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UPQC Implementation of Voltage Sag Mitigation Uses Fruit Fly Optimization

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***Abstract:** This paper provides a novel view of using the UPQC (Unified Quality Power Flow Controller) for voltage sag mitigation using Fruit Fly optimization (FFO) control component designed to compensate Real and Reactive Power for a hybrid system and discuss improved hybrid stability. Detailed analysis of the small-line signal of the hybrid model PV-Wind-battery model is considered for different loading conditions. The FFO algorithm is used to provide excellent performance for varying duty cycles. The simulation results show that UPQC has the ability to improve transmission capabilities and is very useful to use. The voltage is compensated 90% using the UPQC-based FFO algorithm. The proposed system also provides a minimum amount of complete harmonic distortion. The simulation results based on MATLAB / Simulink are supported to support the improved concept.*

***Keywords:** Hybrid System (Photovoltaic (PV), Wind, Battery) UPQC, FFO, Power Quality, Real power and Reactive power Compensation,*

I. INTRODUCTION

A stand-alone hybrid energy system is a small energy system located in a remote location to meet local electricity needs at a specific off-grid location. Usually two or more renewable sources form a hybrid system where the shortage of one source is filled by another [Kratika Yadav Student, 2017]. Of all the sources available, solar and wind energy have become the mainstays in power generation, as they only have a negative impact on the environment. [Belabbas, B et al., 2017; Rashid Al Badwawiet al., 2015]. However, sustainable energy sources have the disadvantage that changes in performance characteristics are very serious, as their performance is highly dependent on climatic conditions, including solar-oriented radiation, wind speed, etc. This article describes the integration of solar wind turbines with its design and control. The combination of PV generation with wind results in the instability of performance characteristics [Di Wu, 2019] For integrated circuits, it is important to maintain the the power transmission.

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To improve the transmission capabilities of the line, several groups of FACTS regulators have studied [B.Ismail et al., 2020]. Of the many controllers of the FACT, the UPFC, provides all the control functions and are considered to be the most powerful, power-efficient device [Abhilash Sen et al, 2020]. Xuhui Shen et al., Proposed a suitable allocation test to improve transmission capacity [Xuhui Shen et al., 2020]. Raghu Thumu et al, examines the combined power control system combined with the continuous power connection of the power control line using elitist control plans [Raghu Thumu li al., 2020]. Vireshkumar Mathad et al., developing Optimal Capacity Building and Creating a UPFC Utilization System. [Vireshkumar Mathad et al., 2020]. For modern solutions with active power factor, corrections can be identified in the form of active for correction (active waveforming) or active filtering. Such a solution is more suitable for eliminating the negative effects of utility loads. If there is a supply voltage error, none can offer adequate compensation [Meirinhos, 2017; Golshannavaz et al., 2018]. Depending on the FACTs, timing solutions emerge. The FACTS converter was modified for the equipment in the distribution network and during the conversion of the integrated circuits [Ikeda et al. 2017]. It is therefore necessary to eliminate the unwanted current and the unconventional current and to compensate for the reactive current. Effective methods must be used to increase the productivity and operation of energy systems. The algorithm for using smart devices has attracted a lot of experts in recent years. Designs have a simple step-by-step approach and research methods are widely used in performance-related issues. PSO (Particle Swarm Optimization) [Shi, YH, 1998], ant colony optimization (ACO) [Dorigo, M, 2004], Artificial bee algorithm (ABC) [Karaboga, D, 2005], Simulated Annealing (SA) algorithm [Kirkpatrick, S, 1983], Bacterial Colony Chemotaxis (BCC) [Li, WW, 2005] and Fruit Fly Optimization algorithm (FOA) [Pan, WT, 2011; Pan, W.T., 2011] around of them. For some other optimization group, Fruit Fly was recently integrated with the algorithm. Wen Tsayo Pan was introduced in 2011 in this algorithm. It follows the behavior of the fruit fly and its simple structure is easy to understand. Fruit fly is much better at finding the best solution compared to other algorithms. The main goal of this proposed approach is to cover Power quality problems in power supply by applying the FFO improvement process in changing the work cycle that provides the best fitness function value. The rest of this article is schematically structured as follows: Section 2 describes the Hybrid System in detail. UPQC mathematical modeling is described in Chapter 3.

Section 4 provides a summary of the proposed Fruit fly optimization methods. Section 5 presents the simulation results and a discussion of the proposed system and Section. 6 completes the overall workflow of the proposed scheme.

II. HYBRID RENEWABLE ENERGY SOURCE

Figure 1 below shows a bank of batteries connected to a hybrid PV and AC Microgrid with a wind system. The system can operate in grid-connected mode or standby mode. Through the DC / AC and AC / DC-DC / AC units, a constant current from each solar PV and wind system is combined and evenly connected, and can be used to power the grid / loads or from a single source only. A battery system that is connected to both converters and also the battery charging condition and discharging condition is only depends on the operating mode. For the stand alone operating mode the RES and betters are acts as a current and power sources, respectively. The RES feed directly to the load and Battery charging or discharging conditions it control the Alternating current. Battery charging power frequency and magnitude is controlled by using the battery converter. MPPT is used to controlled the RES. The same thing can work in variable mode if the battery bank is available as a power source to control the AC powered bus by charging or discharging.

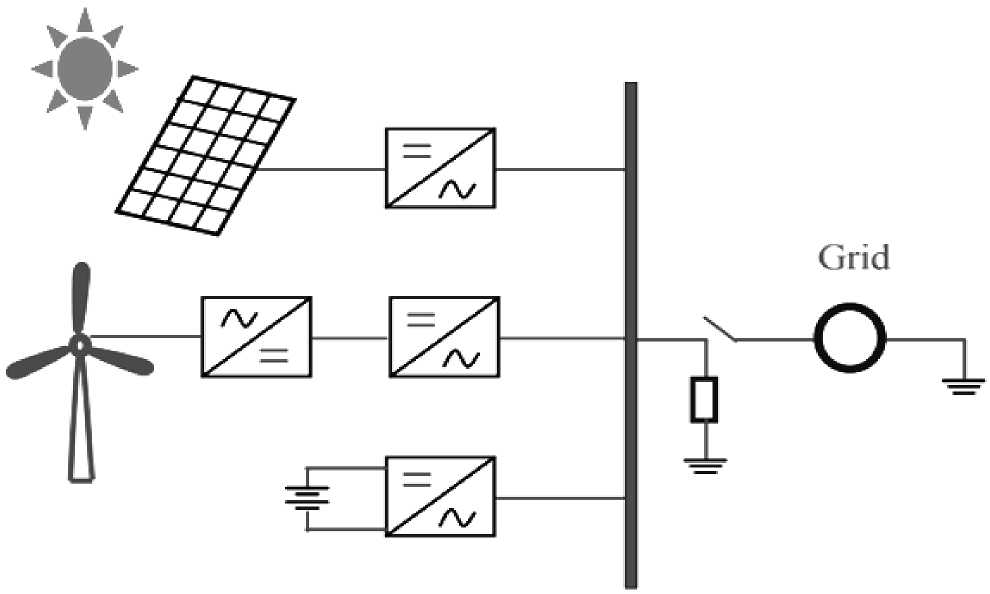

Fig. 1 Hybrid system with AC Microgrid

III. UPQC MATHEMATICAL MODELING

UPQC is a new power quality control tool developed with the same STATCOM and the Static Synchronous Series Compensator (SSSC). Figure 2 shows the UPQC model diagram. [Liangdong Z et al., 1998], where $\dot{U}_1$ and $\dot{U}_2$ are node values in both line spaces where the UPQC is located, and the phase difference between them is θ.

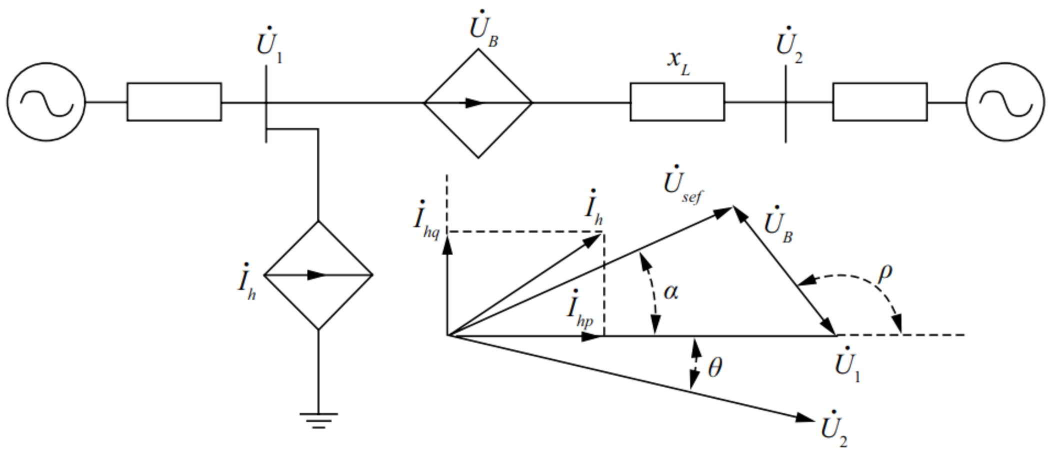

Fig. 2 Model diagram of UPQC

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$\dot{U_B}$ is the series part of the UPQC which is the same as the power supply, U_B is the amplitude and ρ is the phase angle. Therefore the U_B controlled range is [0, U_{Bmax}] and [0, 2π] for ρ.

If U1 is considered to be using reference vector and line power and resistance are not taken into account, the output power line of UPQC

$$P_0 = \frac{U_1 U_2}{x_L} sin\theta \quad (1)$$

$$Q_0 = \frac{{U_2}^2}{x_L} - \frac{U_1 U_2}{x_L} cos\theta \quad (2)$$

If the UPQC is installed in a single line, the voltage at the transmission end becomes $U_{sef}(U_{sef} = U_1 + U_2)$. Meanwhile, line power is

$$P' = \frac{U_{sef} U_2}{x_L} \sin(\theta + \alpha) \quad (3)$$

$$Q' = \frac{{U_2}^2}{x_L} - \frac{U_{sef} U_2}{x_L} cos(\theta + \alpha) \quad (4)$$

For the same UPQC, the partial model is the current source is $\dot{I_h}$). The reference vector is $\dot{U_1}$ $\dot{I_h}$ can be divided into $\dot{I_{hp}}$ and $\dot{I_{hq}}$. $\dot{I_{hp}}$ is the active current and $\dot{I_{hq}}$ is reactive current. The active and reactive power injected into the system is denoted as $I_{hq} > 0$. $I_{hp} < 0$ denotes the active and reactive power absorbs from the system [Chen G, 2004].

IV. FRUIT FLY OPTIMIZATION (FFO)

The Fruit Fly Optimization (FFO) algorithm is a new instruction that solves the problem of flying fruit in the search for the best of the target function. An illustration of the fruit flies is shown in Figure 1.

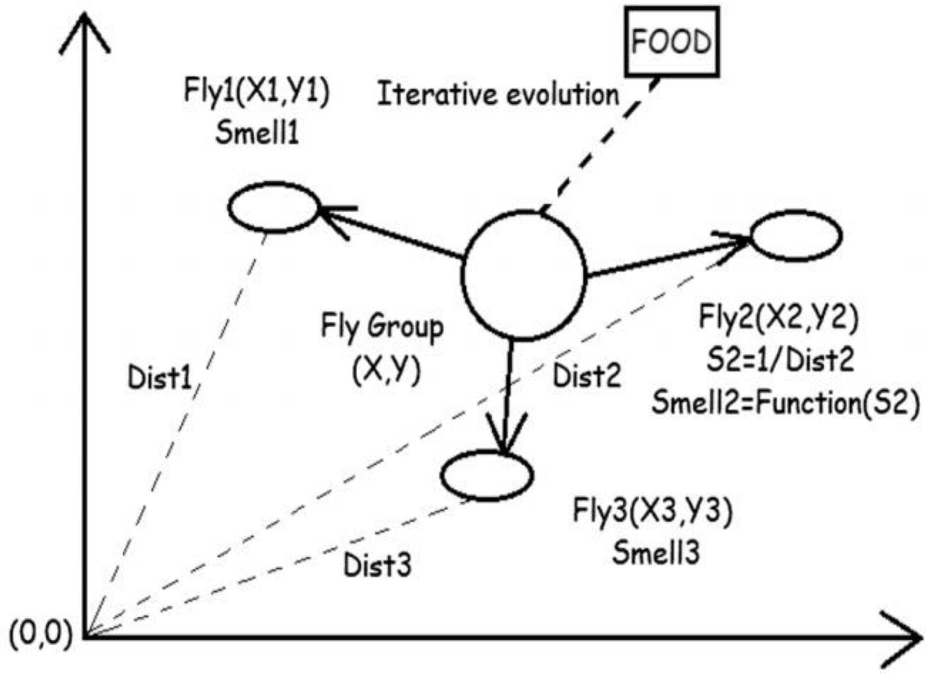

Fig:3 Illustration of the FFO algorithm

The key steps are as follows [Hassan Z et al., 2019]:

Step 1: start the parameter initialization. Set up Sizepop and Maxgen among the larger ones polpulation, and start before the older one's populations:

$$X_{axis}, Y_{axis} \quad (5)$$

Step 2: Fly to explore the olfactory system, which can generate search information and locate steps. Random value (RV) will be a multi-factor search, and people can update simultaneously:

$$\begin{cases} X_i = X_{axis} + RV \\ Y_i = Y_{axis} + RV \end{cases} \quad (6)$$

Step 3: Since the exact location of the food is not known, it is necessary to calculate the taste parameter (Si) by calculating the distance ($Dist_i$) between the fruit flies and the origin of the attachment:

$$Dist_i = \sqrt{{X_i}^2 + {Y_i}^2} \quad (7)$$

$$S_i = \frac{1}{Dist_i} \quad (8)$$

Step 4: instead of fruit flies favor concentration value (Si) in the performance of taste decision, hard work, then we will get each taste of fruit flies $Smell_i$.

$$Smell_i = Fitness(S_i) \quad (9)$$

Step 5: identify the person with the most experience of kindness to the people of drosophila.

$$[bestSmell, bestIndex] = \min(Smell) \quad (10)$$

Step 6: Keep better concentration and direct, and others in the community will fly to this level:

$$bestSmell = bestIndex \quad (11)$$

$$\begin{cases} X_{axis} = X(bestIndex) \\ Y_{axis} = Y(bestIndex) \end{cases} \quad (12)$$

Step 7: To check the this level is better than The level of dismissal, to determine whether the appointment is better than the previous generation, and to achieve a greater number of repetitions; Otherwise, skip step 2 to re-enter the settings.

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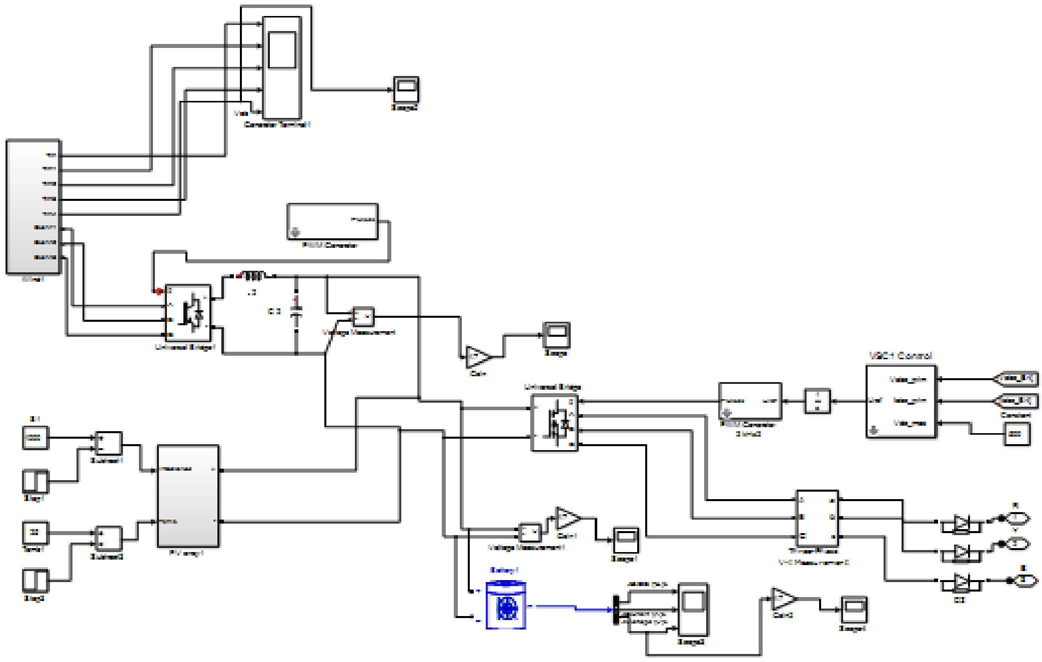
A. Implementation of UPQC Using FFO

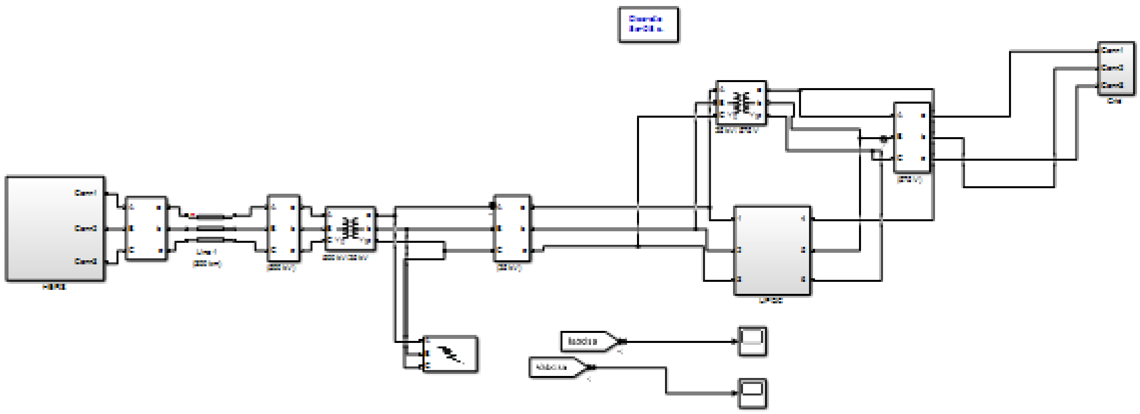
FFO begins with the search for fruit flies in the olfactory system, which can approximate search direction and search and operate on the continuous operations of fruit flies in nature to find the optimal solution of the objective function. As a result, he found the best values of scent concentrations and the coordinates of other people in the population. By following the steps outlined in the above procedure. The FFO algorithm is written in the simulation and its output is directly connected to the UPQC controller, which leads to reactive power compensation.

V. SIMULATION RESULTS AND DISCUSSION

The proposed model includes a hybrid WT (wind turbine), a photovoltaic module and a battery system connected to an UPQC controller. All models of the system can be shown in Figure 4. Algorithm Evaluate the effectiveness of the method implemented in Matlab Simulinks. The dip voltages in the network are entered at different times. Since many types of dip voltage can affect the grid, all faults must be investigated for accurate monitoring tools. That’s why it’s so important to identify them all. In this paper, firstly, to quickly identify the function of the mode (healthy or incorrect), and secondly, to improve the identification phase to minimize incorrect positions resulting from unknown noise and input. The new FFO algorithm is proposed as a solution.



(a)



(b)

Fig: 4 Simulink representation of the proposed system (a) Subsystem of Hybrid Renewable Energy Storage system (b) overall system

At T = 0.22, the solar radiation begins to decrease as shown in Figure 5, while the solar output voltage is shown in Figure 6. At about t = 0.28 seconds, the wind power plant is put into operation and takes control of the load voltage supply and battery charging. The wind system shuts down for about 0.35 seconds and the battery will run out again until solar energy starts to function. After t = 0.39 seconds, solar radiation begins to form so that the sun lights up again. Figure 7 Wind system output voltages. The active power and reactive power at load terminals with the UPQC and UPQC based FFO algorithms are shown in Figure 10 and Figure 11, respectively.

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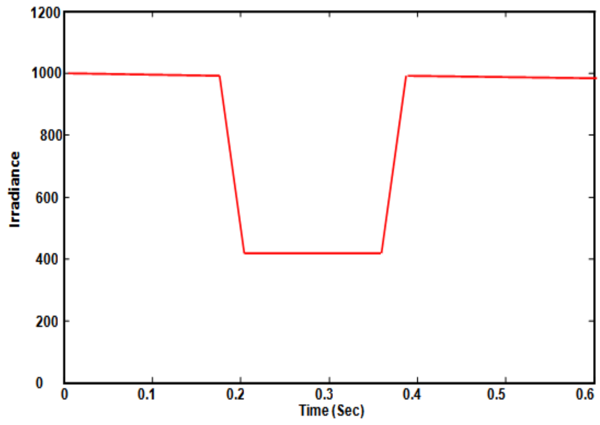

Fig: 5 Solar Irradiance Curve

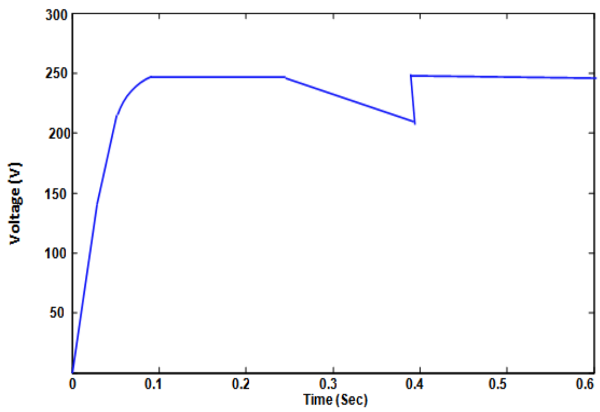

Fig: 6 Solar output voltage

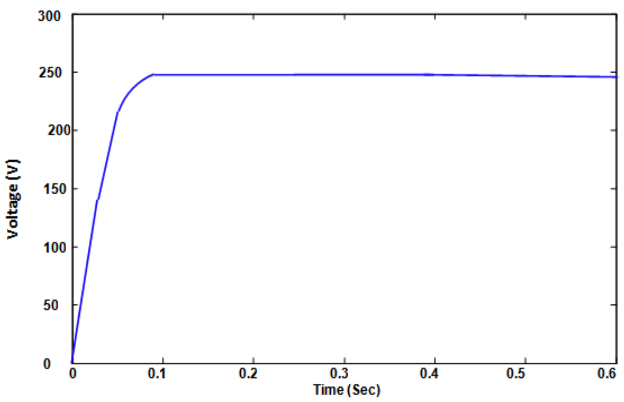

Fig: 7 Wind output voltages

The dip voltage is fed between 0.04 seconds and 0.1 seconds. Figure 8 and Figure 9 shows voltage indicators behaviors using UPQC and UPQC based Fruit Fly Optimization Algorithm this is similar to the three-phase fault. Signals of three amplitudes decrease in equal time intervals. For angles, the signals (φ_a, φ_b, and φ_c) are 0.2π / 3, 2π / 3. The voltage is compensated 90% using the UPQC-based FFO algorithm shown in Figure 9. Actual and reactive performance is also compensated. The actual power compensation uses the UPQC and UPQC based FFO algorithms which are shown in Figures 10 and 11, respectively. The reactive power compensation uses the UPQC and UPQC based FFO algorithms which are shown in Figures 12 and 13, respectively.

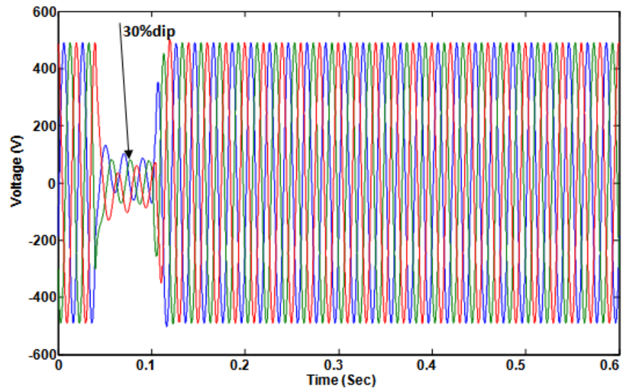

Fig: 8 Output representation of voltage dip using UPQC

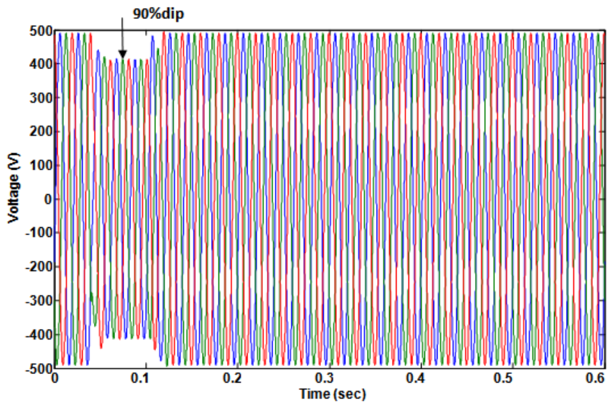

Fig: 9 Output representation of voltage dip using UPQC based FFO algorithm

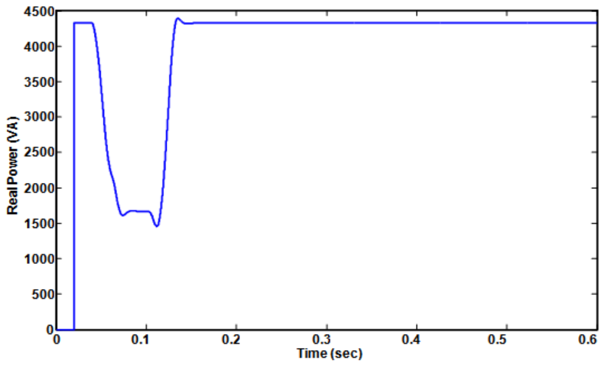

Fig:10 Real Power using UPQC

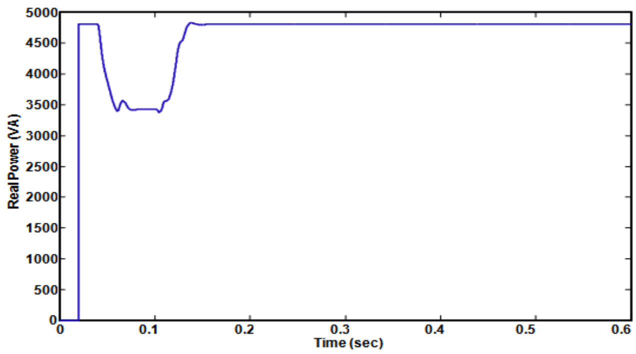

Fig:11 Real Power using UPQC based FFO algorithm

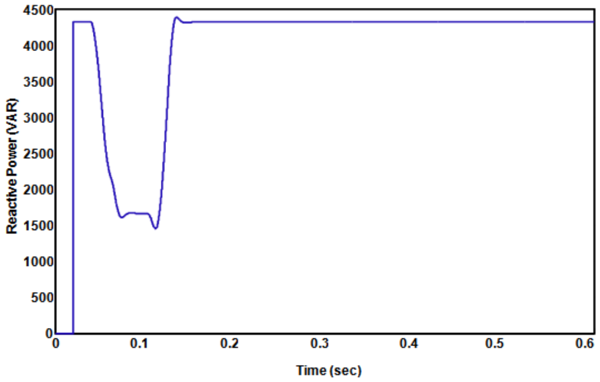

Fig: 12 Reactive Power using UPQC

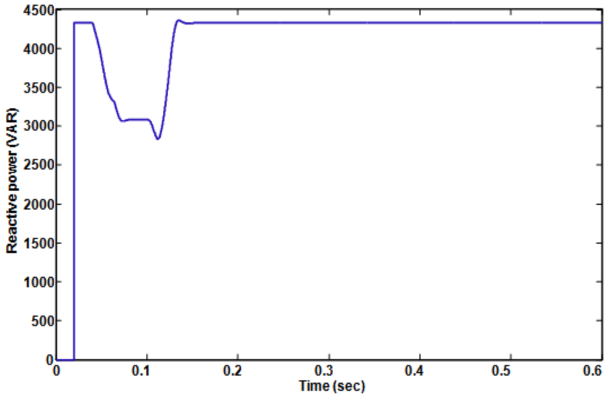

Fig: 13 Reactive Power using UPQC based FFO algorithm

Table 1 shows the parameter evaluation. The three phase voltage is 415V. Voltage sag for using UPQC is 150V (30%sag) and using FFO algorithm is 398V (90%sag) Table 2 shows a comparison of the efficiency of the proposed and existing techniques. The proposed UPQC based Fruit Fly Optimization algorithm shows the 99.3% better than other existing PSO (particle swarm optimization) (96.2%), CS (Cuckoo search) algorithm (97.8%), Grey wolf algorithm (GWO) (98.8%).

Table 1: Parameter evaluation

Three phase voltage	415V
UPQC Sag voltage	150V (30%sag) of 415V
UPQC based FFO algorithm Sag Voltage	398V(90%sag) of 415V
Real power	4800VA
Reactive Power	4300VAR

Table 2: Comparison of the proposed technique with the existing techniques

Optimization Algorithm	Efficiency (%)
PSO[Jaiswalet al., 2018]	96.2
CS [Radhika, A, 2020]	97.8
GWO [Narayan Nahak et al, 2018]	98.8
FFO (proposed)	99.3

VI. CONCLUSION

As can be seen from the simulation results of grid-connected hybrid power, the charging power can be provided by renewable energy sources when the grid can not be supplied and Extra power can be stored in the battery. The use of UPQC increases the time it takes to transition from the grid to renewable energy and vice versa manages energy transfer. The results suggest that UPQC can play an important role in improving the quality of the vision connected to existing lines to ensure that the electrical conductivity does not exceed the limit by injection / absorb the reactive energy to the system faster. It also reduces the voltage dip and current in the system in the event of a fault. The UPQC algorithm based on FFO gives better results compared to UPQC. The voltage is compensated 90% using the UPQC-based FFO algorithm

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2. Power Quality Improvement By Using Upqc In Transmission System-International Conference On Recent Scientific Research In Engineering And Technology,March 22nd 2019, John Cox Memorial CSI Institute of Technology, Kannammoola, Medical College P.O Thiruvananthapuram- 695011, Kerala

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Convener KTU Syllabus revision Commitee (EEE)
Profesor in Charge (CERD)
Reviewer:
Reviewer for IJEPES Elsevier Journal (Certified as outstanding reviewer)
Reviewer for IEI series B Journal
Membership of Professional Bodies:
IEEE member for 13 years
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Important Publications:
1. Anishkumar A. R., P. Sreejaya "Switching logic for converting off-grid PV customers to on-grid by utilizing off grid inverter and battery", Journal of Institution of Engineers (India) Series B - Online DOI 10.1007/s40031-016-0240-x
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