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Using Particle Swarm Optimization with Constriction Factor for Optimization of Parameters of the Unified Power Quality Conditioner

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Abstract: Optimizing Unified Power Quality Conditioner parameters (UPQC) and it's illustrated curve, using Particle Swarm Optimization method are presented In this paper. Active shunt filter is selected by harmonic current rates while selecting active series filter is based on voltage. Total impedance of non load system shows capability of producing resonance. To defeat resonance problems and increasing of bandwidth, PSO method is used. Simulated outcome using mentioned suggested method is represented and compared with genetic algorithm.

Key words: UPQC; THD; Active shunt filter; Particle Swarm Optimization,

INTRODUCTION

Power industry has witnessed significant developments in communication and control infrastructures. This evolution is due to three main factors:

1- Orientations toward regulated industry
2- Efficiency cost Betterment or energy resources pollution reduction that is competitive with power generating traditional resources.
3- Continuous power supply and integrating information technology in almost all aspects of our daily life that requires a reliable advanced power quality which is fed via available power network.

In this context, with technology improvement of electronic devices, some useful solutions including UPQC are used. This includes combined active shunt and series filters compensate voltage and current simultaneously. Not only UPQC compensates harmonic currents but also can balance a non-linear load. Also voltage harmonics and unbalanced power supply, have bad effects on loads that are sensitive to harmonics (Benachaiba C., et al. 2007) Also traditional energy devices such as static voltage restorer DVR which improve power quality, static compensator DSTATCOM that compensate unbalanced current and nonlinear unbalanced loads and SVC combination with DSTATCOM which supply reactive power simultaneously and as a result, load current is compensated (Fujita, H.& Akagi, H. 1998).

The aim is to improve UPQC performance considering frequency changes. To achieve that, a new method based on PSO algorithm is represented and via that, optimized parameters determination and consequently, system optimal operation point is obtained. A unit gain wide band pass with ratio of compensator voltage on voltage and voltage compensator, via series PWM converter and total no load non-resonant impedance is produced. PSO method given results are compared with the other methods using Repetitive calculations under specific conditions with optimal parameters searching that satisfy all constrains.

Power circuit parameters:

UPQC equivalent circuit is shown in figure below. PWM converters exist in both, initial and secondary side. Parameters in this analysis are: UPQC shunt and series transformer ratio, reactor convertor L_f, L_s. High pass filter. C_f, R_f For shunt active filter. C_s, R_s Series active filter.

UPQC shunt and series transformer ratio remains constant and for a series single phase transformer 1 to 2 and for either for the 2 to 1 three-phase transformer. PWM shunt converter is modeled as current source while harmonic generating load is modeled as general current.

Equivalent network inductance L_n is 80 mlH. In respect of high pass filter configuration shunt PWM converter impedance is passed on the initial side.

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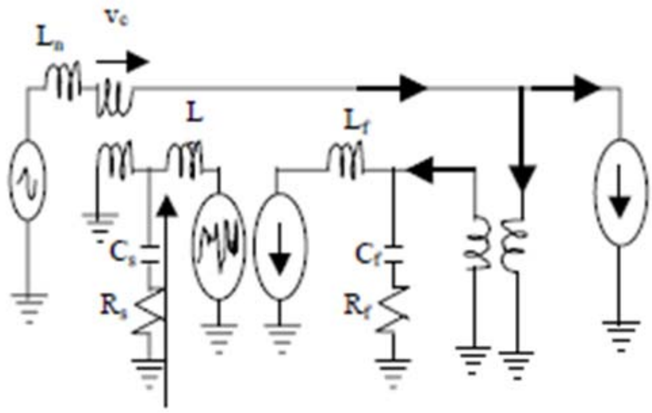

Fig 1: UPQC principle in single device

$$Z_{1f} = \left(\frac{2}{1}\right)^2 \left(R_f + \frac{1}{j\omega C_f}\right) \tag{1}$$

Series Z_{1f} with network series reactor impedance is on the secondary side of the single phase transformer.

$$Z_{2ns} = \left(\frac{2}{1}\right)^2 (Z_{1f} + j\omega L_n) \tag{2}$$

Parallel Z_{2ns} with PWM converter series high pass filter is given

$$Z_{11s} = \frac{Z_{2ns}(R_s + \frac{1}{j\omega C_s})}{Z_{2ns} + (R_s + \frac{1}{j\omega C_s})} \tag{3}$$

The ratio of V_1 to V_2 is as following :

$$\frac{V_1}{V_2} = \frac{Z_{11s}}{Z_{11s} + j\omega L_s} \tag{4}$$

PWM converter Series Impedance referred to the first side

$$Z_{1s} = \left(\frac{1}{2}\right)^2 \frac{j\omega L_s(R_s + \frac{1}{j\omega C_s})}{j\omega L_s + (R_s + \frac{1}{j\omega C_s})} \tag{5}$$

Z_{1s} is series impedance referred to the secondary side of three-phase shunt transformer.

$$Z_{2nf} = \left(\frac{1}{2}\right)^2 (Z_{1s} + j\omega L_n) \tag{6}$$

I_1 to I_2 ratio is

$$\frac{I_1}{I_2} = \frac{(R_f + \frac{1}{j\omega C_f})}{Z_{2nf} + (R_f + \frac{1}{j\omega C_f})} \tag{7}$$

Total Z_r is the impedance connected to feeder when there's no load

$$Z_r = j\omega L_n + Z_{1s} + Z_{1f} \tag{8}$$

Optimizing with PSO algorithm:

Particle Swarm Optimization Algorithm PSO is one of the Evolutionary Computing (EC). This algorithm was announced by kennedy and abrahat in 1995. Because this method is based on simple method and can be executed by computer codes and has been considered by plenty of researchers and has been used with great achievements and engineering problems in the last 8 years. In this section at first, PSO algorithm is described and then a PSO corrected algorithm with a limiting factor is examined. Basic PSO algorithm is based on a physical analogy. Individuals in a society are consistent by Reversible random process in region and are affected by topology neighbor's achievements. Now we describe this idea in an obvious direction. Each particle with less volume and mass in a society behaves in a D-dimensional development space and each particle I is presented

by $X_i = (x_{i1}, x_{i2}, ..., x_{iD})$. A condition which According to the best current situation is exchanging and this

Status is recorded and represented by $P_i = (P_{i1}, P_{i2}, ..., P_{iD})$ and the value of the individual that has the best status

is named *i* which is also recorded. The best total status is also recorded and presented by *P*.

i velocity is status change for the particle *i* and is represented by V_i in the first stage . particle *i* velocity and status is consistent according to the following equation:

$$V_{id}(t+1)=\omega.V_{id}(t)+ rand(0,c_1).(P_{id}(t)-X_{id}(t)) + rand(0,c_2).(P_{gd}(t)-x_{id}(t)) \tag{9}$$

$$X_{id}(t+1)=X_{id}(t)+V_{id}(t+1);\ d=1,2,\ldots,D \tag{10}$$

Inertia moment and constant acceleration C_1 and C_2 show the particle velocity and Random acceleration term weight respectively. Which leads each particle velocity too it's best condition. *rand* $(0,C_1)$ و *rand* $(0,C_2)$ are two separate random value of random functions. From the above, we can find the amount of Triple Jump current term comparison. The first term is particle speed in system memory and the second and third are defined as recognition model and social model respectively. While social model expresses the Efficacy of particle behavior and how to change it's behavior toward a better Position. Each individual in particle society with the name of particle, represents a potential solution and each particle moves in a search space and it is consistent with neighbor jumping experience and objective status

To converge clerk algorithm a corrected method using a useful limiting factor is recommended. Using that, considering equations, particle status and velocity i, are consistent.

$$V_{id}(t+1)=K.V_{id}(t)+rand(0,\varphi_1).(P_{id}(t)-X_{id}(t)) + rand\ (0,\ \varphi 2).(P_{gd}(t)-x_{id}(t)) \tag{11}$$

$$X_{id}(t+1)=X_{id}(t)+V_{id}(t+1);\ d=1,2,\ldots,D \tag{12}$$

Here limiting factor K is a function of φ_1, φ_2 which in fact inertia moment is combined with acceleration. In $C_1 = K\varphi_1$ and $C_2 = K\varphi_1$ relations φ_1, φ_2 2.05 are selected as example. Therfore:

K = 1.49445 و $=C_1 = 1.4944$, $C_1 = 1.2125$.

Simulation and Discussion:

Table 1 illustrates the three UPQC power circuit elements. The first case is one of the repetitive classic methods called (Exhaustive Search) and the second case is obtained from (GA) algorithm. The third case is an outcome of optimizing UPQC parameters using PSO algorithm. Fig.2 shows the ratio of active series filter compensated voltage on the generated voltage by series PEM converter and presents a frequency function. Results corresponding curve with PSO with better approximation with unit gain shows up to 1 kHz and then reduces 10 kHz. Therefore this curve represents a better schema than the other curves. The last case in which data is given by PSO algorithm and shown by an arrow, almost shows a unit gain for a wide band pass that exceeds 1kHz and speed declines from 10kHz to 100kHz. Thus illustrates the best schema of the system.

Table 1: Obtained UPQC parameters form different algorithms for the same repetition

Parameters	Exhaustive Search	Genetic Algorithm	PSO Algorithm
R_f (Ω)	1.12	2.62	11.19
L_f (mH)	2.09	0.47	0.61
C_f (μ F)	137	32	67.53
R_s (Ω)	31.25	5.4	14.49
L_s (mH)	2.15	0.39	0.48
C_s (μH)	10	5.8	103

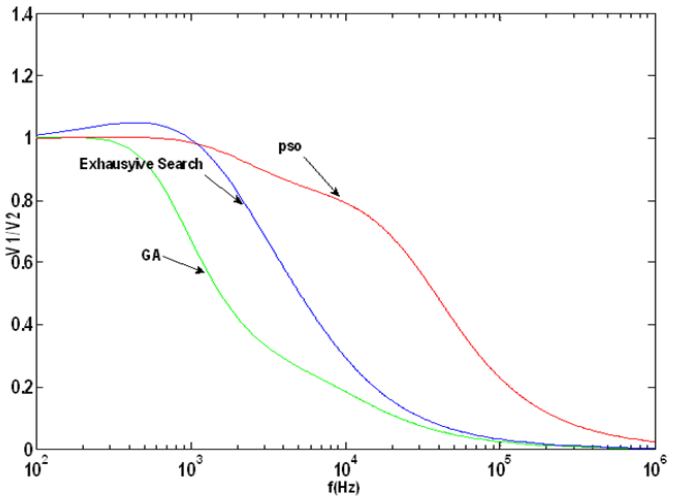

Fig. 2: V_1/V_2 According to frequency

Shunt active filter compensated current Changes on the total generated current by shunt PWM converter is presented in fig.3 as frequency function that voltage changes ratio behaves as above. The last curve describes optimization based on PSO that represents the best system scheme. Total impedance Z_r that is connected power supply when there is no load, its presented as frequency function in fig.4. System frequency range is presented with low impedance and resonance can occur. In this range, series active filter frequency should be able to supply compensating voltage against harmonic currents to increase system stability. Obtained parameters curve, optimized by PSO algorithm, is the best possible schema for the system.

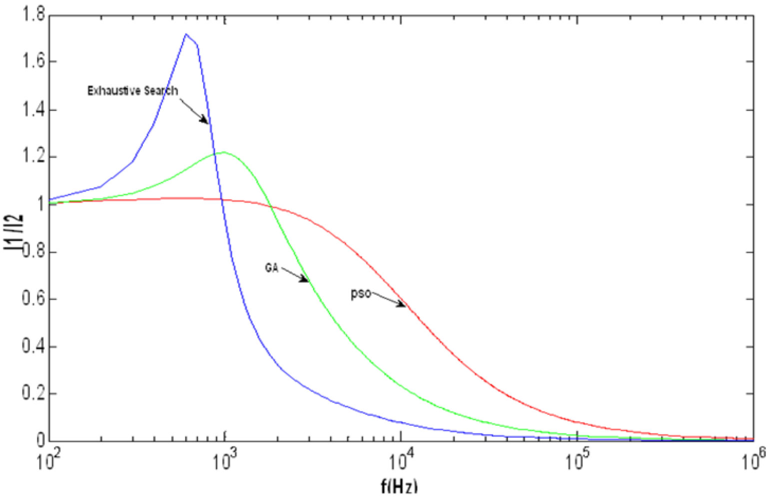

Fig. 3: I_1 / I_2 According to frequency

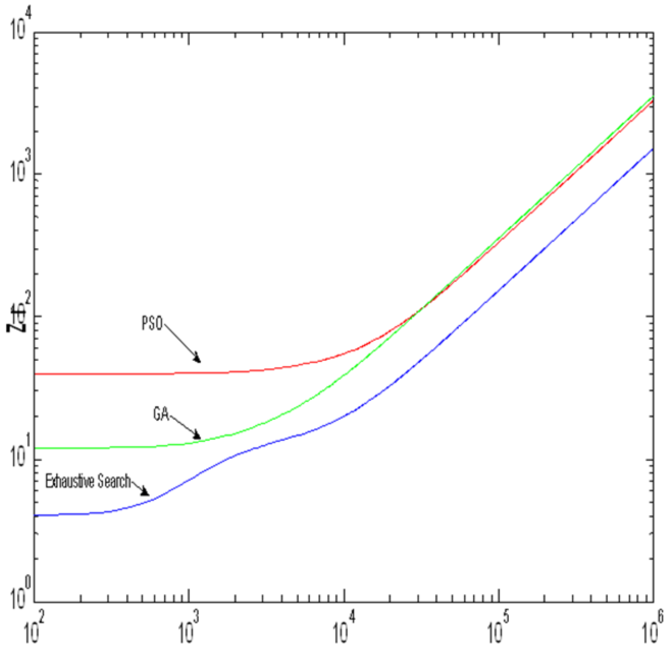

Fig. 4: Z_r (Total Impedance Graph) According to frequency

Conclusion:

Unified Power Quality Conditioner(UPQC) is a device expected to resolve almost all power problems in order to have the advantage of using shunt and series active filter and voltage resource and load current compensation. UPQC has complicated structure in which plenty of elements are used that work together. Due to this we are obliged to select appropriate parameters. a new method based on PSO algorithm is suggested. Simulation results demonstrate the Important effects of Frequency changes on filtering behavior and total no load system impedance. Therefore, selecting appropriate parameters is required. Table 1 shows the optimized parameters relevant to PSO that a wide band pass with unit gain to have current ratio changes and voltage and total normal impedance. In the end optimized parameters by PSO have developed better stability in UPQC.

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