Irradiance is 1000 watt/meter square, so the power 175 watt from 0 to 1second,as Irr value lowers at 800 watt/meter square,and so the power drops to 148watt, from 1 to 1.5 second,

Similarly between 1.5 to 1.8 second power drops to75 watt,since irradinace goes down to 600 watt per meter square.Now again as Irr increases &reaches 1000w/m^2 with time&so the power output also increases to 175 watt.

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As shown in fig 8; Simulation model an Inverter is placed for changing the DC power obtained from Solar PV cell into AC suitable power required by the load. The results of simulation model for inverter output voltage is shown below:

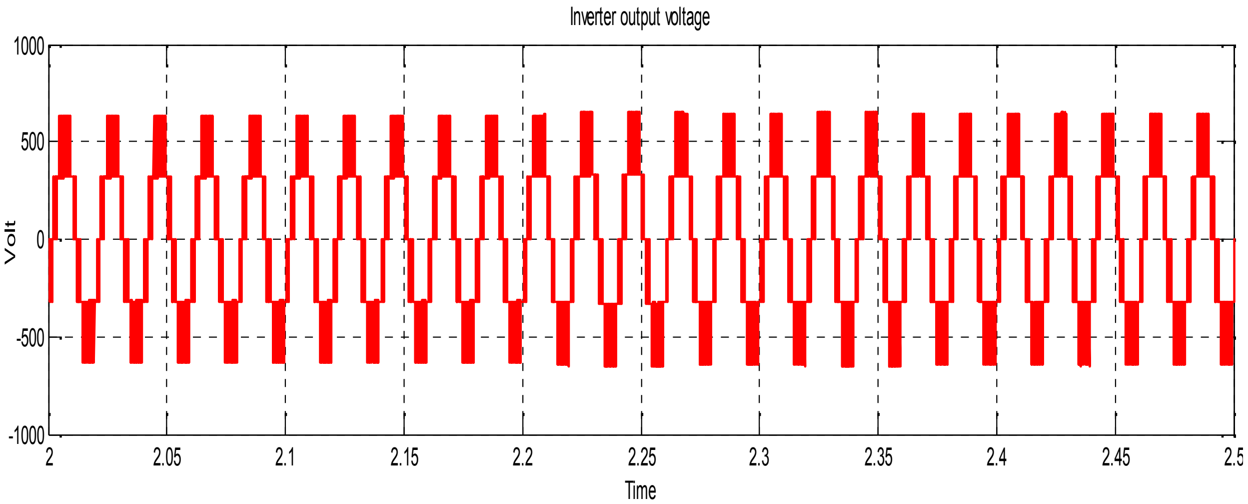

Fig15: Inverter Voltage

DC voltage obtained from PV cell (MPPT) is changed into ac by three level multi inverter which alternates Voltage, at frequency 50 Hz.

Again shown in simulation model fig 8; Grid of 33KV is interconnected to PV model which is stepped down 33/11KV&further (11KV/440V) by the step down transformer to meet the load requirement. The results of Grid are shown below:

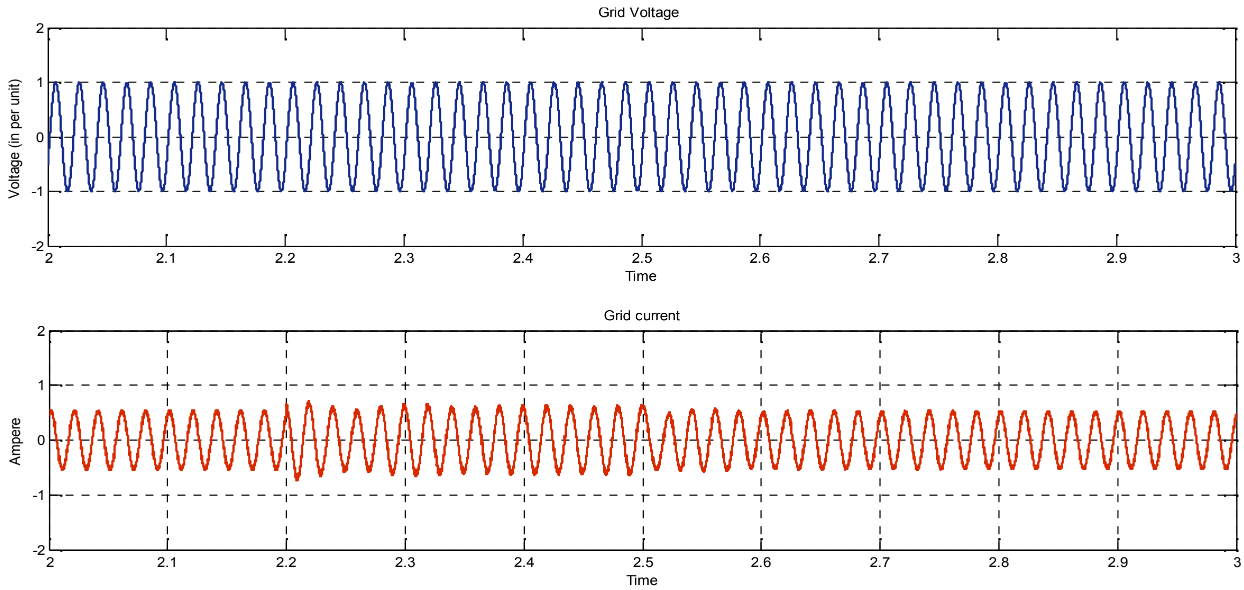

Fig 16: Grid voltage &current

Per unit AC voltage variation of grid voltage (Phase to ground) is between 1 &-1.The AC current drawn by the load between 2 to 2.2 second is 50 ampere (constant), since initial connected load is of 2kw.When additional load of 5kw is switched ON via three phase circuit breaker at t=2.2 to 2.5second, so the current drawn by the load increases to 65 ampere. Again after 2.5 second when the load is removed, current drawn is again 50 A.

Thus the voltage &the current waveform is unaffected. Three phase to ground voltage of 440 V is supplied to the initial connected load of 2kw.The current drawn is 2At time t=2.2sec,an additional load of 5KW is switched ON with the help of circuit breaker, the load current increases to the value 10 A.

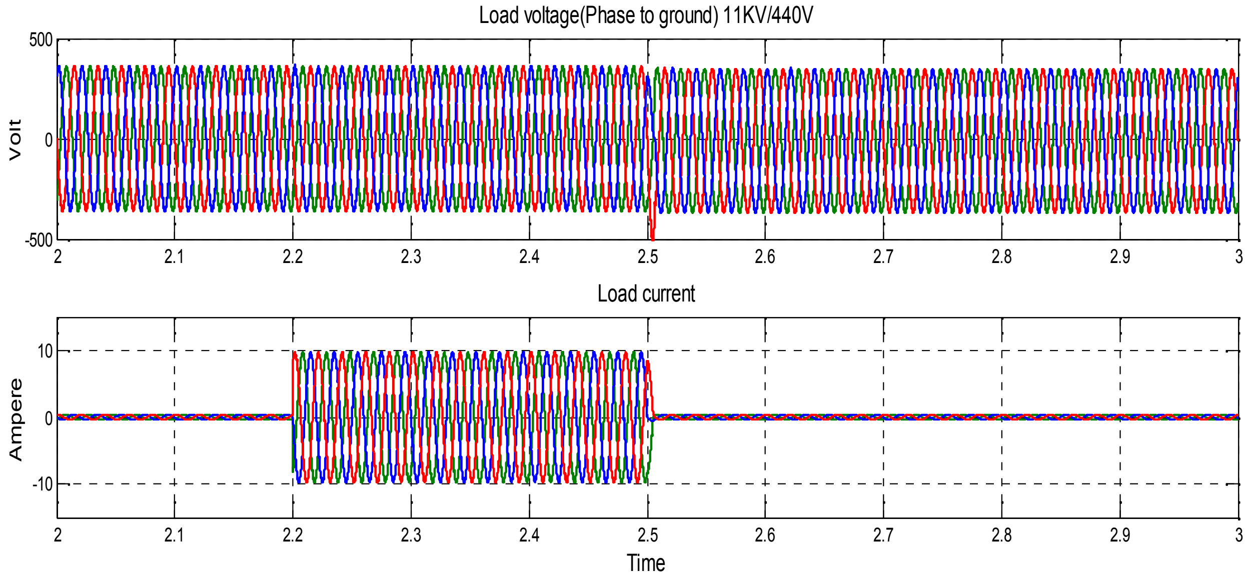

Fig 17: Load voltage &load current

At= 2.5second this load is removed. It is observed that during input of this load the voltage & the current seems waveforms are unaffected. Moreover the THD is also under (IEEE -519-1992) standard it is is below 5%.

RESULT OF INCREMENTAL CONDUCTANCE METHOD:

As explained above since the parameters do not remains constant but changes with time.

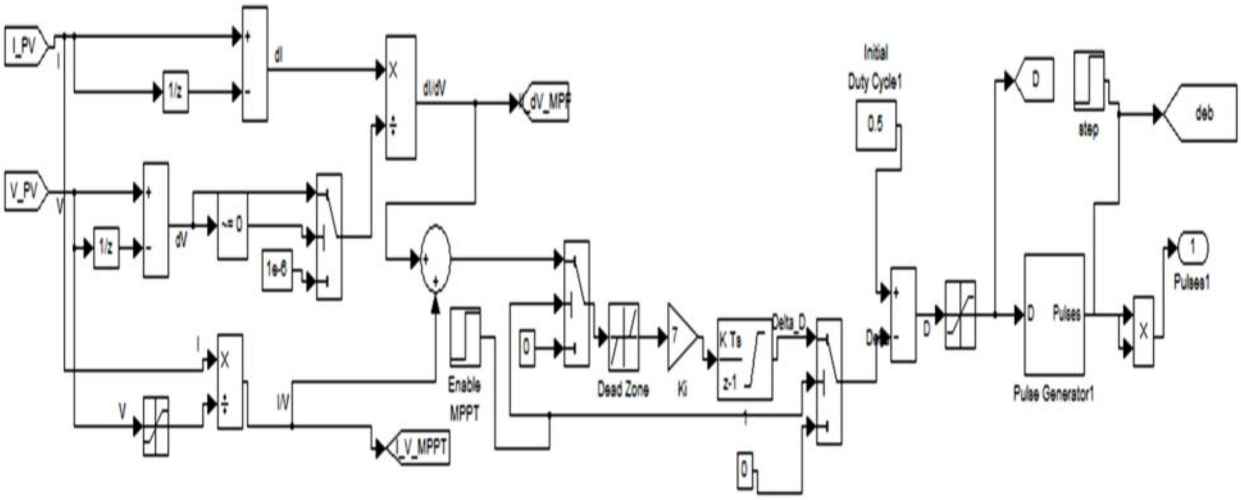

Fig 18:Simulink mode for Incremental conductance

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Therefore its simulation results are shown below.

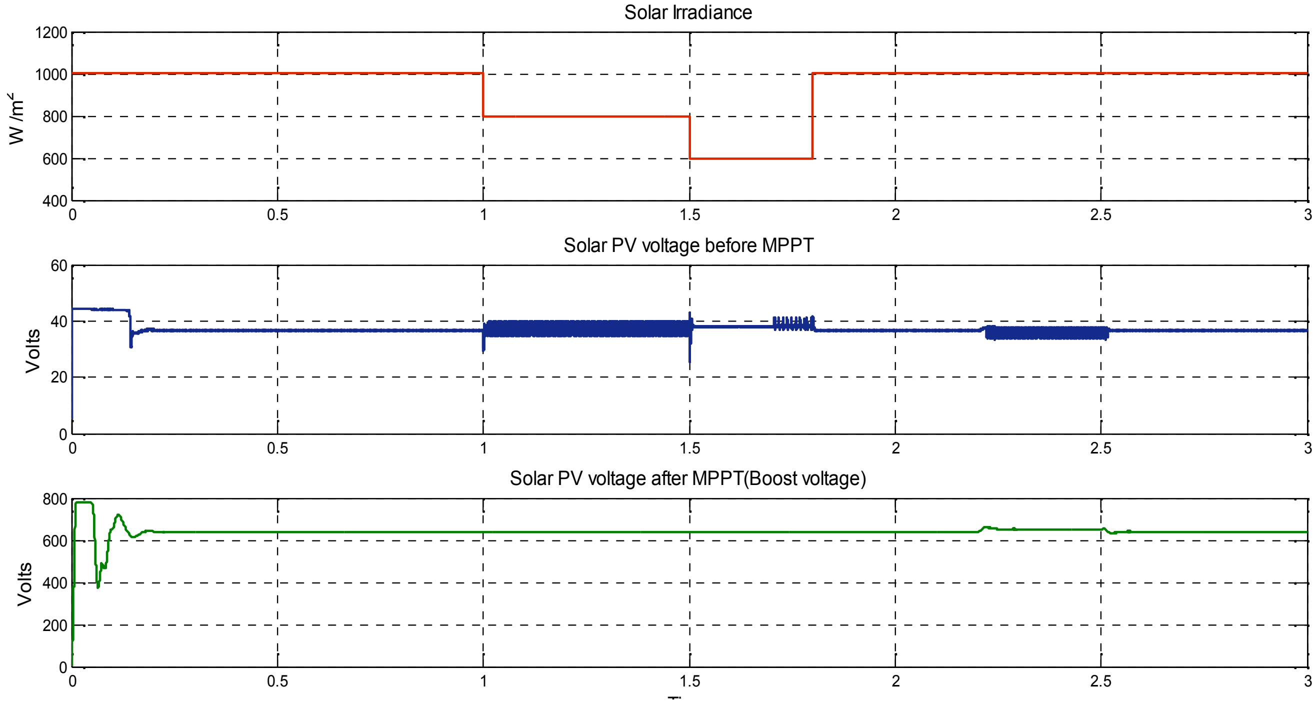

Fig 19: Effect of Solar Irradiance on PV cell voltage before &after MPPT

When Irradinace = 1000 w/m^2,from 0 to1 second PV voltage before MPPT is 40,&after MPPT it variates about620 V which is more than as obtained by [P andO].As irradince drops to 800 w/m^2,(t)=1to1.5sec.Voltage=40V,beforeMPPT &after MPPT 620V i.e. still constant.

Further whenIrradince reduced to 600 w/m^2 from t=1.5 to 1.8 sec,Voltage before MPPT goes more down to 38V but is more than obtained by [P&O].Clearly Voltage after MPPT is still 620V.&as Irradince increased again to 1000 w/m^2 from 1.8 to3 sec,

Voltage before MPPT again 38V &after MPPT still constant at 600V.i.e what ever be the variation voltage will be always constant at 620V.

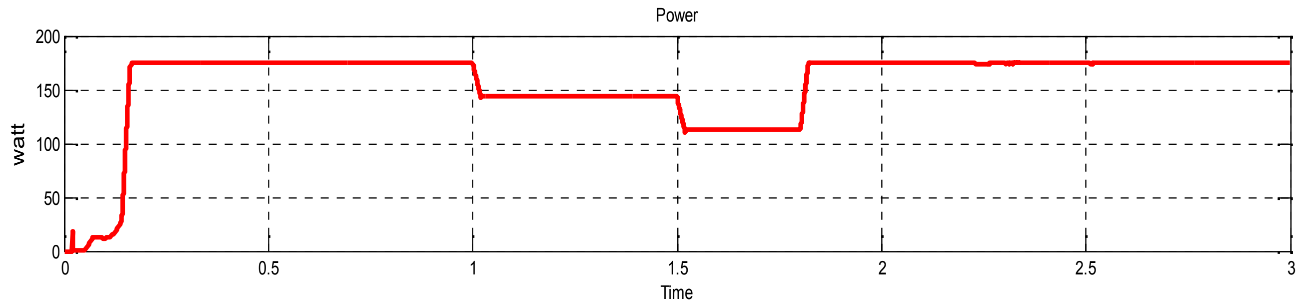

Fig20: Power obtained from PV Cell

Since Irradiance is 1000 watt/meter square, so the power 175 watt from 0 to 1second,as Irr value lowers at 800 watt/meter square,&so the power drops to 148watt, from 1 to 1.5 second,

Similarly between 1.5 to 1.8 second power drops to120 watt,since irradinace goes down to 600 watt per meter square.Now again as Irr increases &reaches 1000w/m^2 with time&so the power output also increases to 175 watt.

As shown in fig 1. Simulation model an Inverter is placed for changing the DC power obtained from Solar PV cell into AC suitable power required by the load. The results of simulation model for inverter output voltage is shown below

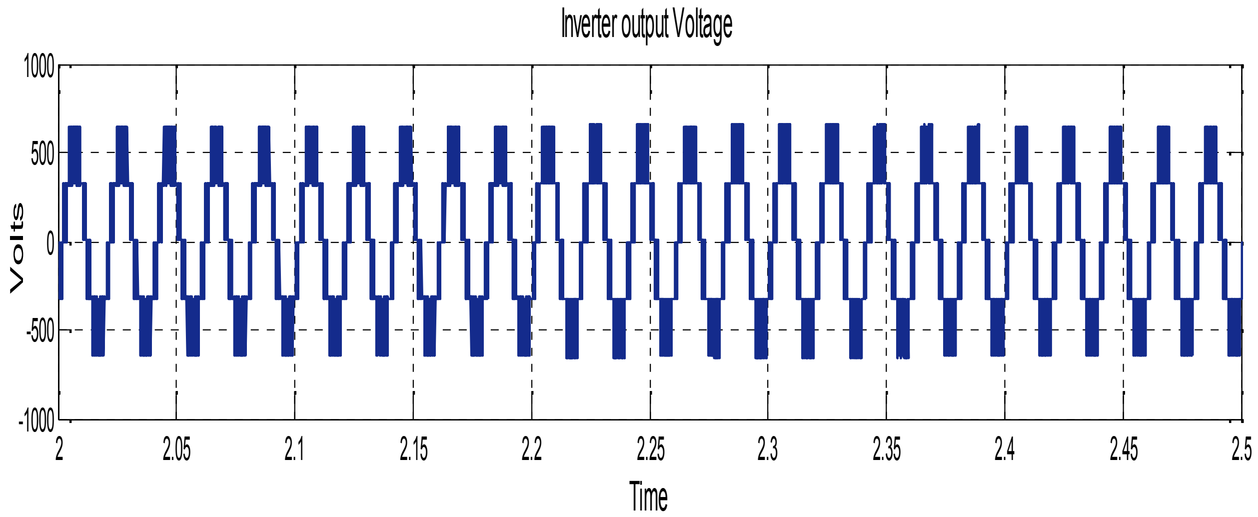

Fig 21: Inverter Voltage

Output voltage obtained from 3-level multi inverter is an AC voltage at frequency .Per unit AC voltage variation of grid voltage (Phase to ground) is between 1 &-1.The AC current drawn by the load between 2 to 2.2 second is 50 ampere (constant), since initial connected load is of 2kw.

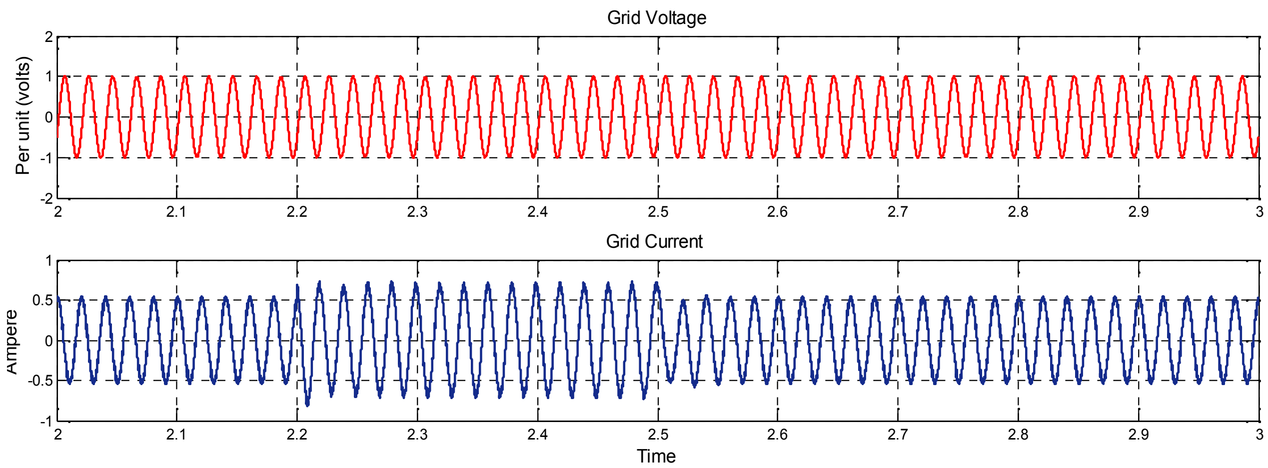

Fig 22: Grid voltage &current

When additional load of 5Kw is switched ON by three phase circuit breaker at t=2.2 to 2.5second, so the current drawn by the load increases to 65 ampere. Again after 2.5 second when the load is removed, current drawn is again 50 A. Thus the voltage &the current waveform is unaffected.

Three phase to ground voltage of 440 V is supplied to the initial connected load of 2kw.The current drawn is 2At time t=2.2sec,an additional load of 5KW is switched ON with the help of circuit breaker, the load current increases to the value 10 A.

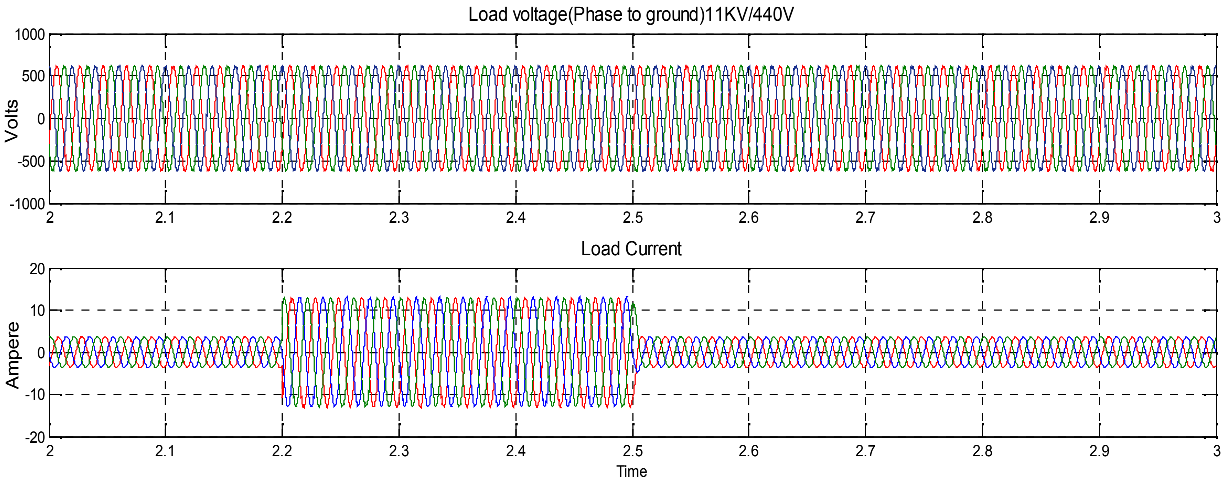

Fig23:Load voltage &current

While, At= 2.5second this load is removed. It is observed that during input of this load the voltage & the current waveforms are unaffected. Moreover the THD is also under (IEEE -519-1992) standard is less than 5%.

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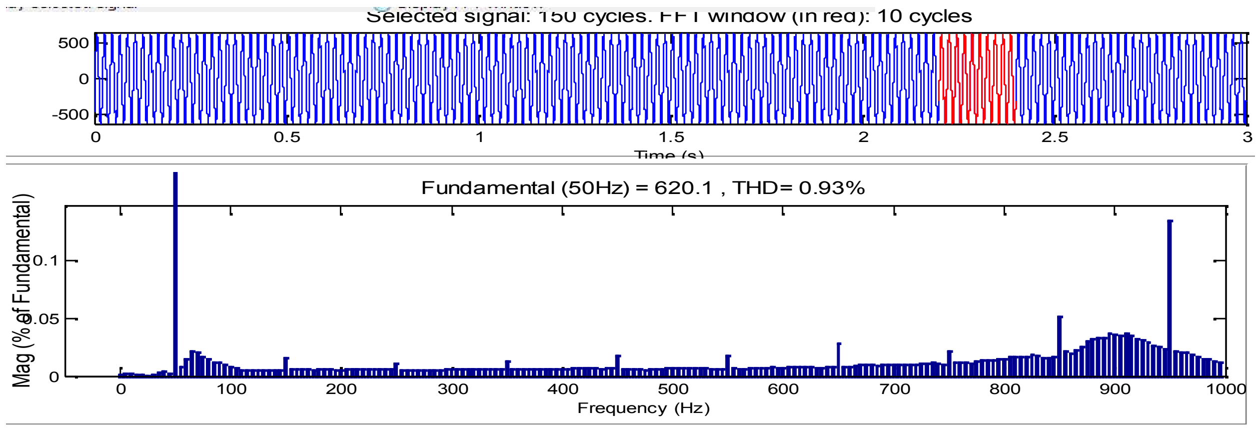

Fig 24: THD by Incremental conductance method(50 Hz

It's clear that THD obtained by incremental conductance method at f=50Hz,is 0.93%

8. CONCLUSION:

The [P&O] &[Inc] MPPT algorithms are simulated &compared using the same conditions. When environmental conditions are constant or change slowly, the P&O MPPT oscillates close to MPP but Inc finds the MPP accurately at changing atmospheric conditions also. Comparison between the two algorithms for various parameters.

REFERENCES

[1] Deepak Verma ,Savita Nema ,Shandhiya, Soubhaghya dash,'Maximum power point tracking(MPPT)techniques :Recaptulation of solar photovoltaic system. Jacob- James Nedumgat, Jayakrishna & K. B., Kothari D. P.,"Perturb &Observe MPPT Algorithm of a Solar PV Systems-Modeling &Simulation'', IEEE conf. on Power electronics application in renewable energy,2013, pp. 1-6

[2] S.K. Kollimalla &M.K. Mishra, N.PGupta "Adaptive Perturb &Observe MPPT Algorithm for PV system", IEEE Conf. on Renewable energy, 2013, pp. 1-6

[3] Hiren Patel &Vivek Agarwal , ," Maximum Power Point Tracking Scheme for PV Systems Operating Under Partially Shaded Conditions", IEEE Transactions On Industrial Electronics, Vol. 55, No. 4, pp. 963-973,April 2008.

[4] M. A. Elgendy, B. Zahawi &D. J. Atkinson," Evaluation Of Perturb&Observe Mppt Algorithm Implementation Techniques" IEEE conf. on Renewable energy conversion,May2009,pp.P.73-79.

[5] R.K. Nema1, Savita Nema1, &Gayatri Agnihotri1," Computer Simulation Based Study of Photovoltaic Cells /Modules &their Experimental Verification" International Journal of Recent Trends in Engineering, Vol 1, No. 3, May 2009.

[6] Rajesh Kumar Nema*, Savita Nema &Gayatri Agnihotri," Design, development &simulation of PC-based scheme for characterization of solar photovoltaic modules".

[7] Vikas Khare, Savita Nema, Prashant Baredar," Solar–wind hybrid renewable energy system: A review Renewable &Sustainable Energy Reviews 58(2016)23–33.

[8] Pratik U. Mankar1 and2R.M. Moharil," comparative analysis of thePerturb-and-observe &incremental Conductance mppt methods",International Journal of Research in Engineering &Applied Sciences

[9] William Christopher &Dr.R.Ramesh," Comparative Study of P&O &InC MPPT Algorithms", American Journal of Engineering Research (AJER) e-ISSN : 2320-0847 p-ISSN : 2320-0936 Volume-02, Issue-12, pp-402-408.

[10] Ms. Sangita S. Kondawar1, U. B. Vaidya," A Comparison of Two MPPT Techniques for PV System in Matlab Simulink", International Journal of Engineering Research andDevelopment e-ISSN : 2278-067X, p-ISSN : 2278-800X, www.ijerd.com Volume 2, Issue 7 (August 2012), PP. 73-79

[11] Savita Nema, R.K.Nema, Gayatri Agnihotri, " Matlab / simulink based study of photovoltaic cells / modules / array &their experimental verification", Volume 1, Issue 3, 2010 pp.487-500Journal homepage: www.IJEE.IEEFoundation.org.

[12] Xuan Hieu Nguyen1* &Minh Phuong Nguyen, "Mathematical modeling of photovoltaiccell/module/arrays with tags in Matlab/Simulink", Nguyen &Nguyen Environ Syst Res (2015) 4:24DOI 10.1186/s40068-015-0047-9.

[13] Deepak Verma†, S. Nema‡ &A. M. Shandilya, "A Different Approach to Design Non-IsolatedDC–DC Converters for Maximum Power Point Tracking in Solar Photovoltaic Systems', Journal of Circuits, Systems,&Computers Vol. 25, No. 8 (2016) 1630004World Scientific Publishing Company10.1142/S021812661630004X.

[14] Habbati Bellia a,*, Ramdani Youcef b, Moulay Fatima," A detailed modeling of photovoltaic module using MATLAB", NRIAG Journal of Astronomy &Geophysics (2014) 3, 53–61

[15] M .Lokanadham, &K.Vijaya Bhaskar / International Journal of Engineering Research &Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 2, Issue 2,Mar-Apr 2012, pp.1420-1424

[16] Savita Nema, R. K. Nema& Gayatri Agnihotr," Inverter topologies &control structure in photovoltaic applications: A review",JOURNAL OF RENEWABLE & SUSTAINABLE ENERGY 3, 012701 _2011