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Original Article

Advanced Modeling and Optimization of Hybrid Renewable Energy Management Strategy Based on Artificial Bee Colony Algorithm in Micro Grid

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Abstract - *The energy demand is expanding on the planet, and looking for fossil fuel is done based on need. These fuels are not manageable; they pollute the climate. Due to a lack of fossil product assets and adverse climate influences, renewable energy sources (RES) were used as the foundation of solar energy. To execute demand reactions in industrial and residential areas and work with the coordination of renewable power resources, and plug in a future smart microgrid, this manuscript suggests a method of "energy management system (EMS)" and optimization technique for it dependent on a developed artificial bee colony (ABC). The ABC technique-based VSD and practical grid voltages for VSC frameworks are suggested in this manuscript. The suggested VSD and VSC are also dependent on ABC as conventional (GA-PSO)-based VSD, yet by including a 2W component eliminator (PSO has created a 2W component) and a committed genetic algorithm (GA), a very quick VSD time under practical grid voltage conditions is accomplished. The ABC method plans the tasks of schedulable loads as per the power utilized. The viability of a technique is confirmed by the swell, sag, and power elements that might be compensated.*

Keywords - *Smart microgrid, Genetic Algorithm (GA), Hybrid energy management system, Artificial bee colony (ABC), Particle swarm optimization (PSO), Emergency power supply (EPS), Voltage sag detection (VSD), Voltage sag compensation (VSC).*

I. Introduction

The scope of planning and operation of a smart grid has broadened with the introduction of new technologies that make up the smart grid, integrating renewable energy resources such as solar and forecasting. A smart grid delivers electricity from suppliers to consumers using digital technology to improve reliability and transparency, save energy, and reduce cost.

The increased digitization of economics places higher demands on a reliable power supply; every momentary interruption will cause a huge economic loss. The need for diversification in the overhaul is driven by the fact that the grid will be used in different ways in the future.

Power quality management addresses events like the voltage, flickering (sags and swells), unbalanced phase voltages, and harmonically distorted supplies. This will facilitate the efficient and reliable operation of the power systems, reduce losses, improve customer satisfaction, and minimize equipment (unity or consumer) failures.

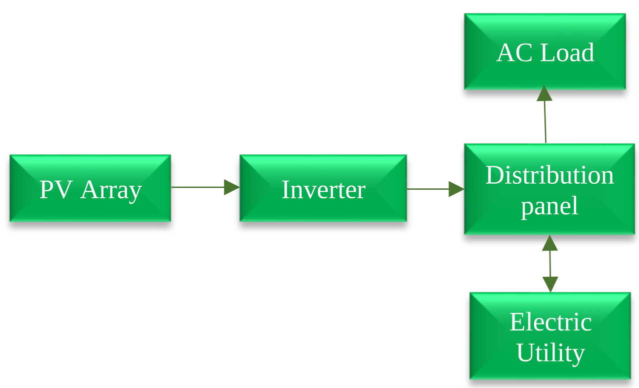


Diagram of the grid-connected photovoltaic system

Power quality management voltage control, load balancing, and harmonics control As of now, the "domestic pumped storage power stations (SPSs)" that are put into operation fundamentally utilize diesel motor sets as EPS for station power load (SPL). Nevertheless, diesel motors are utilized as EPS, ecological contamination, unsuccessful start-up, off-line power supply, and later maintenance costs are dangerous. In this manner, to ensure the stability and reliability of dependable, secure, low-maintenance EPS to ensure the continuous operation of station power schemes [1, 2], [3, 4],

The work [5] surveys and talks about the EPS of SPS and measurably investigates the current EPS design of "pumping power stations" and its principle impacting factors. The work [6] surveyed the arrangement plan and activity method of "standby diesel generator sets" for protected and solid activity in an isolated organization of an offshore wind farm. The works [7, 8] planned an organized activity control methodology for the diesel generator, PV system, isolated wind power microgrid, and battery storage to ensure the isolated framework's long-term constant activity.

This manuscript presents a sort of battery and PV storage framework structure and investigates two control procedures for "battery storage converters" and their switching: stable power controls, specifically PQ control methodology; stable voltage and stable frequency controls, that is, V/F control system. The PV and battery storage frameworks adopt PQ control procedures in grid-associated mode to meet SPL demand and coordinate output. In islanded mode, the PV framework’s o/p power has been enormously impacted by the not-controllable environment when creating power. Through the activity, PQ control is constantly embraced. For this situation, a "battery storage converter" is constrained by V/f to give constant frequency and voltage to the framework and might be exchanged by the frequency and voltage of the grid.

Dissimilar from previously mentioned methods, this manuscript suggests an optimization method for EMS dependent on ABC that residential customers might utilize to reduce their power price in a future smart grid. For this recommendation, an EMS system is presented that consists of loads, controllers, renewable power generation, smart meters, etc. In this system, the scheduling issue is detailed as a "constrained single-objective minimization issue" and tackled by a developed "high-dimensional ABC optimization solver; the tasks of schedulable home applications have been scheduled by a suggested method that takes the forecasted outdoor temperature, power cost, and client preference settings into deliberation. Simulations check the viability of the suggested method.

2. Voltage Sag Detection & Compensation

The voltage sags are the prevailing variables that impact the power supply's nature in the power framework. The voltage sags are a short-term decrease in voltage adequacy (between 0.1 and 0.9 p.u. from nominal voltage) from one-half cycle to a few seconds. Large loads, such as a large motor, short circuits, lightning strikes, and quick re-closing circuit breakers, have all been linked to and caused voltage sag. According to one study, voltage sags cause approximately 92% of all problems in electrical power distribution frameworks [1].

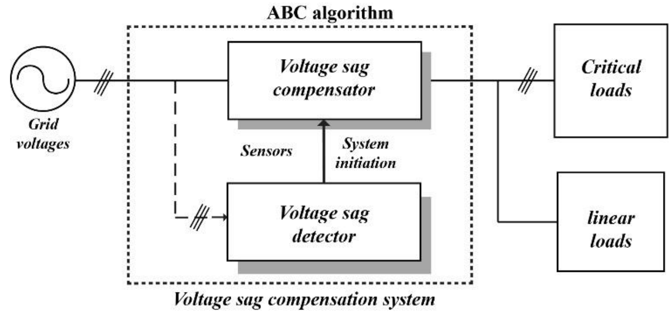


Fig. 1 Typical voltage sag compensation system

The voltage sags have an important effect on non-electronic loads like ac contactors or induction motors and particularly on voltage-sensitive loads, i.e., electronic loads like PLCs, computers, and process control gadgets that, as a whole, have been utilized in modern, profitable industries. The voltage sags might be compensated by numerous compensation models [2], [3], and [4].

Nonetheless, as the first significant component of any VSC system, VSD must detect voltage sag events as soon as possible and initiate the subsequent compensated procedures, as shown in Fig 1. Then VSD performs a significant part of the VSC system, and the shortest delay period of VSD is essential. In previous years, the prevalent method, i.e., conventional GA-PSO-based VSD, caused the high delay time initiated by utilizing the lower cut-off frequency of LPF [5]. This manuscript suggests an ABC method-based VSD that works with two-factor refusal [6] and a dedicated BSF.

3. Whole Design of PV Grid System

Fig. 3 depicts the topology of the grid-connected PV framework. Figure 3 displays the typical PV framework consisting of a PV array, grid, and inverter. The MPPT capability has been essential for the high effectiveness of PV arrays. The VSG has been associated with the PV framework between the grid and inverter.

The PV array with MPPT capability is the main module of the PV Framework [6].In this manuscript, the temperature is set at 25, and light intensity is set at 1000 W/m2; the voltage at MPP Im is 545.6 A, MPP Um is 455 V, short-circuit current Isc is 600 A, and open-circuit voltage Voc is 650 V.

An easy P&O technique [7] from MPPT methods is applied here: It decrements or increases the PV array o/p voltage Upv regularly using the voltage variable u. The control framework keeps changing UTV if power increments or other variations operate in the opposite direction.

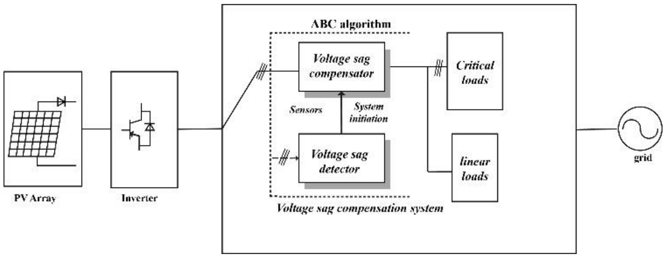


Fig. 2 ABC Topology for grid-connected PV system

This procedure is repeated until UPV reaches MPP voltage. Where u is set at 2V, and Upv's starting value has been set as "open-circuit voltage 650V,"

The PV inverter has been the usual topology for the generation of the PV framework and includes an LC filter and three full bridges, as shown in Figure

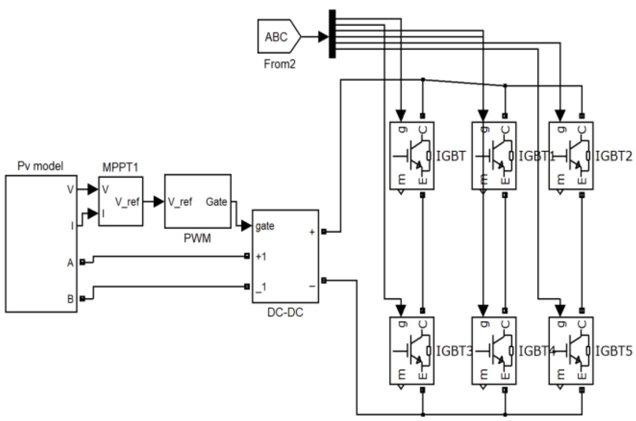


Fig. 3 Inverter model for a grid system

The capacitor C1 on the DC side smooths the PV array o/p as the inverter i/p voltage is 10000 uF. The capacitor C2 and inductor L comprised LC filter values have been 0.25uF and 0.4mH.2) The 2-loop control method of the inverter suggested by [8–10] and built on current has been planned for PV inverters' common running, and its topology has been displayed in Fig 4.

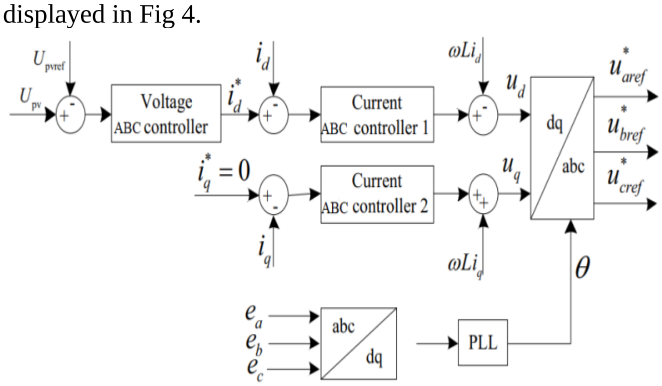


Fig. 4 The 2-loop control method built on current

Fig. 4 depicts an internal voltage-control loop that modifies the i/p inverter voltage to follow the reference voltage of the most extreme power point and an external current-control loop that decouples the inverter current into d and q parts and controls reactive and active current using the ABC method for simultaneous vector current to ensure that the o/p voltage and current have a similar phase and frequency.

Therefore, the PV inverter runs with whole-power feature 1 under the 2-circle control method. The integral and amplification coefficients of a voltage ABC method controller in a voltage circle are 0.25 and 0.06; ABC method 1 and ABC method 2 in a current circle have similar integral and amplification coefficients of 0.4 and 1.

3.1. Ant-Bee Modeling

In this method, the insect honey bee settlement includes of 3collections of honey bees (HBs): used spectators, bee scouts, and HBs. A sustenance source (SS) expresses to possible response for a problem that gets updated. The picked-up nectar quantity about the nourishment source (NS) is executed by the behavior procedure extended by that SS. The HBs scan for NSs in a way that augments the proportion E/T, where T is the time taken to search for and collect, and E is the vitality attained. The E is relative to the nectar measurement of NSs discovered by HBs.

The spectator's inclination of NS depends upon that SS's nectarorial sum F (θ). The fact is, the nectar measure of SS will be extended, probability of spectator HB will be extended constantly. With the lines mentioned earlier, the probability with NS located at θ i is selected by HB, and it tends to be ascertained as

$$Pi = \frac{F(\theta i)}{\sum_{k=1}^{s} F(\theta k)} \quad (1)$$

The principle ventures of the Hybrid ABC method might be depicted with the different stages.

Stage I: Initialization of ABC: This stage sets the control factor values. The initial part of the settlement includes used HBs, and other parts include spectators. The fact is that it will randomly create a situation for every confidence & calculate it. Set the current bee scout number S=0.

Stage II: Present novel SSs discovered by bee scouts: If s is greater than UB, we should arrange the first part of the settlement, create Honey Bees with very high terrible arrangement quality as bee scouts and others as used honey bees, then we can Refresh the bee scout number.

Stage III: Employed honeybees abuse: In this stage, we generate alternative response for every used HB and evaluate it. At that point, the voracious purpose procedure is associated. Here, S=S+1.

Stage IV: Bee scouts study: Send each & every bee scout into the scanning area to discover novel NSs randomly. At this point, while another nourishment source is discovered, measures of it and the covetous choice procedure are associated.

Stage V: Preferences estimation for present SSs: estimate the likelihood assessments of present NSs that the bee spectator ail team has preferred them.

Stage VI: Misusing Onlookers: In this stage, the spectatorial bees make a novel disposition from contemporary sustenance sources selected depending on registered possibilities and evaluate them. At that fact, the rapacious choice procedure is associated with refreshing the connecting used HBs memory roots.

Stage VII: Good location Memorization: This stage states that for every used HB and scout, if its recollected location has been higher than anything the previous proficient good location, at that fact, a good place is undermined by it.

Stage VIII: End criteria found: This stage states that if the end condition isn't satisfied, then go to Stage 2, usually stopping the algorithm.

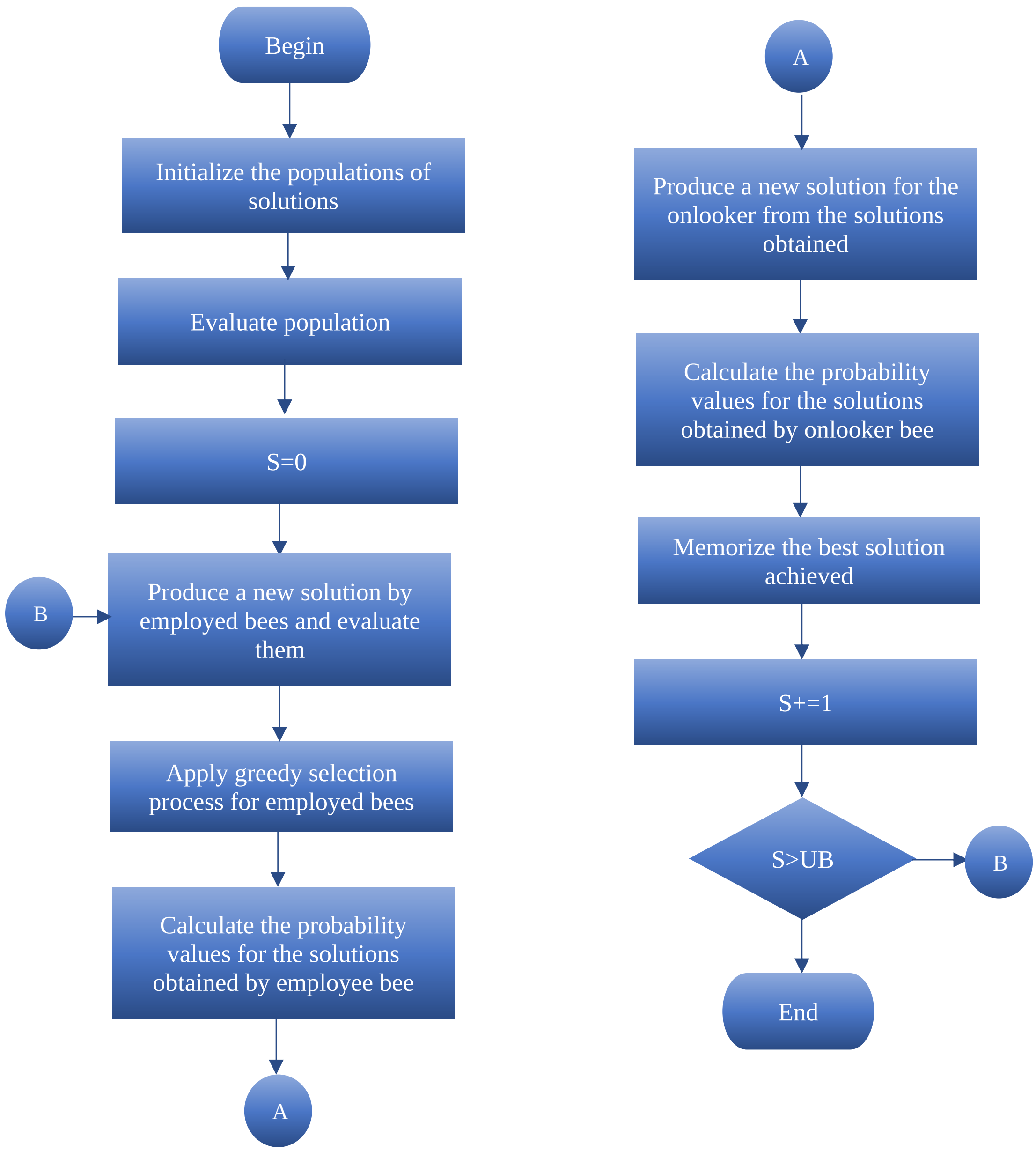


Fig. 5 Flowchart of Ant-Bee Colony algorithm

4. Results of Simulation

As per the above survey, a complete method of ABC-based PV grid depends on Mat lab, as shown in figure 6. It includes an inverter under the ABC control method, PV array with MPPT, VSG, and grid outcomes of ABC tests while the voltage of swell, sag, grid, to 0%, 20%, and 80% of rated voltage correspondingly have been provided as typical faults.

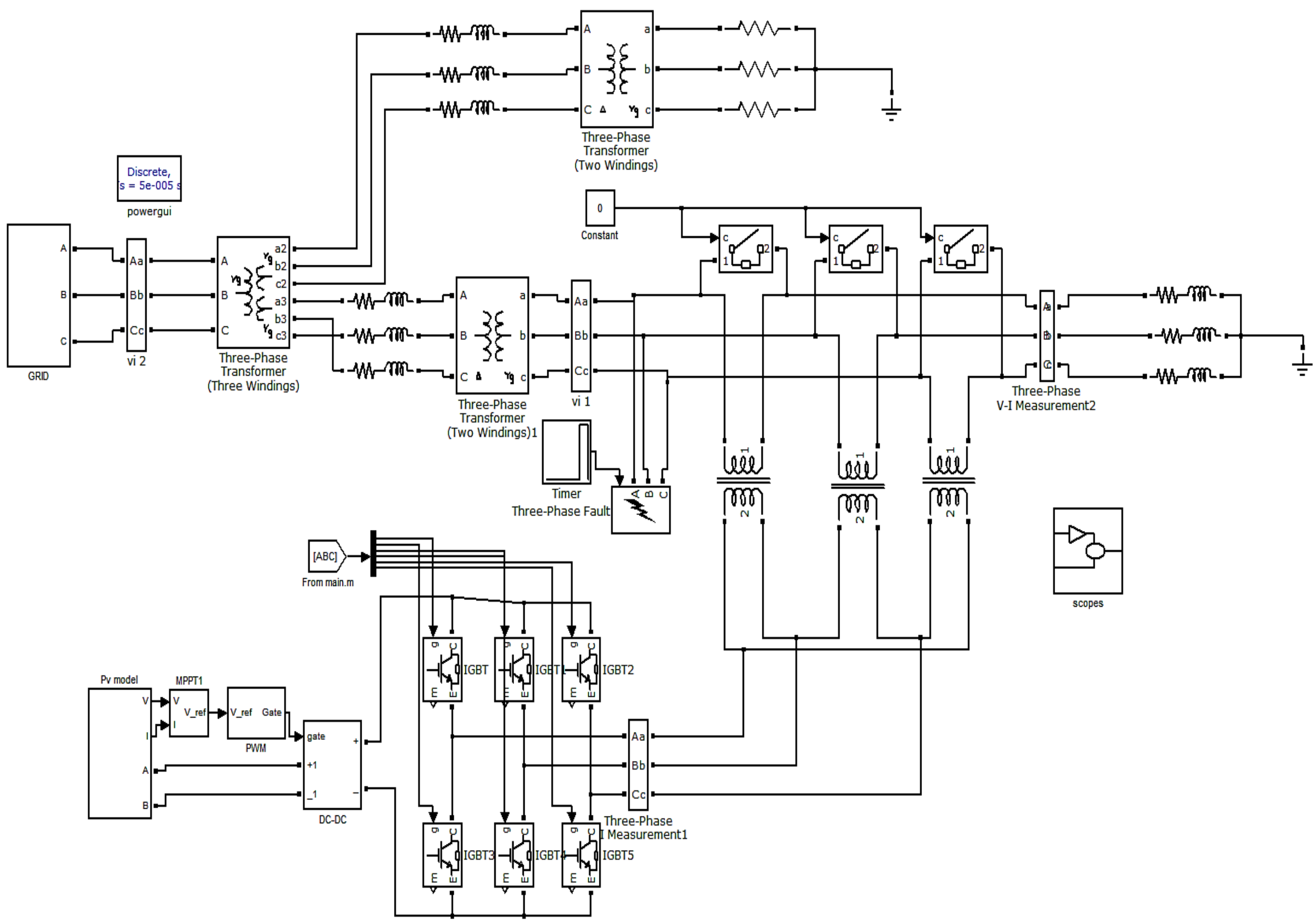


Fig. 6 A simulation model of ABC based PV grid system

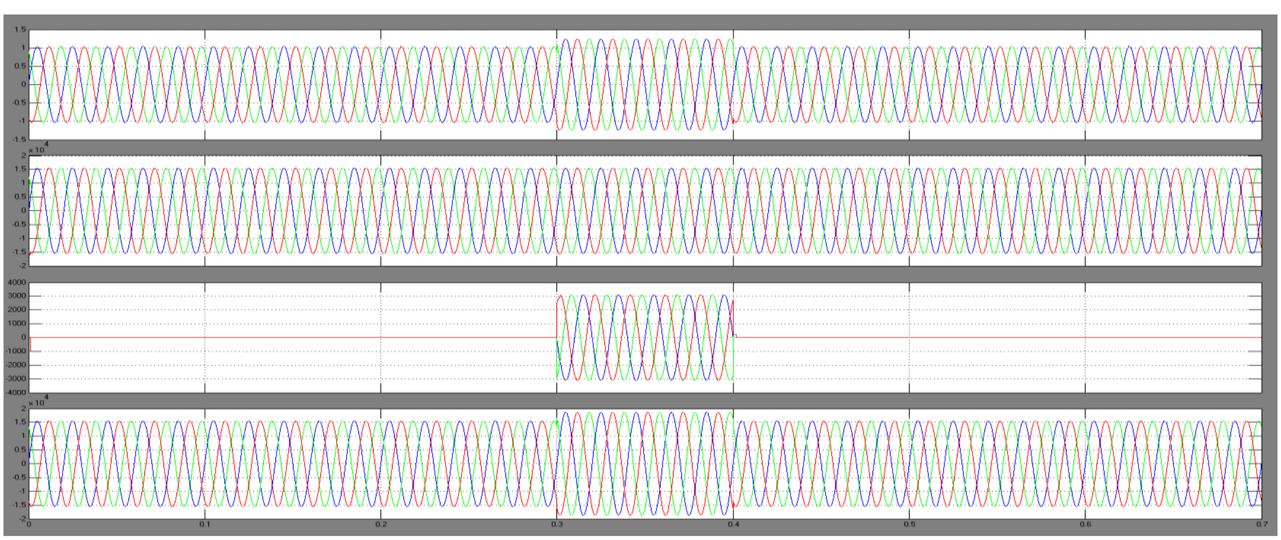


Fig. 7 Voltages swell (LLLG Fault) (a) voltage of grid (b) voltage of load (c) compensated voltage (d) PCC voltage

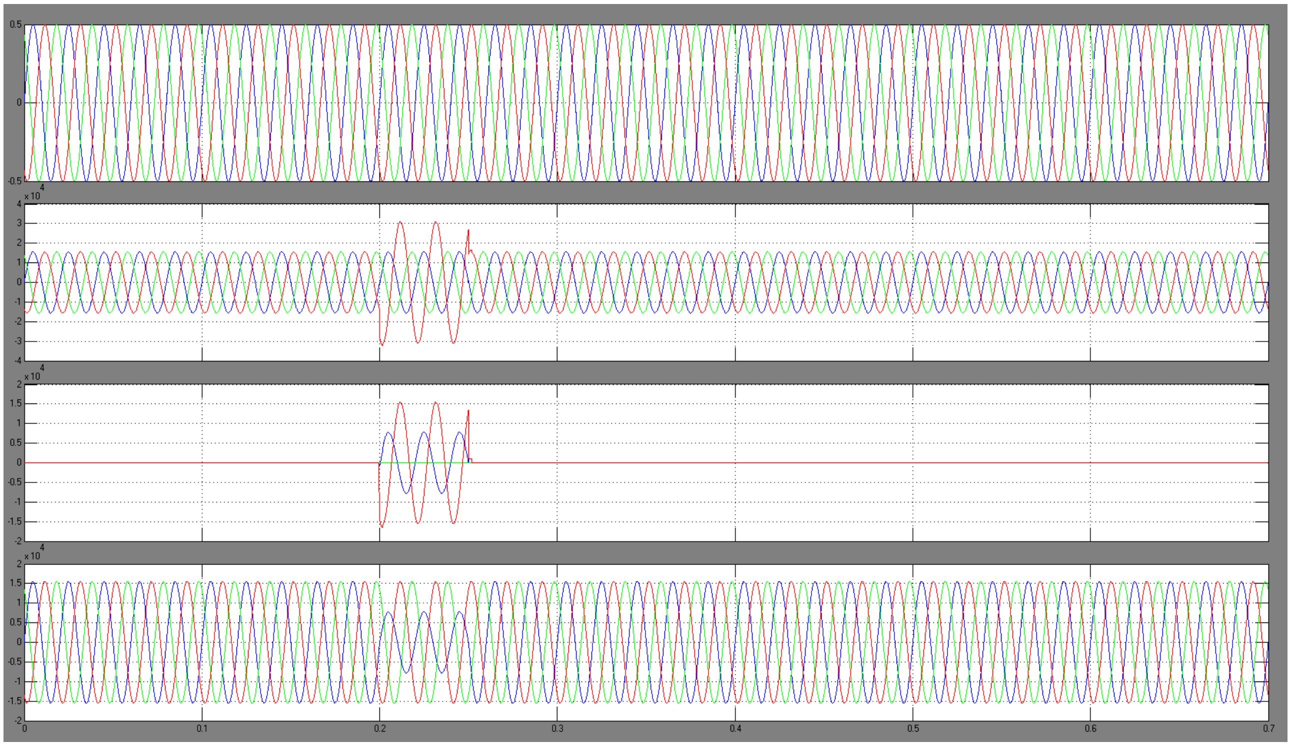


Fig. 8 Voltage sag (LLG Fault) (a) voltage of grid (b) voltage of load (c) compensated voltage (d) PCC voltage

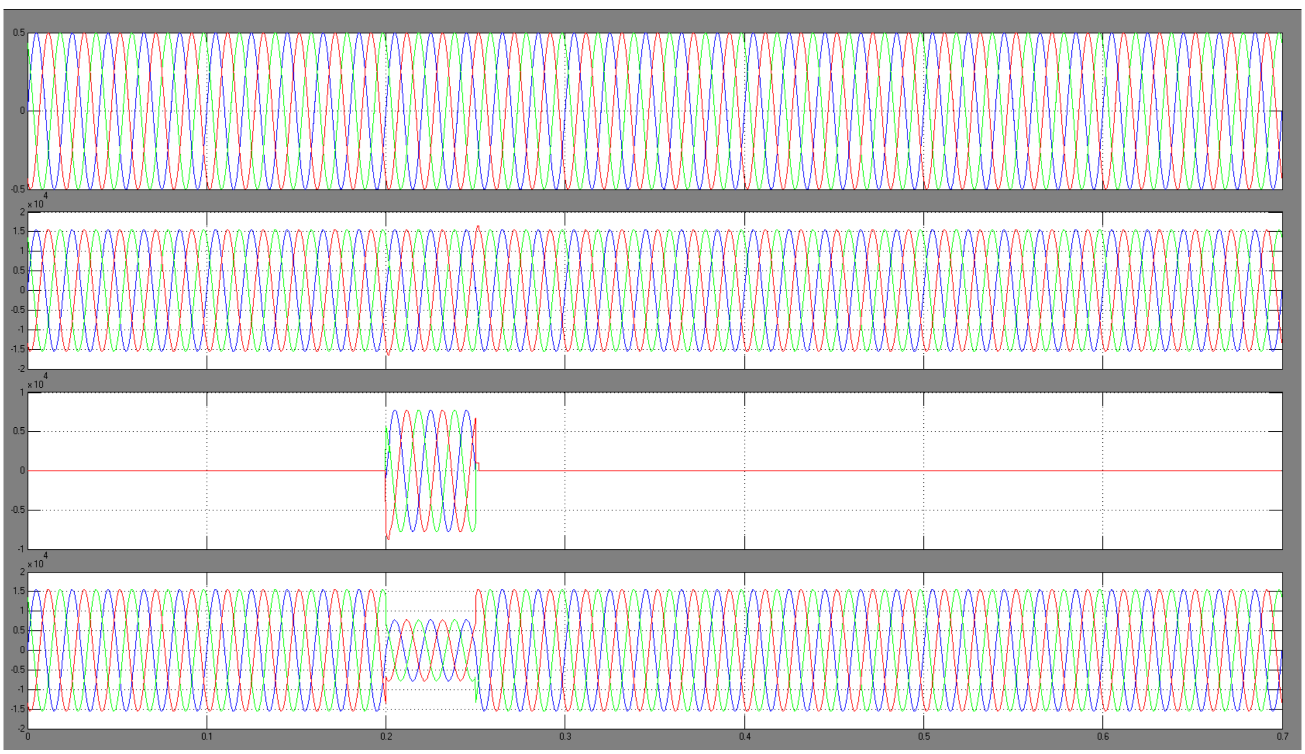


Fig. 9 Voltage sag (LLG Fault) (a) voltage of grid (b) voltage of load (c) compensated voltage (d) PCC voltage

As displayed in fig 8 and fig 9, voltage sags of the grid to 80% of the rated value, so inverter o/p currents (ia, ib, and ic) stay constant with small peaks. In the meantime, the voltages Upv1 at voltage sag moment. Figure 7 displays waveforms when voltages swell to 20% of the rated value. Then waveforms have better quality even if the voltage of the grid increases.

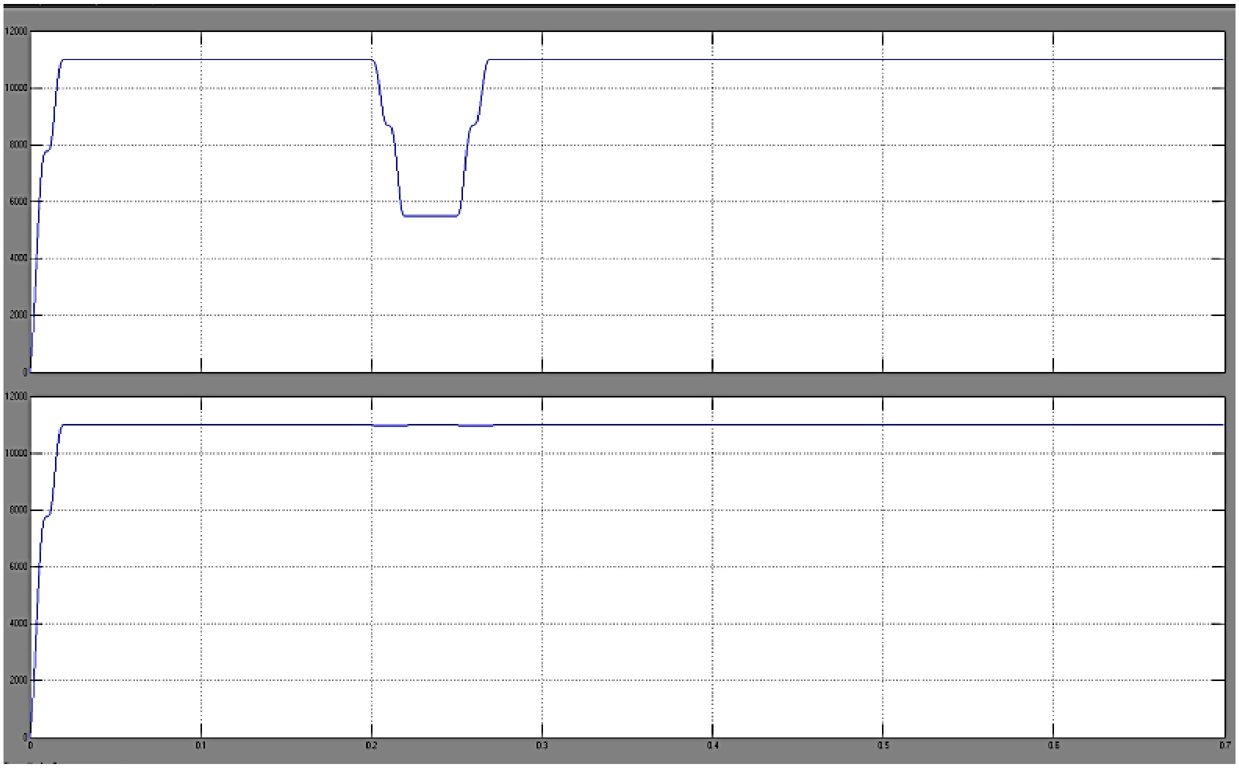


Fig. 10 RMS voltage Vrms (a) sag voltage (b) compensated voltage

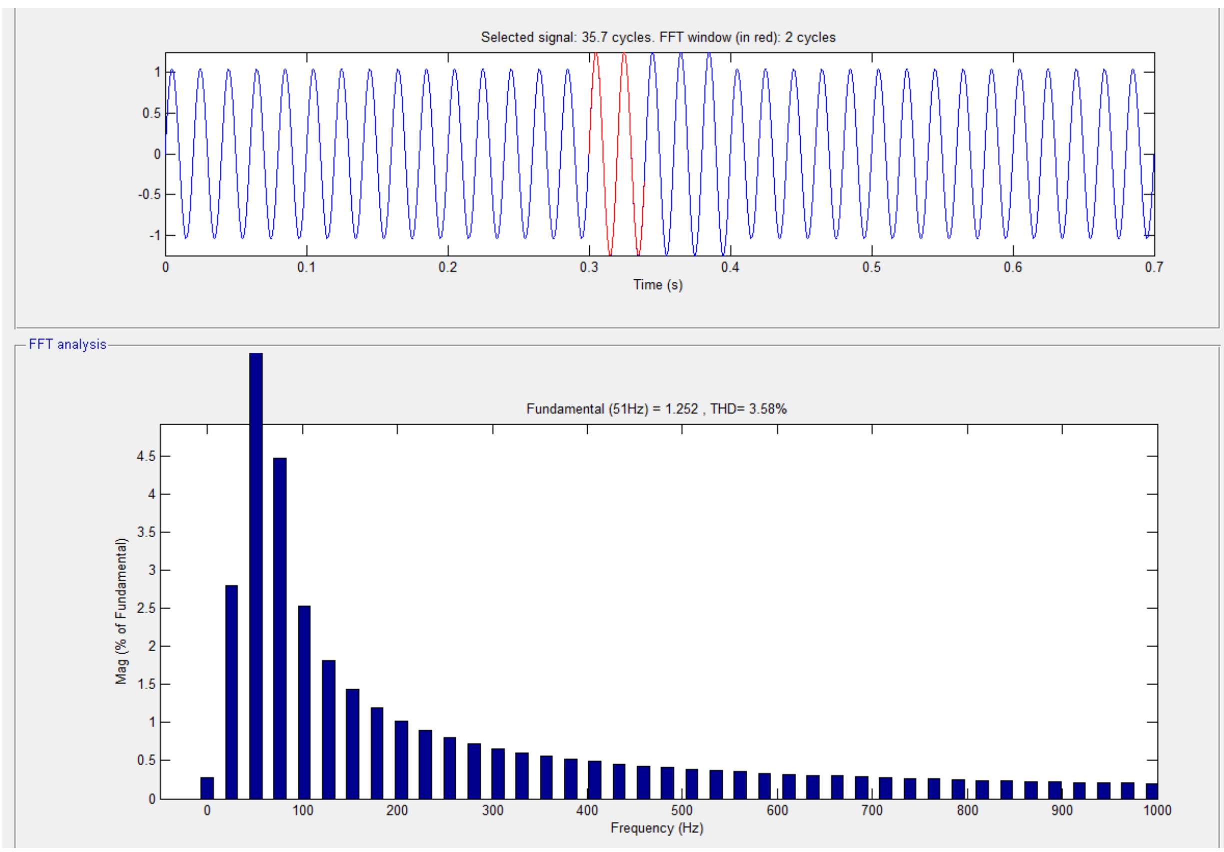


Fig. 11 T.H.D analysis of proposed grid system, i.e., 3.58% voltage swell condition

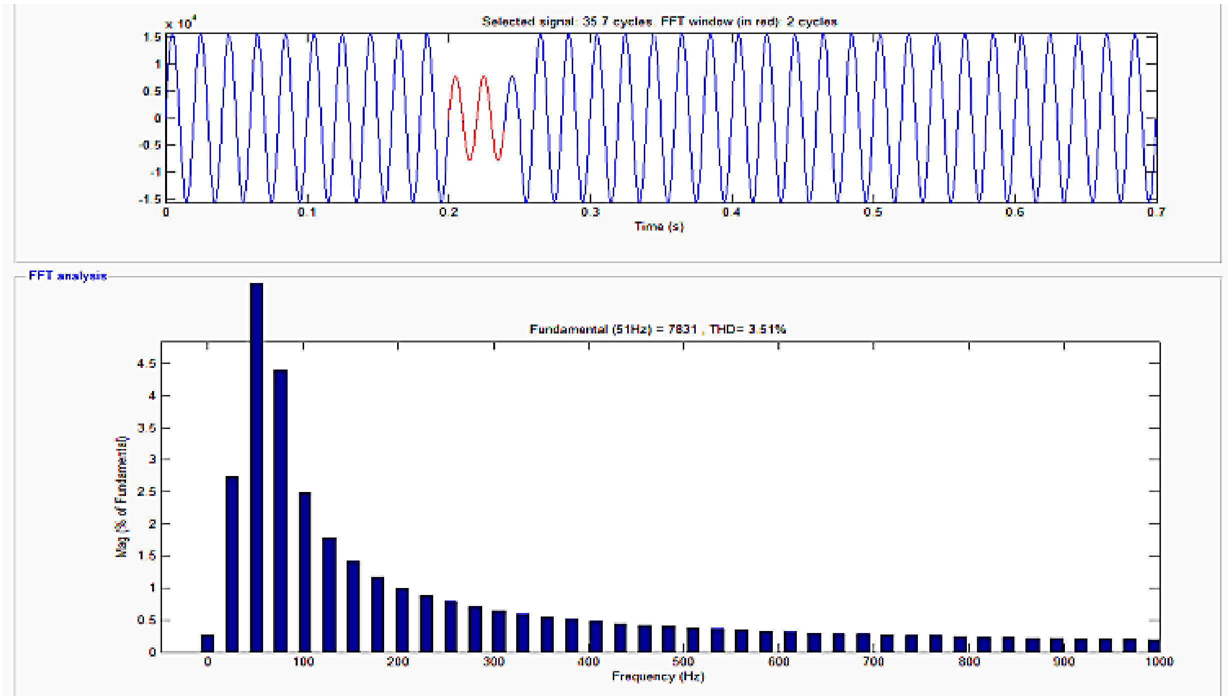


Fig. 12 T.H.D analysis of proposed grid system, i.e., 3.51% voltage sag condition

Table 1. Comparative Analysis of Adaptive Control Strategies

Parameters	Description	GA&PSO	ABC Algorithm
Voltage	Voltage sag & swell	Actual:415v Swell : 430v Sag: 340v	Actual:415v Swell : 450v Sag: 390v
Time	Settling time of voltage sag & swell	0.3-0.4 (0.1 sec)	0.2-0.25 (0.05 sec)
THD	Total Harmonic Distortion	6.64 to 6.85 %	3.51% to 3.58%
Power factor	Power factor	0.7	0.9
Current	Current distortions	Max: 600A Min:200A	Max: 500A Min:100A
Faults	Settling time of voltage sag & swell	LG, LLG	LG, LLG,LLLG

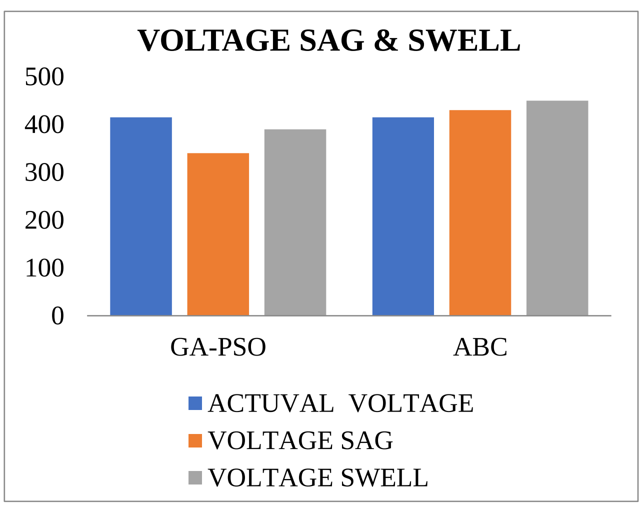
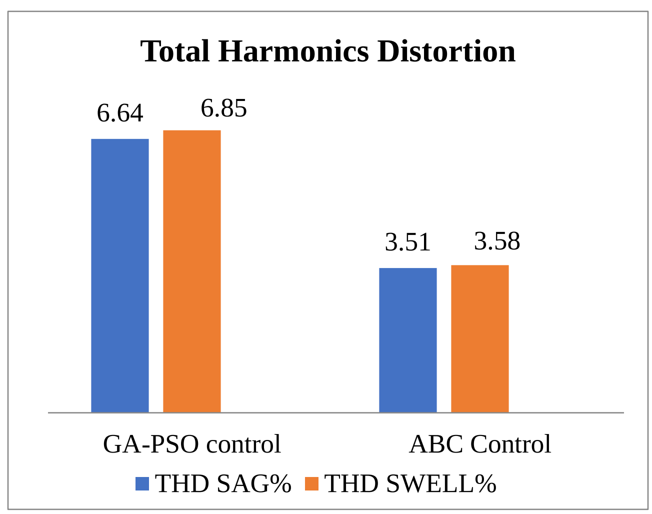
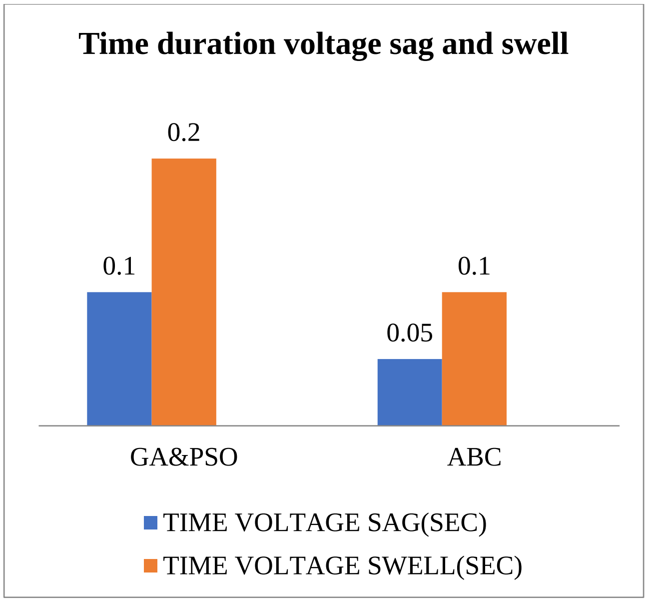


Chart Voltage sag and swell



Flow chart Total Harmonic Distortion



Flow chart time duration Voltage sags&swells

5. Conclusion

A novel design of the ABC algorithm with a PV grid interface is suggested for Mat lab testing of the PV system and simulated on Mat lab. The outcomes of the simulation display new ABC might analyze & compensate voltage swells & sags in a depth degree series with best waveforms of i/p voltage and o/p currents & inverter voltages. It proves the modification of the PV grid platform and VSI design feasibility. This manuscript supports for next survey of PV systems and the plan for VSI devices for ABC testing. Under grid-connected conditions, the ABC control system might coordinate with the PV framework to supply power to SPL. Under the islanded condition, the ABC control of the PV and VSI converter might offer constant frequency and voltage for power load. While faults happen in the grid, the ABC algorithm control method must be switched rapidly to ensure constant pumping voltage compensated power and dependable operation of SPL. The total harmonic disorder is reduced from 6.64% to 3.51% by implementing an ABC algorithm based grid connected converter.

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