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A Bat Algorithm and Hybrid Algorithm based PQ Enhancement in Grid Tied PV System

Satyanarayana Addala[1] and I.E.S Naidu[2]
[1-2]Gitam deemed to be University /Department of EECE, Visakhapatnam, India
Email: addalasatyampersonal@gmail.com, iesnaidu@gmail.com

***Abstract*—Now-a-days grid coupled photovoltaic systems are concentrated by industries and academia for providing an alternative to conventional energy system which were pollution free and eco-friendly. The objective of this paper is to integrate a SAPF with adaptive current control methods (hybrid algorithm) and Bat Algorithm to improve the PQ of a grid-connected Photovoltaic distribution scheme. Harmonics in a grid coupled photovoltaic system can be reduced by using a hybrid algorithm control method and also by Bat algorithm Method. For reducing the harmonics in current, the MSOGI-FLL approach uses nonlinear load currents to extract fundamental constituents. It is required to split the fundamental constituents from grid voltage distortions and eliminate voltage harmonics when the grid voltage is highly polluted. In order to keep dc-link voltage constant during transient situations, fuzzy logic proportional integrator derivative is used. Hybrid and Bat Algorithm is used to compare the balanced stability power between ac and dc sides. MATLAB/Simulink is used to evaluate the hybrid control and Bat control system's performance.**

***Index Terms*— Multiple second order generalized integrator-frequency locked loop (MSOGI-FLL), Hybrid algorithm (HA), and Shunt active power filter (SAPF).**

I. INTRODUCTION

The power electronics/power system research community is very interested in improving the power worth trendy a circulation system by using advanced control. Power semiconductor technology built domestic, profitable, and different tons are polluting the electrical distribution system [1]. Since harmonic currents are produced by nonlinear loads, the quality and stability of power are significantly affected. Passive filters have been used to solve problems in the past, albeit next to the rate of alteration & the sequence equivalent quality tricky. As a result, energetic control strainers (APFs) & diversion kinds consume stood broadly adopted in place of a suitable alternative to avoid these problems.

The Grid-tied system power quality issues were overcome by using the most advanced APF technology. Pollution-free clean power generation is also a major priority, in addition to enhancing power quality. When it comes to this, the incorporation of renewable vigor foundations such according to solar energy (PV) & gust vigor into network-linked & stand-alone systems have increased. Renewable power bases such as sun radiation or photovoltaics' (PV) remain commonly employed towards meet the energy demand since they are pollution-free and improve reliability and power quality while decreasing pressure. As a consequence, under grid abnormal conditions, fundamental constituent (FC) separation is required [2].

For system converter control under highly contaminated and unbalanced electricity reactive power demand, an

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inter frequency adaptive connectivity method is used. The above-mentioned controllers have been used to control voltage regulation and frequency variation. However, in addition to current and voltage harmonic rejection, they have not adequately evaluated dc offset rejection. Furthermore, they were restricting the dc bus voltage with an existing PI controller. These control systems, on the other hand, are being implemented to increase the quality of power enrichment [3]-[4].

The above control techniques have the disadvantage of not being suited for component extraction of load currents and grid voltages, grid synchronization, or dc offset rejection. Furthermore, they are not considered applications for renewable energy producing systems. To address the aforementioned work limits, an adaptive hybrid control system based on an alternating current generator, fundamental constituent extraction (FCE) of distorted grid voltages, and a dc-link bus controller is applied.

Two-phase load currents are separated using the MSOGI-FLL control method. To protect the FCs from excessively partial network energies, an MCCF remains likewise used to protect them. In addition, it is employed for grid synchronization. It also incorporates a fuzzy tuned PID adaptive direct current link electrical energy organizer toward sustains the control equilibrium among dc & AC via maintaining a constant direct current link electrical energy. Use of 2 leg PV dc to dc power renovation employing fusion P and O and PSO-based MPPT process is using toward citation extreme Photovoltaic energy available.

As a result of the hybrid MPP, the algorithm is using to obtain exact universal energy chasing concert underneath different environmental situations. Suitable regularity control remains used in the anticipated hybrid control technique toward predict the system regularity under varying frequencies. The proposed control technique has several notable advantages, including increased flexibility, adaptive nature, ease of implementation, the best swapping action of the inverter towards achieve speed, & a small computing problem.

The hybrid control algorithm is through its paces in a range of scenarios, including different load conditions [5].

The following are some distinguishing features of the proposed paper.

1) Existing harmonics are reduced using the MSOGI &FLL locus stream generation approach, which extracts the FC from nonlinear load currents.

2) Because the MCCF is a perfect strainer with no scheme delay, it is hired to separate the FCs from extremely polluted network energies. It's also used to retain networks in sync.

3) The control method uses a fuzzy modified PID flexible dc-link regulator procedure to keep the dc terminal voltage constant while maintaining balanced electrical energy among the dc & ac terminals.

4) The PV scheme's feed frontward element remains also involved in the control scheme, which recovers structure active presentation & reduces alternations during load conditions moreover irradiation changing conditions.

5) In terms of reactive power compensation, dc drift rejection, basic component separation, & network interconnection, traditional methods of control exceed the present control scheme.

6) The suggested control method is ideally adapted to reducing current and voltage harmonics caused by highly unclean load streams and grid voltages, as well as increasing dc offset rejection and network connections.

II. System Description

In Figure.1, we present a PV integrated grid systems designed schematic diagram. The suggested algorithm uses a 3-phase effectiveness network to connect different loads. PV schemes remain linked towards the effectiveness network through a improvement convertor & an Electrical energy Source Inverter (VSI) [6]. The fusion max power point method remains used to produce a pulse width variation (PWM) signal towards enhance the convertor & progress the electrical energy outline of the PV scheme.

A Fuzzy logic proportional integrator derived feedback regulator has been used towards preserve the direct current link electrical energy next to it is esteemed charge. The 3-phase locus streams were estimated using MSOGI-QSG-FLL control scheme, and the mccf remains employed towards isolate the FC since highly unclean network energies. The VSI switching pulses are transmitted by the hysteresis controller.

III. Hybrid Control Algorithm

The hybrid control algorithm is used in the anticipated fusion controller arrangement, by way of illustrated in Figure.1. This combination is capable of isolating the superior FCs from very contaminated grid voltages and load streams. The Mccf procedure remains used towards discrete FCs since very degraded network energies, while the control algorithm intends toward remove FCs after nonlinear streams, resulting in 3-phase locus

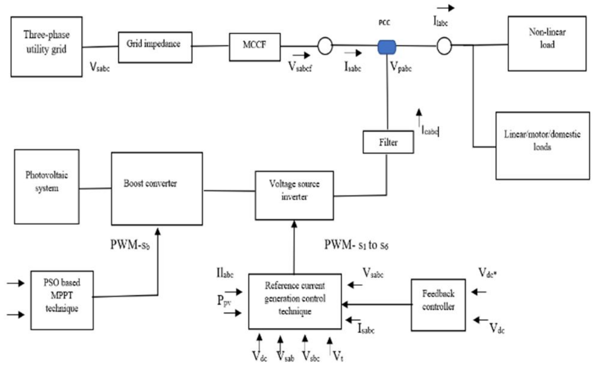


Figure.1. Schematic diagram of the proposed system

streams. The Flpid electrical energy regulator remains used towards keep the VSI output by the side of a constant voltage [7].

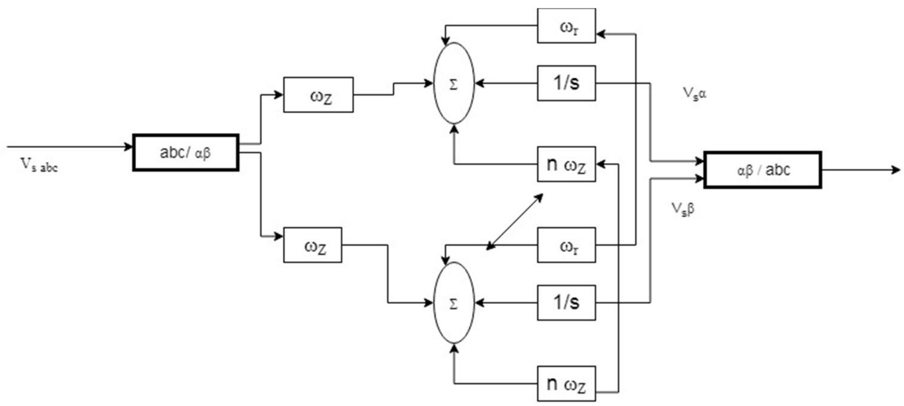


Figure.2. Diagram of the Mccf

A. MCCF Control Method

To continue, grid voltages (Vsa, Vsb, and Vsc) remain transformed toward αβ synchronizes. The prior is the conversion equivalence:

$$V_{s\alpha}=0.8165[V_{sa}-(0.5*V_{sb})-(0.5*V_{sc})] \quad (1)$$

$$V_{s\beta}=0.8165[(0.866*V_{sb})-(0.866*V_{sc})] \quad (2)$$

Where $Vs\alpha$ and $Vs\beta$ are the $\alpha\beta$ synchronizes of network energies.

B. Control Structure

Figure.3 illustrates the control Structure. The VSI control scenario includes popular-stage unit layouts (UA, UB, and UC), prediction of high point ac voltage of spot of conjugating (Vt), power control valvedeficit elements PV cascaded elements (Ipvff), negligible recognition (ZCD), and testing & keeping (T&K) connectors, as well as the fundamental amplitude of load currents (Iap, Ibp).

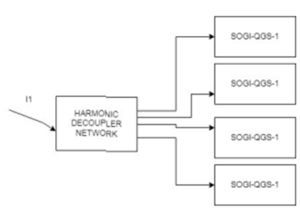


Fig.3.Control Structure for PV Inverter

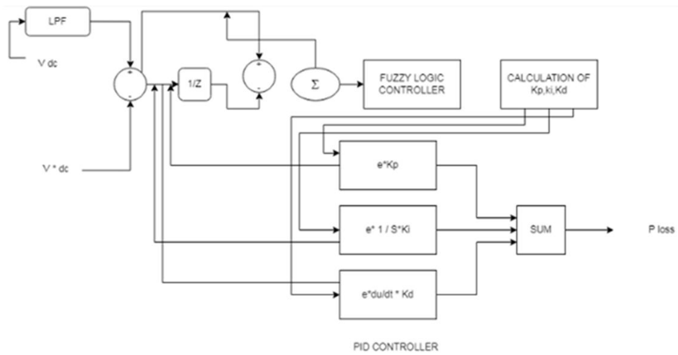


Fig.4.Representation figure of the FLPID electrical energy control

$$I_{pvff} = \frac{2*Ppv}{3*Vt} \quad (3)$$

The PCC's load shifts and the amount of PV electricity changes which causes the grid currents to fluctuate. The Photovoltaic feed-onward reimbursement remains using towards avoid grid current variations. For estimating the basic load current breadth, the one of the regulator set-up uses selective and adaptive filters. Figure 4 shows how the FLL works in transient settings to keep track of the system's frequency.

The SOGI-QSG control strategy is used to multiply the calculated FLL frequency by a number of coefficients for the selective extraction of harmonic components. Figure. 3 shows the design of the MSOGI/QSG/internal FLL system. There are four SOGIs optimized for the fundamental frequencies of the third through seventh harmonics in the MSOGI-QSG-FLL controller. The MCCF coefficients have been adjusted to perfection [6]-[9].

$$\text{Settling time } (t_s) = \frac{4}{\xi*\omega_n} \quad (4)$$

where remains the curbing factor & is the expected regularity For fundamental frequencies of 1, 3, 5, and 7, the band pass strainer provides improvement for h^{th} harmonics by a value among 0&1.The three-phase reference currents are designating as Iar, Ibr, and Icr. Hysteresis current controller receives the network recognized & regulator designed currents. PWM signals remain generating from the error between the current controller and the APF inverter as a result of this. As a result, the VSI produces 3-∅ recompensing streams that remain inserted in the effectiveness network to improve power eminence next to the circulation level.

C. FLPID Voltage Regulator

A typical PI regulator has unsuccessful to maintain a constant dc bus electrical energy in network & load transients. The drawback is overcoming by using a voltage control structure, which calculates PID gains adaptively under transient situations. Fig.5 depicts the FLPID's control diagram. It is possible to obtain the advantages of a PID controller by utilizing the following techniques [10]-[11].

IV. BAT ALGORITHM

The Bat algorithm is a global optimization algorithm inspired. It was motivated by the echolocation behavior of microbats, which emit pulses at varying rates and loudness. Xin-She Yang created the Bat algorithm in 2010.Bat algorithm is a new technique for solving challenging engineering issues that have proven more effective than several prominent traditional and predictive algorithms. A microbat echolocation algorithm is using in the bat algorithm. In complete darkness, microbats use echolocation, an intriguing acoustic wave that helps them find victims[12].

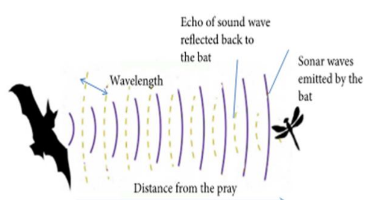


Figure.5. Echolocation Behaviour Of Microbats

To proceed, we must first create a bat population, and then set the frequency of pulses, pulse rates, and loudness. After that, we must determine how much iteration is needed to get the best results. New results are generating, and velocity values are updating. Here, random values will be producing; if yes, we must choose the best answer; if no, the program will return to its previous stage [12]. New solutions for minimum random values are accepted & the best current data is output in form.

V. RESULTS AND DISCUSSIONS

The below output waveforms expose the system to various operating conditions i.e., under non-linear loading position**,** unbalanced grid voltage levels**,** characteristics at grid voltage position & also variation in irradiation level position.

A. Simulation Results under Balanced Voltage Supply, Load Removed, and Dynamic Load Conditions

Fig. 6 shows that the system is running under balanced supply voltage, load removed, and dynamic load conditions. From 0 to 0.08 s shows the grid balanced supply voltage condition. To examine the controller dynamic performance, phase "a" load is removed and shown in Fig.6. From 0.08 to 0.15 s. During 0.15–0.2 s, the proposed system is working under dynamic load condition.

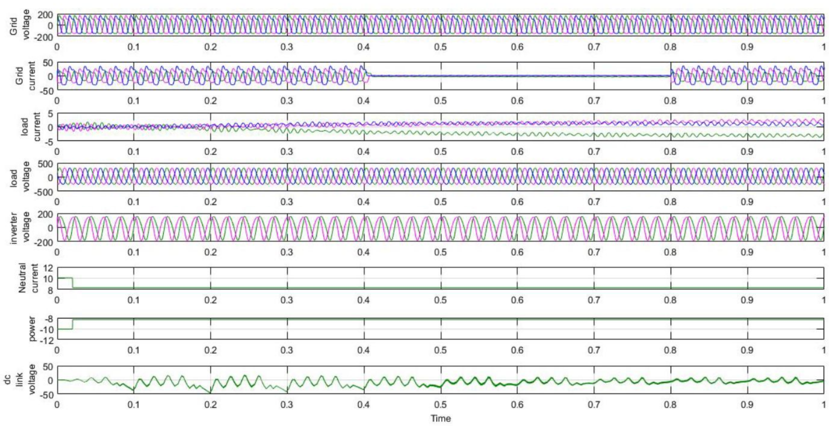


Figure.6. Simulation results under steady state, load removed, and dynamic load conditions

B. Simulation Results under Unbalanced Grid Voltages Condition

To verify the potency of the hybrid control technique under grid transient conditions, the system is working under grid unstable voltages state. The grid and controller performance characteristics are included in Fig., which shows the waveforms of Vsabc, Isabc, Ilabc, Vsabcf ,Inet, Iap, Irabc, Ifabc, Vdc, and THD analysis of grid current with APF. In this test case, the proposed control topology is well verified and the grid currents and voltages THDs are found well within IEEE-519 standard limits.

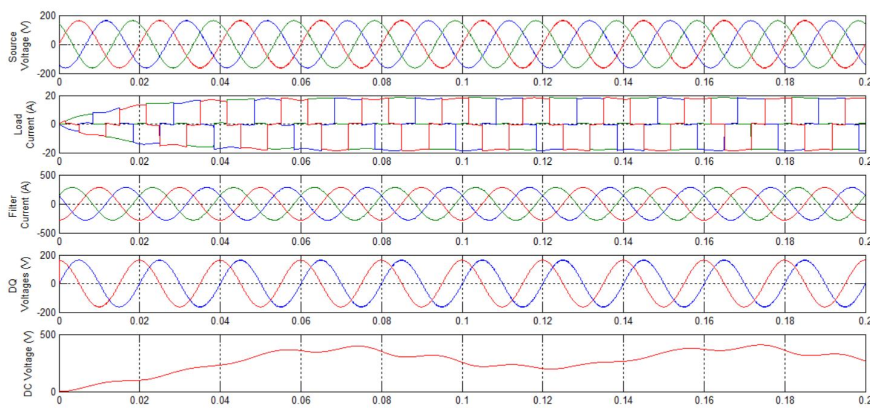


Figure.7. Simulation results under unbalanced grid voltages state condition

C. Simulation Results under Polluted Grid Voltages Condition

Fig.8. shows the operation of the system under distorted grid voltages condition. In this condition, the MCCF is employed to take out the FCs from the extremely polluted grid voltages. The waveforms of Vsabc, Isabc, Ilabc, Vsabc, estimated FLL frequency (w), Vdc, and harmonic spectra of grid current with APF are included. In this condition, the proposed control performance is well justified.

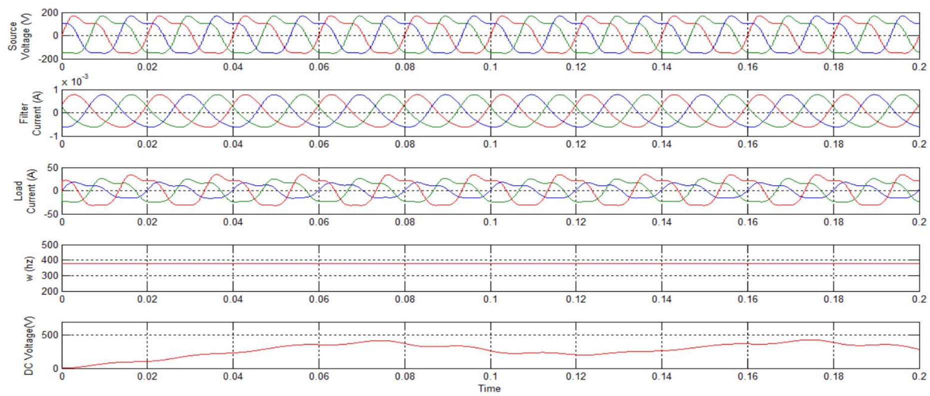


Figure.8. Simulation characteristics under polluted grid voltage condition

D. Simulation Results under Change in Irradiation Level Condition

Fig.9. displays the different irradiation level condition of the PV system. The waveforms of PV system characteristics are as follows: irradiation level (G), voltage of the PV (Vpv), current of the PV (Ipv), Vdc, and dc bus current (Ipv). The wave forms of the grid system are Vsabc, Isabc, load currents (Ilabc), FCE of grid voltages (Vsabcf), Inet, Iap, Irabc, Vdc, and THD analysisof grid current with APF. In this condition, the control scheme performance is well justified.

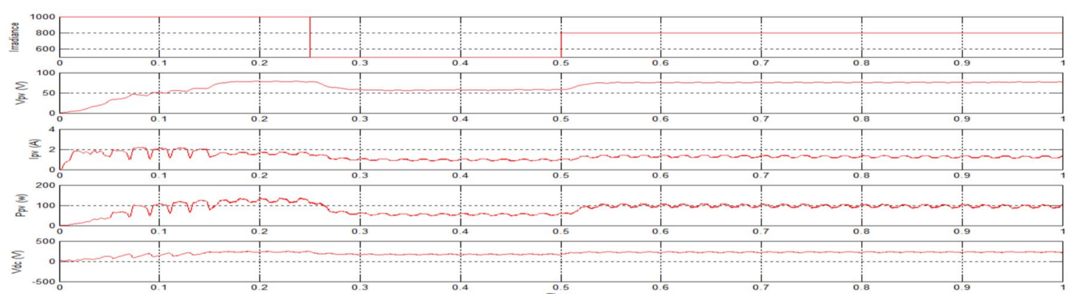
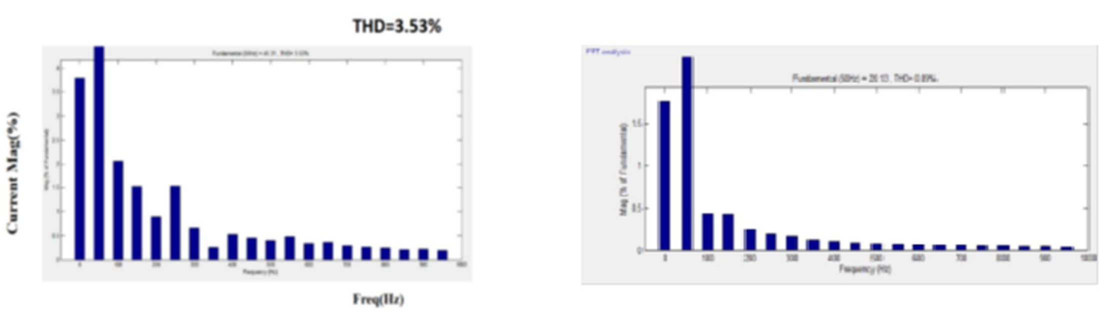


Figure.9. Simulation results under change in irradiation level condition



(a) (b)

Figure.10. (a), (b).Simulated load 1 current THD analysis in hybrid algorithm & with BAT algorithm

The proposed controllers perform effectively in different cases and the comparison analysis of the hybrid algorithm & bat algorithm is represented in table: I.

TABLE I: COMPARISON BETWEEN HYBRID ALGORITHM AND BAT ALGORITHM

Case no	Variable name	Without BAT Algorithm		With BAT Algorithm	
		Fundamental frequency(50HZ)	THD%	Fundamental frequency(50HZ)	THD%
1	I_{abcg}	37.97	1.07	37.97	1.07
	I_{abc}	19.9	30.90	19.9	3.90
	I_{abcf}	11.15	4.05	11.15	4.05
2	I_{abc}	16.89	19.56	16.89	19.56
	I_{abc1}	15.46	4.15	15.46	4.15
3	I_{abcin}	46.3	2.785	46.3	2.785
	I_{abc}	16.92	19.43	16.92	1.43
4	I_{abc12}	46.12	2.83	46.12	2.83
	I_{abcl}	19.89	30.84	19.89	30.84

VI. CONCLUSIONS

It is observed that the observation of nullifying effects of harmonics introduced in the transmission system. The active power filter and current control methods are using simultaneously to reduce the harmonics of voltage & current in a structure by combining both. 3-phase locus fluxes are calculating using the MSOGI-FLL reference current controller. The FLPID criticism controller is used to ensure the electrical energy of the dc bus is constant and free of swell by the side of the dc bus termini. The MCCF is used to remove voltage harmonics from network voltage that remain volatilizing. The anticipated control strategy's simulated results are satisfactory, and the overall vocal distortion of network voltages and currents is well inside bounds. The suggested control strategy is effective and reliable thru load & network-side instability. The THD of the injected grid currents is within acceptable limits. When it comes to balanced, consistent power between ac and dc, the hybrid algorithm control method and Bat algorithm Method are impressive. The system has been simulated by using MATLAB/Simulink with the hybrid algorithm control method and Bat algorithm Method.

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