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ADAPTIVE CONTROL OF VSC TO IMPROVE POWER QUALITY IN GRID CONNECTED PSO BASED SOLAR PV BATTERY SYSTEM

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Abstract— This paper presents an implementation of an Adaptive Learning Based Back Propagation (AL-BP) control technique for improved power quality grid interactive solar PV - battery supported system catering the balanced and unbalanced three phase four wire (3P-4W) nonlinear loads and single phase loads of various nature simultaneously. The PSO-based MPPT technique is employed to solve problems related to mismatching phenomena, such as partial shading, in which the PV arrays are commonly submitted. Considering the search of the global maximum power point under partial shading, Moreover the source currents remain balanced and sinusoidal for all operating and loading conditions such as in highly unbalance loading conditions where a load on one of the phase is disconnected.

An AL-BP control technique is used to control the voltage at point of common coupling and to improve power quality under various loading conditions through mitigation of harmonic currents, reactive power compensation, active power balancing and neutral current compensation in the 3P-4W system. It also improves the system power factor in highly nonlinear and unbalanced loading conditions. The AL-BP control scheme has the capability to self tune the arbitrary nonlinear systems such as grid-interactive critically unbalanced 3-phase 4-wire system feeding highly nonlinear loading systems.

I.INTRODUCTION

due to serious environmental concerns, advancement in the technologies and decrease in price, the SolarPhotovoltaic (PV) based power generation has increased during last few years. A large amount of green house gases is generated by the thermal power plants. The easy availability of solar energy irrespective of the geographical location, the electric power-generation using solar-photovoltaic plants, has been found better and more suitable in comparison to other electrical power generation systems based on renewable energy sources. Conventional self tuning adaptive control systems are more suitable for linear systems or some specific non linearsystems . The neural network algorithm is often used in recent years for nonlinear adaptive filtering based systems . An adaptive load shading scheme using an adaptive artificial neural network, and its transient stability analysis for electrical utility systems have been presented. A back propagation neural network based training scheme has been discussed in. A back propagation through time base learning algorithm and a new recurrent adaptive control theory have been presented in. A back propagation neutral network is proposed for nonlinearity compensation in optical current sensors based photonic transducer system.

II .CHARACTERISTICS OF SOLAR CELLS

The sun based cell, which is for the most part built of PV wafers, changes over sun oriented illumination's light energy straightforwardly into voltage and flow for load, and conveys power without the utilization of an electrolytic impact. The electric energy is acquired from the PN interface of semiconductor straightforwardly; accordingly, the sun based cell is otherwise called PV cell .The same circuit of sun based cell as displayed in Figure2

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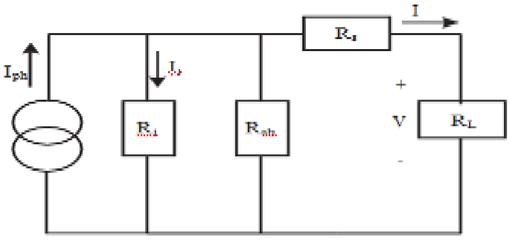


Fig1: equivalent circuit of pv array

The latest source The cell photovoltaic current is addressed by Iph, the nonlinear obstruction of the p-n intersection is addressed by Rj, and the natural shunt and series protections are addressed by Rsh and Rs, separately. Typically, the worth of Rsh is very high, though the worth of Rs is somewhat low. Therefore, the two of them may be disregarded to improve on the investigation. PV modules are comprised of PV cells that are assembled in bigger groupings. They are additionally interconnected in series-equal mix to shape PV clusters. The numerical model used to work on the PV exhibit is addressed by the condition

$$I = n_p I p_h - n_p I_{\gamma s}[e^{\frac{q}{KTA} * \frac{V}{n}} - 1]$$

Where I addresses the PV cluster yield current, V addresses the PV exhibit yield voltage, ns addresses the quantity of series cells, np addresses the quantity of equal cells, q addresses the charge of an electron, k addresses the Boltzman steady, An addresses the p-n intersection ideality factor, T addresses the cell temperature, and Irs addresses the cell invert immersion current. The sun powered cell's uniqueness from the best p-n intersection charater is dictated by factor A chooses the deviation of sun oriented cell from the best p-n intersection attributes. Its worth reaches from one to five. The photograph current Iph relies upon the sunlight based irradiance and cell temperature as below .Where I_{scr} is the cell short circuit current at reference temperature and radiation, Ki is the short circuit current temperature coefficient and S is the solar irradiance in mW/cm2. The Simulink model of PV array is shown in Fig. 4. The model includes three subsystems. One subsystem to model PV module and two more subsystems to model I_{ph}andI_{rs}.

III.SCHEME AND WORKING PRINCIPLE

The block diagram of proposed power quality improved ALBP control based 3 phase 4 wire grid-interactive solar-PV battery system is presented in Fig. 1(a). The photograph of the experimental proto type is shown in Fig 1(b). The proposed system operates in three phase balanced mode of operation while feeding highly unbalanced and nonlinear loads. The proposed scheme consists of a four leg IGBT based voltage source converter (VSC), three inductors for interfacing between grid and VSC, a solar-PV array, a boost converter for MPPT, a 3-phase RC filter, a battery energy storage, a DC bus capacitor and a bidirectional DC-DC converter for battery charging. The AC side of VSC is connected to the grid through interfacing inductor and fourth leg of VSC is connected to the neutrals of both source (grid) and load. The fourth leg of VSC supplies all the harmonic currents demanded by the neutral of the load. Therefore, load does not demand any harmonic current from neutral of the grid, which in turn significantly reduces the losses in neutral wire of source/grid and also improves the power quality of the three phase four wire system in critically unbalanced loading conditions. The proposed control algorithm is implemented using a DSP based controller that generates the desired gating pulses for all eight IGBT switches of four leg voltage source converter in order to achieve the desired performance. The VSC is controlled through adaptive learning based back propagation control technique based control scheme. The pso algorithm is used for maximum power point tracking . The bidirectional converter is used to control the flow of battery power during charging or discharging. The VSC supplies adjustable reactive power to the grid in order to maintain a constant system voltage at point of common coupling (PCC).

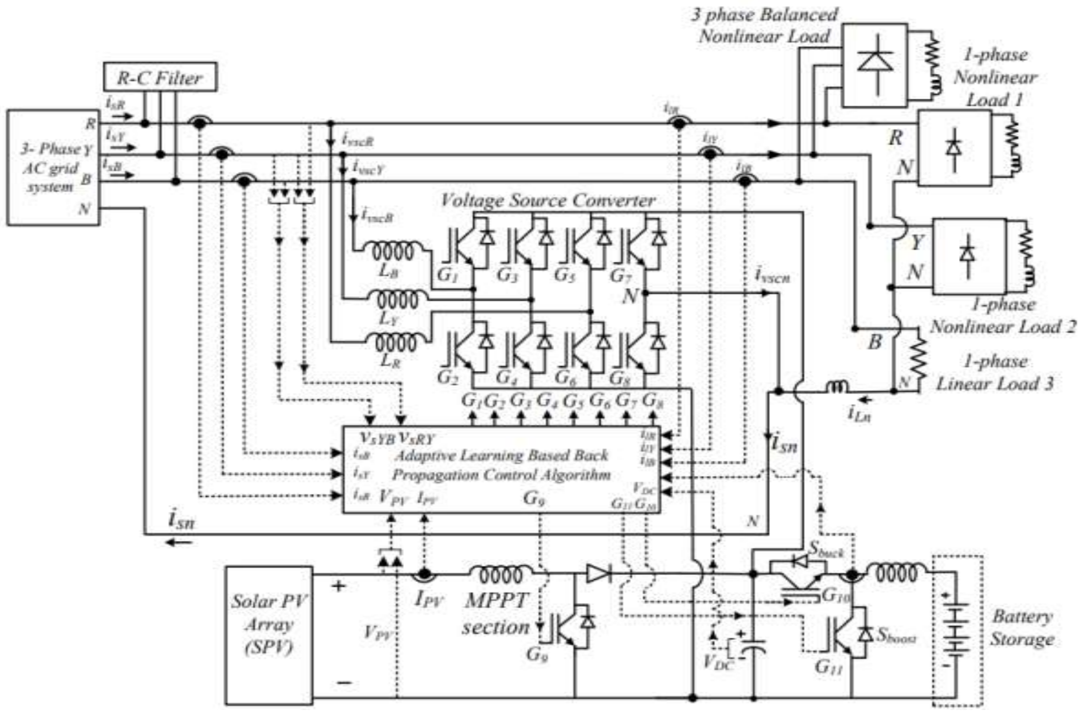


Fig.1(a) Block diagram of adaptive control of voltage source converter based scheme for grid-interactive solar PV- battery system feeding unbalanced 3 phase and single phase nonlinear and linear loads

IV.CONTROL ALGORITHM

The AL-BP Algorithm for battery supported improved power quality three phase four wire (3P4W) system, is used for extraction of fundamental real and imaginary power components of load currents of all phases [31]. A. Adaptive Learning Back Propagation Based Control Algorithm The mathematical-modeling of proposed AL-BP control algorithm is as follows. The voltage (VT) at point of common coupling is estimated as,

$$v_T = \sqrt{\frac{2}{3}(V_{Ph_R}^2 + V_{phy}^2 + V_{phB}^2)}$$

In-phase normalized signal of grid voltages are estimated as follows,

$$u_{Rp} = \frac{v_{ph_R}}{v_T}, u_{yp} = \frac{v_{ph_y}}{v_T}, u_{B_P} = \frac{v_{phB}}{v_T};$$

type activation-function using equations . These equations are used to estimates the outputs of feed-forward block.

$$z_{Rp} = f(i_{LRP}) = \left[\frac{1}{1 + e^{-\frac{I}{Rp}}}\right];$$

$$z_{Yp} = f(i_{LYP}) = \left[\frac{1}{1 + e^{-\frac{I}{Yp}}}\right];$$

$$z_{Bp} = f(i_{LBP}) = \left[\frac{1}{1 + e^{-\frac{I}{Bp}}}\right];$$

The outputs of feed-forward block (ZRp, ZYp, ZBp) are given as input to a hidden layer of back propagation neural network. The outputs of hidden layer are estimated using equations .

$$Ir = \omega_{m_1} + \omega_{Rp} z_{R_P} + w_{yp} z_{Rp} + w_{Bp} z_{Rp};$$

$$Iy = \omega_{m_1} + \omega_{Rp} z_{y_P} + w_{yp} z_{yp} + w_{Bp} z_{yp};$$
$$Ib = \omega_{m_1} + \omega_{Rp} z_{B_P} + w_{yp} z_{Bp} + w_{Bp} z_{Bp};$$

where Wm1, WRp, WYp, WBp are the initial-weights of the hidden-layer. The revised value of weight of real component of phase R is estimated using equation .whereWp(k) is the average weight of active power constituent of load currents, WRp(k) is the revised weight value of phase R at k th sampling period. WRp1(k), ZRp(k) are the amplitudes of fundamental weight of active power constituent of load currents of phase R and feed-forward block output at k th sampling time respectively. f'(iRp1) is the derivative of iRp1. The η is learning rate of the proposed neural network based control scheme. Similarly revised weights of real power constitutes of load currents of phase Y and phase B are estimated value of iRp1, iYp1, iBp1 are processed via sigmoid function, which is working as an activation function of neural network in order to estimate the fundamental real power constituents of load currents (WRp1, WYp1, WBp1) as,

$$w_{Rp} = f(i_{LRP}) = \left[\frac{1}{1 + e^{-\frac{I}{Rp}}}\right];$$
$$w_{Yp} = f(i_{LYP}) = \left[\frac{1}{1 + e^{-\frac{I}{Yp}}}\right];$$
$$w_{Bp} = f(i_{LBP}) = \left[\frac{1}{1 + e^{-\frac{I}{Bp}}}\right];$$

Average weight of fundamental real power signal (Wp) is calculated as follows,

$$\omega_p = \frac{w_{Rp_1} + w_{yp_1} + w_{Bp_1}}{3};$$

V.PARTICLE SWARM OPTIMIZATION TECHNIQUE

Particle swarm optimization (PSO) is a population based stochastic optimization technique developed by Dr.Ebehart and Dr. Kennedy in 1995, inspired by social behavior of bird flocking or fish schooling. PSO shares many similarities with evolutionary computation techniques such as genetic Algorithms (GA). The system is initialized with a population of random solutions and searches for optima by updating generations. However, unlike GA, PSO has no evaluations operator such as cross over and mutation. In PSO, the potential solutions, called particles, fly through the problem space by following the current optimum particles. PSO has been successfully applied in many areas: function optimization, artificial neural networking training, fuzzy system control and other areas where GA can be applied. The PSO technique conducts searches using a population of particles, corresponding to individuals. Each particle represents a candidate solution to the problem at hand. In a PSO system particles change their positions by flying around in a multidimensional search space until a relatively unchanged position has been encountered or until computational limitations are exceed. The advantages of PSO over other traditional optimization techniques can be summarized as follows:

- PSO is a proportional based search algorithm. This property ensures PSO to be less susceptible to getting trapped on local minima.
- PSO uses payoff information to guide search in the problem space. Therefore PSO can easily deal with non-differentiable objective functions.
- PSO uses probabilistic transition rule and non-deterministic rules. Hence, PSO is a kind of stochastic optimization algorithms that can search a complicated and uncertain area. This makes PSO more flexible and robust than conventional methods.
- Unlike GA and other heuristic algorithms, PSO has the flexibility to control the balance between the global and local exploration of search space.

• Unlike the traditional methods, the solutions quality of proposed approach does not rely on the initial population. Concept of modification of a searching point by PSO is shown in fig

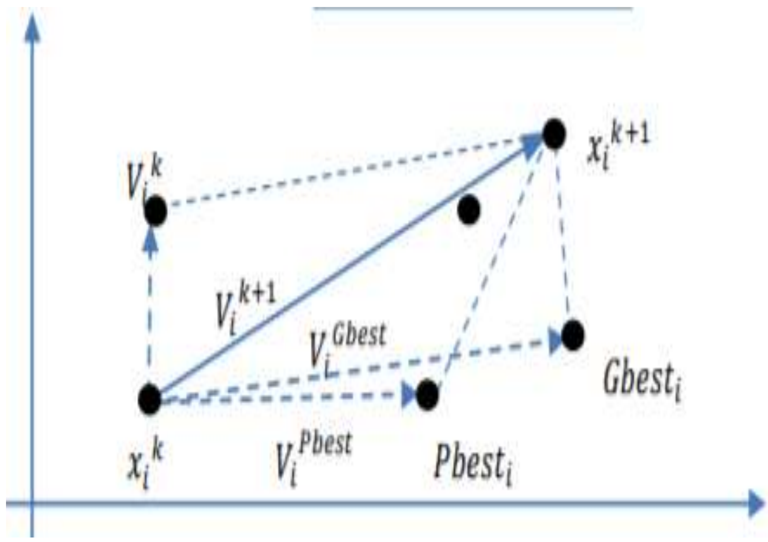


Fig.1(b) pso graphical representation.

simulation circuit

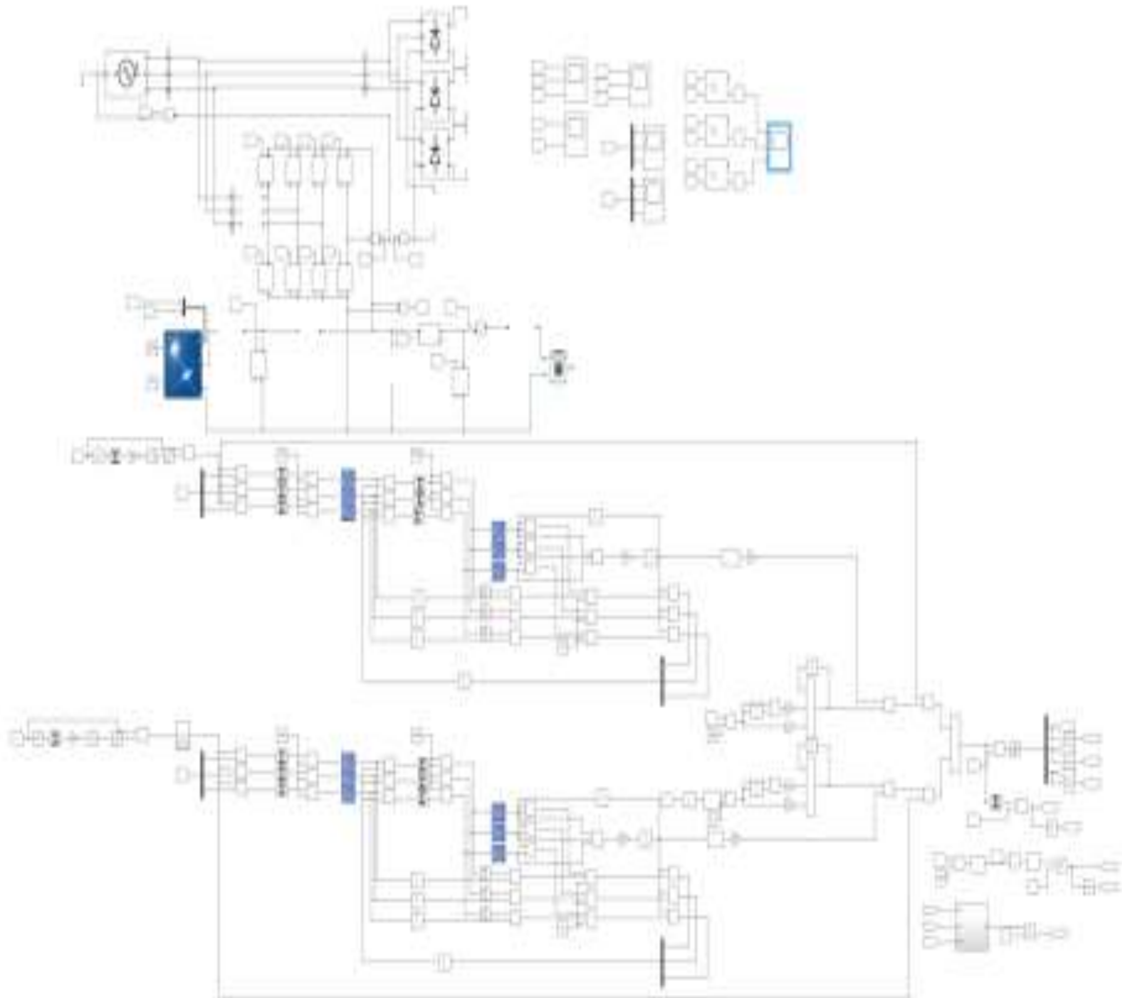


Fig.1(c) simulation.

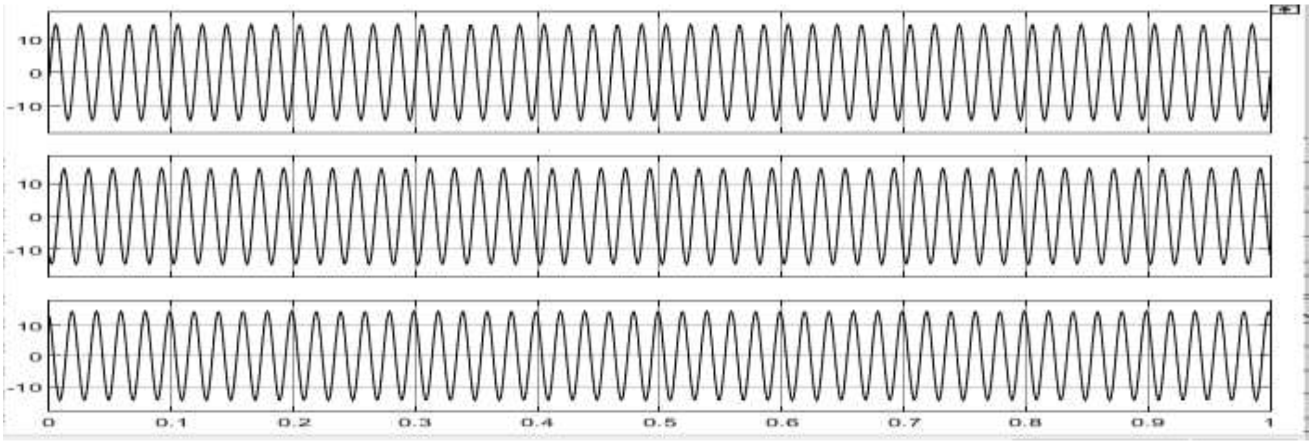


Fig.1(d)Vsry(source side).

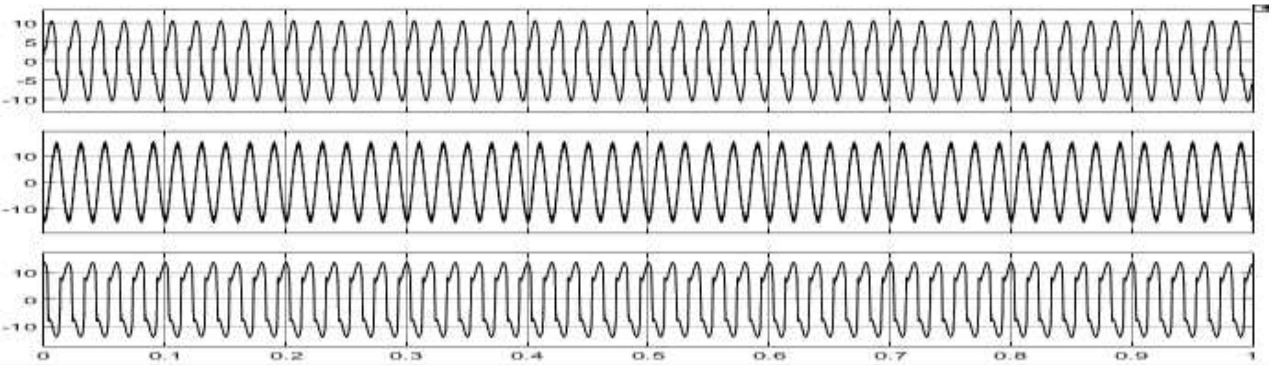


Fig.1(e)Vsryb(load side).

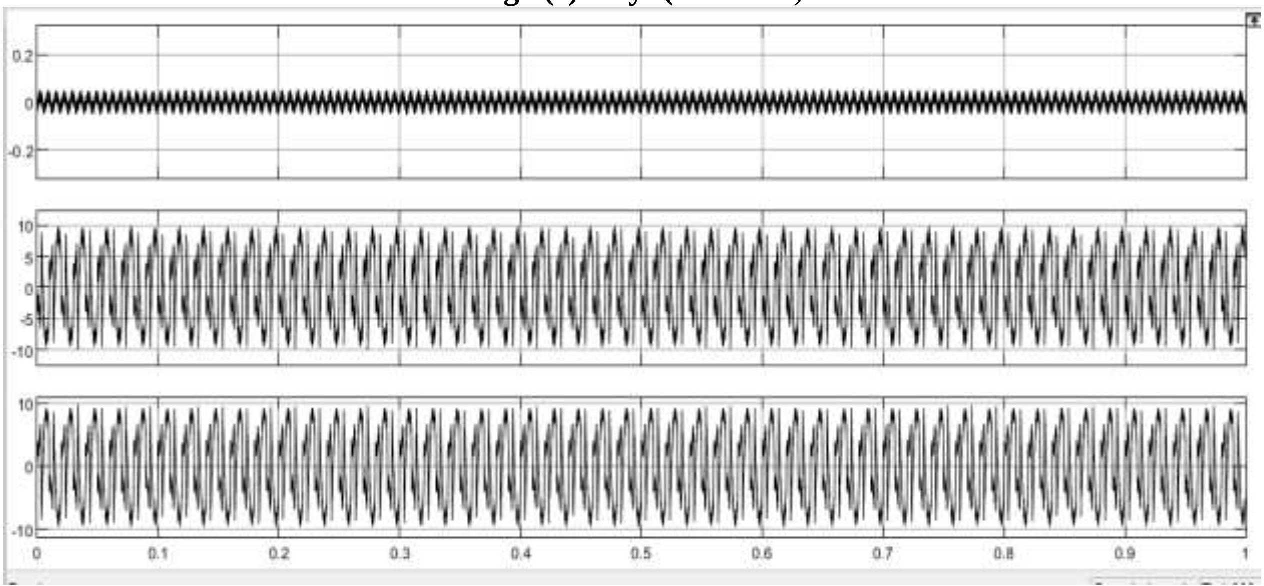


Fig.1(f) Isn,iln vscn(at common coupling).

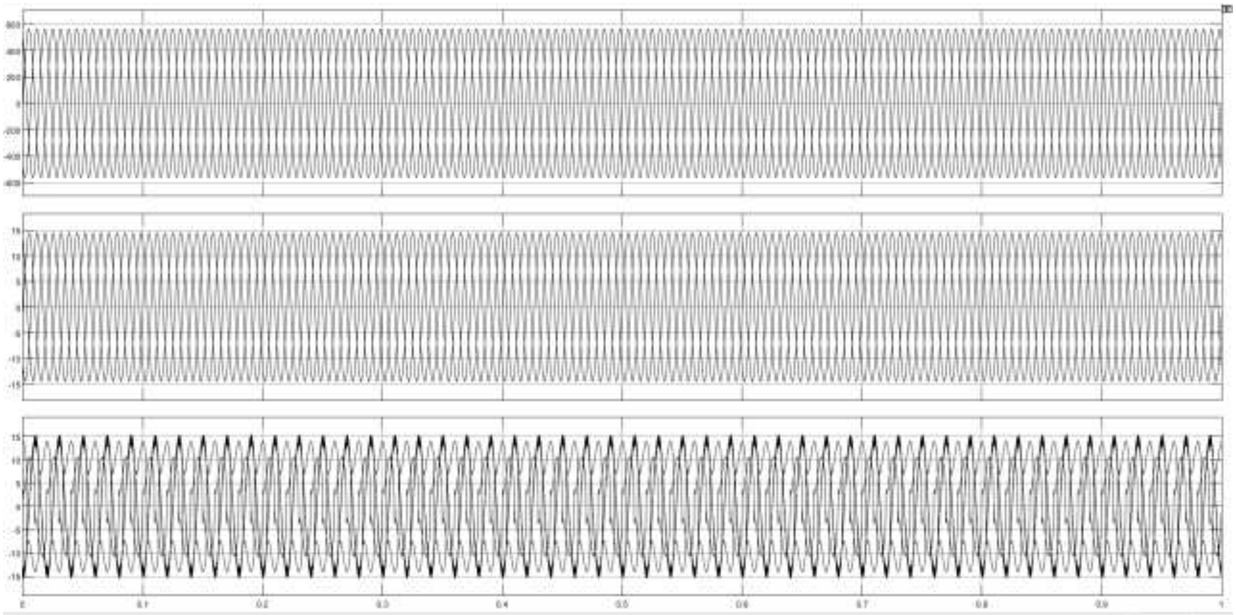
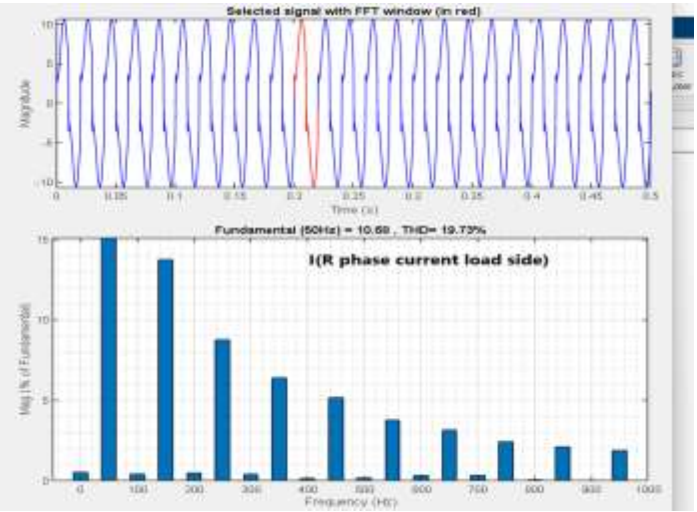
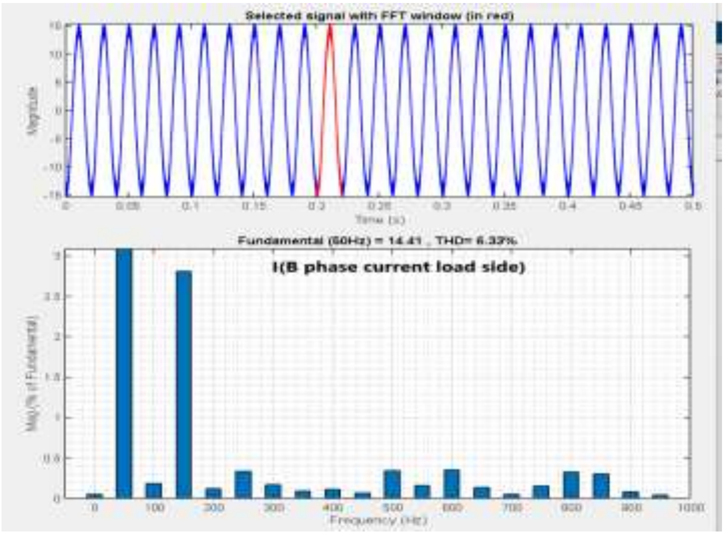
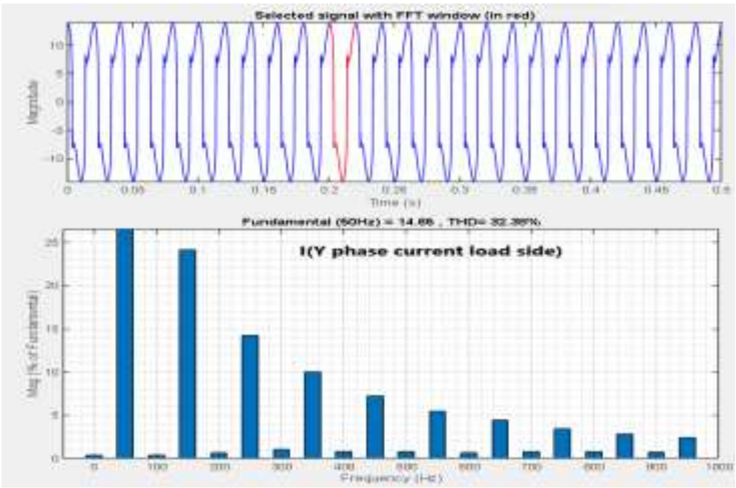


Fig.1(g)Isryb(source side).

THD CALCULATION LOAD SIDE







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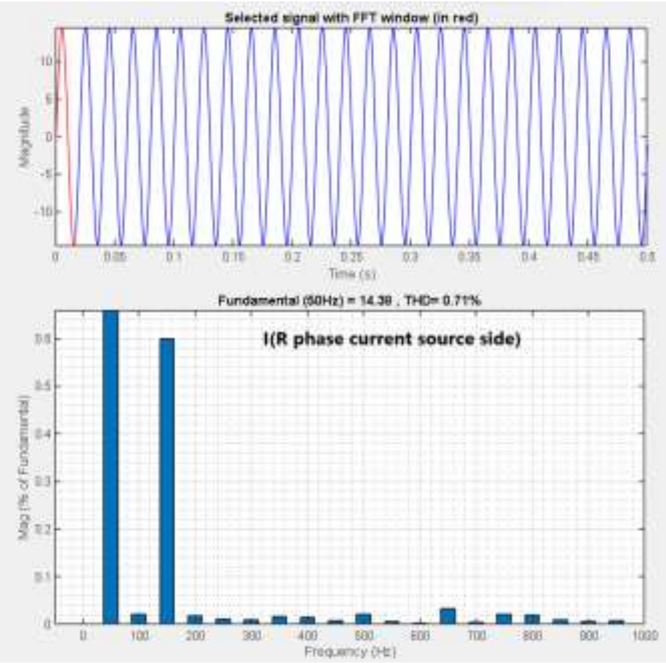
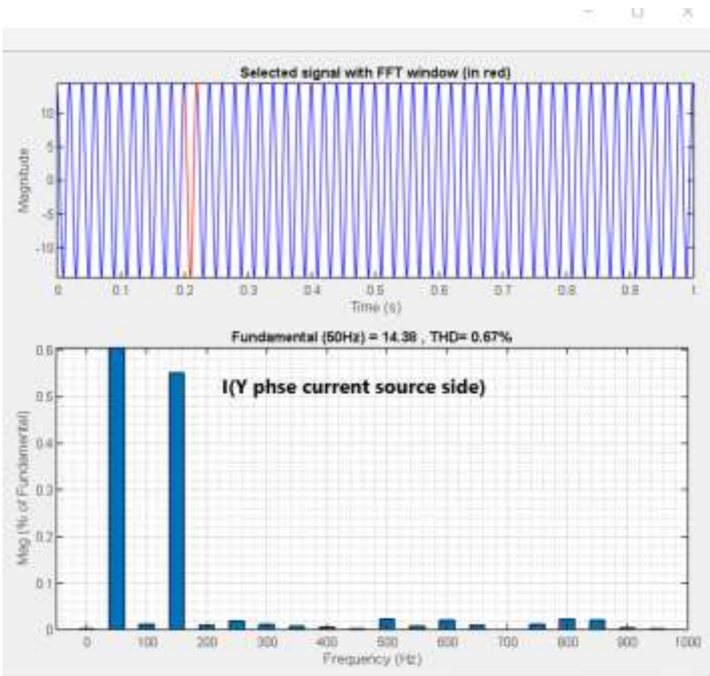
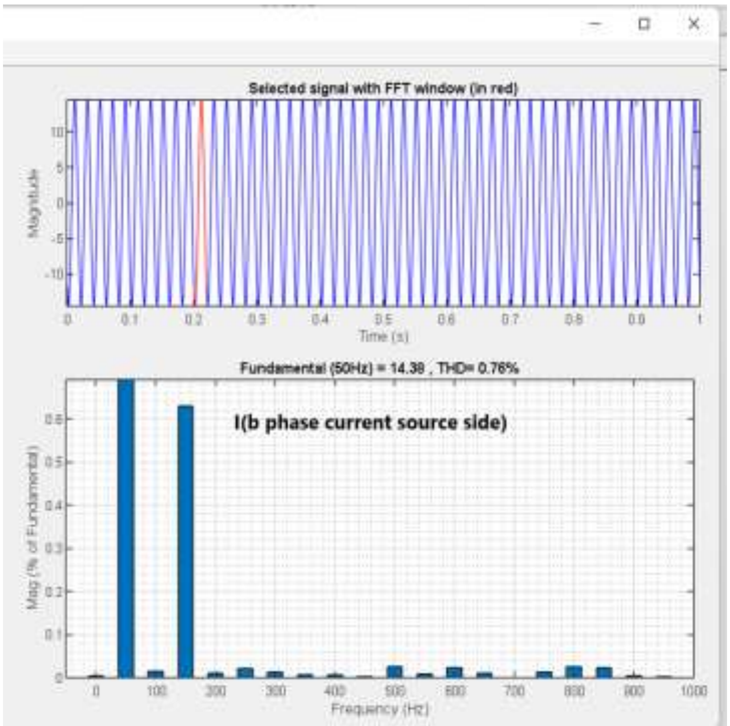
THD CLACULATION SOURCE SIDE







CURRENT WAVE	THD WITH INC MPPT	THD WITH PSO MPPT
I (R phase load current)	19.73%	19.73%
I (B phase load current)	6.33%	6.33%
I (Y phase load current)	32.38%	32.38%
I (R phase source current)	3.63%	0.71%
I (B phase source current)	3.83%	0.76%
I (Y phase source current)	3.30%	0.67%

COMPARISON THD VALUES

VI.CONCLUSION

technique for grid interactive improved power quality solar PV-battery supported system catering the balanced and unbalanced three phase four wire (3P-4W) nonlinear loads and single phase loads of various nature simultaneously has been successfully presented in this work. simulated performances of the AL-BP control technique for grid interactive improved power quality solar PV-battery supported system have shows that the proposed scheme is found capable of catering the balanced and unbalanced three phase four wire (3P-4W) nonlinear loads and single phase loads of various nature simultaneously. Moreover, the source currents have also been found balanced and sinusoidal for all operating and loading conditions such as in highly unbalance loading conditions where load on one of the phase is disconnected. The proposed system is meeting the IEEE standard of power quality. The extraction of maximum power from solar PV array energy is carried out by the (PsO) scheme. –particle swarm optimization-based MPPT method to acquire.

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