ISSN: 2454-9940

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

E-Mail :
editor.ijasem@gmail.com
editor@ijasem.org

www.ijasem.org

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN 2454-9940

www.ijasem.org

Vol 18, Issue 4, 2024

MARCFS ALGORITHM FOR DIFFERENT FACTS DEVICES TO IMPROVE VOLTAGE PROFILES IN IEEE33 AND IEEE 57 BUS SYSTEMS

K. Swarna Latha[1] Dr. P. Mallikarjuna Sharma[2] Prof. M. Manjula[3]

1. Research Scholar, EE Department, University College of Engineering, Osmania University, Hyderabad

swarna.kandukuri2007@gmail.com

2. Professor, EE Department, Vasavi College of Engineering, Hyderabad

pmsarma2010@gmail.com

3. Professor, EE Department, University College of Engineering, Osmania University, Hyderabad

majulagooga@gmail.com

Abstract: Innovative and revolutionary advancements in the field of grid-connected inverters have been described in order to improve the power quality of the DER. Both the cuckoo search algorithm and the random forest method can be used for optimizing power system performance, focusing on efficiency and reliability. While the cuckoo search algorithm is inspired by the brood parasitism of some cuckoo species to find optimal solutions, random forest applies ensemble learning techniques to improve decision-making and prediction accuracy in managing power distribution. By hybridizing the two can get accurate results in optimization of power systems. The present research focused on implementing the hybrid algorithm in IEEE-33 and IEEE 57 bus systems with DG interconnected with DVR and DSTATCOM and DG interconnected with MCUPQC. The MCUPQC system offers a unique compensation mechanism, which is meticulously managed by the MARCFS algorithm. In the present work we compared different fact devices with proposed algorithm and the another algorithm of basic GA and hybrid CSAGWO algorithms. This approach ensures optimal performance and precision by dynamically adjusting to various operational conditions. Compare with other algorithms the proposed algorithm given better results.

Key words: DG, DSTATCOM, DVR, MCUPQC, MACRFS algorithm, Comparison

.Introduction

Nowadays, Power electronics-based FACTS devices allow for more precise continuous control of power flows, which has several advantages, such as keeping load bus voltages within acceptable ranges, managing active and reactive electrical power flows in thermally constrained lines, enhancing safety measures, and running electrical systems near their capacity limits, among other benefits[1]. The oscillation in the power system consequent to disturbance, leading to oscillation in the system, will decide the stability of the system. These oscillations should be mitigated for stability restoration. Hence, the role of controllers in damping oscillation plays a significant role. One of the major issues in the controller's design is the location of the controller and its robustness. Merlin and Back [5] were the first to propose an algorithm for distribution system reconfiguration; their method was a based-on branch exchange search with all tie lines initially closed thus creating a arbitrarily meshed system; subsequent switch opening was continued until radial configuration was achieved[2]. Similarly, in a method was proposed where the network was initially meshed, switches were ranked based on current carrying magnitude, the top-ranked switch was opened and the power flow calculation was carried out. The process was repeated until system was radial. The branch exchange was performed wherever a loop had been identified. Configuration with lower power losses was kept. In [3], a generalized approach has been proposed in which the tie line with the highest voltage difference is closed and the neighboring branch is opened in the loop formed, leading to reduction of power losses.

2. Literature review

The random forest algorithm offers several advantages in power systems, such as improved accuracy in predicting power demand and system behavior. It can handle large datasets efficiently and provides robustness against over-fitting, making it ideal for analyzing complex power networks. It can efficiently manage the variability and complexity of power grid data, leading to enhanced decision-making and predictive capabilities for system stability and reliability. The cuckoo search algorithm offers several advantages in power systems, such as enhanced optimization capabilities for better voltage stability and reduced power losses. It efficiently handles the complex, non-linear nature of the system, resulting in improved overall performance and reliability. **Jayaraman et al. (2018),** describe about the design of passive filters for harmonic reduction. Power elements such as resistors, inductors, and capacitors are combined to create passive harmonic filters. Simple passive filters for power systems are often built using capacitors and inductors and tuned for a particular frequency. If more than one frequency needs to be removed, multiple filters may be employed, or at higher voltages, double tuned filters may be used to reduce the number of components needed. The drawback of these passive filters is that they offer an incredibly affordable solution to harmonic issues at all voltage levels. Never apply passive filters without taking into account how they will affect the entire network. **M T L Gayatri et al. (2018),** used an active power filter to improve the power quality of the PV-WECS microgrid in real-time. Active harmonic filters are power-electronic components that create harmonic currents that are out of phase with the undesirable harmonic currents to be removed from electrical networks. These active harmonic filters were very popular in the 20th century in power electronics. Generally, there are two types of active harmonic filters: a shunt active filter that provides current harmonic compensation and a series active filter that provides voltage harmonic compensation. The disadvantage of these active filters is that they are suitable for low and moderate frequency compensation; they cannot handle large amounts of power, require a complex control system, and are expensive. **Vijeta Barathe et al. (2018),** implemented a design and simulation study of a hybrid filter for improving the power quality of a PV-Wind hybrid system. To reduce the disadvantages of both passive and active filters, the development came as a hybrid filter, which is a combination of passive and active technology, and is called the foundation for flexible AC transmission system (FACTS) devices. Most FACTS devices generally consist of shunts and series converters. **Agarwal R.K. et al. (2017).** A DSTATCOM is to compensate for voltage flicker/imbalance, reactive power, negative-sequence current and total harmonic distortion (THD). In other words, the DSTATCOM has the capability of improving power quality at the point of installation in power distribution 29 systems or industrial power systems. It also discusses the control strategy of the DSTATCOM to minimize the power quality problems during power delivery. As the operational circumstances of the PV system. **Santanu Kumar Dash et al. (2018),** created a control approach that may provide a quick and reliable solution. To concurrently correct for the load current and harmonics of the supply voltage, the active series and shunt filters are used. The name of this apparatus is unified power quality conditioner (UPQC). The suggested system works as a power supply and a

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT
ISSN 2454-9940
www.ijasem.org
Vol 18, Issue 4, 2024

harmonic and reactive power compensator, increasing conversion efficiency while also offering important functionality at any time. **Devi et al. (2021),** proposed a dynamic voltage restorer (DVR) for power-quality improvement. DVR are a class of custom power devices that provide reliable distribution of power quality. They employed a series of voltage boost technologies using solid-state switches to compensate for voltage sags and swells. A series-connected solid-state device is proposed that injects voltage into the system to regulate the load-side voltage, which provides line voltage harmonics compensation such as THD improvement, reduction of transients in voltage, and fault current limitations.

3. Need of Hybridization

Both the cuckoo search algorithm and the random forest method can be used for optimizing power system performance, focusing on efficiency and reliability. While the cuckoo search algorithm is inspired by the brood parasitism of some cuckoo species to find optimal solutions, random forest applies ensemble learning techniques to improve decision-making and prediction accuracy in managing power distribution.By hybridizing the two can get accurate results in optimization of power systems. The present research focused on implementing the hybrid algorithm in IEEE-33 and IEEE 57 bus systems with DG interconnected with DVR and DSTATCOM and DG interconnected with MCUPQC. The Multi-Converter Unified Power Quality Conditioner (MCUPQC) with DVR and DSTATCOM represents a significant advancement in power quality management. By integrating DVR and DSTATCOM functionalities into a single system, MCUPQC offers enhanced reliability, efficiency, and cost-effectiveness in mitigating voltage sags, swells, harmonics, and improving power factor.

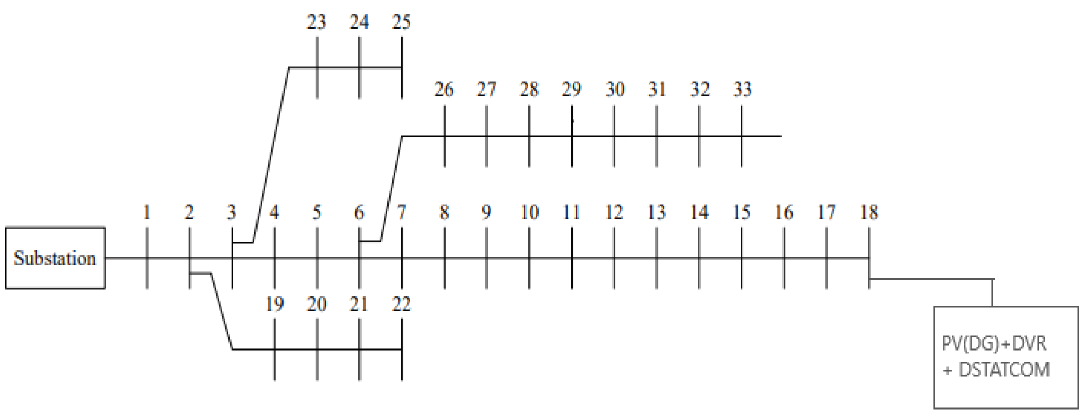


Figure:1 Sample line diagram for IEEE bus system connected to PV based DG inter connected to DVR and DSTATCOM

ISSN 2454-9940
www.ijasem.org
Vol 18, Issue 4, 2024

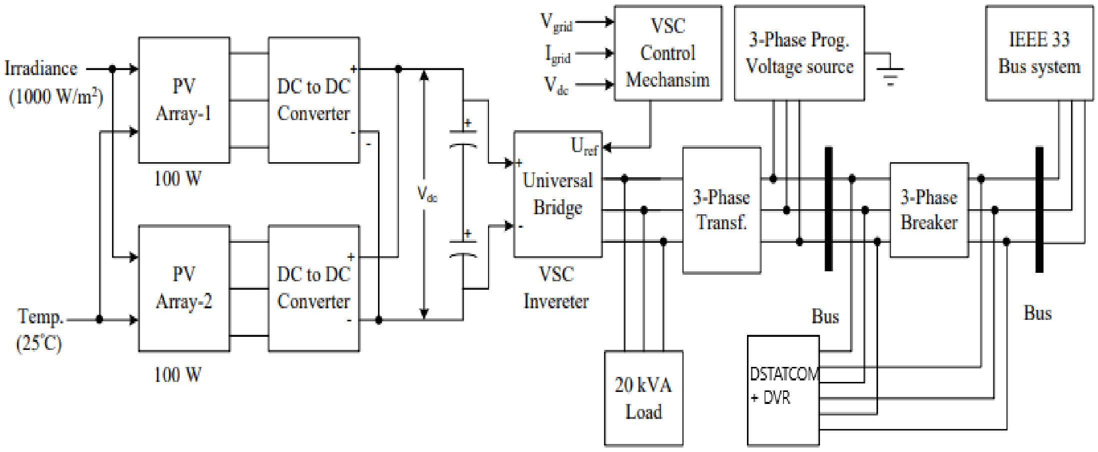


Figure : 2 PV based DG connected with DSTATCOM and DVR

The MCUPQC operates by controlling the switching of the individual converter modules. The control system monitors the power quality parameters (voltage, current, etc.) and generates appropriate switching signals to compensate for any deviations from the desired values, the connected MCUPQC system shown in the figure5.5. Figure 5.6 shows the inter connectivity of MCUPQC controlled with proposed algorithm has been shown. For IEEE33 and IEEE 57 bus systems.

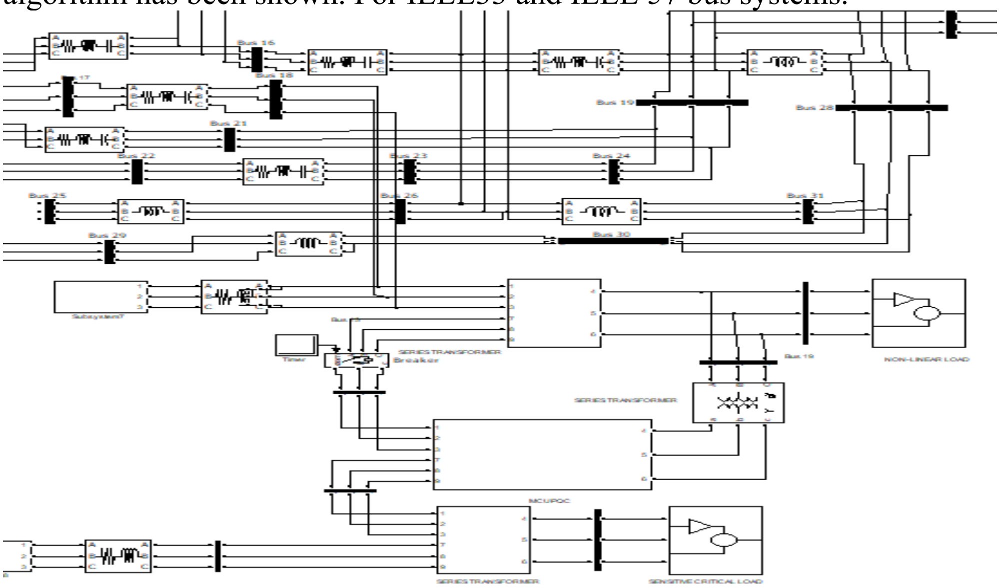


Figure 3: MCUPQC inter connection(at 18th) for IEEE 33 bus system

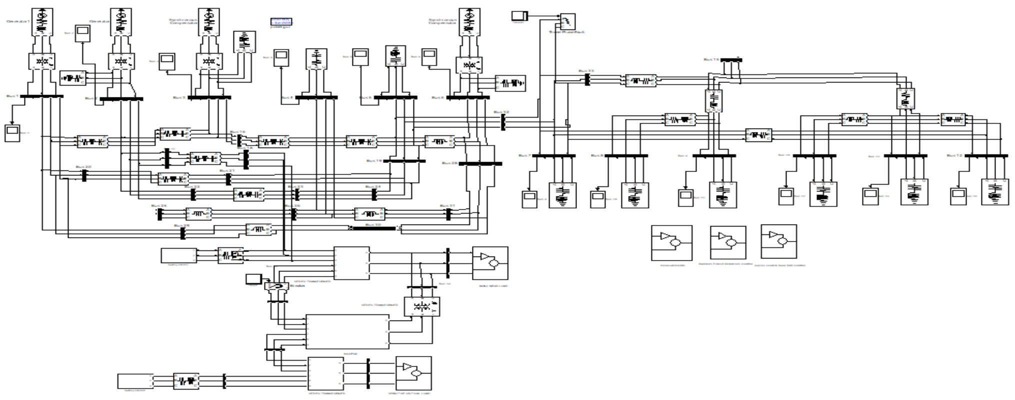


Figure 4: MCUPQC inter connection for IEEE 33 (18^{th}) bus system

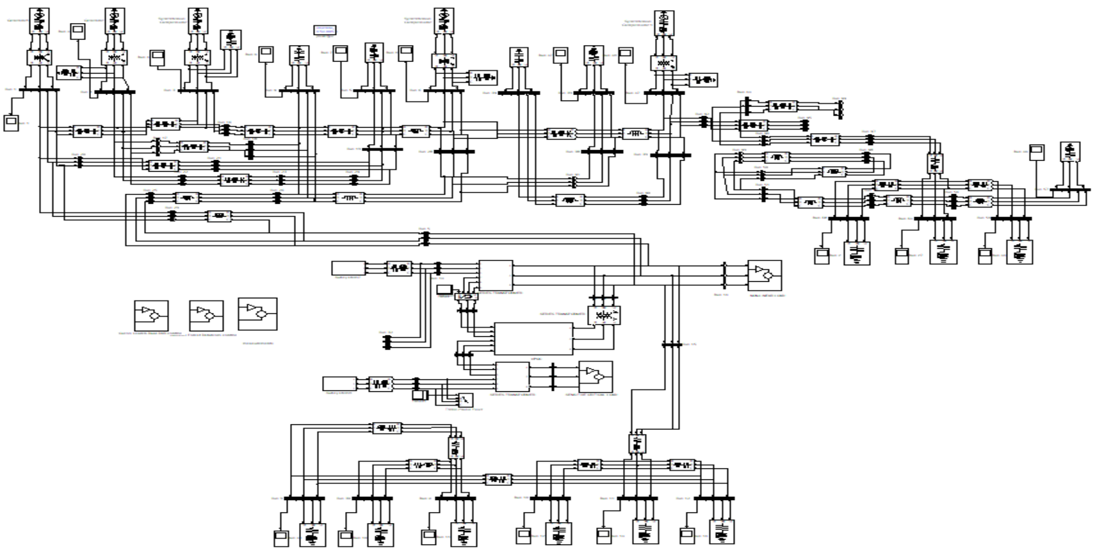


Figure 5: DG MCUPQC inter connection(at 30^{th}) for IEEE 57 bus system

3.1 Problem formulation

Voltage constraints: The optimization process must stay within the specified boundaries; furthermore, the voltage limitations must not be exceeded. The expression must be expressed as

$$V_k^{min} \leq |V_k| \leq V_k^{max} \quad \text{……………………………………………………..(1)}$$

Active power balance constraints:A simpler way to illustrate the relationship between system power generation and total power losses is as

$$P_{TL} + \sum P_{D(k)} = \sum P_{DSTATCOM(k)} \quad \text{…………………………………………………(2)}$$

Reactive power balance constraints: The expression can be expressed as the injected reactive power of each node within the specified constraints.

$$Q^{min}_{DSTATCOM(k)} \leq Q_{DSTATCOM(k)} \leq Q^{max}_{DSTATCOM(k)} \quad k = 1, 2, \ldots\ldots nb \qquad \text{.....................(3)}$$

Loss sensitivity factor: To find the best spot for DG and DSTATCOM to inject power using LSF, which can shorten the search time and narrow the search space, we can express it as

$$LSF(k, k+1) = \frac{\partial P_{Loss(k,k+1)}}{\partial Q_{(k+1,eff)}} = \left(\frac{2Q_{k+1,eff} * R_{k,k+1}}{|V_{k,k+1}|^2} \right) \qquad \text{.......................................(4)}$$

The objective function for optimal location of DG and DSTATCOM is as follows:

$$\text{Max}(f_1) = w_1 * P_i + w_2 * Q_i - w_3 \left[\sum_{m=1}^{n} \{(v_m - v_{min})^2 + (v_m - v_{max})^2\}\right] \text{..........(5)}$$

Vmin is 0.95 pu and Vmax is 1.05 pu, with w1, w2, and w3 serving as weighing factors. The ideal spot for DG and DSTATCOM is on the bus that has the highest value of this objective function f1.

$$\text{Min}(\{f_2\} = \left(\frac{Pt_{loss}}{P_{loss}}\right) * (0.001) + \left[\sum_{m=1}^{n} \{(v_m - v_{min})^2 + (v_m - v_{max})^2\}\right] \text{-----(6)}$$

where,

P_{loss}: Net real power loss of the network before the installation of DSTATCOM.

V_{min}: Minimum allowable limit of voltage

V_{max}: Maximum allowable limit of voltage

The voltage at the terminals has been determined to be

$$V_t = \sqrt{\frac{2}{3}(V_a^2 + V_b^2 + V_c^2)} \text{...(7)}$$

the units of in-phase energy have been determined as

$$V_{ina} = \frac{V_a}{V_t}, V_{inb} = \frac{V_b}{V_t}, V_{inc} = \frac{V_c}{V_t}, \text{...(8)}$$

quadrature units have been calculated as

$$V_{qa} = \frac{-V_{inb} + V_{inc}}{\sqrt{3}} \text{...(9)}$$

$$V_{qb} = \frac{(\sqrt{3}V_{inc} + V_{inb} + V_{inc}}{\sqrt{2}\sqrt{3}} \text{...(10)}$$

$$V_{qc} = \frac{(\sqrt{3}V_{ina} + V_{inb} - V_{inc}}{\sqrt{2}\sqrt{3}} \text{...(11)}$$

The following formulas determine the load current for each phase.

$$I_{la} = I_b \sin(\omega T - \phi) \text{...(12)}$$

$$I_{lb} = I_b \sin\left(\omega T - \phi - \frac{2\pi}{3}\right) \text{..(13)}$$

$$I_{lb} = I_b \sin\left(\omega T - \phi + \frac{2\pi}{3}\right) \text{...(14)}$$

The components of actual and reactive power in DC could be expressed as

$$P_d = P_l - P_1 \text{ .... (15)}$$

$$Q_d = Q_l - Q_1 \text{..(16)}$$

ISSN 2454-9940
www.ijasem.org
Vol 18, Issue 4, 2024

P1 represents the real power oscillating component and Pl represents the active load power. There is an oscillation component to reactive power (RP), and there is also an instantaneous reactive load power (Ql). The final equations for load and RP are as:

$P_{load} = V_t(I_{la}V_{ina} + I_{lb}V_{inb} + I_{lc}V_{inc})$……………………………………(17)

$Q_{load} = V_t(I_{la}V_{qa} + I_{lb}V_{qb} + I_{lc}V_{qc})$……………………………..……..(18)

Consequently, the loading injection components have been implemented. Provided by the source, current active power modules include

$I_{s1} = \left(\frac{2P_{load}}{3V_t}\right)$…………………………………………………………….(19)

$I_{s2} = K_p v_e + k_i \int v_e d_t + K_d \frac{d}{dt}(v_e)$………………………………………….(20)

The active component amplitude of reference source current is

$I_{samp} = I_{sp} + I_{sq}$…………………………………………………………….(21)

This is an inspection of an active power source's active power component.

$I_{sa} = I_{slamp} * v_{ina}$……………………………………………………………..(22)

$I^*_{sb} = I_{slamp} *_{v_{inb}}$…………………………………………………………..……..(23)

$I^*_{sc} = I_{slamp} *_{v_{inc}}$……………………………………………………………....(24)

RP component of reference current

$I^*_{qa} = I_{slamp} *_{v_{qa}}$……………………………………………………………..…..(25)

$I^*_{qb} = I_{slamp} *_{v_{qb}}$………………………………………………………….…....(26)

$I^*_{qc} = I_{slamp} *_{v_{qc}}$………………………………………………………………..(27)

The final reference current is provided in

$I^*_{sra} = I_{sa} *_{v_{ina}}$……………………………………………………………….(28)

$I^*_{srb} = I_{sb} *_{v_{inb}}$……………………………………………………………….(29)

$I^*_{src} = I_{sc} *_{v_{inc}}$……………………………………………………………….(30)

Controlling the DVR in the filtering and transformer circuits will offer a lesser number of conversion circuit losses at the typical level of the supply voltage. Whenever the installed DVR detects a voltage imbalance or distortion in the system, it supplies the injected voltages needed by the test system. A reference voltage (Vref) and a current supply voltage (Vsupply) form the basis of the feedback loop that controls the system. The control algorithm retrieves the reference voltages (Vref) from the supply and load voltages when the gate pulses supply the VSI to regulate the load voltage at the control algorithm's reference voltage.

The ability of the current solution to reduce the system's Total Harmonic Distortion, as indicated in equation 4.7, is the first parameter in the fitness function description.

$\min(f_3) = min\left\{\sum_{j=1}^{n} \frac{\sqrt{\sum_{n=2}^{\infty} x^2\ jn}}{xjn}\right\}$……………………………………………..(31)

in which case the signal's Total Harmonic Distortion (xjn) is being examined. Reduce the Voltage Drop (f4) as Much as Possible. The amplitude of each phase's sag is the second parameter under the fitness function description throughout the fault period. Since the load terminal housing the voltage sensitive load must operate precisely at 1.0 pu, the aim function is designed to minimize the variation from the operational voltage. The goal can be expressed mathematically as equation 4.8 if the fault timing falls between t0 and tf.

$\min(f_4) = min\left\{\sum_{j=1}^{n}\left(1 - max\left(x_j(t_i)\right)\right)\right\} \qquad t_0 \le t \le t_f$ ------(32)

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN 2454-9940

www.ijasem.org

Vol 18, Issue 4, 2024

3.1 Multi-agent ensemble method of learning for Cuckoo search algorithm

	Algorithm implementation (MARCFSA implementation)
	Begin
	% Initialization
1	Generate randomly population of host nests Xi with i- 1,2 ,……………N
2	Find the fitness function of population Fi
3	While (current iteration < $iteration_{max}$) or (Stop criterion)
4	% generation new solutions by Levy flights
5	From the current population (Called k) Generate randomly a new population (Called I)by Levy flights and evaluate their fitness
6	Update the current population by comparing the fitness of each solution in to population:(F_{li} is better than the F_{kj}) Replace $nest_{ki}$:**end if**
7	% generation new solutions Random Walk
8	From the current population (Called k) Generate a new population (Called I) by Random Walk
9	K-rand(N,D)>Pa
10	For i=1:N
11	$X_i^{new}\ Xbest_i + rand\ \times (i,:) \otimes (Xbest_j - Xbest_k)$
12	**End for i**
13	Update the current population by comparing the fitness of each solution in two population: **If**(F_{li} is better than the $F_{k,i}$) replace nestk,I by nestI,I; **end if**
14	Find the best solution by ranking the current population
15	% update the best solution by local search
16	Calculate RI based on the best fitness in two iterations by (17)
17	If RI<toll
18	K=eye(D,D);
19	**For** j=1:D
20	$X_{1new,j}$= $k_{(j,i)} \times d_{max} \times rand + Xbes\ (i)$
21	$X_{2new,j}$= $k_{(j,i)} \times d_{min} \times rand + Xbes\ (i)$
22	End for j
23	If D> Pr,Kr = rand (D,D)>0.8
24	For j=1:D
25	$X_{3new,j}$= $kr_{(j,i)} \times d_{max} \times rand \times Xbes\ (i)$
26	$X_{4new,j}$= $kr_{(j,i)} \times d_{min} \times rand \times Xbes\ (i)$
27	**End for j**
28	**End if**
29	Update the current best solution by comparing the fitness of each solution with the new solutions

Cuckoo random forest search algorithm for MCUPQC

An integrated random cuckoo forest search algorithm implemented for optimizing the power quality in selected bus systems.

Step1: As before discussed the cuckoos search very randomly the bus power in and out.

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT
ISSN 2454-9940
www.ijasem.org
Vol 18, Issue 4, 2024

Step 2: Optimal finding and communicate the UPQC system to compensate.
Step3: Checking the fitness of each bus very randomly once compensation done.
Step 4: Continuous checking of harmonics.
Step5: Feed back mechanism once the issue solved.

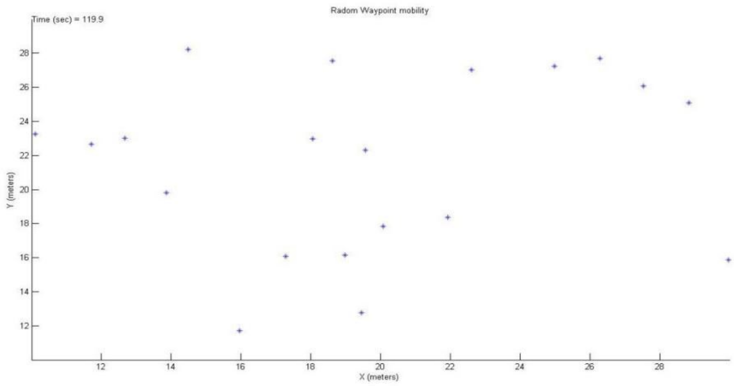


Figure 6: Random forest cuckoo search for optimal power and voltage loss in bus system.

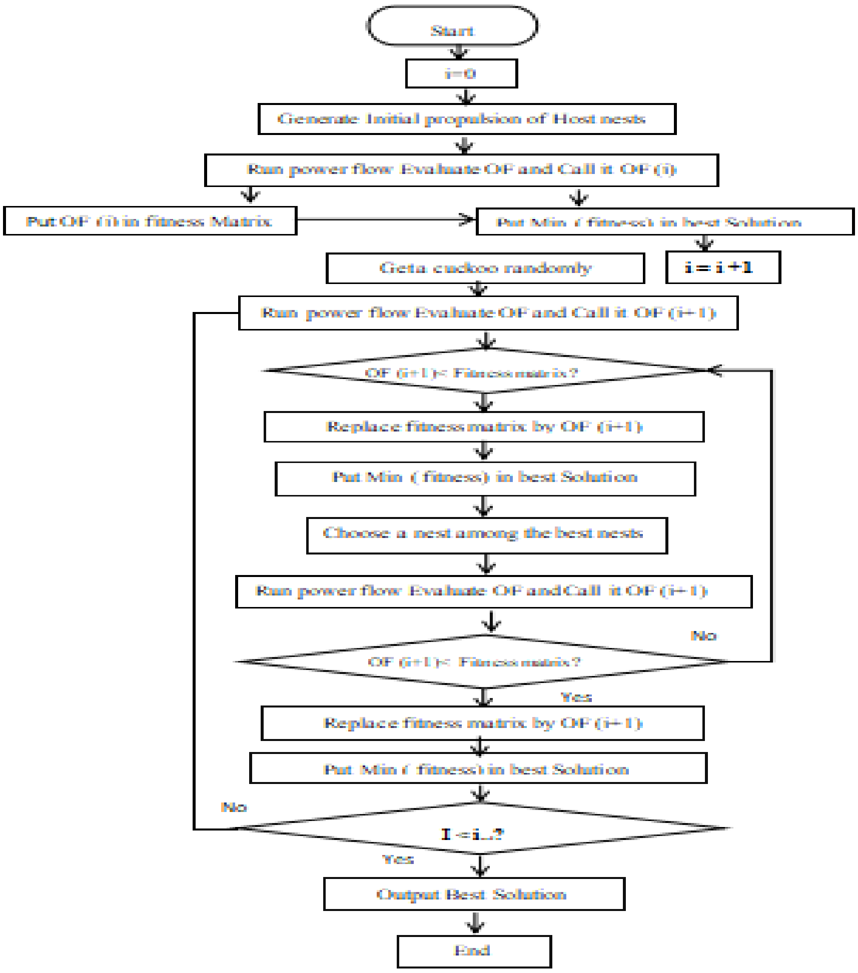


Figure 7 : Flow chart for Algorithm

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN 2454-9940

www.ijasem.org

Vol 18, Issue 4, 2024

4. Results and Discussions

Two different fact devices DVR and DSTATCOM interconnected with DG in both IEEE 33 and 57 bus systems. The unique algorithm divided into cuckoo search controlled DSTATCOM and random forest algorithm controlled DVR hybridized at unique command status controller with multi agent random cuckoo forest search algorithm. The voltage compensations with a unique controller are given in the following figures. The settling time is discussed for the voltage compensation of SAG and Swell.

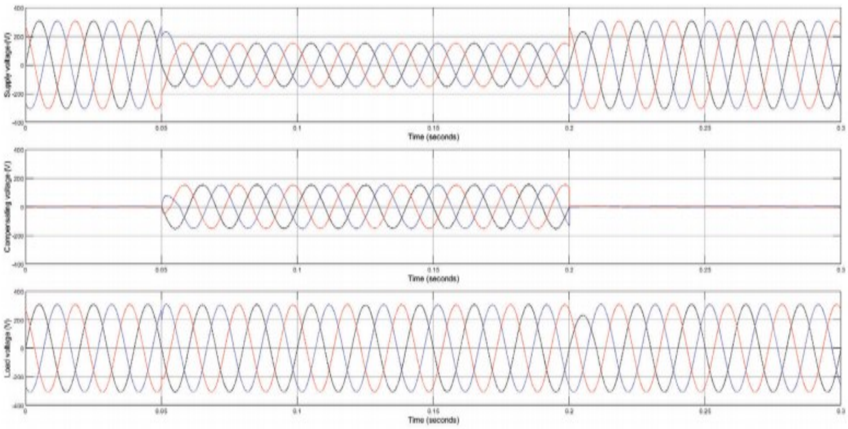


Figure 8: SAG compensation for DG interconnected DSTATCOM and DVR voltage profiles in 33 bus system

Voltage SAG settling time has been observed in the figure 5.10, the settling time is 0.15 seconds with the proposed algorithm. Voltage swell observed in the 33 bus system in figure 5.8 and the settling time is 0.13 seconds. The hybrid algorithm gives better voltage profiles compared with individual algorithms.

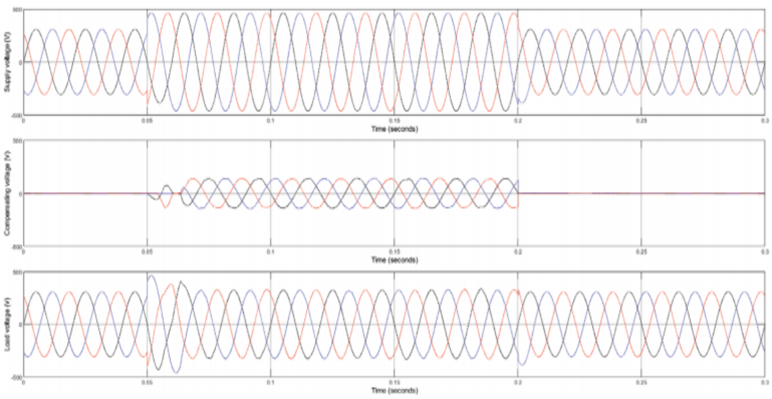


Figure 9: Swell compensation for DG interconnected DSTATCOM and DVR voltage profiles in 33 bus system

Sag disturbances are found to be more in IEEE 57 bus system and the compensated time for settling is same as other bus system as shown in figures9 and figure 10 and the swell compensated in the same settling time (0.15 seconds) can conclude that hybrid algorithm is more efficient than others.

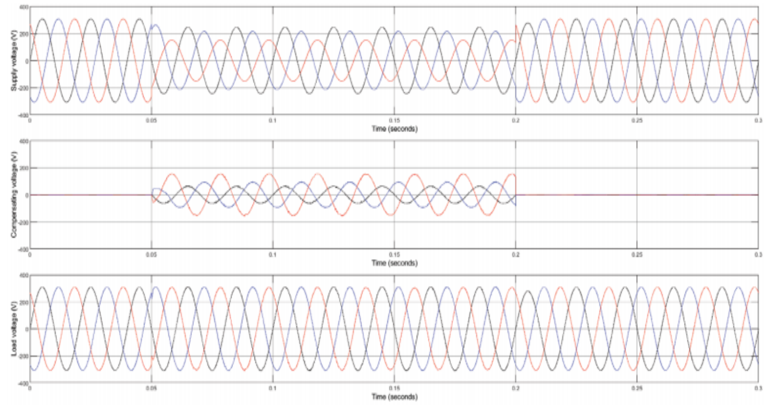


Figure 10: SAG compensation for DG interconnected DSTATCOM and DVR voltage profiles in 57 bus system

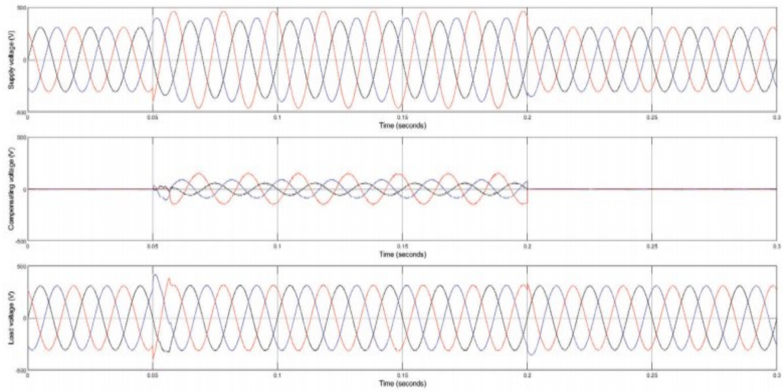


Figure11: Swell compensation for DG interconnected DSTATCOM and DVR voltage profiles in 57 bus system

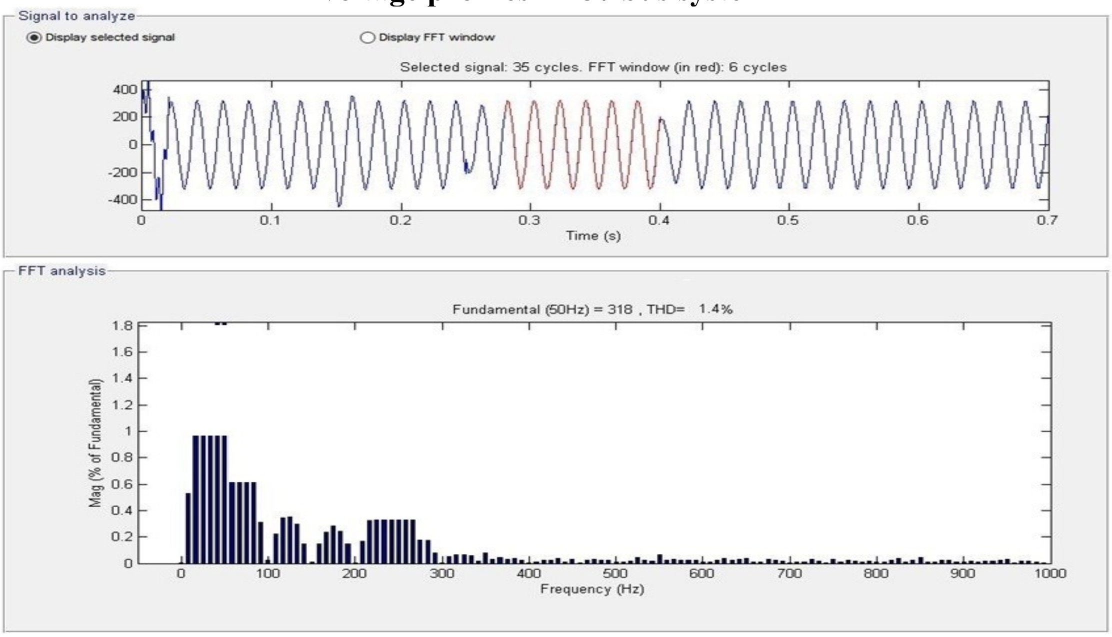


Figure12: THD Sag for DG interconnected DSTATCOM and DVR voltage profiles in 33 bus system

Fundamental (50Hz) 318, THD 1.4%: This indicates that the fundamental frequency of the signal is 50 Hz, and the Total Harmonic Distortion (THD) is 1.4%.

THD is a measure of the harmonic content in the signal, and a lower THD indicates a cleaner signal.

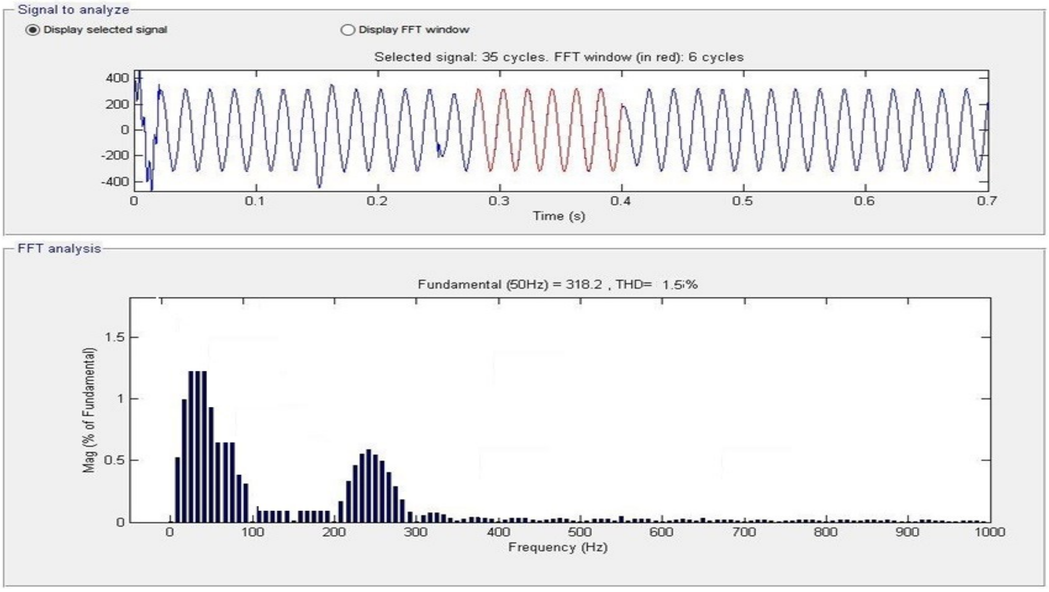


Figure 13:THD Swell for DG interconnected DSTATCOM and DVR voltage profiles in 33 bus system

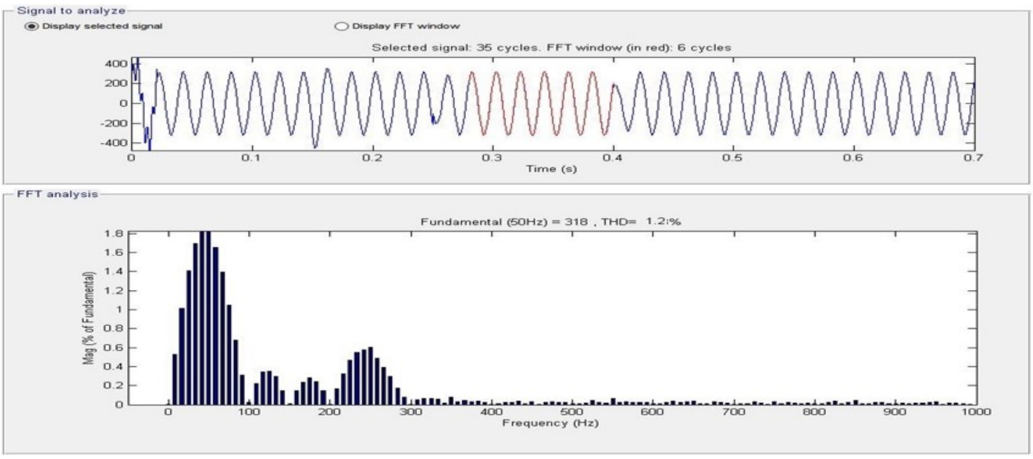
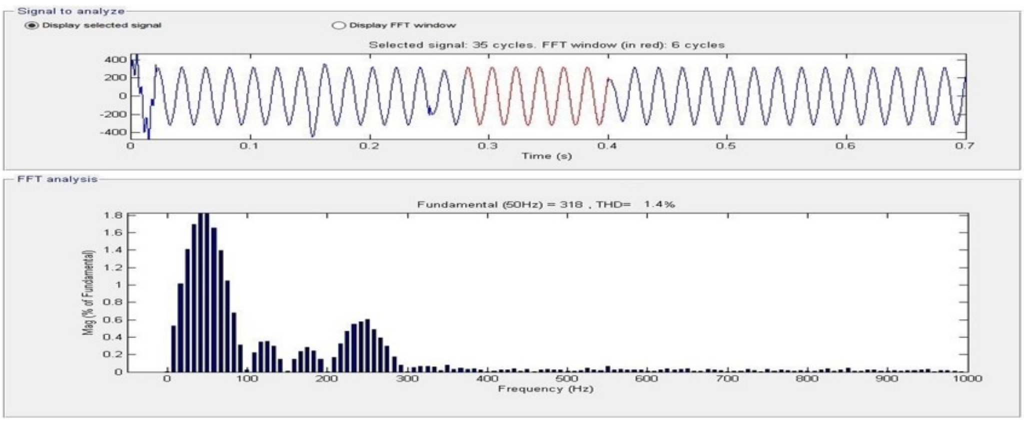


Figure14: THD Sag for DG interconnected DSTATCOM and DVR voltage profiles in 57 bus system



INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN 2454-9940

www.ijasem.org

Vol 18, Issue 4, 2024

Figure 15: THD Sag for DG interconnected DSTATCOM and DVR voltage profiles in 57 bus system

4.1 Unique compensation with MCUPQC controlled by MARCFS algorithm

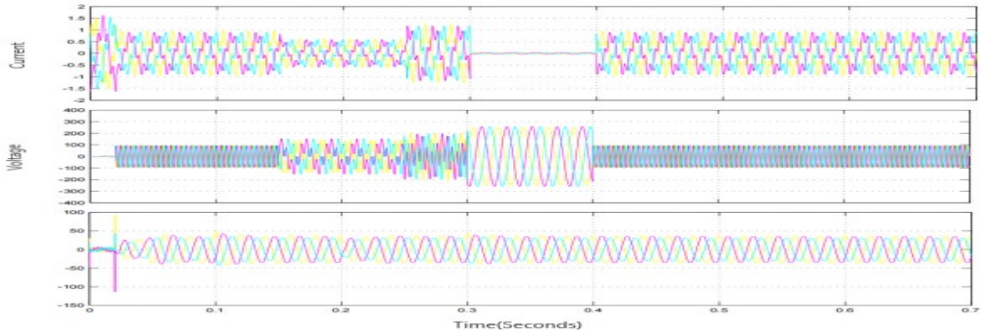


Figure 16: Unique compensation for voltage profiles in MC-UPQC 33 bus

Figure 5.11, which depict the compensation for voltage profiles in a 33-bus system using a Unified Power Quality Conditioner (UPQC). The voltage waveform also shows some distortions, indicating voltage fluctuations or sags/swells. Further, the injected voltage waveform from the UPQC appears distorted as well. Thus, this indicates that, in fact, the UPQC injects compensation signals to mitigate some power quality problems.

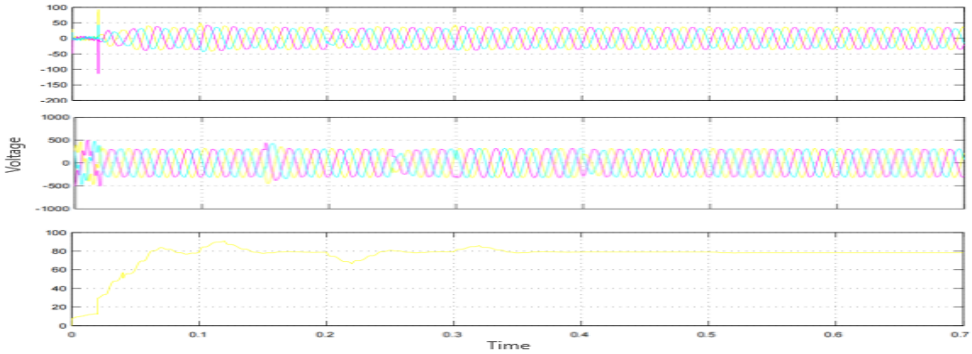


Figure 17: Sag and swell compensation for voltage and current profiles 57 bus system

The voltage and current compensation profiles for the 57-bus are shown in above Figure 17 Injecting a voltage waveform with both positive and negative pulses is typical of power compensation quality devices. The gadget is actively injecting voltage on two fronts because it increases voltages during sags and reduces voltages during swells. The MCUPQC manages system disturbances, as illustrated in Figure18 The injected voltage waveform clearly indicates that the MCUPQC is effectively addressing these disturbances and improving the power quality for the load. Even when the injected voltage waveform is interrupted, it demonstrates that the MCUPQC is actively injecting compensation signals to counteract the disturbances.

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT
ISSN 2454-9940
www.ijasem.org
Vol 18, Issue 4, 2024

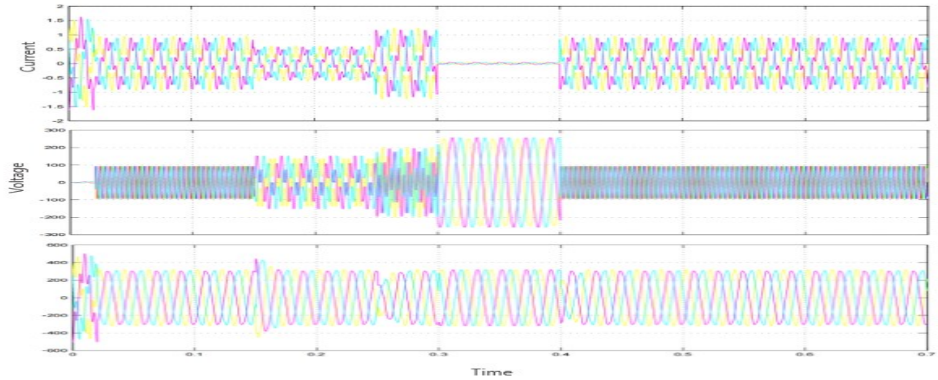


Figure 18: Unique compensation for profiles MCUPQC

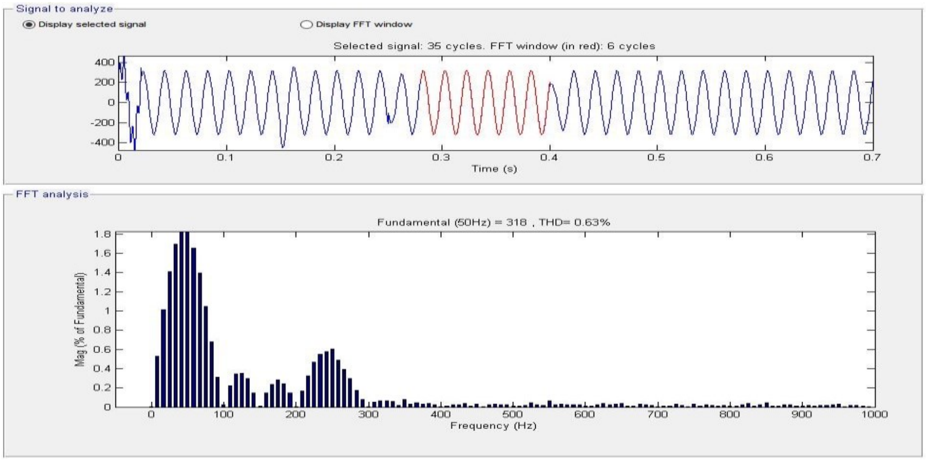
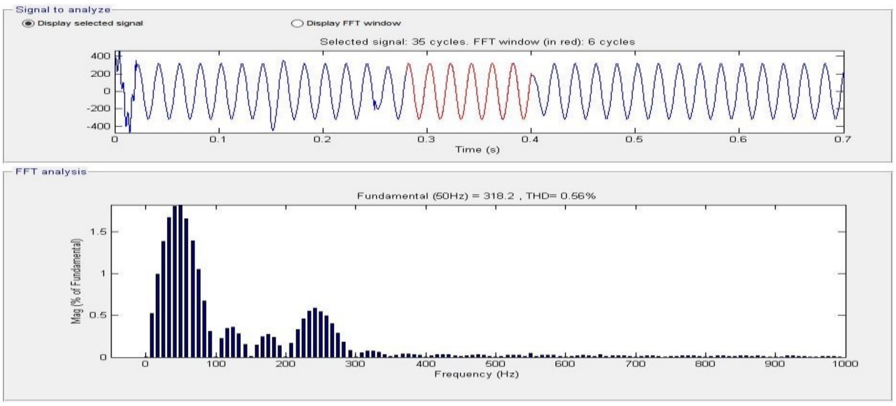


Figure 19: THD for 33 bus system with MCUPQC

Above Figure 5.14, wave forms and FFT analysis indicate that the MCUPQC is effectively reducing harmonic distortion in the 33-bus system. Low THD value indicates improved power quality, which benefits the overall system performance.FFT analysis plots the magnitude spectrum of the signal in terms of percentage of the fundamental frequency, which is 50 Hz. The fundamental frequency appears as the dominant peak at 50 Hz while the other peaks are harmonic components. The THD value has been reported to be 0.63%. It hence indicates that the harmonic distortion in the system is low.



INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT
ISSN 2454-9940
www.ijasem.org
Vol 18, Issue 4, 2024

Figure 20: THD for 57 bus system with MCUPQC

The waveform and FFT analysis in Figure20 indicate that the MCUPQC is reducing harmonic distortion in the 57-bus system. This is because the low THD value indicates improved power quality, which benefits the overall system performance. An FFT analysis displaying the magnitude spectrum of a signal, plotted in terms of percentage of fundamental frequency (50 Hz), which shows peaks at 50 Hz corresponding to the fundamental whereas other peaks consist of harmonic components. The THD value reported is 0.56%. This implies that the distortion caused by harmonics in the system is minimal.

Table: 1 Comparison of different FACT with Hybrid algorithm for IEEE 33 and 57 bus systems

S. No.	Compensator	Settling time (sec.)	V_{THD}	I_{THD}
1	DG+DVR+ DSTATCOM Sag Swell-33 bus	0.05-0.2(0.15)	1.4-1.5%	1.20%
2	DG+MCUPQC Sag, Swell **33 bus**	0.3-0.4 (0.1)	0.63%	0.51%
3	DG+DVR+ DSTATCOM Sag Swell-(57)	005-0.2 (0.15)	1.4-1.2%	1.02%
4	DG+MCUPQC (57)	0.28-0.4(0.12)	0.56%	0.48%

The chapter compares the two fact controllers the first one is DG with DSTATCOM and DVR and another is DG with MCUPQC controlled with MARCFSA algorithm. In both MCUPQC given better results compare with other controller. The MCUPQC system offers a unique compensation mechanism that is precisely controlled by the MARCFS algorithm, ensuring optimal performance and stability. This allows for efficient adjustments in real-time, enhancing the overall functionality of the system. The table 5.4 comparison made with advanced hybrid algorithm the settling time decreased to 0.12 seconds with a less THD of 0.56%.

5. Comparisons

Algorithms and FACTS (Flexible AC Transmission Systems) are both critical elements in the improvement of power efficiency and control in the power system. While FACTS devices provide solutions in terms of physical devices, algorithms are also provided to facilitate the optimization of system performance. This comparison emphasizes the key possibilities and the interdependence of the two methods.

5.1 FACTS Devices

Physical components: FACTS devices are implemented in the power system as tangible devices. Some of them are STATCOM, SVC, TCSC, UPQC etc. **Direct control:** FACTS devices directly manipulate the electrical characteristics of the transmission line, such as voltage, reactive power, or impedance. **Real-time response:** Due to their location in the grid, they can react swiftly to changes in system

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT
ISSN 2454-9940
www.ijasem.org
Vol 18, Issue 4, 2024

conditions. **Investment costs:** Installation and maintenance of FACTS devices can be quite expensive.

5.2 Algorithms

Software-based solutions that operate on digital controllers or computers are known as algorithms. They analyze and control the power system by utilizing mathematical models and optimization techniques. The delivery of control signals to FACTS devices or other system components is frequently carried out by algorithms. The availability of real-time data and system limitations enables them to make informed decisions. The ability to adapt algorithms can change subject to system requirements and control objectives. When optimization issues arise, one evolutionary approach that can be employed is the GA algorithm. Complex optimization problems can be solved using the hierarchical CSAGWO method. One machine learning approach that can be used for data classification is the Multi agent Random Cuckoo forest search algorithm. Comparison of voltage improvements for IEEE 33 and 57 bus systems as shown in figures 21 and 22.

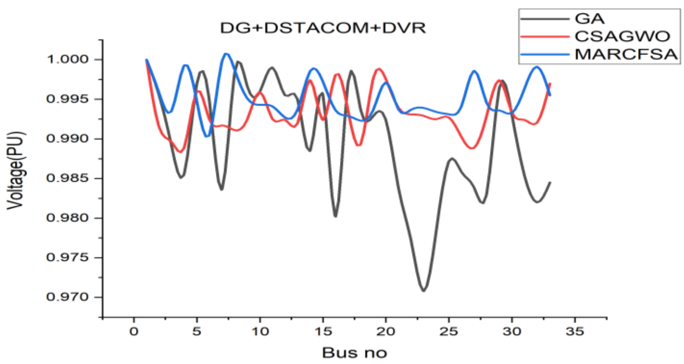


Figure 21: Algorithm comparison for IEEE-33 bus system

The graph presents the voltage profile across different buses in a power system, comparing three different optimization algorithms: GA, CSAGWO, and MARCFSA. The voltage is expressed in per unit (PU) values, and the x-axis represents the bus number. All three algorithms exhibit a similar overall voltage profile, with voltage values fluctuating around 0.985 PU. This indicates that all three methods are effective in maintaining voltage stability within the system. In the initial iterations (lower bus numbers), there are significant fluctuations in the voltage profiles, especially for the GA algorithm. This suggests that the GA algorithm takes more iterations to converge to a stable solution compared to the other two algorithms. As the number of iterations increases (higher bus numbers), the voltage profiles of all three algorithms tend to converge towards a more stable and consistent pattern. This indicates that all three algorithms are able to find solutions that maintain voltage stability.

ISSN 2454-9940
www.ijasem.org
Vol 18, Issue 4, 2024

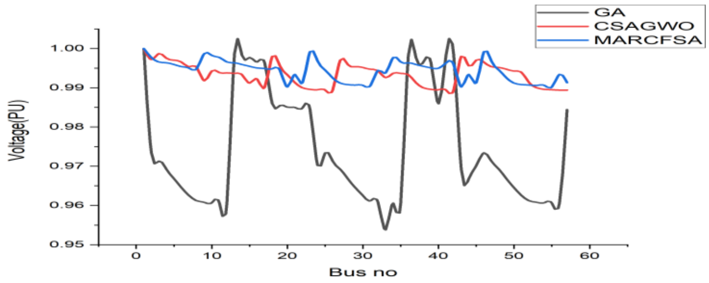


Figure 22: Algorithm comparison for IEEE-57 us system

All three algorithms exhibit a similar overall voltage profile, with voltage values fluctuating around 0.985 PU. This indicates that all three methods are effective in maintaining voltage stability within the system.

5.2.1 Algorithm Comparison:

The use of different hybrid algorithms in the IEEE bus system can significantly enhance the performance and reliability of power systems. By combining techniques like Cuckoo Search with other optimization methods, these hybrid algorithms can more effectively navigate complex solution spaces, leading to better handling of power quality issues and more robust system configurations. This approach ensures that power systems are both adaptable and efficient in real-world scenarios.

GA: The GA algorithm shows a higher degree of fluctuation in the initial iterations but converges to a stable solution in the later iterations. This suggests that GA may require more computational effort to find optimal solutions.
CSAGWO: The CSAGWO algorithm exhibits a smoother voltage profile compared to GA, especially in the initial iterations. This indicates that CSAGWO may converge faster to a stable solution.

MARCFSA: The MARCFSA algorithm shows a relatively stable voltage profile throughout the iterations, suggesting that it may be the most efficient algorithm in terms of convergence speed and solution quality.

5.3 FACTS comparison

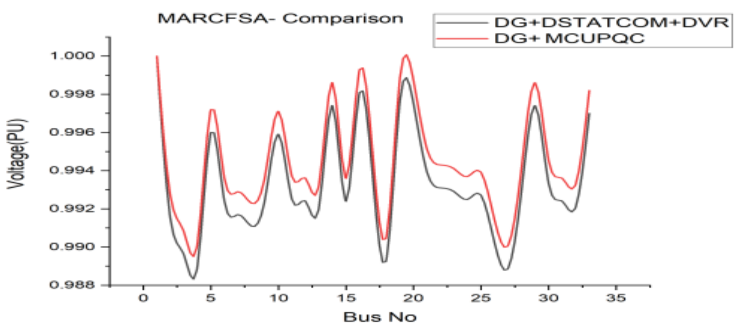


Figure 23: Integrated FACTS comparison for IEEE-33 bus system

ISSN 2454-9940
www.ijasem.org
Vol 18, Issue 4, 2024

The graph presents the voltage profile across different buses in a power system, comparing two different power quality improvement devices: DG+DSTATCOM+DVR and DG+MCUPQC in figures 6.3 and 6.4. The voltage is expressed in per unit (PU) values, and the x-axis represents the bus number. Both devices exhibit a similar overall voltage profile, with voltage values fluctuating around 0.995 PU.

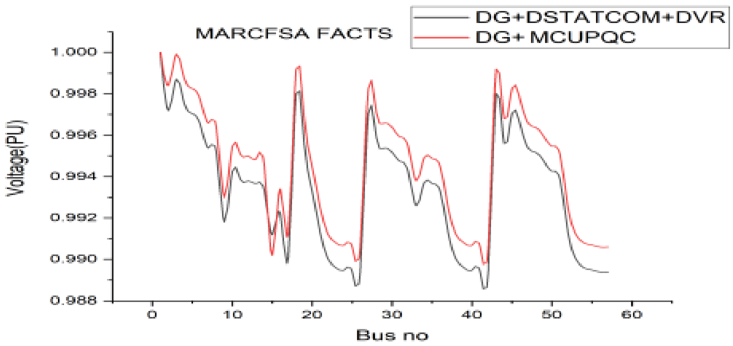


Figure 24: Integrated FACTS comparison for IEEE-57 bus system

Device Comparison: DG+DSTATCOM+DVR: This device shows a slightly higher degree of fluctuation in the initial iterations but converges to a stable solution in the later iterations. This suggests that this device may require more computational effort to find optimal solutions.

MCUPQC: The MCUPQC device exhibits a smoother voltage profile compared to DG+DSTATCOM+DVR, especially in the initial iterations. This indicates that MCUPQC may converge faster to a stable solution.

Table 2: Comparison of **FACTS devices and** Algorithms

Method	Max voltage (THD)	Vmax (PU)	Vmin (PU)	Power loss	Compensation time	Injected voltage
GA (DG+DS+DVR)	19%	1	0.1	3.78 MW	0.5 sec	20%
AGWO(DG+DS+DVR)	<2%	1	0.6	3.07 MW	0.2 sec	80%
MCUPQC (MARCFSA)	<1%	1	0.8	2.17 MW	0.1 sec	99%

The above table compares and contrasts three methods for controlling voltage and minimizing power loss in a power system. Those are the ways:

1. **GA (DG+DS+DVR):** A genetic algorithm that incorporates a dynamic voltage restorer, a dynamic stabiliser, and a distributed generator.

2. **AGWO (DG+DS+DVR):** Array of grey wolf optimisers, dynamic voltage restorer, and dynamic stabilisers with distributed generation.
3. **MCUPQC (MARCFSA):** A reactive power flow method with multiple converters and a multi-objective coordinated unified power quality conditioner.

6. Conclusions

The MCUPQC approach outperforms all others according to the table, boasting the quickest compensation time, lowest power loss, and lowest max voltage THD. Although it takes somewhat longer to compensate than the MCUPQC approach, the AGWO method likewise works effectively, with minimal maximum voltage THD and power loss. Maximum voltage total harmonic distortion (THD), power loss, and compensation time are better when compare with the GA technique.

7. References

1. Ambarnath Banerji, Sujit K. Biswas , Bhim Singh , "DSTATCOM Application for Mitigation of Voltage Sag Caused by Dynamic Loads in Autonomous Systems" International Journal of Power Electronics and Drive System (IJPEDS), vol.2, No.2, June 2012.
2. Rajan Sharma, Parag Nijhawan,"Effectiveness of DSTATCOM to Compensate the Load Current Harmonics in Distribution Networks under Various Operating Conditions", International Journal of Scientific Engineering and Technology, Vol.2, No.7, pp:713-718, 1 July 2013.
3. Rajan Sharma and Parag Nijhawan, "Role of DSTATCOM to Improve Power Quality of Distribution Network with FOC Induction Motor Drive as Load", International Journal of Emerging Trends in Electrical and Electronics (IJETEE – ISSN: 2320-9569), Vol.5, No.1, July 2013.
4. H. E. Brown, G. K. Carter, H. H. Happ and C. E. Person, "Power Flow. Solution by Impedance Matrix Method," IEEE Trans. Power Apparatus and System, April 1963.
5. Robert G. Andretich, Homxier E. Brown, Harvey H. Happ and Conrad E. Person, "The Piece-wise Solution of The Impedance Matrix Load Flow," IEEE Transactions on Power Apparatus and Systems, October 1968, Vol. PAS-87, No. 10, pp.1877-1882
6. William F. Tinney and Clifford E. Hart, "Power Flow Solution by Newton's Method," IEEE Transactions on Power Apparatus and Systems, Nov. 1967.
7. B.Stott and JL Mainho, "Linear Programming for Power System network security applications", IEEE Transactions on Power Apparatus Systems, 1979, Vol. 98, pp. 837-848
8. Ahmed, S.F., Alam, M.S.B., Hassan, M. *et al.* Deep learning modelling techniques: current progress, applications, advantages, and challenges. *Artif Intell Rev* **56**, 13521–13617 (2023). https://doi.org/10.1007/s10462-023-10466-8
9. T. Ackermann, G. Anderson, L. Soder, "Distributed generation- A definition", Electric Power Systems Research, 2001, Vol. 57, pp. 195-201.
10. S. Sultana, P.K.Roy, "Multi-objective quasi oppositional teaching-learning based optimization for optimal location of distributed generator in radial

distribution systems", International Journal of Electrical Power and Energy Systems, 2014, Vol. 63, pp.534-545.

11. Belkaıd, I. Colak, K. Kayıslı And R. Bayındır, "Improving PV System Performance using High Efficiency Fuzzy Logic Control," 2020 8th International Conference on Smart Grid (icSmartGrid), 2020, pp. 152-156
12. Cotfas, Daniel Tudor; Cotfas, Petru Adrian; Machidon, Octavian Mihai (2018). *Study of Temperature Coefficients for Parameters of Photovoltaic Cells. International Journal of Photoenergy, 2018(), 1–12.* doi:10.1155/2018/5945602
13. P Sigh, SK. Bishnoi, NK. Meena, "Moth Search Optimization for optimal DERS Integration in Conjunction to OLTC Tap Operation in Distribution Systems", IEEE Systems Journal, 2019, pp. 1-9.
14. P Sigh, SK. Bishnoi, NK. Meena, "Moth Search Optimization for optimal Integration of DERs for Annual Energy Loss minimization in distribution systems", IEEE International Conference on Power Electronics (IICPE), 2018,pp.1-6.
15. K. Kim, L. Jung, S. Lee and U. Moon, "Security Constrained Economic dispatch using Interior point method", Proceeding of IEEE International Conference on power System Technology, 2006, pp. 1-5.