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Power Quality Enhancement in Smart Grid Using DPFC Based Hybrid Algorithm

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Abstract
In the Smart Grid (SG), all different types of Non-conventional sources are interrelated among the power grid system to improve quality, consistency, and steadiness by using smart and sophisticated devices. This paper propose the hybrid algorithm utilized Distributed Power Flow Controller (DPFC) for detecting and mitigation of the Power quality (PQ) events in SG. The hybrid algorithm is the combination of Cuttle Fish Algorithm (CFA) and Particle Swarm Optimization (PSO) algorithm. The main purpose of the proposed system is detecting the voltage disturbances in the PQ events of the power system and improvement of PQ in voltage disturbances of power system using DPFC based hybrid algorithm. Here, the Multi Wavelet Transform (MWT) is utilized to extract the features of the inputs for PQ events detection. The anomalous practices of PQ occasions are relieved by the cross breed calculation base DPFC. The proposed half and half calculation is used to support the Dc-connect voltage of DPFC for remunerate the O/P voltage to alleviate the PQ Issues. At long last, the presentation of proposed half and half strategy is execute in Matlab/Simulink stage and contrasted and the current methods, for example, FA-UPFC, Without DPFC and ABC-DPFC individually.

Keywords: *Smart Grid, Power Quality, Multi Wavelet Transform, Distributed Power Flow Controller, Cuttlefish Algorithm, Particle Swarm Optimization Algorithm.*

1. INTRODUCTION

Electric power systems [1] are renovated by the information and communication technologies through power system operation owing to the augmenting constraint of electric power. Further more , power system harmonics, inter harmonics, Sags and swells in the voltage, transients, frequency deviation, and voltage disturb among the power system segments [2] are existent in the PQ system. The source of PQ is based on a solitary large resource of interruption which is allied to the grid or united to the smaller nonlinear loads. Therefore, a significant problem to developing, activating, handling, and enlarging power systems [3] is the PQ investigation and control. Subsequently, the PQ interruption in SG is diminished by the use of the diverse regulators like FLC, ANN) controller, and Artificial Intelligence (AI) techniques. Moreover, the gravitational search algorithm (GSA), PSO algorithm, Bat Algorithm (BA) and Firefly algorithm (FA) are used to enhance the PQ among dissimilar procedures. At that point the assorted devices like STATCOM, IPFC and UPFC are utilized to achieve the movement of controller development. Up and coming SG work [4] is balanced by consolidating the PQ expansion and force framework with the lattice interfacing converters. The Power Quality occasions which are recognized and improved by utilization of DPFC with the assistance of the proposed versatile methods are offered right now. CFA and PSO calculations are joined to frame the versatile strategy. The proposed versatile strategy is utilized to keep up the DC connect voltage.

2. MODERN RESEARCH WORKS: A BRIEF REVIEW

The presentation of PQ aspects in SG is the base for several research works in the literature. The review of some of them are given below,

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To handle the immediate power and enhance the general network voltage eminences of SG have offered by MoayedMoghbelet. al, [5] the finest compensations of basic immediate power and harmonic currents at preferred finest buses have effect on The STATCOM and the active power line conditioner (APLC).

The PQ of AC subsystem with the micro grid is organized by Mahdi Shahparasti et.al, [6]. The control policy of grid-associated method depends on both the voltage eminence of the AC subsystem .

An original managerial PQ control format of a grid-off MG, voltage and frequency control intentions at a specified position has been anticipated by Hee-Sang Koet. al, [7] therefore, the power alteration systems with activating position and limits control the active and immediate powers.

PQ enhancement, power flow control, immediate power reparation, and removal of power swings have been examined by PouriaGoharshenasanKhorasaniet. al, [8] in both grid associated and inaccessible methods the process performs the entire aforesaid target.

3. PROPOSED METHOD WITH DPFC FOR IMPROVEMENT OF PQ ISSUES

In this section the brief description about the proposed system with DPFC utilized proposed technique for recognition and alleviation of the PQ issues in the power grid. The Power Quality issues detection refers to segmenting out Power Quality issues from the supply that method requires the feature extraction from the I/P Power quality issues extract by Multi Wavelet Transform (MWT)[9]. The mitigation of PQ issues by utilized the proposed hybrid technique, which is the combination of CFA and PSO algorithm, which is utilized tomaintain the dc-link voltage of DPFC[10]. The PSO used for enhance the update function and recuperating the performance of the Cuttle Fish Algorithm. The structure of the proposed system is shown in Fig. 1.

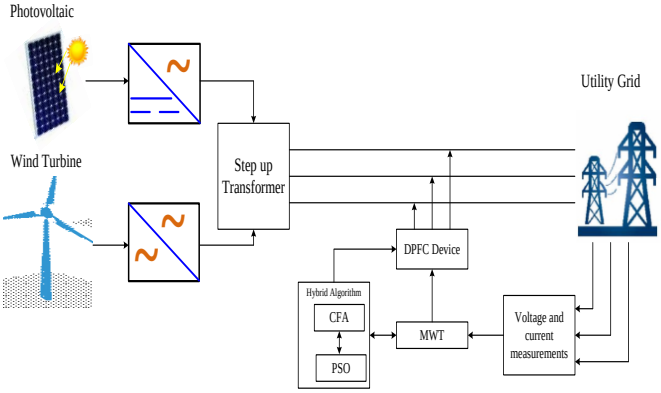

Fig. 1 Block Diagram of Proposed Method

Initially, the power parameters are evaluated with the reference values. The MWT is utilized to extract the features of inputs for PQ issues detection. The abnormal behaviours of PQ issues are controlled by the DPFC. Finally, the proposed system is simulated in Matlab platform. So that the performance is evaluated and compared with the active methods such as base, FA-UPFC and ABC-DPFC models respectively.

3.1. The Power Flow Control using Proposed Hybrid Algorithm

Right now about the streamlining parameter and the procedure of the proposed CFA with PSO calculation. The CFA is using for controlling the DPFC power parameters and the PSO is improving the refreshing capacity of the CFA for recovering the presentation of the proposed framework.

3.1.1. Mechanisms of skin color change in Cuttlefish Algorithm

Cuttlefish is a kind of cephalopods which is notable for its capacities to change its shading to either apparently vanishes into its condition or to deliver dazzling showcases. The proposed cuttlefish calculation CFA is planned dependent on these two procedures (reflection and visibility) and they utilized as an inquiry methodology to locate the new arrangements. The detailing of finding the new arrangement (S_{new}) utilizing reflection and visibility is depicted in (1),

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$$S_{new} = \text{Reflection} + \text{Visibility} \quad (1)$$

As other meta-heuristic streamlining calculations, CFA begins with irregular answers for introduce the populace. At that point the six cases are applied until stop condition is meeting. The primary strides of CFA calculation are outlined as follow:

Initialization

Introduce the populace P (cells) of N introductory arrangements, spread over d-dimensional issue space aimlessly positions (p) utilizing (2).

$$P[i].p[j] = \text{rand}(0,1) * (U_L - L_L) + L_L; \qquad i = 1,2,\dots,N; j = 1,2,\dots,d \quad (2)$$

Group 1, Simulation of case 1 and 2

Right now, new arrangement is delivered dependent on the reflection and visibility of examples. The definitions of these procedures are depicted in (3) and (4), individually.

$$reflection_j = R * G_i[i].P[j] \quad (3)$$

$$visibility = V * (BestP[j] - G_i[i].P[j]) \quad (4)$$

Here R and V are Evaluated from equations (5) and (6),

$$R = \text{rand}(0,1) * (r_1 - r_2) + r_2 \quad (5)$$

$$V = \text{rand}(0,1) * (v_1 - v_2) + v_2 \quad (6)$$

Group 2, Simulation of case 3 and 4

Right now new arrangement utilizing refreshed reflection and visibility of examples. The adjusted reflection is referenced in condition (7) .

$$\text{reflection}_j = R * \text{Best}.P[j] \quad (7)$$

Group 3, Simulation of case 5

In this group update the visibility pattern with out effecting Reflection . The modified visibility is mentioned in equation (8),.

$$\text{visibility}_j = V * (\text{Best}.P[j] - AV_{Best}) \quad (8)$$

Group 4, Simulation of case 6

In this group, generate the random solution and find the best fitness value. The proposed hybrid algorithm flow chart is shown in figure 2.

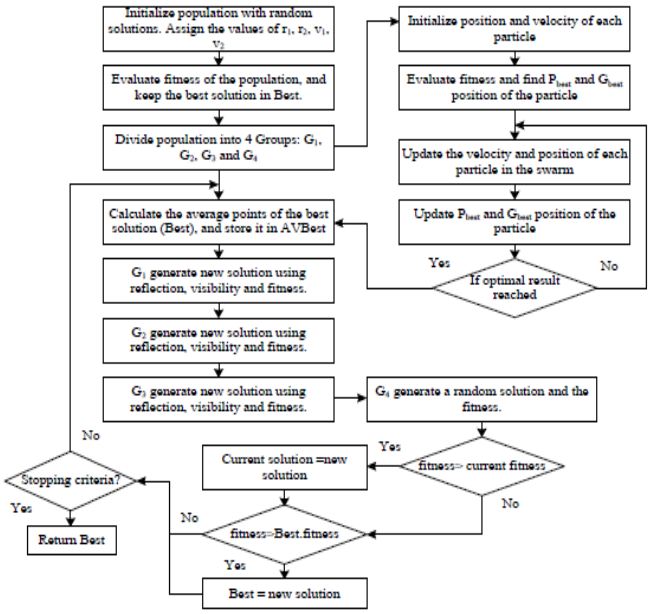

Fig.2 The flow diagram of proposed hybrid algorithm

3.1.2. Improving the CFA Update Function using PSO Algorithm

In PSO algorithm first initialize , the particle population and the velocity of the initial population are mentioned in equations (9) & (10).

$$x_i = (x_{i1}, x_{i2}, \dots, x_{iD}) \in S \quad (9)$$

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$$v_i = (v_{i1}, v_{i2}, \dots, v_{iD})$$

(10)

The best nearby and global positions are allocated, where the best neighborhood position experience by every molecule is characterized as condition (11),

$$p_i = (p_{i1}, p_{i2}, \dots, p_{iD}) \in S$$

(11)

The velocity of each particle is described as equation (12),

$$v_i^{k+1} = wv_i^k + C_1 rand_1 \left(p_{best}^i - s_k^i\right) + C_2 rand_2 \left(g_{best} - s_k^i\right)$$

(12)

The w is the weighting function that is usually utilized in equation (13),

$$w = w^{max} - \frac{w^{max} - w^{min}}{iter^{max}} \times iter$$

(13)

Here,w^{max} denoted as final weight, w^{min}described as initial weight, $iter^{max}$ is maximum iteration number and $iter$ denotes current iteration number. Then the position of each particle are presented as equation (14),

$$x_i^{t+1} = x_i^t + v_i^{t+1};\ i = 1,2, \dots, P$$

(14)

The calculation refreshes the Local and Global Best of the molecule positions which lead to better target work esteems contrasted with another past one these bests are refreshed.. At last with the assistance of PSO the CFA execution are improved and the adequacy of the proposed method is assessed and the outcomes are reachable in the resulting area.

4.RESULTS AND DISCUSSION

The Simulink model is shown in the figure 3, analyze the efficacy of the proposed control method is analyzed and compared with the traditional approaches such as FA-UPQC, without DPFC and ABC-DPFC. Mainly, Minimize the PQ events in the SG operation; it improves the efficiency of the overall process in SG like as distribution, generation and storage.

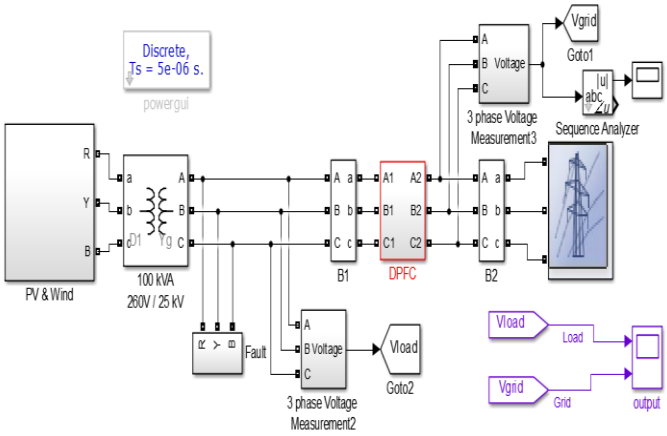
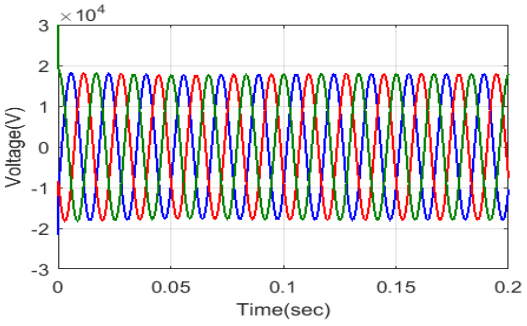


Fig.3 The Simulation model for DPFC connected power system

4.1. The Output Response of the Proposed System

As, it's a custom power device projected to compensated the PQ events. Initially, the PV and WT generated voltage is evaluated based on the requirements. Then, the generated voltage is applied to the SG and the feature extraction of the generated signal is processed by MWT. The generated voltage, low level and high level components and the required output voltage is shown in figure 4.



(a)

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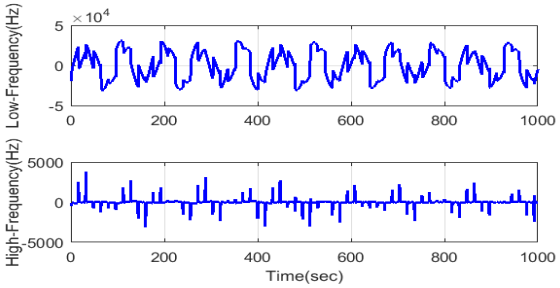

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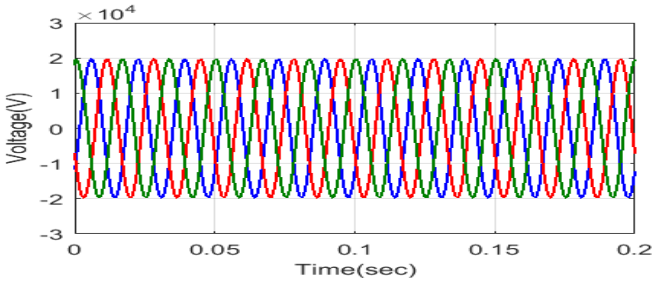


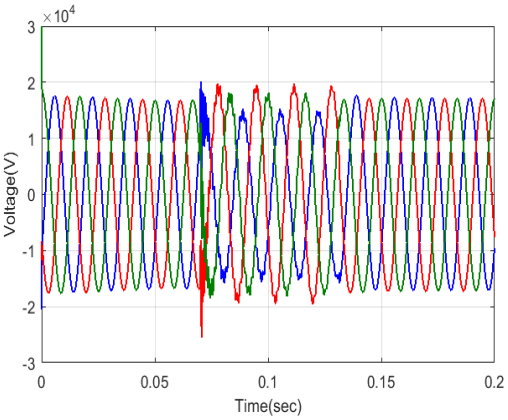
(c)

Fig.4 The analysis of (a) generated voltage, (b) feature extracted signal and (c) required output voltage

The output reaction of the proposed DPFC incorporated SG is described in a observed segment. The performance analyses are based at the PQ activities, which suggests the effectiveness and compared with a few current techniques. Here, six PQ activities are provided for examine with the hybrid algorithm optimized DPFC linked SG.

4.1.1. Harmonic Distortion

The harmonic distortion describes that the non-sinusoidal shape of the voltage or modern-day waveforms. The waveform corresponds to the sum of various sine-waves with distinctive magnitude and phase, having frequencies that are multiples of energy machine frequency. Here the harmonic distorted signal, high and low level components and the injected voltage is illustrated in figure 5.



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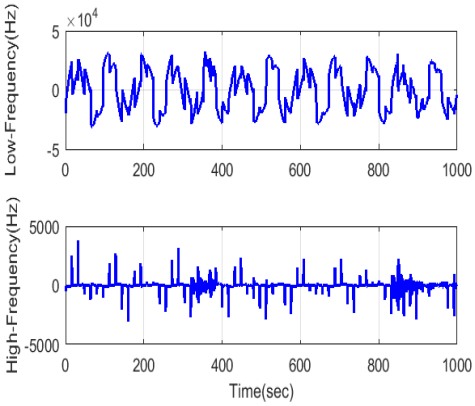

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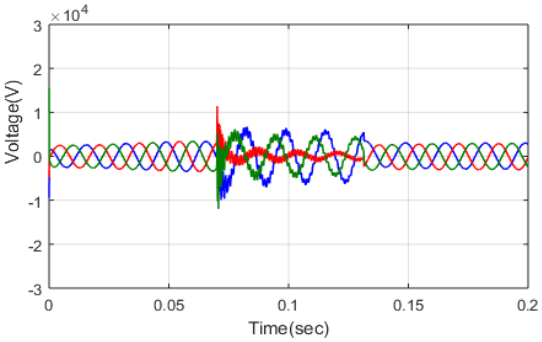

(iii)

Figure.5: The performance analysis of (i) harmonic affected signal, (ii) feature extracted signal and (iii) Injected voltage

In this process the distorted signal is processed with MWT feature extraction process and the PQ event is classified by utilized the low and high level components. Then the proposed hybrid algorithm is used to inject the adequate injected voltage signal for achieving the required output

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voltage. Another PQ event performance is evaluated as follows.

4.1.2. Short Interruption

The short interruption interrupted signal and corresponding low and high level components and the injected voltage are illustrated in figure 6. In which the injected voltage is used for gathering the adequate voltage to improve the power quality using the proposed algorithms.

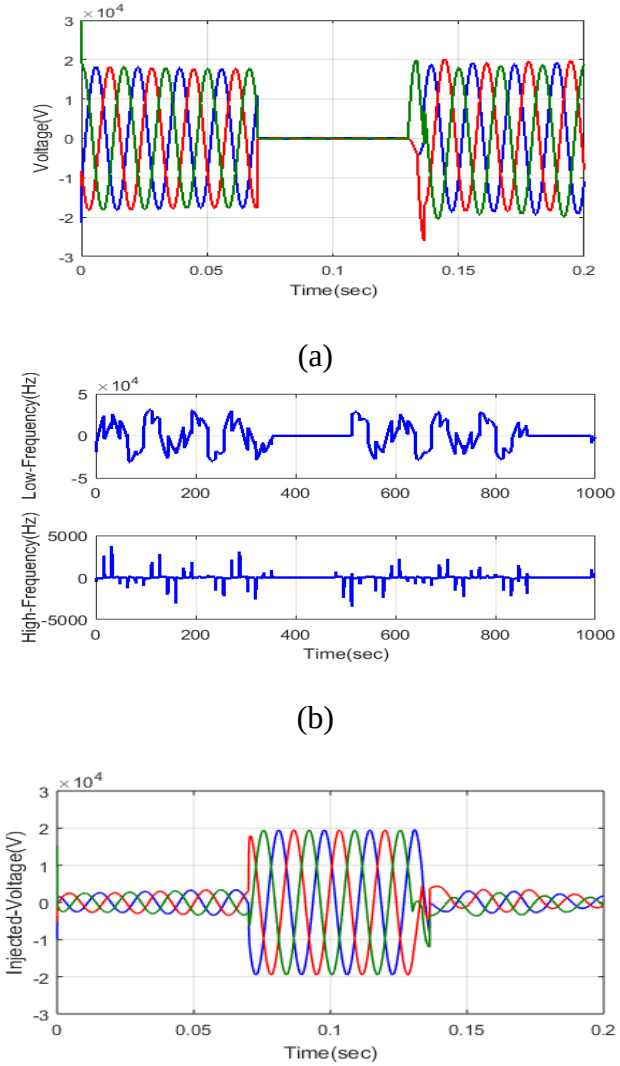
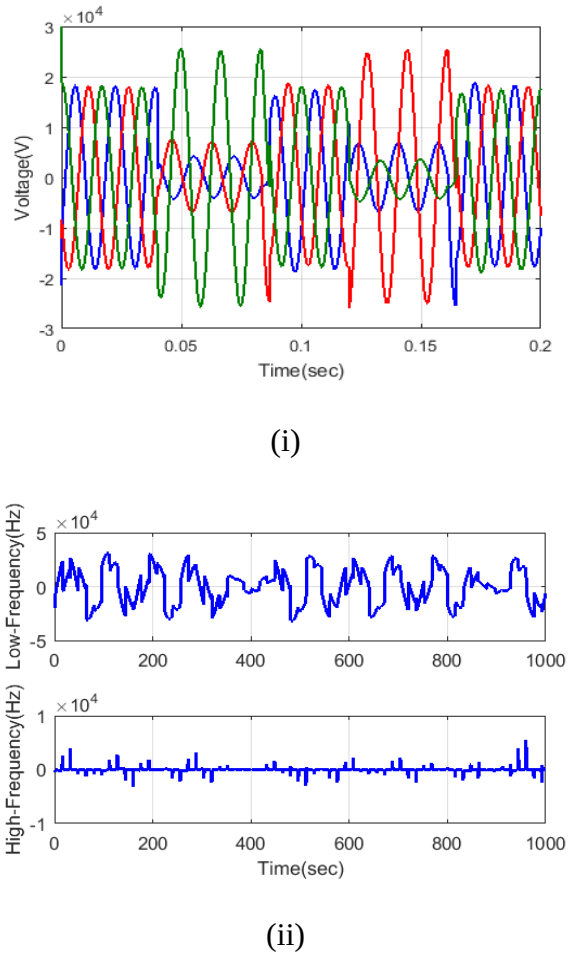


Figure.6: The performance analysis of (a) interrupted voltage signal, (b) feature extracted signal and (c) injected voltage

In this interruption the interrupted voltage signal is affected between 0.07-0.14 sec. The corresponding high and low level components in MWT for classification also presented. Then the injected voltage for compensate the interruption and give the high PQ signal using the proposed technique. Then the next PQ event is evaluated in a followed section.

4.1.3. Voltage spike

The Voltage Spike interrupted signal and corresponding low and high level components and the injected voltage are illustrated in figure 7. In which the injected voltage is used for gathering the adequate voltage to improve the power quality using the proposed algorithms.



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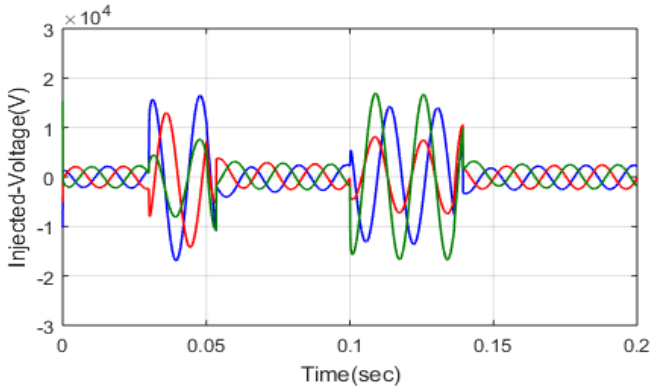


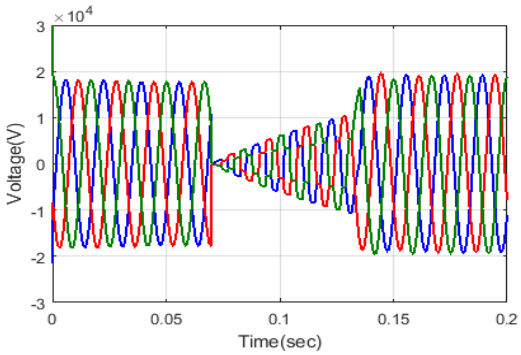
(iii)

Figure.7: The performance analysis of (i) the disturbed signal, (ii) feature extracted signal and (iii) Injected voltage

In this voltage spike is affected in 0.03-0.07 sec and 0.10-0.14 sec in that time the PQ is less in the grid. To improve the PQ the proposed algorithm controls the voltage of the grid by utilized the injected voltage by identify the PQ events using the MWT.

4.1.4. Unbalance Voltage

The Unbalance voltage interrupted signal and corresponding low and high level components and the injected voltage are illustrated in figure 8. In which the injected voltage is used for gathering the adequate voltage to improve the power quality using the proposed algorithms.



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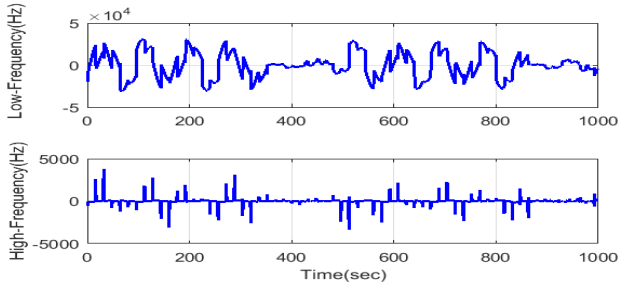

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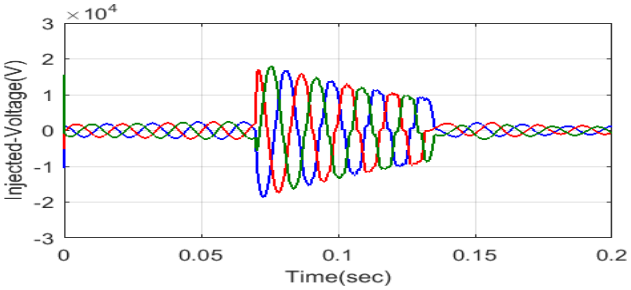


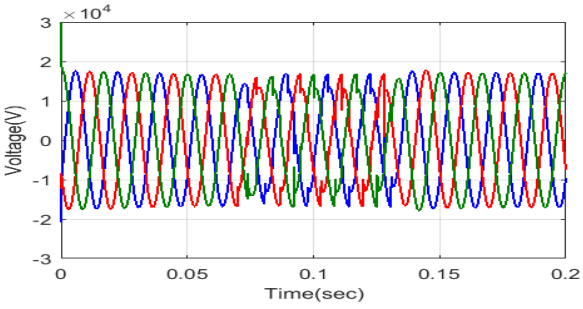
(c)

Figure.8: The performance analysis of (a) harmonic affected signal, (b) feature extracted signal and (c) Injected voltage

In this system the process is evaluated in 0.07-0.14 time seconds, that time the voltage has different amplitude and different angles. Then the voltage notching response is analyzed in the next section.

4.1.5. Voltage notching

The Voltage notching interrupted signal and corresponding low and high level components and the injected voltage are illustrated in figure 9. In which the injected voltage is used for gathering the adequate voltage to improve the power quality using the proposed algorithms.



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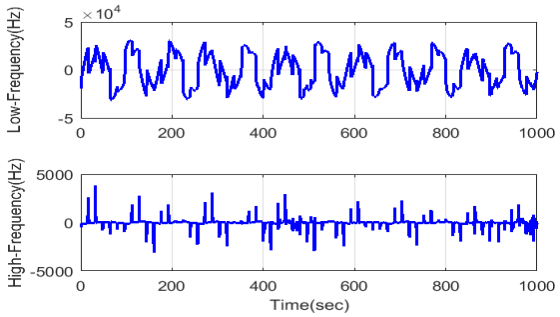

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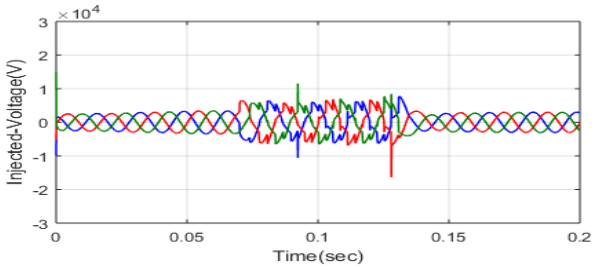


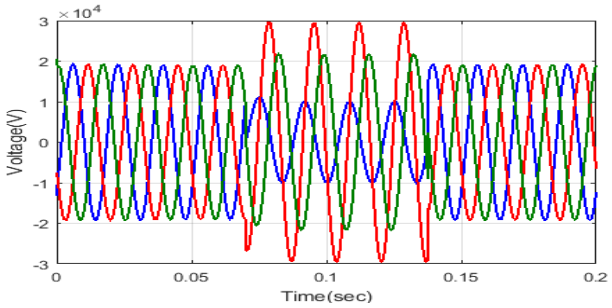
(iii)

Figure.9: The performance analysis of (i) harmonic affected signal, (ii) feature extracted signal and (iii) Injected voltage

The notching is performed in 0.07-0.14 sec, which can reduced the quality of the power and it controls the grid stability. By using the proposed techniques and the DPFC device can improve the PQ by compensating the output voltage. Finally the voltage fluctuation is presented in the next subsection.

4.1.6. Voltage fluctuation

The Voltage fluctuation interrupted signal and corresponding low and high level components and the injected voltage are illustrated in figure 10. In which the injected voltage is used for gathering the adequate voltage to improve the power quality using the proposed algorithms.



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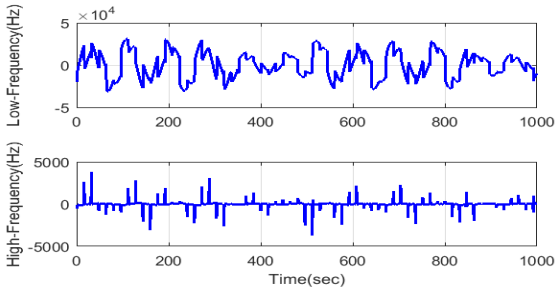

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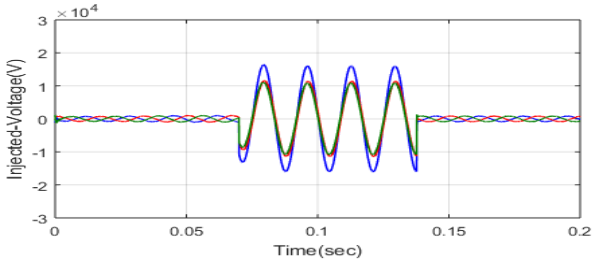

(c)

Figure.10: The performance analysis of (a) harmonic affected signal, (b) feature extracted signal and (c) Injected voltage

In this fluctuations are affected the grid parameters and reduced the performance of the proposed system. Then the proposed system compensates the fluctuated voltage in 0.07-0.14 sec and improves the PQ. The most importance is shared to under voltages.

4.2 Comparison Analysis of the Proposed Techniques

In this section the figure 11 shows the analysis of Proposed system with six PQ issues and compare with some previous techniques..

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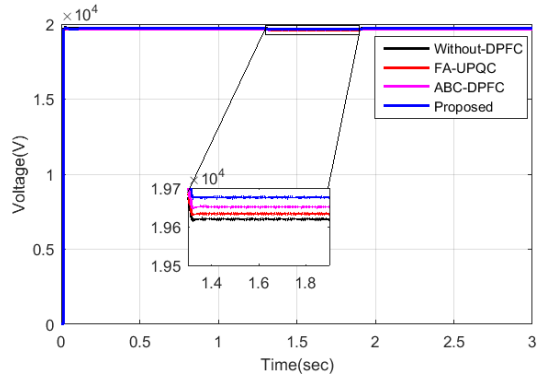

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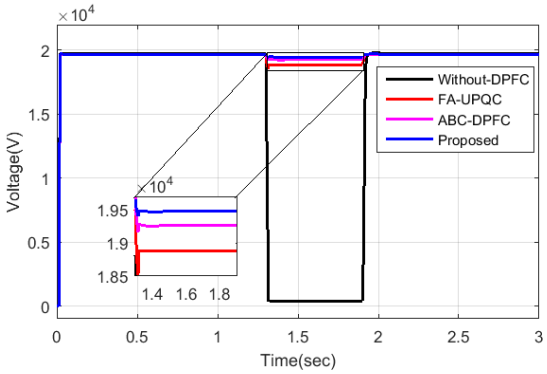

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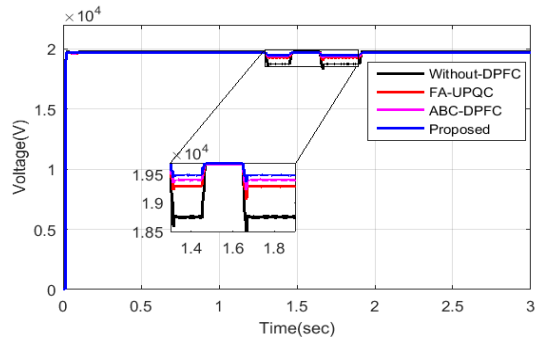

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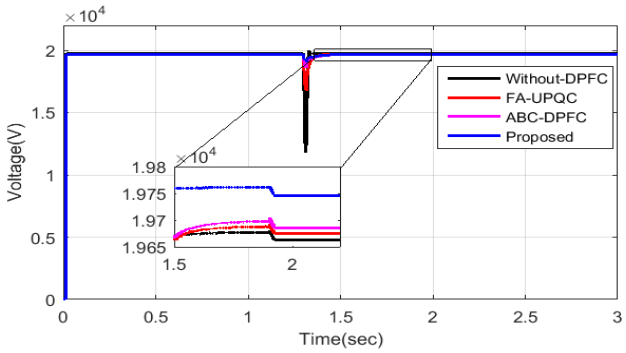

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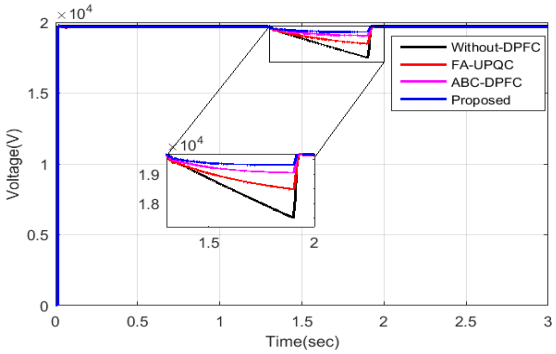

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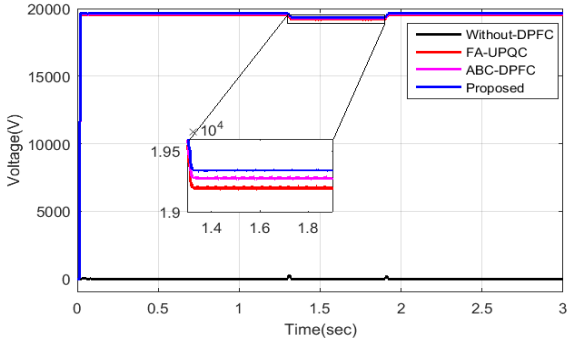

(f)

Fig.11 The comparison analysis (a) Harmonic Distortion, (b) Short Interruption, (c) Voltage spike, (d) Unbalance Voltage, (e) Voltage notching and (f)Voltage fluctuation of the proposed system

CONCLUSION

In this paper the Hybrid algorithm is a merged of Cuttle Fish Algorithm and PSO algorithm for changeable the DC-link voltage of the distributed power flow controller for mtigating the PQ problems. Experimental results have confirmed an improvement in the voltage for the safe operation of the DPFC during the occurrence of the Harmonic Distortion, Short Interruption, Voltage spike ,Unbalance Voltage, Voltage notching and Voltage fluctuation.The viability of the proposed strategy was contrasted and different unsurprising systems, for example, FA-UPFC, Without DPFC and ABC-DPFC utilizing MATLAB/Simulink. From the examination, it has been satisfied that the proposed control system is a great deal productive in improving the DPFC activity of the

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plan than past procedures.

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