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HARMONIC SUPPRESSION IN A SYSTEM USING UNIFIED POWER QUALITY CONDITIONER (UPQC) BY CUCKOO SEARCH ALGORITHM

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Abstract-This project presents a phase angle controlled three phase topology of a unified power quality conditioner. The phase angle shifting of the load voltage required to mitigate a given value of voltage sag is determined and the same is used during a healthy operating condition in order to provide the reactive power compensation of a distribution network. The current drained by non-linear loads has a high harmonic current, distorting the voltage at the utility grid and affecting the operation of critical loads. The Shunt Active Filter (PAF) is controlled as a non sinusoidal current source which is used for compensating the harmonic current of the load. While the Series Active Filter (SAF) is controlled as a non sinusoidal voltage source which is used for compensating the grid voltage. The Cuckoo Search algorithm for radial distributed system is suitably modified to incorporate the UPQC model. The result are verified by using MATLAB/Simulink platform.

Keywords – MATLAB Simulink, UPQC, Cuckoo Search Algorithm

I.INTRODUCTION

UPQC has been widely studied in order to improve universal power quality by many researchers. The function of UPQC is to mitigate the disturbance that affects the performance of the critical load. The UPQC, which has two inverters that share one dc link capacitor, can compensate the voltage sag and swell, the harmonic current and voltage, and control the power flow and voltage stability. However, the UPQC cannot compensate for the voltage interruption because it has no energy storage in the dc link. Unified Power Quality Conditioner (UPQC) is a versatile custom power device which consists of two inverters connected back-to back and deals with both load current and supply voltage imperfections. UPQC can simultaneously perform as shunt and series active power filters.

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The usage of power quality conditioners in the distribution system network has increased during the past years due to the steady increase of nonlinear loads connected to the electrical grid. The current drained by nonlinear loads has a high harmonic content, distorting the voltage at the utility grid and consequently affecting the operation of critical loads .By using a unified power quality conditioner (UPQC) it is possible to ensure a regulated voltage for the loads, balanced and with low harmonic distortion and at the same time draining undistorted currents from the utility grid, even if the grid voltage and the load current have harmonic contents. The UPQC consists of two active filters, the series active filter (SAF) and the shunt or parallel active filter (PAF). The PAF is usually controlled as a non sinusoidal current source, which is responsible for compensating the harmonic current of the load, while the SAF is controlled as a non sinusoidal voltage source, which is responsible for compensating the grid voltage. Both of them have a control reference with harmonic contents, and usually, these references might be obtained through complex method. Some works show a control technique to both shunt and SAFs which uses sinusoidal references without the need of harmonic extraction, in order to decrease the complexity of the reference generation of the UPQC. This conditioner consists of two single-phase current source inverters where the SAF is controlled by a current loop and the PAF is controlled by a voltage loop. In this way, both grid current and load voltage are sinusoidal, and therefore, their references are also sinusoidal. The proposed control scheme is developed in ABC reference frame and allows the use of classical control theory without the need for coordinate transformers and digital control implementation. The references to both SAF and PAFs are sinusoidal, dispensing the harmonic extraction of the grid current and load voltage.

II.UNIFIED POWER QUALITY CONITIONER

Unified power-quality conditioner (UPQC) systems were widely studied by many researchers as an eventual method to improve the PQ in electrical distribution systems. The term "power quality" (PQ) has gained significant attention in the past few years. The advancement in the semiconductor device technology has made it possible to realize most of the power electronics based devices/prototypes at commercial platform. As a rule of thumb in all areas of engineering, the proper utilization of the resources that we have in the most efficient way has lead to great development and is the major concern for most engineers in their respective fields. The function of UPQC is to mitigate the disturbance that affects the performance of the critical load. Reactive power compensation is one of the common yet very important issues for power system engineers at transmission as well as at distribution level. It is a well-known fact that a typical distribution network consist of distribution transformer, motor loads, etc., demands reactive power. This load-reactive power demand level is mainly affected by the type of loads present on the network. The capacitor banks have been used to compensate the load-reactive power demand. It is the Simplest and under certain conditions, is a very effective way to compensate the load-reactive power demand. This traditional way has certain major disadvantages, such as fixed compensation, possible Occurrence of resonance condition with nearby loads, switching transient, bulky size, aging effect. The series active power filter is provided the voltage compensation. It generates the compensation voltage that synthesized by the PWM converter and inserted in series with the supply voltage, to force the voltage of PCC to become sinusoidal and balanced. The voltage in d axes consists of average and oscillating components of source voltages. The average voltage is calculated by using second order LPF (low pass filter).The load side reference voltages are calculated. The switching signals are assessed by comparing reference voltages and the load voltages. The shunt active power filter is provided the current and the reactive power if the system need compensation. It acts as a controlled current generator that compensated the load current to force the source currents drained from the network to be sinusoidal, balanced and in phase with the positive-sequence system voltages. The conventional SRF method can be used to extract the harmonics contained in the supply voltages or currents. For current harmonic compensation, the distorted currents are first transferred into two-phase stationary coordinates using p-q transformation.

III.CUCKOO SEARCH ALGORITHM

A new approach to solving the issue of optimization planning for UPQC has been presented by using Cuckoo Search Algorithm. Results of testing this paper indicate that not only this algorithm includes all limits of issue well, but it has also the benefits all such as the most appropriate convergence in the response, high computational speed and high accuracy. More and more modern heuristic algorithms inspired by nature are emerging and they become increasingly popular. For working out all power quality associated problems, unified power quality conditioner (UPQC) is one of the most well-known devices that are used.

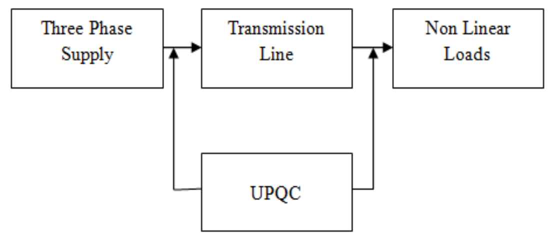

Fig 2.1 Block diagram of UPQC

Once the first cuckoo chick is hatched, the first instinct action it will take is to evict the host eggs by blindly propelling the eggs out of the nest, which increases the cuckoo chick's share of food provided by its host bird. This algorithm is based on the obligate brood parasitic behavior of some cuckoo species in combination with the L´evy flight behavior of some birds and fruit flies. This paper presents, cuckoo search algorithm (CSA) is used to improve the performance of unified power quality conditioner (UPQC) for voltage sag mitigation. CSA is an optimization algorithm which inspired by the obligate brood parasitism of some cuckoo species by laying their eggs in the nests of other host birds.

Cuckoo are fascinating birds, not only because of the beautiful sounds they can make, but also because of their aggressive reproduction strategy. Some species such as the ani *and* Guira cuckoos lay their eggs in communal nests , though they may remove others' eggs to increase the hatching probability of their own eggs. Quite a number of species engage the obligate brood parasitism by laying their eggs in the nests of other host birds (often other species).There are three basic types of brood parasitism: intra specific brood parasites, cooperative breeding, and nest takeover based on the interesting breeding behavior such as brood parasitism of certain species of cuckoos. We will first introduce the breeding behavior of cuckoos and the characteristics of Levy flights of some birds and fruit flies, and then formulate the new CS, followed by its implementation. Finally, we will compare the proposed search strategy with other popular optimization algorithms and discuss our findings and their implications for various optimization problems.

A. Flow Chart Of Cuckoo Search Algorithm

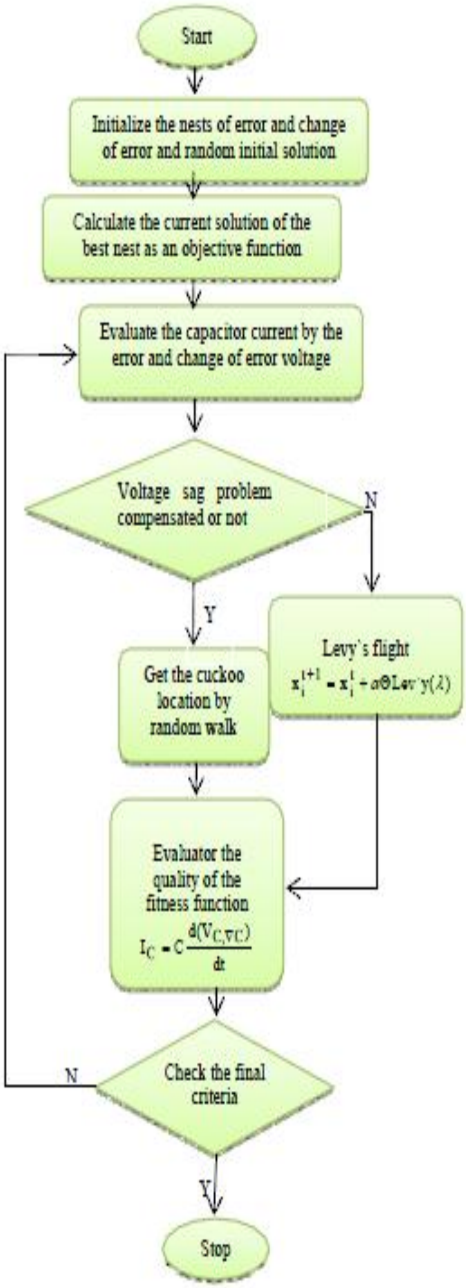

Fig.3.1 Flow Chart of Cuckoo Search Algorithm

B. Validation and Parameter Studies

After implementation, we have to validate the algorithm using test functions with analytical or known solutions. For example, one of the many test functions we have used is the bivariate Michaelwicz function

$f(x, y) = -\sin(x)\ \sin2m(x2\_) - \sin(y)\ \sin2m(2y2\_)$,

where m = 10 and (x, y) 2 [0, 5] × [0, 5].

This function has a global minimum $f_* = -1.8013$ at (2.20319, 1.57049). The landscape of this function is shown . This global optimum can easily be found using Cuckoo Search, and the results are shown where the final locations of the nests are also marked with _· in the figure. Here we have used n = 15 nests and pa = 0.25. In most of our simulations, we have used n = 15 to 50. From the figure, we can see that, as the optimum is approaching, most nests aggregate towards the global optimum. We also notice that the nests are also distributed at different (local) optima in the case of multimodal functions. This means that CS can find all the optima simultaneously if the number of nests are much higher than the number of local optima. This advantage may become more significant when dealing with multimodal and multi objective optimization. We have also tried to vary the number of host nests (or the population size n) and the probability pa. We have used n = 5, 10, 15, 20, 50, 100, 150, 250, 500 and pa = 0, 0.01, 0.05, 0.1, 0.15, 0.2, 0.25, 0.4, 0.5. From our simulations, we found that n = 15 and pa = 0.25 are sufficient for most optimization problems. Results and analysis also imply that the convergence rate, to some extent, is not sensitive to the parameters used. This means that the fine adjustment is not needed for any given problems. Therefore, we will use fixed n = 15 and pa = 0.25 in the rest of the simulations, especially for the comparison studies presented in the next section.

C. Test Functions

There are many benchmark test functions in literature and they are designed to test the performance of optimization algorithms. Any new optimization algorithm should also be validated and tested against these benchmark functions. In our simulations, we have used the following test functions.

De Jong's first function is essentially a sphere function

$f(x) = \sum_{i=1}^{d} x^2 i$, $\quad x_i \in [-5.12, 5.12]$, (3.1)

whose global minimum $f_* = 0$ occurs at $x_* = (0, 0, ..., 0)$. Here d is the dimension.

Easom's test function is unimodal

$f(x, y) = -\cos(x)\cos(y)\exp[-(x - \pi)2 - (y - \pi)2]$,

where $(x, y) \in [-100, 100] \times [-100, 100]$.
It has a global minimum of $f_* = -1$ at (π, π) in a very small region.
Shubert's bivariate function
$f(x, y) = -\sum_{n=1}^{5} i\cos[(i+1)x+1] \sum_{i=1}^{5} \cos[(i+1)y+1]$,
has 18 global minima in the region $(x, y) \in [-10, 10] \times [-10, 10]$.
The value of its global minima is $f_* = -186.7309$.
Griewangk's test function has many local minima
$f(x) = 1/4000 \sum_{i=1}^{d} x_i^2 - \prod_{i=1}^{d} \cos(x_i/\sqrt{i}) + 1$, (3.2)
Ackley's function is multimodal
$f(x) = -20 \exp[-0.2 \frac{\sqrt{1}}{d} \sum_{i=1}^{d} x_i^2$ (3.3)
$\exp[1/d \sum_{i=1}^{d} \cos(2\pi x_i)] + (20 + e)$,
with a global minimum $f^* = 0$ at $x^* = (0, 0, ..., 0)$
in the range of $-32.768 \leq x_i \leq 32.768$ where i =1, 2, ..., d
The generalized Rosenbrock's function is given by
$f(x) = \sum_{i=1}^{d-1} [(1-x_i)^2 + 100(x_{i+1} - x_i^2)^2]$ (3.4)
which has a minimum $f(x^*) = 0$ at $x^* = (1, 1, ..., 1)$.
Schwefel's test function is also multimodal
$f(x) = \sum_{i=1}^{d} [-x_i \sin(\sqrt{|x_i|})]$ $-500 \leq x_i \leq 500$, (3.5)
with a global minimum of $f^* = -418.9829d$ at $x^*_i = 420.9687 (i = 1, 2,.d)$.
Rastrigin's test function
$f(x) = 10d + \sum_{i=1}^{d} [x_i^2 - 10\cos(2\pi x_i)$ (3.6)
has a global minimum $f^* = 0$ at $(0, 0, ..., 0)$ in a hypercube $-5.12 \leq x_i \leq 5.12$
where i = 1, 2, ..., d.
Michalewicz's test function has d! local optima
$f(x) = -\sum_{i=1}^{d} \sin(x_i) [\sin(i x_i^2)/\pi]^{2m}$, (m=10) (3.7)
where $0 \leq x_i \leq \pi$ and i = 1, 2, ..., d.
The global minimum is $f^* = -1.801$ for d = 2, while $f^* = -4.6877$ for d =5

IV.SIMULATION DIAGRAM

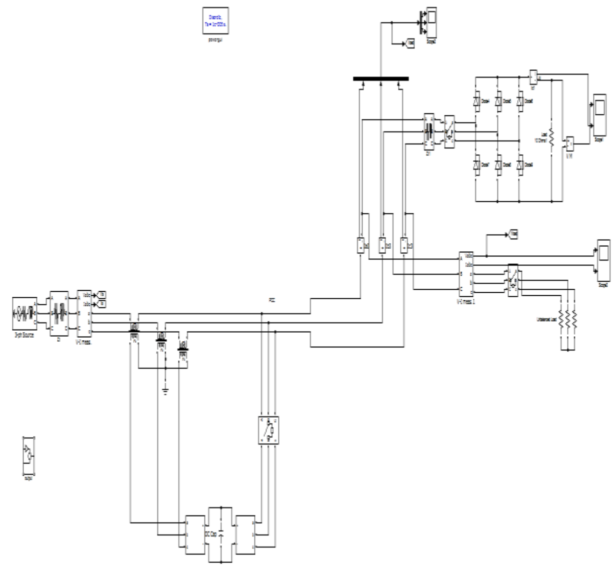

Fig.4.1 Simulation circuit of UPQC

The UPQC Simulation diagram is shown up and it has series active filter and shunt active filter and for the both the pulse is given by the Cuckoo Search algorithm.

A. Load Current

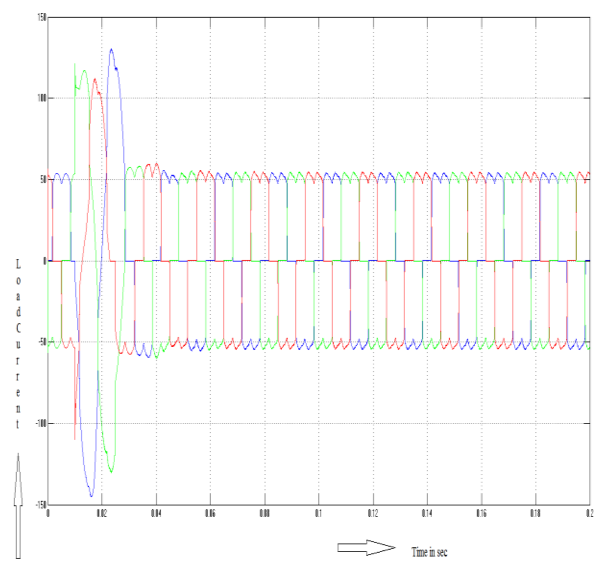

Fig.4.2 Waveform of Load Current

The load current is taken from the non-linear load which is the actual load current taken from the load.

B. Reference Current

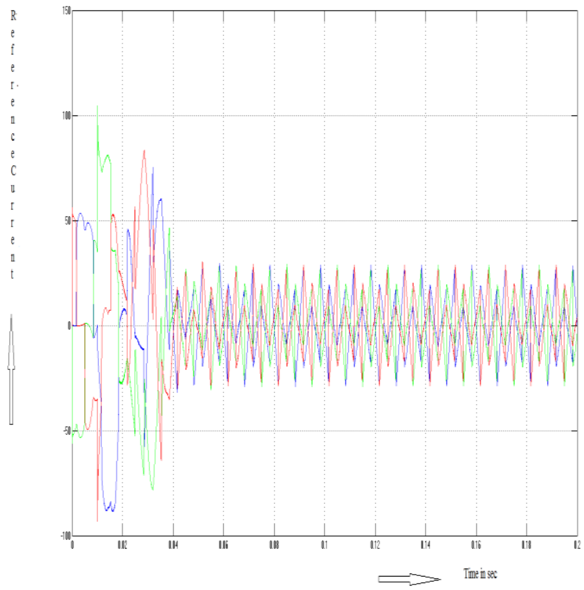

Fig.4.3 Waveform of Reference Current

B. Compensated Current

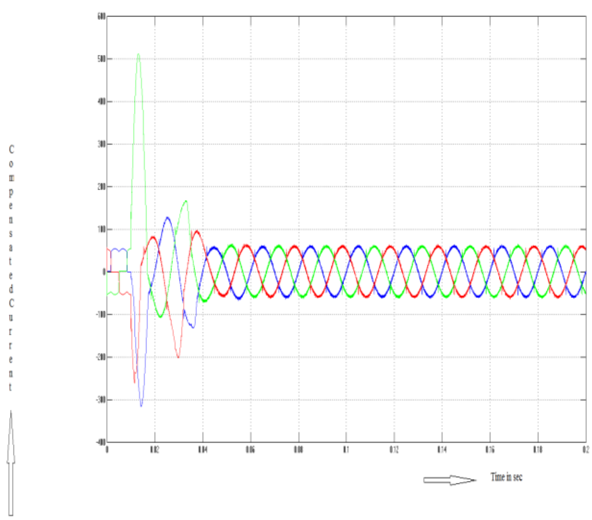

Fig.4.4 Waveform of Output Current

The load current and the reference current which is used to get the output and the both waveform gets matched and gives the output.

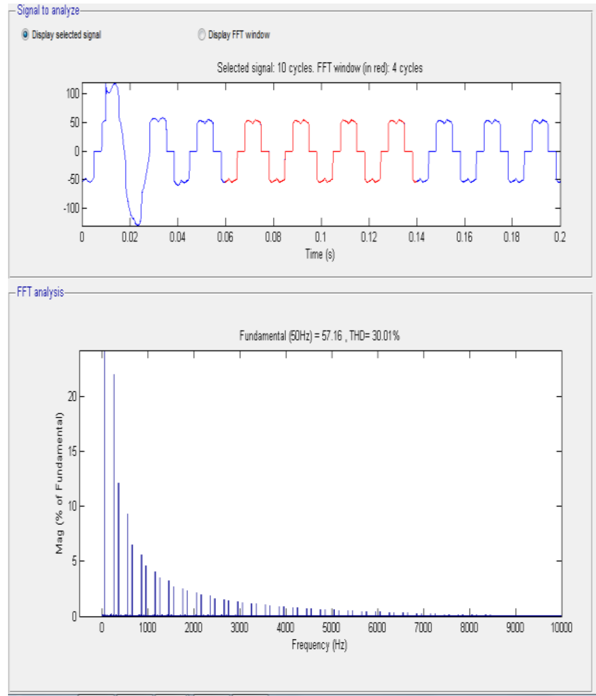

Fig.4.5 THD value of Load Current

The above figure shows the THD value of the Cuckoo Search algorithm by using the R-Load before compensation the FFT tools is to find the THD value.

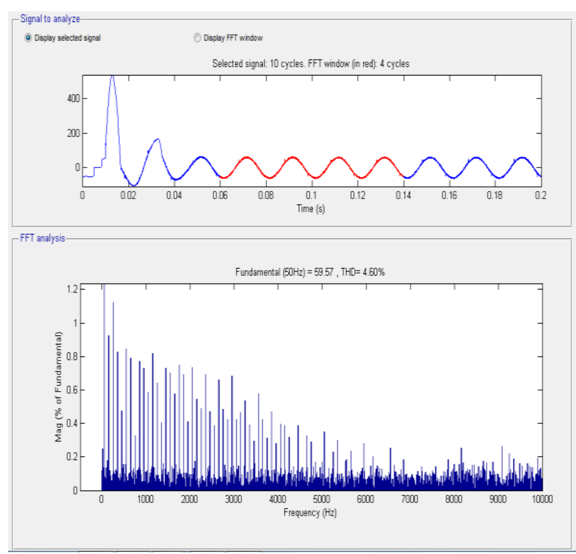

Fig.4.6 THD value of Output Current

The above figure shows the THD value of the Cuckoo Search algorithm by using R-Load after compensation and the FFT tools is used to find the THD value.

V. COMPARISON OF RESULT

S.NO	LOADS	BEFORE COMPENSATION THD (%)	AFTER COMPENSATION THD (%)
UPQC By Cuckoo Search Algorithm	R LOAD	30.01	4.60
	RL LOAD	30.05	4.34

VI. CONCLUSION

In this paper, we have formulated a new meta-heuristic Cuckoo Search Algorithm, based on the breeding behavior such as brood parasitism of certain species of cuckoos. The proposed algorithm has been validated and compared with load flow algorithm. The Cuckoo Search algorithm is implemented in UPQC and it is used to reduce the harmonic current in the output. Simulations and comparison show that CS is superior than the load flow algorithms. Subsequently, CS is more generic and robust for many optimization problems, comparing with other meta-heuristic algorithms. This potentially powerful optimization strategy can easily be extended to study multi objective optimization applications with various constraints . This algorithm easily complies with the constraints and has a good performance in the response in terms of convergence and also has the high accuracy.

VI. FURTHER ENHANCEMENTS

We can change the control algorithm and analyse the THD value in the output and just compare the result.

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BIOGRAPHIE

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