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Article Title: **Power Quality Enhancement using GWO PI Controller Assisted DVR**

Power Quality Enhancement Using GWO PI Controller Assisted DVR

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ABSTRACT

In this system we are implementing GWO based controller to ensure the PQ issues and also provides a regulated load voltage. The rise seen in number of sensitive loads interfaced to the distributed power system in recent times, have accentuated the need for enhancement of Power Quality (PQ).In case of commercial and industrial electrical consumers, PQ issues like voltage swell/sag have detrimental effects on the operation of advanced electrical and electronic loads like computers, variable speed drives, etc. Considering and for overcoming the stated PQ issues, Flexible AC Transmission System (FACTS) devices are employed. In this work, a Dynamic Voltage Resonator (DVR), a series compensated FACTS device has been implemented for enhancing a reliability and voltage stability of distributed power system. Thus, it ensures constant load voltage through injection of required voltage for compensating effects of voltage fluctuations. An effective control of DVR is established Grey Wolf optimization controller owing to its computational simplicity and ability to handle vast amount of input data. An effectiveness of the proposed GWO based DVR for balancing a load voltage is ascertained. The proposed DVR based technique efficiently manages voltage distortion, resulting in a steady regulated load voltage.

Keywords: GWO, Power Quality (PQ), Dynamic Voltage Resonator (DVR), Flexible AC Transmission System (FACTS).

1. Introduction

Due to the rise in loads that are sensitive to power disruptions, the power quality concerns are of utmost importance in the majority of sectors today. An indicator of the voltage and current available to manufacturing, profitable and residential electrical users is called the power quality. The issue affects both customers and utilities. Due to changes in user requirements and equipment, the advantages to providing appropriate power quality is a moving target. Problems initiated by how sensitive electrical equipment is for voltage quality frequently have extreme serious

consequences for users. Power quality is considered a broad subject with many subfields. Power quality is affected by a variety of various occurrences, under and over voltages, such as sags, swells, surges or spikes outages, harmonics, flicker, electrical noise and frequency deviations. Because of this, investigating such occurrences requires a variety of measurements and analytical techniques and a variety of corrective measures can be taken to neutralize or reduce their impacts. Though, many electronic devices, including computers, solid state relays, process controllers, adjustable speed drives and optical devices are sensitive for varying degrees of power quality However, lot of electronic devices (including process controllers, solid state relays adjustable speed drives, optical devices and computers) are responsive to a different extent to power quality.

2. Basic DVR Operating Principles

In order to make up for the difference between the normal and defective voltages, DVR works via inserting three 1ϕ AC voltages in series with 3ϕ incoming network voltages during a sag. In general, ratings as well as performance of DVR are influenced by the principal design factors listed below:

- Extreme duration of 3 phase voltage sag,
- Short circuit impedance of an injection transformers
- Maximum MVA load and power factor,
- Maximum allowed voltage drop across DVR under steady state conditions,
- Maximum 3 phase as well as 1ϕ voltage sags has to be remunerated,
- Short circuit power, step down transformer connections at the output and input sides of the DVR, in addition to short circuit impedance.

3. Location of DVR

The only goal is to provide a single user or a group of users with value added protection. The only sort of system taken into account here is a radial grid structure and relating DVR would typically be accessible in medium or low voltage distribution system. Low voltage systems in Europe typically have four wires and medium voltage systems sometimes have three wires. Both systems' primary objectives are to inject synchronized voltages in response to symmetrical faults and occasionally, an inverse voltage component during non-symmetrical failures. A creation of zero sequence voltages as well as the flow of zero currents in sequence are two major differences among Low Voltage (LV) connection and Medium Voltage (MV) connection. A DVR must maintain a low impedance in the four wire system for zero sequence currents and the zero sequence currents has to either flow in power converter or in a delta winding of an injection transformer.

4. Advantages

- It used primarily in transmission lines to compensate for the voltage sag and voltage swell that occurs on it.
- Significant losses, injects only missing part of the supply voltage and less maintenance.

5. Applications

- Transmission And Distribution Systems
- Power Quality Related System
- Three Phase Systems.
- Active and Reactive control systems
- HVDC Applications

6. Objective

- To overcome the PQ issues like voltage swell/sag Flexible AC Transmission System (FACTS) devices are employed.
- To ensures constant load voltage through injection of required voltage to compensate effects of voltage fluctuation.

7. Thesis Organization

- Chapter 2: Literature Review
- Chapter 3: Existing System
- Chapter 4: Proposed System
- Chapter 5:Resultand discussion
- Chapter 6: Conclusion
- Chapter 7: Reference

8. Literature Review

The following is a brief review of the work that has been done so far:

C. Sankaran provided a comprehensive explanation of issues with electricity quality and its impact on the power system. He presented numerical examples of power quality problems and the methods to overcome them as well as its worst impacts on power system operation, which result in disruptions and significant economic losses. Along with that, he included graphs for illustrating multiple power quality difficulties.

N.G.Hingorani et al. developed a power electronics based technique termed FACTS (flexible Ac transmission system) for enhancing stability, controllability and power transmission capacity of ac transmission systems. By thoroughly describing FACTS controllers, he revolutionized the study of power electronics including STATCOM, TCSC, UPFC SSSC, SVC, IPFC plus voltage

regulators, phase shifters and special controllers with a detailed comparison of their performance attributes. He discussed FACTS from a practical perspective and emphasized some of its principal advantages in power sector.

Satyaveer Gupt et al. presented a comprehensive survey on custom power devices in supplying network. He provided a brief overview of the corrective measures that distribution level power quality issues could be reduced through.

N.H. Woodley et al. characterized a connection of world's first Dynamic Voltage Restorer on a system for shielding perilous client load from voltage disturbances. The suggested DVR was installed on 12.47 kV system at an automated yarn manufacturing and weaving factory where it shielded a plant from distribution system interruptions. A test load consists the combination of reactive and non-linear rectifier load elements to offer a range of kW loads with vary harmonic current as well as power factors. By connecting together multiple impedance components in series with an incoming line, voltage sags were added to a line voltage waveform.

Rosli Omar et al. conversed a unique control approach constructed on Space Vector Pulse Width Modulation (SVPWM) technique for generating pulses & investigating it via computer simulation by implementing PSCAD/EMTDC software. The findings of simulation indicates a better compensation for rectifying voltage sags.

9. Grey Wolf Optimization Base Pi Controller

The majority of industrial applications favor constant speed motors. In order to achieve constant speed, closed loop control is typically performed using traditional PI controllers; however, difficulties with maximum peak overshoot do arise. By this reason, the lifetime of the motor and the load are affected, also the input source current will be more. To overcome these drawbacks, GWO Algorithm is proposed for the effective speed control.

9.1 PI controllers

In order to gain improved system responses, PI controllers are used extensively in several industries. Normally PI controllers react to the error signal in the closed control loop and try to modify the constraint to achieve the system response. The error is controlled by the controller to provide a signal to the system which is represented as follows:

$$U(s) = K_p\left(1 + \frac{1}{\tau_i}\right) \quad (1)$$

In time domain,

$$U(t) = K_p\left[e(t) + \left(\frac{1}{\tau_i}\right)\int edt\, edt\right] \quad (2)$$

here K_p and τ_i are the gains of proportional and integral correspondingly.

9.2 GWO Algorithm

One population based optimization approach used for fine tuning the PI controller is this one. The standard activity of grey wolves serves as the inspiration for this algorithm. With the GWO method, there are four clusters that represent the leadership order:

a) As Alpha (α), the dominant wolf, who makes decisions, may be male or a female.

b) A subordinate wolf that acts as the alpha's beta (β) in making decisions

c) Lower ranking wolf as Omega (ω)

d) Controls omega and should report alpha and beta as Delta (δ)

The following models are be used to explain hunting behavior and encircling:

$$\vec{D} = \left|\vec{C}.\overrightarrow{G_p}(t) - \overrightarrow{G_p}(t)\right| \qquad (3)$$

$$G(t+1) = \overrightarrow{G_p}(t) - \vec{A}.\vec{D} \quad (4)$$

Where the coefficient vectors are A, C, D is the current in then existing iteration's, a vector indicating preys' position as Gp and grey wolf as G in position vector.
The following equations are used to calculate the coefficient vectors A and C:

$$\vec{A} = 2\vec{a}.\overrightarrow{rand_1} - \vec{a} \quad (5)$$

$$\vec{C} = 2.\overrightarrow{rand_2} \qquad (6)$$

Where, during iterations $rand_1$ and $rand_2$.
'a' reduces linearly from 2 to 0 .
The number of Nref and Nact duty ratios is determined through the sensors. Given that grey wolf is how the (D) is duty cycle defined as equation (3) modified as,

$$D_i(k+1) = D_i(k) - A.D \qquad (7)$$

The expression for the GWO fitness function is

$$P\left(d_i^k\right) > \left(d_i^{k-1}\right) \qquad (8)$$

Where, a power has been denoted as P, d signifies the duty cycle, the number of current grey wolves is represented as i and the number of iterations is k
For GWO algorithm, a flowchart as in figure (1).

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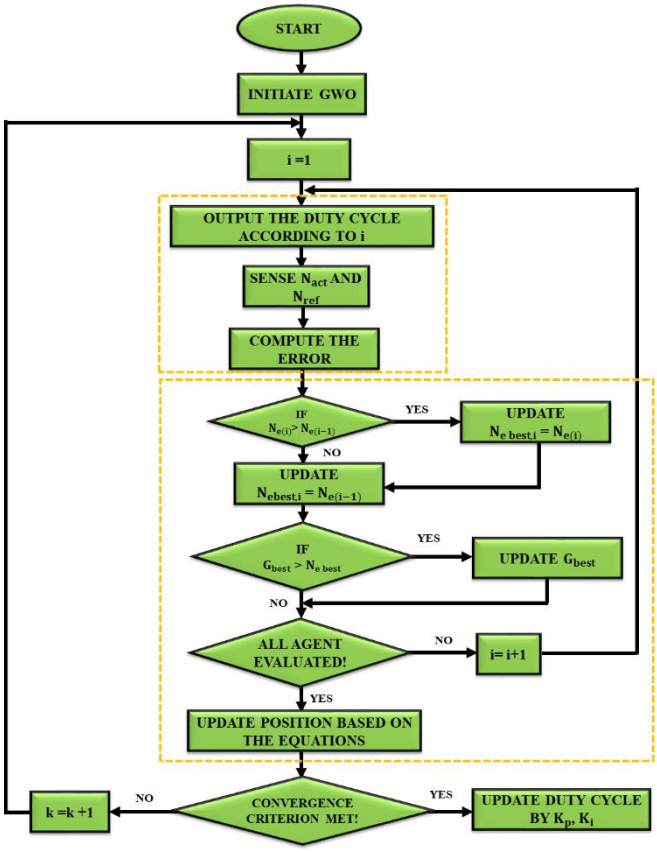

Figure 1: *Flow chart of GWO Algorithm*

Step 1: A and C vectors are modified in first step.
Step2: Modify number of repetitions to zero (k=0)
Step 3: Thee grey wolf pack size is modified as 1 (i=1)
Step 4: Measure N_{act} by the controller.
Step 5: Relate N_{ref}(3000rpm) and N_{act} rapidity for the converter.
Step 6: If N(i) is higher than N(i-1), then update $N_{max}$where i=N(i), else update N_{max} where i=N(i=1)
Step 7: Relate G_{max} with N_{max}, if N_{max} update more to G_{max}. If not, proceed to the next wolf and complete step 4, then continue until manipulating the duty cycle.
Step 8: The third process is repeated until convergence.

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10. Experimental Analysis

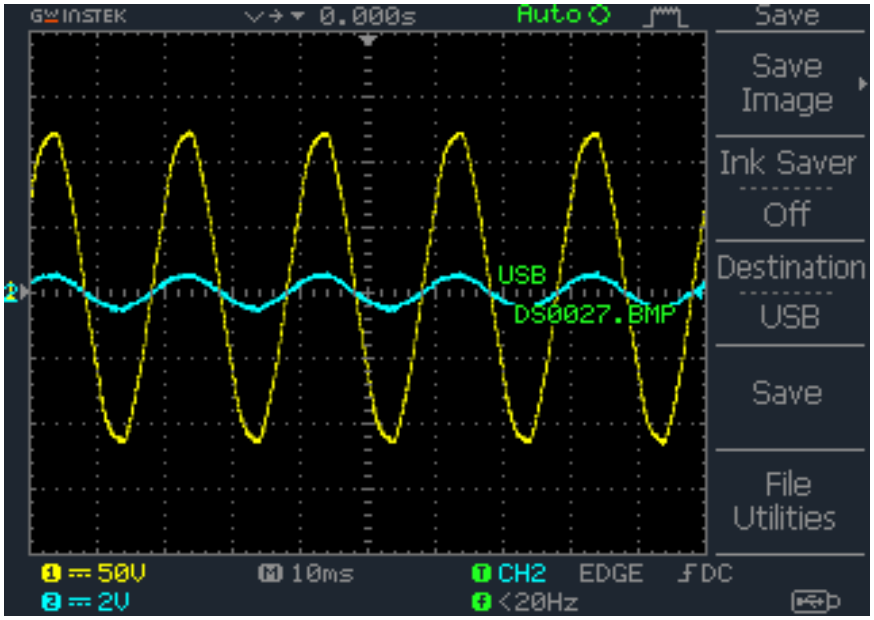

Figure 2: *Input AC supply Waveform*

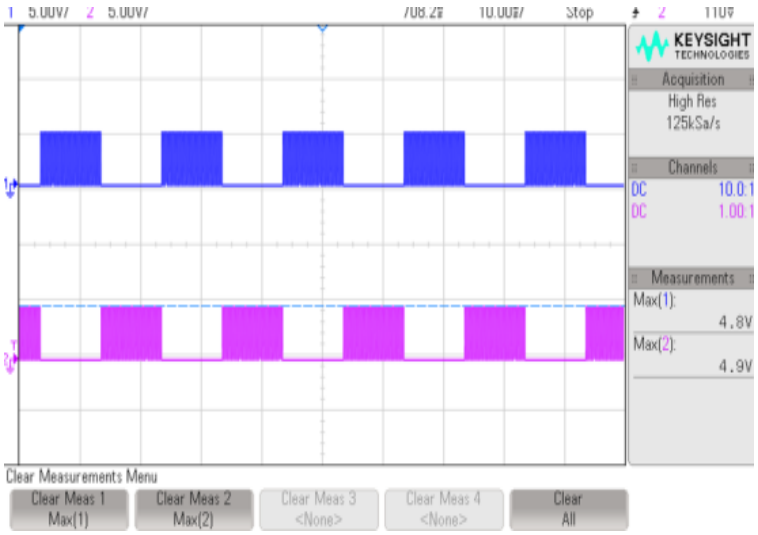

Figure 3: *PWM Pulses to the Converter*

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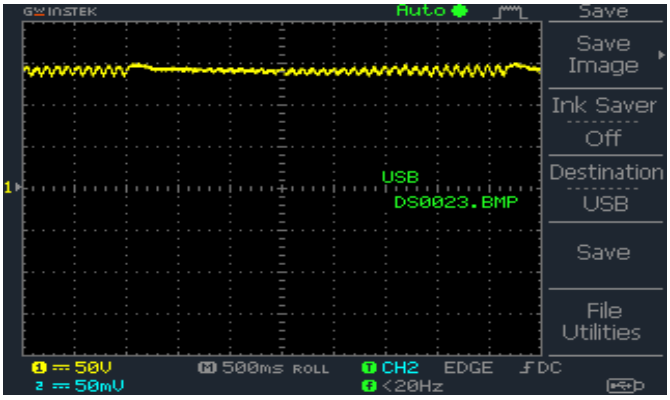

Figure 4: *Converter Output DC Voltage Waveform*

11. Conclusion

Nowadays, due to the majority of industrial load types, including those that manufacture semiconductors and produce chemicals, are sensitive to power fluctuations as a result of the development of power electronics, so customers and power companies should take such cases into consideration when determining how to withstand power fluctuations as long as they stay within the designated limit. Custom power devices (CPD) are utilized for this, since DVR is a series type CPD, which is the most economically feasible choice. On the side of sensitive load, CPDs coupled in shunt, series or a combination of the two. For this paper a PV fed DVR is utilized. The three phase inverter is managed by a fuzzy logic controller and the maximum power from Photovoltaic has been tracked by a GWO based PI controller algorithm.

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