

Grid Variables Synchronization using Optimization Algorithm for Distributed Generation System under Grid Fault Conditions



Alwin Vinifred Christopher, Ramesh Rengaswamy, Prakash P

Abstract: Power system has electrical energy as the vital part the energy can be acquired from the sustainable and non-sustainable sources like solar, wind, biomass, water, and coal, nuclear, oil, thermal respectively. In past the synchronization is the real issue because of the time utilization for the estimation of grid variables. In this work the solar based distributed generator is considered for the analysis. The grid connected photovoltaic framework, the grid can expend the energy from the photovoltaic panel and distribute the energy when the dark condition. The grid and PV framework can go about as a distributed energy sources. In this paper the grid associated PV system with the novel PR controllers are proposed to provide quick synchronization process and the hybrid swarm cuckoo search optimization algorithms (HSCS) is used to pick the best parameter to generate control pulses. The demonstration is done under the SIMULINK model. The performance PI, PID and Proportional Resonant (PR) controller with cuckoo search optimization algorithm are analyzed separately and found better solution for the problem stated.

Keywords: Grid connected photo voltaic system, LC filter, Converter, Hybrid swarm cuckoo search optimization algorithm, PR controller.

I. INTRODUCTION

The traditional electricity frame work, basically consisting of huge and rationalized energy production capabilities joint to the end users, has been turned against a distributed energy generation function, Here renewable energies are enhancing necessary member. In the supplying process, the electricity structure of the upcoming process will make major need of power microelectronic components, instruction, and intelligence operations [1].

On the other hand, network and wireless communication systems have birthed another modern economic and industrial revolution. New industries and economies based on communication services have sprung up from the widespread availability of information.

Amid the grid related process, each and every DG procedure is ordinarily coordinated to contribute or embed energy to the grid supply, which is the current regulate form in unbending harmony with the network.

The controller presented execute a steady DG item and deal with the voltage at point of basic coupling (PCC) past and later the grid is disconnected [6]. A phase locked loop (PLL) is have to control the frequency and angle quotation of the PCC. A vital attitude to inspect in grid connected associated process is harmonization with the grid voltage for identity power aspect process, it is vital that the matrix current suggestion signal is in phase with the network voltage. This grid harmonization can be refined by applying a PLL [7-10].

The prevalence of DG framework are consolidated over grid/load along power electronic controller. Current-controlled voltage-determined inverters (VSIs) are much of the time utilized for grid connection. Under the keen grid environment, DG gathering ought to be conceded in the system reasonable control scheme, where they can be have to amplify system precision by contributing backup generation in hidden mode, and to give extra systems of support (e.g. voltage support and reactive power control) in the grid connected form. These working condition activities are capable in nature as in light of the load/production profile, calm-side authority control, and worldwide system development controllers [11-14].

Among these PLL systems, the modifying algorithm based congruity functions acquire more debate as a result of their extraordinary power and speedy reaction. This kind of PLL procedure might be the astounding one for single-stage PV function working in invalid structures. In any case, it will likewise cause excluded pressure, similar to frequency strokes [15]. The request can be clarified in quickly as the limit of steady and connected to the supply grid without skipping under voltage sags or swells in an assigned time, helping the applicability grid by embedding reactive current worried to disregard grid collapse, and contributing active power to the system all of a sudden after a fault approval [16]. The structure, control and working of grid associated sustainable power systems, alongside single-stage PV capacities.

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In light of a most reduced penetration scope of PV functions, the grid measures fundamentally tended to elementary request for such systems. For instance, the majority of the grid connected PV systems should halt to empower the nearby pull in the event of grid transient eruption, e.g. voltage sags [17].

As effectively embedded, PV blend are essentially connected to low and medium voltage function, which is shifted from generally power station or immense wind power station.

The present powerful grid concern could be conclusive in the most minimal penetration range scheme. The reputation of power generation from PV blend on the electrical frameworks has been confirm slight. Lately, numerous countries have already adjusted their grid codes for medium or high voltage sustainable power source capacities, and a few countries have additionally declared indistinguishable worry for low level voltage apparatuses. For event, the German grid code needs the mix joined to medium or awesome voltage system would be satisfactory ride over voltage droop and at the correct time to contribute reactive current to the censure grid [18-20].

The grid connected PV framework is conceded to build up the bounty measure of electrical energy for a few tasks and it can defeat the congruity issue. In past what sort of techniques are utilized to take care of the issue is characterized in section 2, the inspiration is included section 3, the problem formulation is incorporated into segment 4, The proposed philosophy is characterized in section 5, and the algorithm is neglected in section 6, results are made in area 7, and the conclusion part in section 8.

II. LITERATURE REVIEW

Generally wind and photovoltaic (PV) frameworks, are ending up exceptionally aspiring by the guaranteed grid code concern for the grid connection for distributed generation capacities. The transmission system operations (TSOs) are particularly worried around the most reduced voltage-drive-through lien and it has been presented by P. Rodriguez et al [21]. The increase of STATCOM and dynamic voltage controller (DVR), moreover on extraordinary control functionalities for the extant spirit converters of dispersed generation station have accord to upgrade their criticism under defective and coloured scheme and to execute these worry the outcomes would be secured. For finishing up substantial outcomes with united systems, it was imperative to poll on definite and active grid voltage harmony advancements, which are meet all requirements to work underneath irregular and distorted conditions. This paper audits the integration progressive facility of three propelled harmony works the confined twin synchronous allusion shape phase locked loop (PLL), the second frame built up integrator PLL, and the three-phase improved PLL, organized to endeavor underneath such conditions. Although another capacity rely upon frequency locked loop would presented, PLL have been titled by their association with dqo controllers. In following, the shifted techniques would be conceded and discretized, and their accomplishment would be examined in a fundamental request controlled for evaluate their conviction and effort appearance.

Vaccaro et al [22], has settled the approach of smart micro grid (SMG) was by and large distinguished as one of

the better skilled and empowering mechanism for smart grids. In this circumstance, the advancement of brought together and scattered frameworks for decapitate complex control and checking applications was still in its initiation and requests to be test. To find this issue this paper build up an idea of self-sorting out specify plot, rely upon self-arranging associate, for clear up the real supervision and checking issues of a SMG without the utilization of supported data expansion and taking care of. Reproduction issue got to for a 18-bus enquiry system are conceded and presented for decide the suggestion and lawfulness of the normal new plan.

Being decrease of petroleum fossil fuel many developing nations like Pakistan are confronting energy disaster and this was given by M.M. Sabir et al [23]. At any rate decapod Pakistan has persist exceptionally effectively being vitality change and at government run and in private level an awesome power was being thought up to vanquished this energy inconvenience. In abundantly accessible energy sources sun energy is the effortless and inescapable energy source. As the consequence of wide increment of sun powered energy use as an extra source with fossil fuel the sun powered following systems are achieve ubiquity. To get to perfect energy from solar oriented capacity unmistakable following of sun was authorized against azimuth and inclination point. Typically there are two brands of sun powered follows one is single axis and next one was double axis. For dual type of solar powered trackers DC motor set servo motor are requirement for definite migration control. We inspect in the present work structure of an incredible proportional integral derivative (PID) controller for DC motors of twofold pivot solar based following capacity. The issue was devised as development issue and three flock intelligence based metaheuristic advancements like firely technique (FFA), particle swarm algorithm (PSA), and cuckoo search calculation (CSA) are taken care of for capital alter of PID controller. The review shows that CSA was exceptional as related with FFA and PSO because of its quick merging rate, little deviation and classic deviation of organized parameter was achieved. Likewise alluding to achievement sphere FFA and CSA shows great accomplishment as identified with PSO for the issue concern under planned.

This paper bargains a novel utilization of regular mixed p-norm (CMPN) algorithm-based flexible control approach with the need of increase the lowest voltage ride through (LVRT) facility of grid connected photovoltaic (PV) power stations and this was presented by H.M. Hasanien et al [24]. Through a DC-DC boost converter, a grid based inverter, a DC-connect capacitor and a three-phase step up transformer the PV designs are joined to the bit of common coupling (PCC). The DC-DC converter is worn for a power point tracing capacity in light of the factionary wide circuit voltage procedure. The grid part inverter was utilized to rule the DC-link voltage and extreme voltage at the PCC over a vector control pattern. The CMPN strategy depends adaptable proportional integral (PI) controller was worn to check the power electronic circuits by its snappy intersection. The arranged algorithm re-established the PI controller hikes connected without the utilization of fine tune or improve.

The PV power plant is joined to the IEEE 39 bus New England enquiry function for practical feedback. The ability of the arranged control scheme is connected with that curtailed Taguchui progressed rely upon capital PI controller expensing into account dominating the system to balanced and unbalanced faults, and foiled rewinding of circuit breakers by the presence of stable defect. The legality of adaptable control scheme is extensively supported by the recreation occasions,

which are performed by PSCAD/EMTDC programming by the planned altering controlled PV power station; the LVRT productivity of such system would be upgraded.

The need of a least mean forth (LMF) based development for single step three phase grid bound based solar photovoltaic system (SPV) and it was conceded by R.K. Agarwal et al [25]. It subsist of a SPV design, three phase grid, voltage source converter (VSC), and even/uneven loads. This method has an SPV pattern combined with a VSC to contribute three-phase active energy and furthermore execute as a steady reward for the sensitive power coverage. It additionally yields to an IEEE519 standard on mixing by settling the quality of power in the three-phase distribution structure. Along these lines, this blend serves to bear the harmonic mitigations, load harmonizing, power factor modification and adjusting the terminal voltage at the intersection of common coupling. For raising the ability and high power to be gotten from the SPV pattern at contrasting ecological environment, a single step system is worn alongside P&O strategy for maximum power point tracking (MPPT) joined with the LMF situated control system. The arranged strategy was based and expected utilizing MATLAB/Simulink with achievable sim power tool box and the attitude of the framework under different loads and environmental conditions are analysed scientifically on advanced system in the research centre.

Notations used in below expression

- $p_{pv}(\tau)$ Output power from the solar
- P_{rate} Rated power
- l_f Loss factor
- R_{ir} Solar irradiation
- R_{stdir} Standard irradiation

- α_c PV cell temperature at current step
- α_s Temperature standard condition
- V_i Input voltage
- V_o Output voltage
- η Efficiency
- f Frequency
- η_{inv} Efficiency of the inverter
- $p(\tau)$ Output power of inverter

III. PROPOSED MODEL

Distributed Generation (DG) technology consolidates wind turbines, micro turbines, photovoltaic systems, fuel cells, energy storage and synchronous generator applications to supply active energy to distributed systems associated near the buyers load. The grid associated system the PV which go about as a distribution generation, where the grid synchronization is the basic assignment when the utility signal is influenced from the harmonics or disturbances. It requires significantly more time amid quick synchronization. The reference phase signal is given by the phase recognizing strategies, and it is synchronized with the grid voltage which is required to met the power quality. So the synchronization plot must be against the power system issues like harmonics, voltage sag swell issue, and unbalances. Decent synchronization schemes distinguish the phase angle, voltage and frequency in productive way.

The proposed strategy incorporates the plan of grid tied PV system, from which the voltage frequency and phase angle is estimated. In past works, different strategies are determined to quantify the previously mentioned parameters. Be that as it may, the plan procedure takes lotof time, this can be kept away from by the novel synchronization procedure of hybrid particle swarm and cuckoo inquiry optimization algorithm. The new model of PR controller is intended for control the current. The output current from the LC filter is given to the input of the controller to produce the pulse and it is given to the inverter.

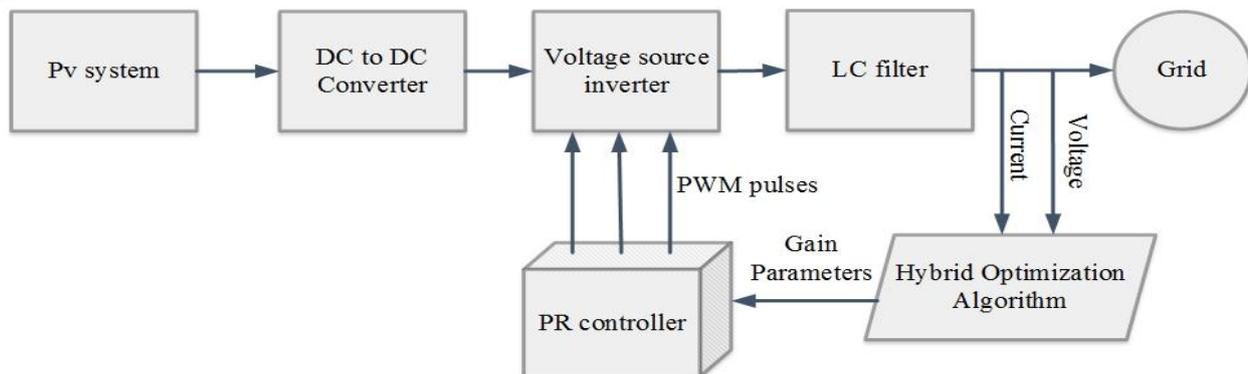


Fig. 1. Block Diagram of Proposed approach -Grid tied PV system

The figure 1 shows the grid connected PV system, in which the distribution generators are taken as the solar based and it can cause a few changes because of the light levels and the temperature variety of the PV system. The Dc to DC converters are takes place with the end goal of

transformation with the levels changes like low or high, it will changes as per our applications.

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At that point the inverters are utilized for the conversion of direct current into alternating current from the photovoltaic source.

The inverter yield is then connected to the input of the LC filter with a specific end goal to expel the harmonics exhibited in the output of the inverter voltage or current. The output of the filters are voltage and current, which is given the synchronization block, which contains the PSO and CS algorithms for recognizing the phase, voltage, and frequency. At that point ascertain the active reactive power. The error of the current is given to the input to the controller, and the duty cycle is computed for the generation of pulses in the pulse width modulation, and the pulses can tune the inverter to produce the suitable waveform.

IV. MATHEMATICAL MODELING

A. PV panel [26-28]

The current and voltages are generated from the PV system to generate the power, the current is given by,

$$I = i_l - i_0 \left[e^{\left(\frac{q(v+ri)}{\beta k \alpha} \right)} - 1 \right] - \frac{v+ri}{r_{sh}} \quad (1)$$

The open circuit voltage is given as,

$$v = \left[\frac{k\alpha}{q} \right] \ln \left[\frac{i_l}{i_0} \right] \quad (2)$$

The output power depends on the solar irradiation and the temperature of the panel and it can be calculated by,

$$p_{pv}(\tau) = p_{rate} I_f \frac{R_{ir}}{R_{stdr}} [1 + \gamma(\alpha_c - \alpha_s)] \quad (3)$$

B. DC to DC converter

The dc to dc converters are used to convert the dc current or voltage into same form, but the switching levels are varied depends on the applications.

The duty ratio of the boost converter is given by,

$$D = 1 - \frac{v_i \times \eta}{v_o} \quad (4)$$

The switch current of the converter can be calculated by,

$$\Delta I = \frac{v_i \times D}{f \times L} \quad (5)$$

C. Inverter

The DC power is transformed into AC by the inverter and the developed equations are as follows,

$$p(\tau) = p_{pv}(\tau) \eta_{inv} \quad (6)$$

D. LC filter

The filters are used to eradicate the harmonics presented in the output of the inverter and the resonance of the LC filter can be evaluated by,

$$f = \frac{1}{2\phi\sqrt{LC}} \quad (7)$$

The PR controller transfer function is given by,

E. PR Controller [29]

The controllers are taken the error as input and error cleared signals are given to the output from the controller. Here we have the proportional and resonance gain, the proportional gain can be calculated by

$$k_p = \frac{2\phi f L}{k_{gi} k_{pwm}} \quad (8)$$

The Laplace transform of the PR controller can be defined as,

$$G = k_p + \frac{2k_r d}{d^2 + \omega^2} \quad (9)$$

F. HSCS ALGORITHM

The HSCS [28-30] is produced by Elbert and Kennedy in 1995 and Deb and Yang in 2009. It is the conduct of flocks and cuckoo respectively. The synchronization is the real issue in network associated PV system. In past the PLL (Phase locked loop) is favoured for obtain the phase angle, frequency and voltage from the grid side inverter. The PLL consume more time for the estimation of parameters under faulty condition. Here the HSCS algorithms used to generate best pulses for quick synchronization

Step 1: Initialize the population; it can be represented by,

$$\alpha = \alpha_1, \alpha_2, \alpha_3, \dots, \alpha_\eta \quad (10)$$

Where the number of particles can be represented as α_η . The population includes upper bound, lower bound, initial velocity and position.

The velocity can be updated by,

$$v_n(k+1) = \omega v_n(k) + \mu_1 s_1 (p_n - \alpha_n(k)) + \mu_2 s_2 (p_g - \alpha_n(k)) \quad (11)$$

Where ω is the inertia weight, $v_n(k)$ is the particles

velocity, p_n p_g is the currently best and global best

respectively. Then the term μ_1 , μ_2 represents the

acceleration constants and S_1 , S_2 is the random variable with the range of about 0 to 1.

Step 2: The fitness function (Objective function) evaluation is done. Whereas the fitness value of new and old are compared. The better result is selected for next generation

Step 3: The population and fitness function can be evaluated through the PSO, in which the global optimal solution can be find out by cuckoo search. In each iteration the position can be updated by

$$\alpha_n(k+1) = \alpha_n(k) + \lambda \times l(\beta) \quad (12)$$

Where ' λ ' denotes the step size parameter, $\alpha_n(k)$ is the nest position, $l(\beta)$ random search vector,

Step 4: If the conditions are satisfied then find the optimal solution and corresponding flow chart is shown in figure 2.

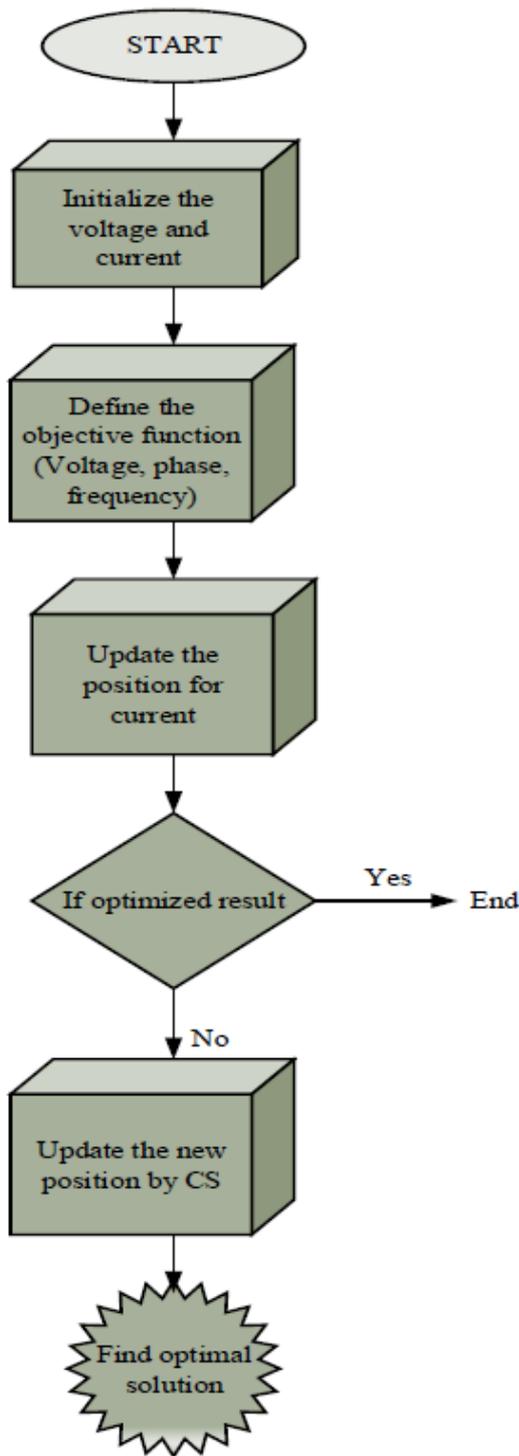


Fig. 2. Flow chart of HSCS

V. RESULT AND DISCUSSION

This section gives the discussion on analysis of generated output of PR, PI and PID controllers with proposed algorithm for generating control pulses. The gain parameters are generated by HSCS algorithm and which is fed to the Inverter for the generation of grid synchronized variables. Simulation results are summarized for different type of controller. The time required for generation of grid variables and THD are summarized in the Table I. The figure 3 demonstrates that the I-V and P-V characteristics of the photo voltaic cell, The PV cells can be displayed with the diode and current source is put parallel to the diode. The current generation relies upon the equation

(1). The power and voltage is appeared in figure3 from which we can without much of a stretch comprehend the power value is exceedingly enhancing as for the voltage. The peak power value is 300 W, and the voltage is changed from 0 to 400V.

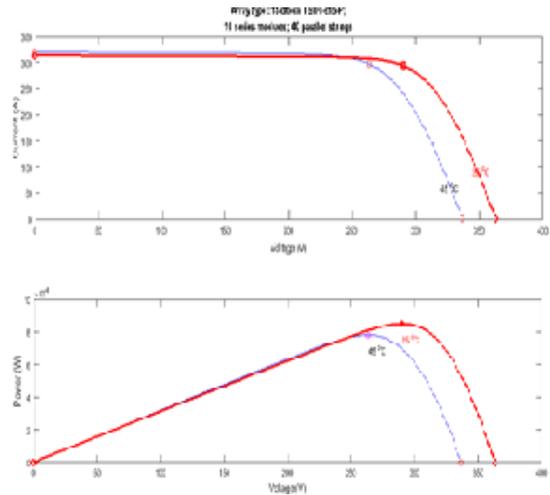


Fig.3. I-V and P-V characteristics of PV panel

A. PR CONTROLLER

The grid associated PV system is intended for producing the power as per the applications. Here the solar module type is SPR-305-WHT, in which the attributes, current, voltage and power is figured. This procedure is completed over the MATLAB/SIMULINK show and the execution are given underneath with the current controller.

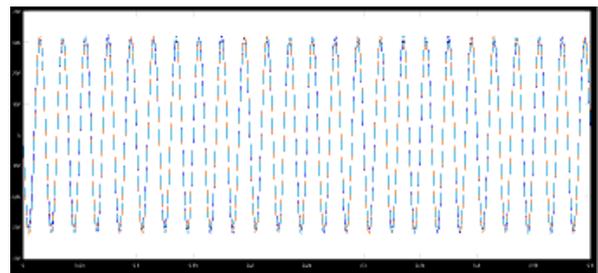


Fig.4. Inverter Voltage, Grid Voltage

Figure 4 Shows the 1φ Inverter Voltage and Grid voltage. The grid variables are synchronized with Inverter variables when PR controller is used. The dashed waveform shows grid voltage.

The execution of the PR controller can yield the stable output of voltage and current. The output of the inverter and the grid is relatively same output in voltage and current. The voltage is around 300 V. The elapsed time of this synchronization can take 47.50 seconds in 3φ system under faulty condition.

B. PI CONTROLLER

The PI controller output is given below, in this controller the proportional and integral gains are calculated to show the better performance. The grid voltage is extracted from the PI controller is shown in figure 5. The three phase voltage is given, but it is never reaching the input PV voltage.

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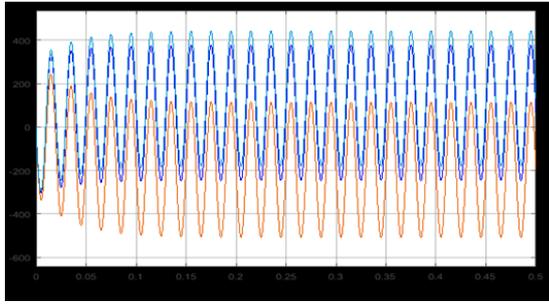


Fig. 5. Grid voltage and Inverter voltage

The output of PI controller power is appeared in figure 5. The grid power is provided to the remote zones amid the day and evening time. The grid power is provided to the loads as indicated by the client use of the system. The active and reactive power is generated through the system. It can keep up the power request of the system.

C. PID CONTROLLER

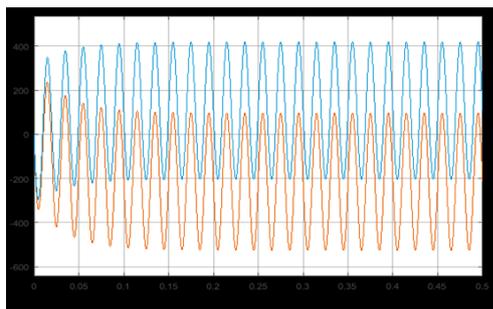


Fig.6.Grid Voltage

The figure 6, demonstrates that the three phase grid voltage, after the tuning of controller the grid voltage is gotten, which is almost equivalent to the 400v. The voltage is shifted in accordance to the time. At first some distortion is showed up in the voltage, after that it is cleared through the filter. The three phase voltage is constant close to the input voltage of the PV panel.

The grid current is appeared in figure 6, it comes to over the most extreme value. It never shows up the steady value of the current. In which the amplitude of the current is changed as for the time. At beginning stage the current is near 150, after some interim of time the present esteem is comes to close to 100A. The three stage current have some nonlinear distortion. The current can be controlled with the PID controller, in which the error current (Difference between the real and reference current) is given to the input of the controller, Then the output waveform is seemed like some higher order harmonics. This can be rectified with the assistance of LCL filter. The Processing time, Time required for synchronization and THD percentage comparison between the PR,PI and PIR controllers are summarized in Table I

Table I Summary of Results

Type of Controller	Type of system Analyzed		Time Taken to generate gain parameters in Secs		Time to generate Inverter output under faulty condition in Secs		THD %
	1φ	3φ	1φ	3φ	1φ	3φ	
PR	Yes	Yes	15.3	27.5	30.7	47.5	11.23
PI	Yes	Yes	19.7	37.4	32.7	49.9	27.42
PID	No	Yes	21.5	40.8	33.5	51.4	20.39

The simulation model of proposed system is shown in figure 7 and figure 8

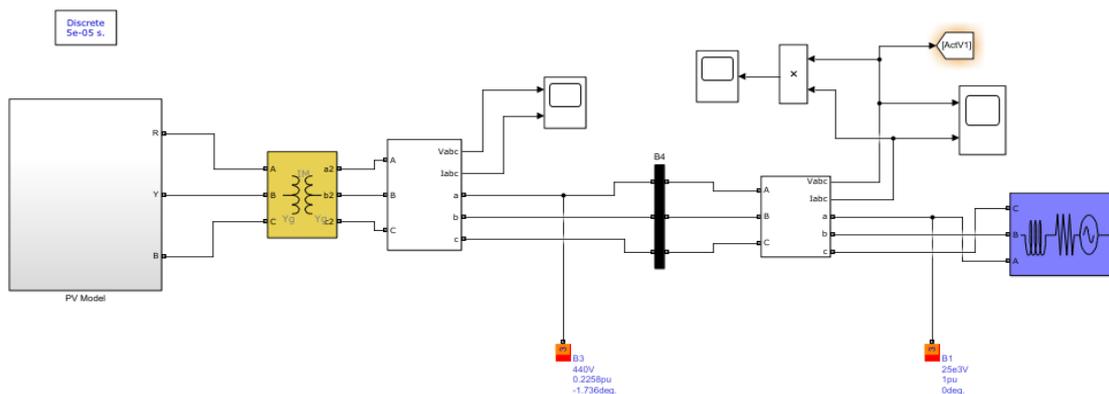


Fig.7. Simulink model of the proposed methodology

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