Synchronization of grid-tie PV inverter in Active power filter System By using PLL algorithm

[1] Ashvini D. Sherki,[2]Chandrakala R. Gowder,[3]M.S.Tajne, [4]D.B.Waghmare
[1]UG Student,[2]Assistant Professor,[3]Assistant Professor, [4]Head of Department
Department Electrical Engineering
Shri Sai College of Engineering & Technology, Bhadrawati

***Abstract* –This paper the development of a 3-phase grid connected PV inverter and PV inverter consists of a transformer with the grid frequency for isolation between input and output and it has the output power of 50Hz, and P&O technique was used for MPPT (Maximum Power Point Tracking) and Active Phase Shift technique was used through changes in reactive power to prevent a islanding operation, and mentioned about the result of comparison of the conversion performance of the inverter based on the efficiency of the low frequency transformer. The output of three phase inverter is fed to three phase grid that is the grid tie inverter. That overall system are based on the solar renewable energy source, the generation of energy is to store to battery source and invert to three phase supply. The hole system is developed in MATLAB Simulink software**

***Keywords: PV inverter, Transformer, MPPT(P&O Technique), Active Phase Shift technique & FPGA transmitter*.**

I. Introduction

In the paper we can discuss about solar inverter three phase grid tie inverter. The today's worlds are depending on renewable sources because of one time installment and low cost and as well as high energy source are increases. The intelligent control of output voltage and current of a three-phase photovoltaic grid connected inverter is essential to be considered. The output voltage and the voltage-current relationships on the PV depend on various levels of solar radiance and various cell temperatures. The voltage-current characteristic is a complex and nonlinear function and difficult to identify the dynamic model [1]. The maximum power point tracking available from a photovoltaic module using the algorithm of math function the two inputs of MPPT that is the voltage and current and produced the gate pulses for inverter device of igbt's.
The dc-link power is fed to a utility grid at a unity power factor, as indicated. The line power factor can be programmed to be leading or lagging for static volt-ampere reactive(VAR) compensation, if desired. The control strategy consists of two cascaded loops, a fast internal current loop, which regulates the grid active and reactive current, and an external voltage loop, which controls DC link voltage [2], [3], [4].The current loop is responsible for power quality issues and current protection; thus harmonic compensation and dynamics are the important properties of the current controller. The DC link voltage controller is designed for balancing the power flow in the system [5].There are many PWM techniques which can be divided into two categories, sine wave PWM (SPWM) that be used in a single-phase or multi-phase inverter and multilevel space vector modulation that is used only for multi-phase inverter [6][7][8].

A. Present PV Scenarioin India

In terms of overall installed capacity, India comes fourth after japan, Germany and U.S (with installed capacity of 110 MW). In the area of photovoltaic India today is the second largest manufacturer in the world of PV panels based on crystalline solar cells. Industrial production in this area has reached a level of 11MW per year which is about 10% of the world's total PV production. A major drives has also been initiated by the government to export Indian PV products, systems, technologies, and services. Solar Photovoltaic plant and equipment has been exported to countries in the middle East & Africa.

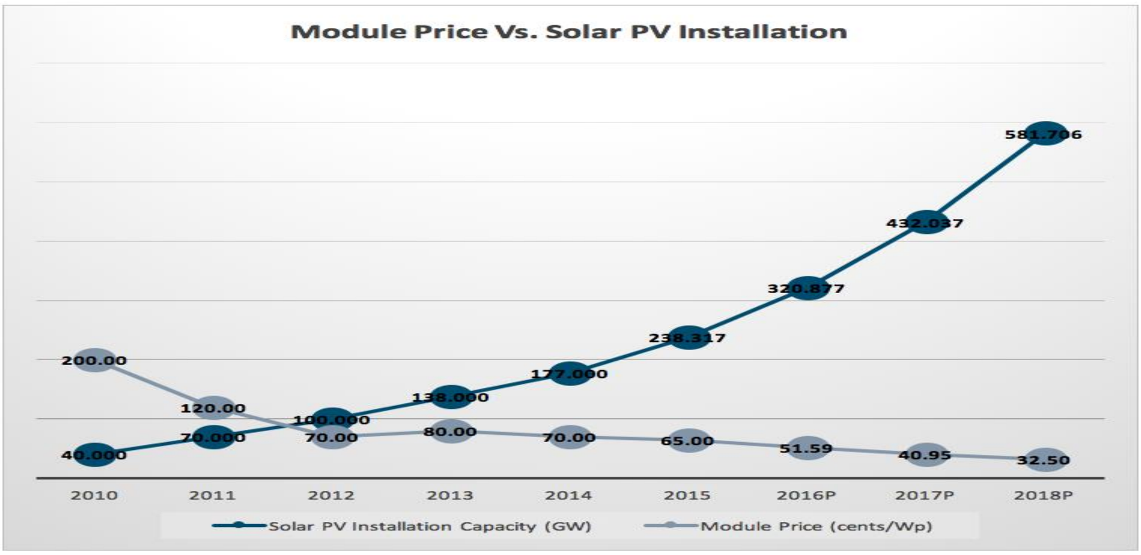
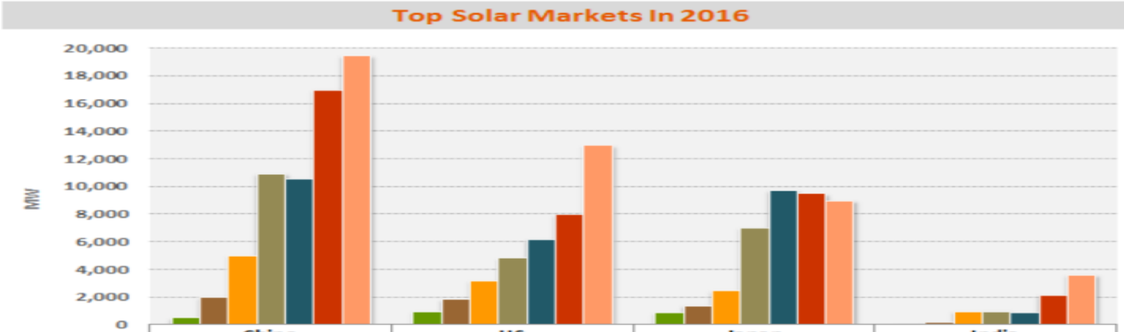


Fig. 1 Model Price vs Solar PV installation



	China	US	Japan	India
2010	520	961	893	12
2011	2,000	1,855	1,404	172
2012	5,000	3,192	2,467	986
2013	10,950	4,840	7,042	1,004
2014	10,600	6,200	9,740	883
2015F	17,000	8,000	9,500	2,154
2016F	19,500	13,000	9,000	3,645

Fig. 2 Top Solar Market in 2017

II. LITERATURE SURVEY

[1]High-Performance Constant Power Generation in Grid-Connected PV Systems

In this paper the PV system has been proposed the maximum supply in power due to that there is a fast & smooth transition between maximum power point tracking & constant power generation. The control strategy proposed that the solar irradiance levels, high- performance & stable operation are always achieved.

Conclusion:

1.Maximum power point tracking operation is mandatory for Grid connected PV systems in order to maximum the energy yield.

2.The proposed solution can ensure a stable constant power generation operation.

3.In comparison with traditional methods, the proposed control strategy forces the PV system to operate at the left side of the maximum power point & hence it can achieve a stable operation as well as smooth transitions.

[2]Reactive Power Capacity Enhancement of a PV-Grid System to Increase PV Penetration Level in Smart Grid Scenario

This paper provides a possible solution of reactive power support to improve the voltage profile. In this paper a novel scheme is proposed that the auxiliary circuit in conjunction with a PV grid system which increases the system reactive power compensation capacity compared to the original capacity of the main PV system.

Conclusion:

1.Distributed power generation is being contemplated for reducing the stress on the power grid.

2.Reactive power compensation without hampering power quality is a challenging task.

3.The demonstrated proposed scheme method of enhancing the reactive power capacity of the inverter based distributed generation system.

[3]Stability of Photovoltaic and Wind Turbine Grid-Connected Inverters for a Large Set of Grid Impedance Values

This paper proposed the analysis of stability problems of grid connected inverters used in distributed generation. The measurement is vast which is made on a single phase system & on a three phase system used as scale prototype for photovoltaic & wind turbines which validates the analysis.

Conclusion:

1. Wind turbine three phase systems & photovoltaic is a single phase system can be connected at different grid conditions.

2.The conclusion shows that as the grid condition is different than the designing can be compromised.

3.The system can become unstable due to the reduced bandwidth or the change in the resonance frequency.

[4] System Stability Impact of Large-Scale and Distributed Solar Photovoltaic Generation: The Case of Ontario, Canada

This paper presents a comparative investigation of solar photovoltaic effect on system stability at different penetrating levels. There is a relavant dyanamics models. Based on that the impact is examined through Eigen values, voltage stability & transient stability analysis.

Conclusion:

1.In this paper, the impact of solar photovoltaic generator penetration level on the stability on power system was assessed.

2.The dynamic behavior of the system containing SPVG installations was examined for different penetration levels by means of small signal stability, voltage stability & time domain contingency analysis.

3.Voltage stability & transient stability demonstrated that the dynamic SPVG can considerably improves system stability.

[5]New Control of PV Solar Farm as STATCOM (PV-STATCOM) for Increasing Grid Power Transmission Limits during Night and Day

In this paper a novel concept of utilizing a photovoltaic solar farm inverter as STATCOM which is calling as PV-STATCOM for improving stable power transfer limits of the interconnected transmission system. The total inverter rating of PV solar farm which remains in sleep during night time, and it is utilized with voltage & damping control to enhance stable power transmission.

Conclusion:
1. Solar farms are idle during nights.
2.The PV solar system is a new control as a STATCOM calling as PV-STATCOM.
3.The power transfer can be increased more than day time even when the solar distributed generator is generating a high amount of real power.

III. Block Diagram

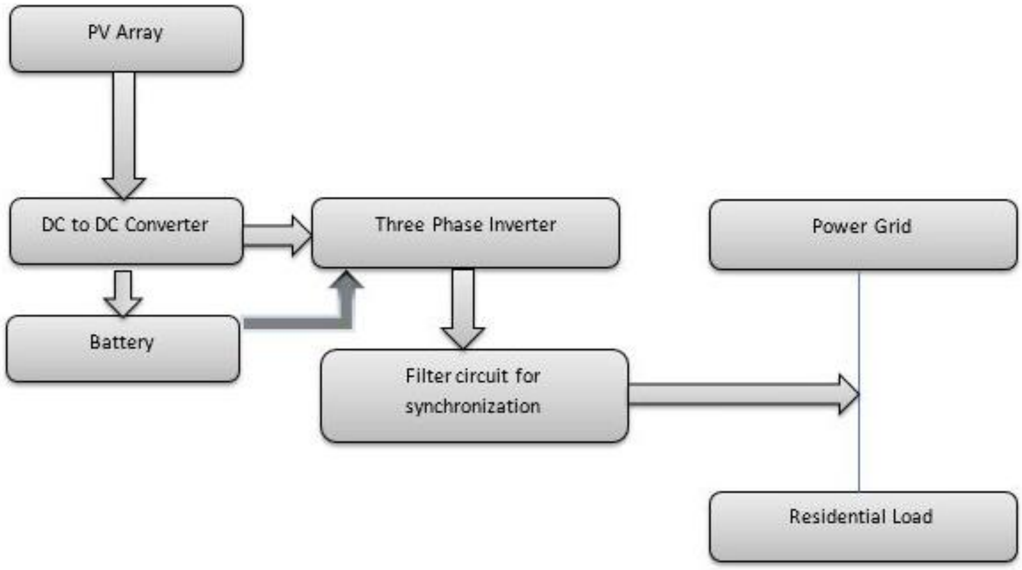


Fig3: Block Diagram

IV. Methodology

A. PV cell modeling

Typically a solar cell can be modeled by a current source and an inverted diode connected in parallel to it. The PV cell has its own series and shunt resistance. Series resistance is due to the diode resistance(of the bulk material) & resistance of metal contacts whereas parallel resistance represents the electron hole recombination before t reaches the load [9].
A current source (I) along with a diode and series resistance (Rs) is considered. The shunt resistance (Rsh) in parallel is very high, has a negligible effect and can be neglected. The output current from the photovoltaic array can be given by [10].

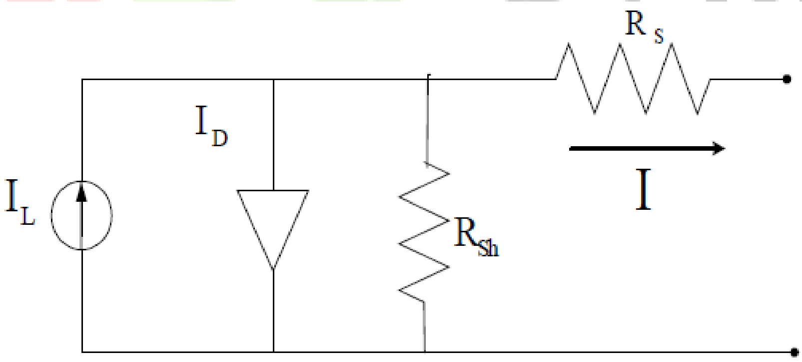


Fig-4. Equivalent circuit of a solar cell

$$I_L = I_D + I_{Sh} + I \ldots\ldots(1)$$

$$I_D = I\left(e^{\frac{q(V+IRs)}{KTA}} - 1\right) \ldots\ldots(2)$$

$$I = I_L - I\left(e^{\frac{q(V+IRs)}{KTA}} - 1\right) - \frac{V+IRs}{R_{sh}} \ldots\ldots(3)$$

VO: voltage appearing across diode.
V: load voltage.
I: Cell Current (A)
RS: internal (series) resistance of the system.
IO: Reverse saturation current of the diode.

T: Temperature in kelvin.
K: Boltzmann constant (1.38 x 10-23 J / K).
n = Ideality factor (≈1.92).
q: electronic charge (1.6 x 10-19C).

V. SIMULATION & WORKING PRINCIPLE

A. *Battery*

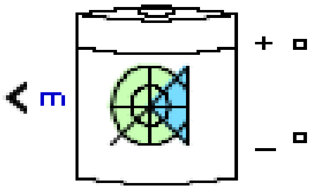


Fig-5: Battery

The Battery block implements a generic dynamic model parameterized to represent most popular types of rechargeable batteries. The equivalent circuit of the battery is shown below:

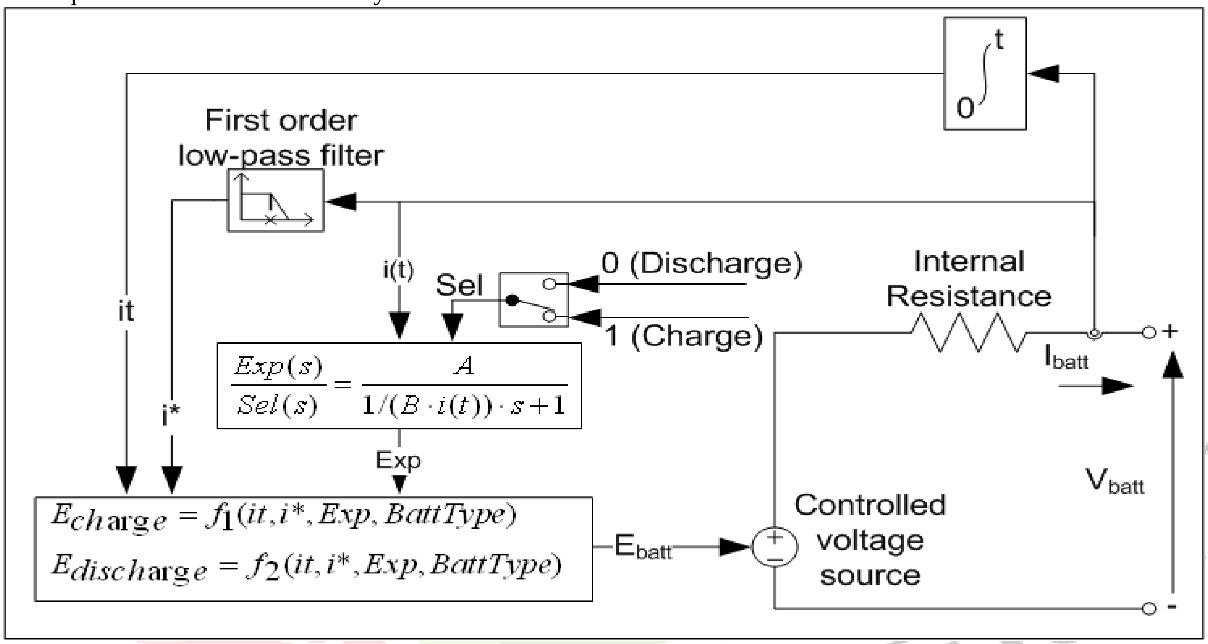


Fig-6: Lead acid Model

Discharge model (i* > 0)
f1(it,i∗ ,i,Exp)=E0−K· QQ−it· i∗ −K· QQ−it· it+Laplace−1(Exp(s)Sel(s)· 0).
Charge Model (i* < 0)
f2(it,i∗ ,i,Exp)=E0−K· Qit+0.1· Q· i∗ −K· QQ−it· it+Laplace−1(Exp(s)Sel(s)· 1s).
Lithium-Ion Model
Discharge Model (i* > 0)
f1(it,i∗ ,i)=E0−K· QQ−it· i∗ −K· QQ−it· it+A· exp(−B· it).
Charge Model (i* < 0)
f2(it,i∗ ,i)=E0−K· Qit+0.1· Q· i∗ −K· QQ−it· it+A· exp(−B· it).
Nickel-Cadmium and Nickel-Metal-Hydride Model
Discharge Model (i* > 0)
f1(it,i∗ ,i,Exp)=E0−K· QQ−it· i∗ −K· QQ−it· it+Laplace−1(Exp(s)Sel(s)· 0).
Charge Model (i* < 0)
f2(it,i∗ ,i,Exp)=E0−K· Q↓it↓+0.1· Q· i∗ −K· QQ−it· it+Laplace−1(Exp(s)Sel(s)· 1s),
where,
EBatt = Nonlinear voltage (V)
E0 = Constant voltage (V)
Exp(s) = Exponential zone dynamics (V)
Sel(s) = Represents the battery mode. Sel(s) = 0 during battery discharge, Sel(s) = 1 during battery charging.
K = Polarization constant (Ah−1) or Polarization resistance (Ohms)
i* = Low frequency current dynamics (A)
i = Battery current (A)
it = Extracted capacity (Ah)
Q = Maximum battery capacity (Ah)

A = Exponential voltage (V)
B = Exponential capacity (Ah)−1
Charge and Discharge Characteristics
The parameters of the equivalent circuit can be modified to represent a particular battery type, based on its discharge characteristics. A typical discharge curve is composed of three sections, as shown in the next figure:

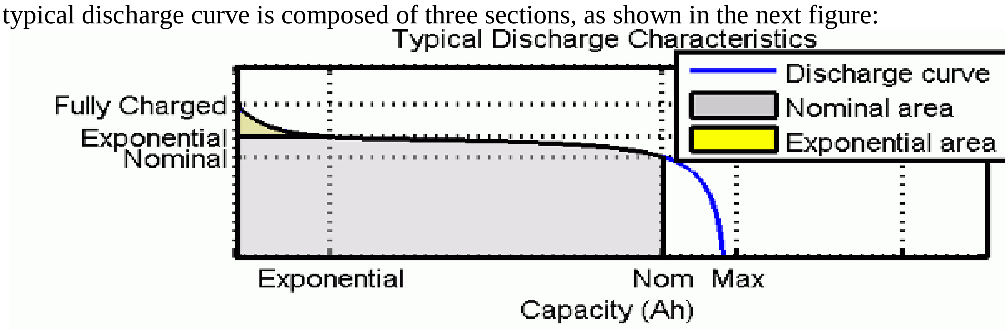


Fig-7: Discharge Characteristics

The first section represents the exponential voltage drop when the battery is charged. Depending on the battery type, this area is more or less wide. The second section represents the charge that can be extracted from the battery until the voltage drops below the battery nominal voltage. Finally, the third section represents the total discharge of the battery, when the voltage drops rapidly.
When the battery current is negative, the battery will recharge following a charge characteristic as shown below:

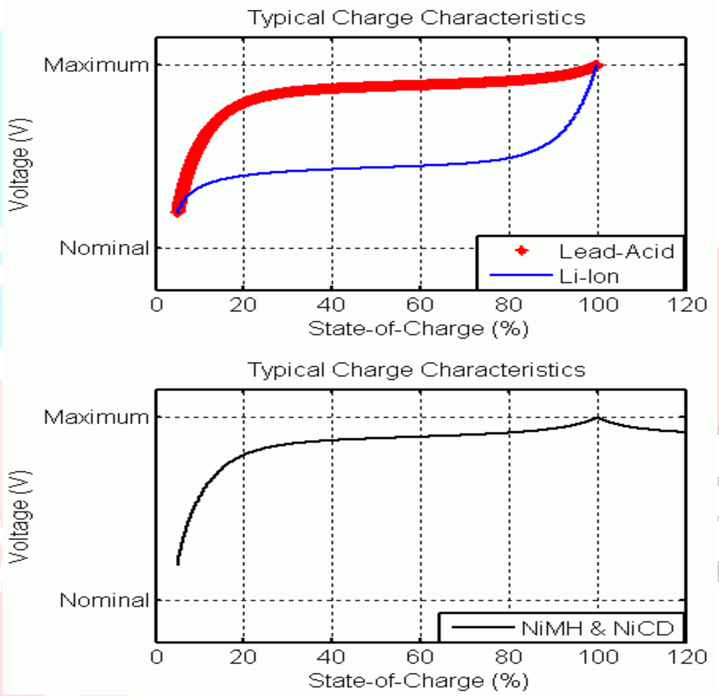


Fig-8: Typical Charge Characteristics

Note that the parameters of the model are deduced from discharge characteristics and assumed to be the same for charging.
The Exp(s) transfer function represents the hysteresis phenomenon for the Lead-Acid, NiCD and NiMH batteries during charge and discharge cycles. The exponential voltage increases when battery is charging, no matter the SOC of the battery. When the battery is discharging, the exponential voltage decreases immediately.

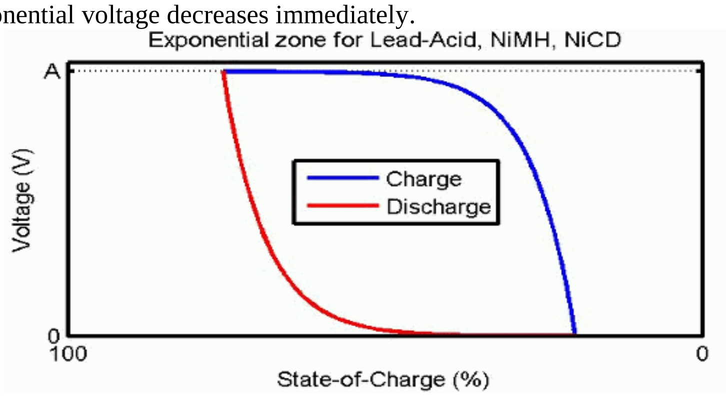


Fig-9: State of Charge

Temperature Effect
For the lithium-ion battery type, the impact of temperature on the model parameters is represented by the equations
Discharge Model (i* > 0)

$f1(it,i*,i,T,Ta)=E0(T)-K(T)\cdot Q(Ta)Q(Ta)-it\cdot (i*+it)+A\cdot exp(-B\cdot it)-C\cdot it$

$Vbatt(T)=f1(it,i*,i,T,Ta)-R(T)\cdot i$

Charge Model ($i^* < 0$)

$f1(it,i*,i,T,Ta)=E0(T)-K(T)\cdot Q(Ta)it+0.1\cdot Q(Ta)\cdot i*-K(T)\cdot Q(Ta)Q(Ta)-it\cdot it+A\cdot exp(-B\cdot it)-C\cdot it$

$Vbatt(T)=f1(it,i*,i,T,Ta)-R(T)\cdot i$,

with

$E0(T)=E0\downarrow Tref+\partial E\partial T(T-Tref)$

$K(T)=K\downarrow Tref\cdot exp(\alpha(1T-1Tref))$

$Q(Ta)=Q\downarrow Ta+\Delta Q\Delta T\cdot (Ta-Tref)$

$R(T)=R\downarrow Tref\cdot exp(\beta(1T-1Tref))$,

where:

Tref = Nominal ambient temperature (K)

T = Cell or internal temperature (K)

Ta = Ambient temperature (K)

E/T = Reversible voltage temperature coefficient (V/K)

α = Arrhenius rate constant for the polarization resistance

β= Arrhenius rate constant for the internal resistance

ΔQ/ΔT = Maximum capacity temperature coefficient (Ah/K)

C = Nominal discharge curve slope (V/Ah). For lithium-ion batteries with less pronounced discharge curves (such as lithium iron phosphate batteries), this parameter is set to zero.

The cell or internal temperature (T) at any given time (t) is expressed as:

$T(t)=L-1(PlossRth+Ta1+s\cdot tc)$,

where:

Rth = Thermal resistance, cell to ambient (°C/W)

tc = Thermal time constant, cell to ambient (s)

Ploss is the overall heat generated (W) during charge/discharge process and is given by

$Ploss=(E0(T)-Vbatt(T))\cdot i+\partial E\partial T\cdot i\cdot T$.

B. MPPT(Perturb & Observer Technique)

Perturb and Observe is the most regularly utilized MPPT strategy because of its simplicity of execution. The working voltage is expanded the length of (dP)/dV is sure, i.e. the voltage is expanded the length of we get more power. On the off chance that (dP)/dV is detected negative, the working voltage is diminished. The voltage is kept put if (dP)/dV is close to zero inside of a preset band. The time multifaceted nature of this calculation is less however on coming to near to the MPP it doesn't stop at the MPP and continues annoying. This calculation is not suitable when the variety in the sun oriented illumination is high. The voltage never really achieves a careful esteem yet annoys around the most extreme force point (MPP)[12].

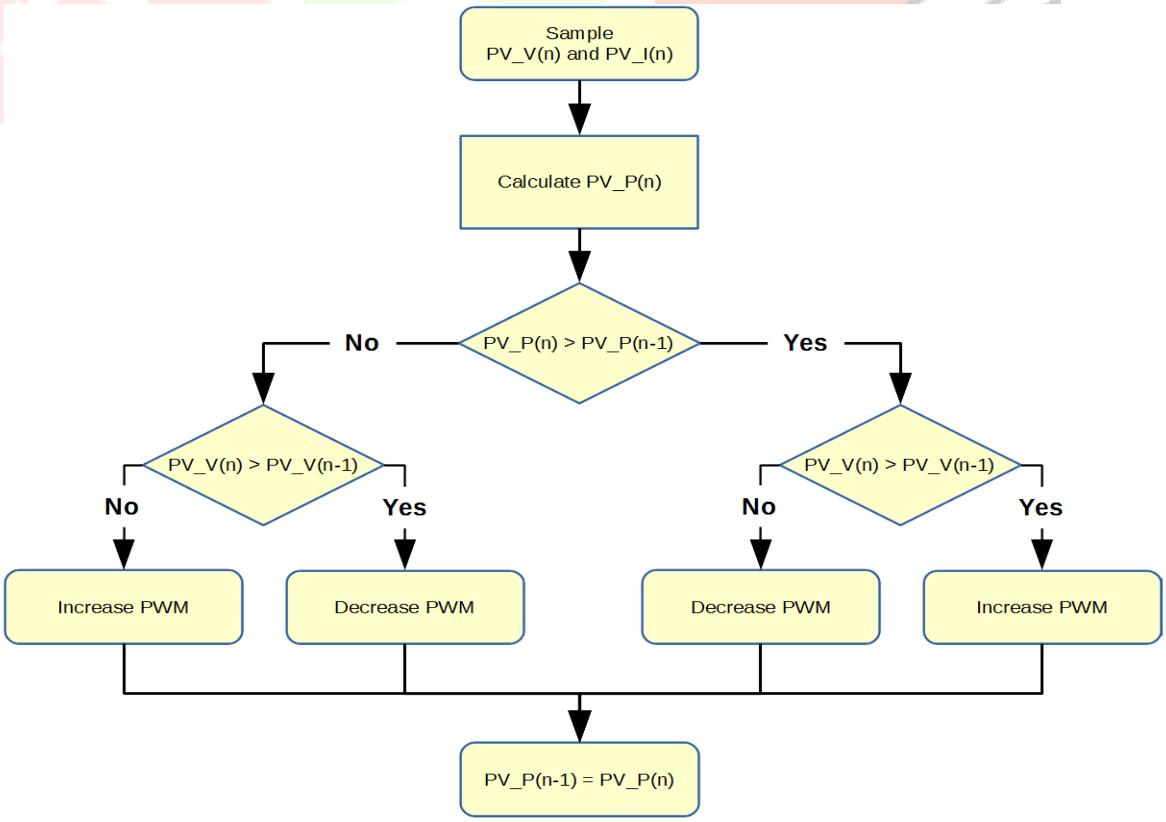


Fig-10. Flowchart of Perturb and Observe

C. Boost Coverter

The major disadvantage of a Buck type converter is the switch is at the output of PV panel so when it's ON it transfers power but when Off no output to the PV panel occurs which implies the operating point remains near the open circuit voltage which is a loss . This issue is not there in boost converter mechanism. In a boost converter the Load matching is done by varying the resistance of the input side by altering the Duty ratio for which a DC-DC converter [6] is required. Basically this is called Tracking. Another purpose of using a Boost regulator in spite of the fact that it has a lower efficiency than its counterparts is that this DCDC converter can be used to feed a load or a system with higher voltage demand thus justifying its name.[11]

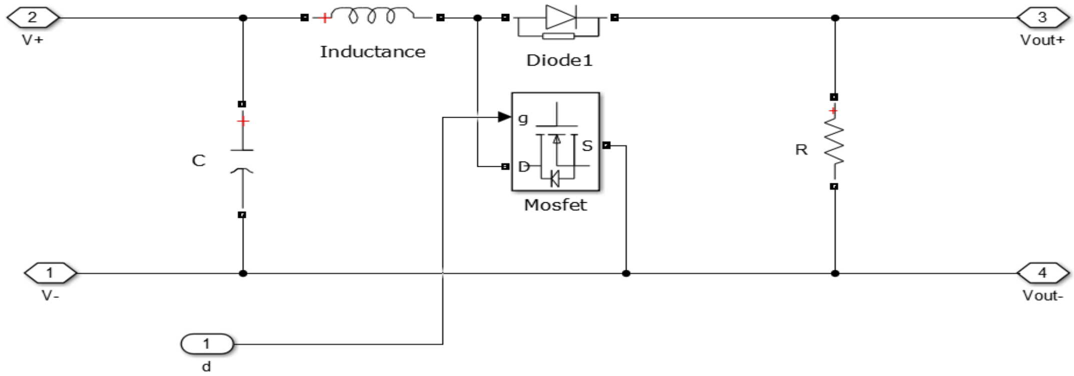


Fig 11:-Simulink model of a Boost Converter 5v to 12v DC

D. Phase Lock Loop:

A phase-locked loop or phase lock loop abbreviated as PLL is a control system that generates an output signal whose phase is related to the phase of an input signal. There are several different types; the simplest is an electronic circuit consisting of a oscillator and a phase detector in a feedback loop. The oscillator generates a periodic signal, and the phase detector compares the phase of that signal with the phase of the input periodic signal, adjusting the oscillator to keep the phases matched.

Keeping the input and output phase in lock step also implies keeping the input and output frequencies the same. Consequently, in addition to synchronizing signals, a phase-locked loop can track an input frequency, or it can generate a frequency that is a multiple of the input frequency. These properties are used for computer clock synchronization, demodulation, and synthesis. Phase-locked loops are widely employed in radio, telecommunications, computers and other electronic applications. They can be used to demodulate a signal, recover a signal from a noisy communication channel, generate a stable frequency at multiples of an input frequency (frequency synthesis), or distribute precisely timed clock pulses in digital logic circuits such as microprocessors. Since a single integrated circuit can provide a complete phase-locked-loop building block, the technique is widely used in modern electronic devices, with output frequencies from a fraction of a hertz up to many gigahertz.

By efficiently utilization of the phase loop lock technique PWM signals can be generated. This generated PWM signals are feed to the gates of the semiconductor switches of three phase inverter to obtained a three phase sinusoidal wave form.

E. Simulation

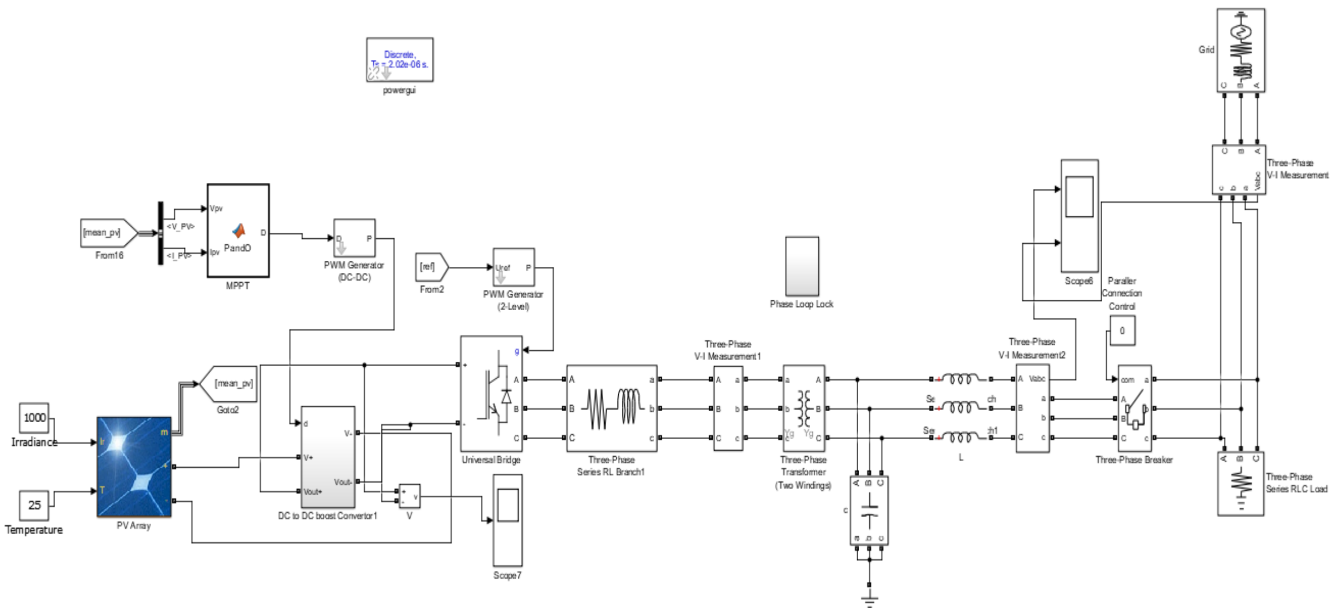


Fig-12: Simulink model of Three Phase Solar to Grid Tie Inverter

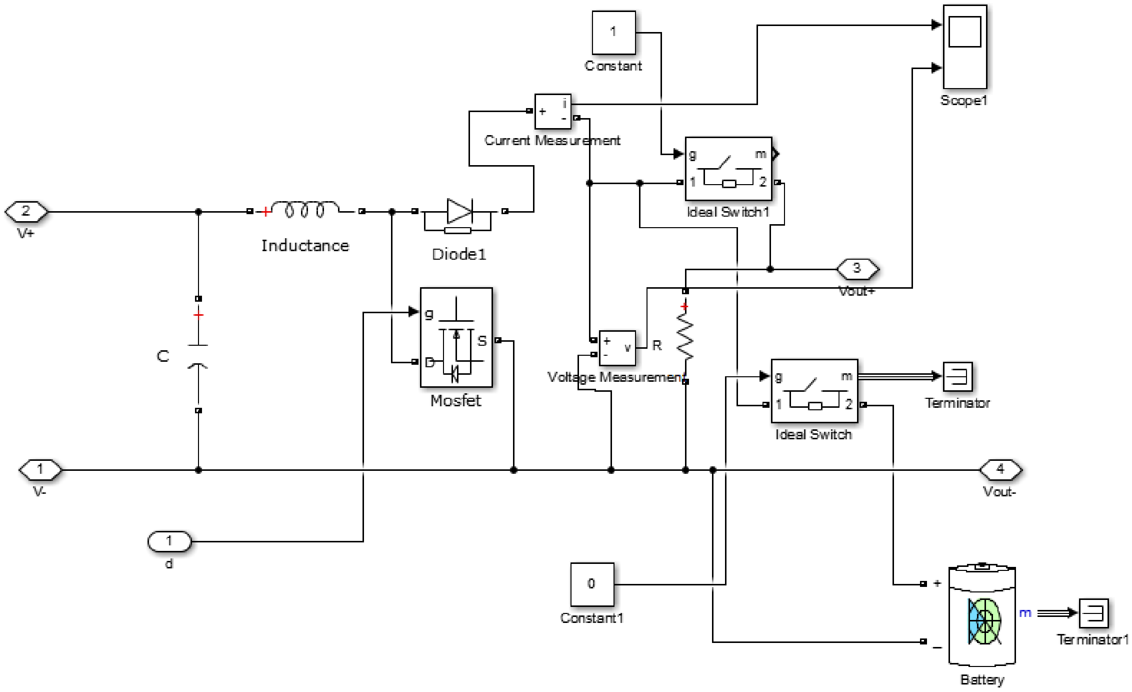


Fig-13: Converter with Battery

VI. RESULT

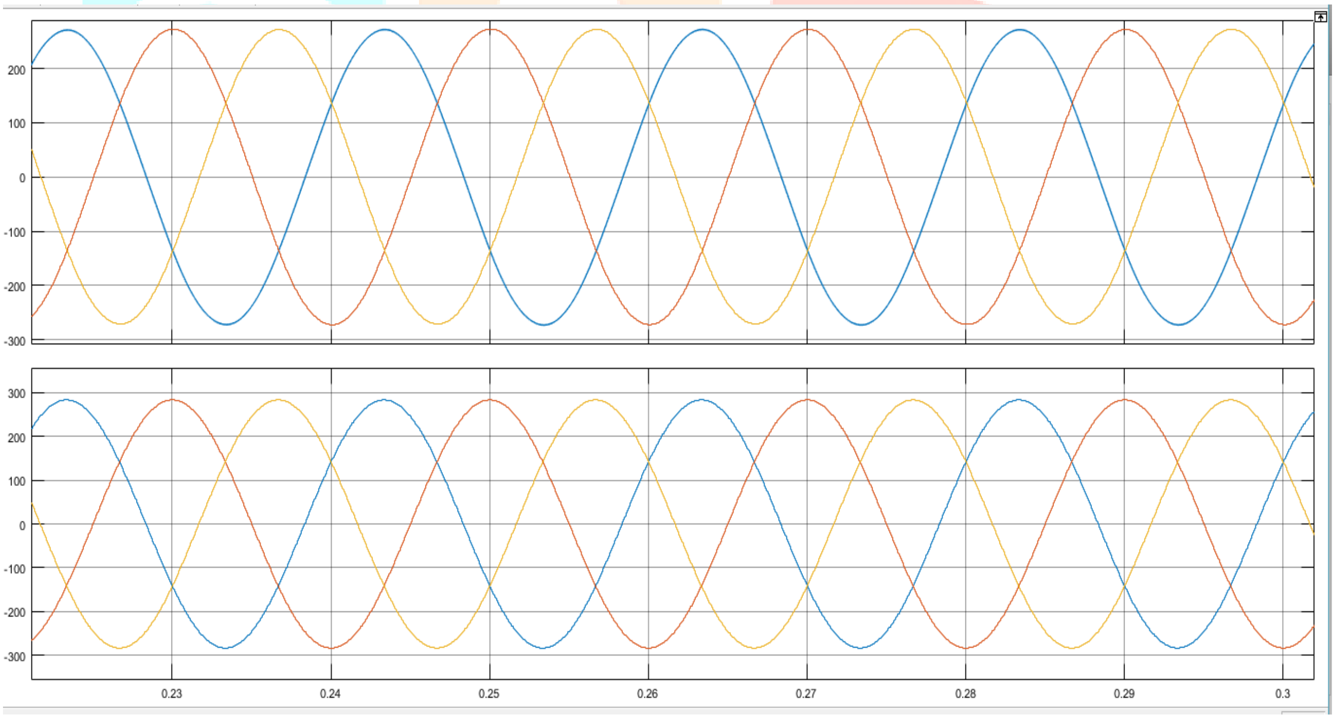


Fig-14: Output result

VII. FUTURE SCOPE

Future scope:
The proposed MPPT technique using P&O is not much efficient for maximum power point tracking hence improvement is needed in the tracking algorithm. This proposed frame work needs to be implemented on hardware.
Conclusion:
The simulation of proposed system in matlab/Simulink has been successfully simulated. Also the solar inverter to power grid synchronization is achieved. .

VIII. CONCLUSION

Hence its conclude that, the output of three phase inverter is fed to three phase grid that is the grid tie inverter. That overall system are based on the solar renewable energy source, the generation of energy is to store to battery source and invert to three phase supply. The hole system is developed in MATLAB Simulink software.

IX. REFERENCES

1. Ariya Sangwongwanich, Yongheng Yang, and Frede Blaabjerg, "High-Performance Constant Power Generation in Grid-Connected PV Systems," IEEE TRANSACTIONS ON POWER ELECTRONICS, , VOL. 31, NO. 3, MARCH 2016, pp.1822-1825
2. Rupesh G. Wandhare, Vivek Agarwal, "Reactive Power Capacity Enhancement of a PV-Grid System to Increase PV Penetration Level in Smart Grid Scenario," IEEE TRANSACTIONS ON SMART GRID, VOL. 5, NO. 4, JULY 2014, pp.1845-1853
3. Marco Liserre, Remus Teodorescu, Frede Blaabjerg, "Stability of Photovoltaic and Wind Turbine Grid-Connected Inverters for a Large Set of Grid Impedance Values," IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 21, NO. 1, JANUARY 2006, pp.263-272
4. Rajiv K. Varma, Shah Arifur Rahman, Tim Vanderheide, "New Control of PV Solar Farm as STATCOM (PV-STATCOM) for Increasing Grid Power Transmission Limits During Night and Day," IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 30, NO. 2, APRIL 2015, pp.755-763
5. Behnam Tamimi, Claudio Cañizares, and Kankar Bhattacharya, "System Stability Impact of Large-Scale and Distributed Solar Photovoltaic Generation: The Case of Ontario, Canada," IEEE TRANSACTIONS ON SUSTAINABLE ENERGY, VOL. 4, NO. 3, JULY 2013, pp.680-688
6. "Three-Phase Single-Stage Grid Tied Solar PV Energy Conversion System using PLL-less Fast CTF Control Technique" Rahul Agarwal 1, Ikhlaq Hussain 1*, Bhim Singh, Department of Electrical Engineering, Indian Institute of Technology Delhi, New Delhi 110016, India
7. " Hybrid Phase Locked Loop for Controlling Master-Slave Configured Centralized Inverters in Large Solar Photovoltaic Power Plants" Prashant Jain Member, IEEE BHEL R&D, Vikasnagar, Hyderabad 500093, INDIA prashantjain@bhelrnd.co.inVivek Agarwal Fellow, IEEE Electrical Engineering Department, IIT Bombay, Mumbai 400076, INDIA agarwal@iitb.ac.inBishnu Prasad Muni GM, BHEL R&D, Vika.snagar, Hyderabad 500093, INDIA bpmuni@bhelrnd.co.in
8. Yuan Huang , An Luo&Zhiyong Chen "A Harmonic Control Strategy for Three-phase Grid connected Inverter with LCL Filter Under Distorted Grid Conditions" National Electric Power Conversion and Control Engineering Technology Research Center Hunan University Changsha, China (2016)
9. Kyoung-Jun Lee, Student Member, "A Novel Grid Synchronization PLL Method Based on Adaptive Low-Pass Notch Filter for Grid-Connected PCS" IEEE, Jong-Pil Lee, Member, IEEE, Dongsul Shin, Dong-WookYoo, Member, IEEE, and Hee-Je Kim (2014)
10. E.I. Ortiz-Rivera, F.Z. Peng"Analytical model for a photovoltaic Module using the electrical characteristics provided by the manufacturer data sheet," IEEE 36th On Power Electronics Specialists Conference, Recife, pp. 2087–2091, June 2005.
11. G. Saccomando and J. Svensson, "Transient operation of grid-connectedvoltage source converter under unbalanced voltage conditions," in IEEEIndustry Applications Conference, 2001, vol. 4, pp. 2419–2424.
12. I. Agirman and V. Blasko, "A novel control method of a VCS withoutAC line voltage sensors," IEEE Transactions on Industry Applications,vol. 39, no. 2, pp. 519–524, Mar. 2003.
13. R. Teodorescu and F. Blaabjerg, "Flexible Control of Small WindTurbines With Grid Failure Detection Operating in Stand-Alone andGrid-Connected Mode," IEEE Transactions on Power Electronics, vol.19, no. 5, pp. 1323–1332, Sep. 2004.
14. F. Blaabjerg, R. Teodorescu, M. Liserre, and A. V. Timbus, "Overviewof Control and Grid Synchronization for Distributed Power GenerationSystems," IEEE Transactions on Industrial Electronics, vol. 53, no. 5,pp. 1398–1409, Oct. 2006.
15. Ohsato, H., Kimura, G., Shioya, M.: "Five-Stepped PWMInverter Used in Photovoltaic Systems", IEEE Transactions on Industrial Electronics, 1991, 38 (5), pp. 339-397.
16. Colak, I., et al.: "The Design and Analysis of a 5-LevelCascaded Voltage Source Inverter with Low THD", 9thInternational Conference on Power Engineering Energy andElectrical Drives, Ankara, 18-20 March 2009, pp. 575-580.
17. Pranay, S., Kanojiya, R., Maurya, N.: "Performance ofSinusoidal Pulse Width Modulation based Three PhaseInverter", International Conference on Emerging Frontiers inTechnology for Rural Area (EFITRA), 2012, pp. 22-26.
18. Villalva, Marcelo Gradella, and Jonas Rafael Gazoli. "Comprehensive approach tomodeling and simulation of photovoltaic arrays." Power Electronics, IEEETransactionson24.5 (2009): 1198-1208.
19. Sridhar, R., et al. "Modeling of PV array and performance enhancement by MPPT algorithm." Int J ComputAppl7.5 (2010): 35-39.
20. Berrera, M., et al. "Experimental test of seven widely-adopted MPPTalgorithms." PowerTech, 2009 IEEE Bucharest. IEEE, 2009..
21. Kalirasu, Athimulam, and SekarSubharensu Dash. "Simulation of closed loop controlledboost converter for solar installation." Serbian Journal of Electrical Engineering 7.1(2010): 121-130.