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**RESEARCH ARTICLE**

# Power Quality Disturbances and Improving Power System Reliability

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***Abstract: Create unfavorable influence on production processes and assemblies, reducing product quality, making the production processes interrupt, and thus causing huge economic losses. Here we introduce customer power technology which is emerging area in mitigating power quality disturbances and improving power system reliability. The various power quality disturbances and exiting solutions are also discussed. . Power stability highly demanded due to the harms of disturbances. The response time is about 25 ms, and this is much less than some of the traditional methods of voltage correction such as tap-changing transformers.***

**Introduction**:- Since the electricity invented it helps to reduce the human efforts in almost all the sectors; these days it's hard to think that how to execute a day without electricity. But there is another big deal about the electricity that the continuous power supplies with the stable strength. In this paper we are going to introduce a way of electric stability with the help of Bee Colony Optimization approach. Power stability in needed because of Sensitive equipment and non-linear loads are now more commonplace in both the Industrial, commercial sectors, for the personal uses with the high cost of equipments on the bases of benefited standards of the each for the individual uses the domestic environments. Because of this a high awareness of power quality is developing amongst electricity users. Occurrences affecting the electricity supply that were once considered acceptable by electricity companies and users are now often considered a problem to the users of everyday equipment. Power stability highly demanded due to the harms of disturbances include interruptions; voltage sags and swells; harmonic distortions and surges. With the day by day inventions, more and more production processes and assemblies (like semiconductor manufacturing, computer integrated manufacturing system and paper making, etc.) rely on those equipments whose kernels are CPU chips or power electronics devices. Moreover, owing to rapid use of large numbers of non-linear loads and various faults in power system, many power quality problems will be caused, such as voltage sag, swell, asymmetry, flicker, fluctuation, and harmonics and so on. These problems may create unfavorable influence on production processes and assemblies, reducing product quality, making the production processes interrupt, and thus causing huge economic losses. Here we introduce customer power technology which is emerging area in mitigating power quality disturbances and improving power system reliability. The various power quality disturbances and exiting solutions are also discussed.

Custom power devices like Dynamic Voltage Restorer (DVR) and Distribution Static Compensator (D-STATCOM) are used to correct all types of voltage sags at distribution level. These devices works based on the voltage source converter (VSC) principle. A DVR is a series device that generates an ac voltage and injects it in series with the supply voltage through an injection transformer to compensate the voltage sag. On the other hand, a D-STATCOM is a shunt device that generates an ac voltage, which in turn causes a current injection into the system through a shunt transformer. For lower voltage sags, the load voltage magnitude can be corrected by injecting only reactive power into the system. However, for higher voltage sags, injection of active power, in addition to reactive power, is essential to correct the voltage magnitude. Active power injection of the device must be provided by an external energy source or energy storage system. The response time of both DVR and D-STATCOM is very short and is limited by the power electronics devices. The response time is about 25 ms, and this is much less than some of the traditional methods of voltage correction such as tap-changing transformers.

**Existing Work:-** There could be completely different definitions for power quality (PQ), depending on one's frame of reference. Power quality is the study or description of both voltage and current disturbances. Power quality can be seen as the combination of voltage quality and current quality. Generally, PQ is concerned with deviations of voltage and/or current from the ideal, and has nothing to do with deviations of the product of voltage and current (power) from any ideal shape. One should realize that there is no general consensus on the use of these definitions. A consistent set of definitions is given as follows:

**Voltage quality** is concerned with deviations of the voltage from the ideal. The ideal voltage is a single-frequency sine wave of constant amplitude and frequency.

**Current quality** is the complementary term to voltage quality. It is concerned with the deviation of the current from the ideal. The ideal current is again a single-frequency sine wave of constant amplitude and frequency, with the additional requirement that the current sine wave is in phase with the voltage sine wave.

**Power quality** is the combination of voltage quality and current quality.

**Quality of supply** is a combination of voltage quality and the non-technical aspects of the interaction from the power network to its customers.

**Quality of consumption** is the complementary term to quality of supply.

**Variations** are small deviations of voltage or current characteristics from its nominal or ideal value, e.g. the variation of voltage rms. value and frequency from their nominal values, or the harmonic distortion of voltage and current. Variations are disturbances that are measured at any moment in time.

**Events** are larger deviations that only occur occasionally, e.g. voltage interruptions or load switching currents.

**Barrier ahead the Power Stability**

**Transients** These are sub cycle disturbances with a very fast voltage change. They typically have frequencies often to hundreds of kilohertz and sometimes megahertz. The voltage excursions range from hundreds to thousands of volts. Transients are also called spikes, impulses and surges. Two categories of transients are described in [], impulsive transient and oscillatory transient. Examples of transients include lightning, electro-static discharge; load switching, line/ cable switching, capacitor bank or transformer energizing and ferro-resonance.

**Long- Duration Voltage Variations** Long-duration variations encompass root-mean-square (rms) deviations at power frequencies for longer than 1 min. A voltage variation is considered to be long-duration when the limits are exceeded for greater than 1 min. These variations are categorized below:

**Over voltage:** An over voltage is an increase in the rms voltage greater than 110 percent at power frequency for duration longer than 1 min. Examples include load switching, incorrect tap settings on transformers, etc.

**Under voltage:** An under voltage is a decrease in the rms ac voltage to less than 90 percent at power frequency for duration longer than 1 min. Examples include load switching, capacitor bank switching off, overloaded circuits, etc.

**Sustained interruptions:** These come about when the supply voltage stays at zero longer than 1 min. They are often permanent and require human intervention to repair the system restoration. Examples include system faults, protection maltrip, operator intervention, etc.

**Short- Duration Voltage Variations**

Short-duration variations encompass the voltage dips and short interruptions. Each type of variations can be designated as instantaneous, momentary, or temporary, depending on its duration these variations can be categorized as:

**Interruptions:** This occurs when the supply voltage or load current decreases to less than 0.1 pu for a time not exceeding 1 min. The voltage magnitude is always less than 10 percent of nominal. Examples include system faults, equipment failures, control malfunctions, etc.

**Sags (dips):** Sag is a decrease to between 0.1 and 0.9 pu in rms voltage or current at power frequency for durations from 0.5 cycle to 1 min. Examples include system faults, energization of heavy loads, starting of large motors, etc.

**Swells:** A swell is an increase to between 1.1 and 1.8 pu in rms voltage or current at power frequency for durations from 0.5 cycle to 1 min. Swells are not as common as sags. Sometimes the term momentary over voltage is used as a synonym for the term swell. Examples include system faults, switching off heavy loads, energizing a large capacitor bank, etc.

**How to deals with Power Quality Problems**

There are two approaches to the mitigation of power quality problems. The solution to the power quality can be done from customer side or from utility side. First approach is called load conditioning, which ensures that the equipment is less sensitive to power disturbances, allowing the operation even under significant voltage distortion. The other solution is to install line conditioning systems that suppress or counteracts the power system disturbances. A flexible and versatile solution to voltage quality problems is offered by active power filters. Currently they are based on PWM converters and connect to low and medium voltage distribution system in shunt or in series. Series active power filters must operate in conjunction with shunt passive filters in order to compensate load current harmonics. Shunt active power filters operate as a controllable current source and series active power filters operates as a controllable voltage source. Both schemes are implemented preferable with voltage source PWM inverters, with a dc bus having a reactive element such as a capacitor.

Active power filters can perform one or more of the functions required to compensate power systems and improving power quality. Their performance also depends on the power rating and the speed of response. However, with the restructuring of power sector and with shifting trend towards distributed and dispersed generation, the line conditioning systems or utility side solutions will play a major role in improving the inherent supply quality; some of the effective and economic measures can be identified as following:

**Earthing practices:** A large number of reported power quality problems are caused by incorrect earthing practices. Verification of earthing arrangements, particularly when harmonics problems are reported, should always be conducted early in a power quality investigation.

**Transfer switches:** Transfer switches are used to transfer a load connection from one supply to another, allowing the choice of two supplies for the load (or sub network), should one supply suffer power disturbances then the other supply will be automatically switched in reducing the possibility of supply disruption to the load.

**Static breakers:** The power electronic equivalent of a circuit breaker with a sub-cyclic response time is nothing but static circuit breaker. The static breaker will allow the isolation of faulted circuits in the shortest possible time frame; other nearby loads will therefore have improved power quality.

**Active filters and SVCs:** The control of reactive power, and therefore harmonics, can be achieved by controlling a proportion of the power systems current through a reactive element. Conventionally this is achieved by switching inductors and capacitors in shunt with the power system, using thyristors. With the SVC the control of the current is achieved by controlling the output voltage magnitude of an inverter. SVCs are used to absorb or inject reactive currents to eliminate the harmonic distorting currents drawn by non-linear loads. Unified power flow controllers (UPFCs) are similar to SVCs but allow both series and shunt compensation.

**Classification of Fault :** Fault in Power System occur because of insulation failure in plant which may be caused by a system over-voltage such as switching surge or a lighting stroke, or may be due to broken insulators or conductors, and various other causes on the transmission line. Faults on Power Systems are divided into three-phase balanced faults and unbalanced faults.

**Balanced fault**: fault is defined as the simultaneous short circuit across three phases. It occurs infrequently, but it is most severe type of fault encountered. Because the network is balanced, it is solved on a per-phase basis. The other two phases carry identical currents except for phase shift. The reactance of the synchronous generator under short circuit conditions is a time-varying quantity, and for network analysis three reactances were defined. The sub-transient reactance of the first few cycles has short circuit current, transient reactance in the next 30 cycles and the synchronous reactance thereafter. Since the duration of the short circuit current depends on the time of operation of the protective system, it is not always easy to decide which reactance to use.

**Unbalanced Fault:** Unwanted loss of power stability discussed as the unbalanced fault for example; sudden lose of load. The effect of sudden loss of load is the abrupt change in the electrical torque Te due to the change in the fundamental frequency of the armature current that induces impact torques on the shaft or torsional oscillations as in the magnitude of which is proportional to the change in Te in relation to mechanical torque Tm (or DT). The higher the change, the higher will be the machine vibration response. This happens in a few cycles prior to clearance and again after clearance. At the instant of a fault, the power developed by the generator abruptly decreases to zero and its terminal voltage will drop to almost zero in magnitude. Since the prime mover is incapable of responding instantly, Tm will be greater than Te resulting in the increase of engine speed. The generator over speed protection will normally operate once the frequency exceeds a certain level.

**Proposed Work**: A power system is one of the most complex architecture that satisfy the power demands of the users. Modern Power systems are highly complex and nonlinear that perform the analysis on availability and demand and take the relative decision on supply. These kind of system are capable to resolve the problems like fault tolerance, load balancing, load sharing, stability etc. Power system stability is one the complex architecture among these. The presented work is about to achieve the power system stability using Artificial Bee colony optimization algorithm. The work is able to provide the transient stability as well as steady state stability. As the optimization function is defined in the system, the work is intelligent and completely dynamic in nature. The work will be able to provide the automatic voltage regulation and also leads to the small magnitude and low frequency oscillation in the system.

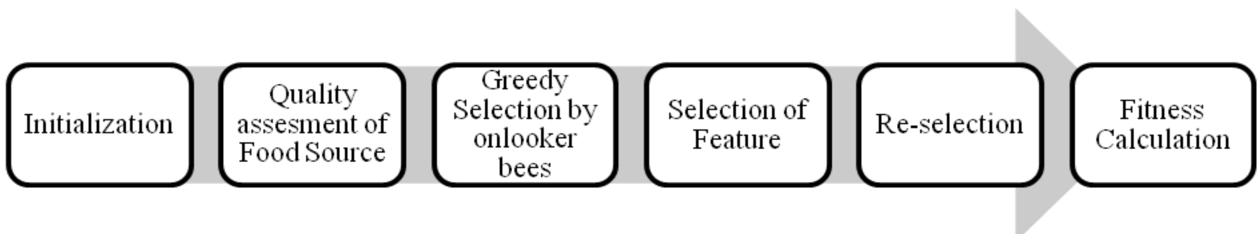
**Objective:** The main objective of the work is design an artificial bee colony optimization based power system stability model so that dynamic voltage regulation will be achieved.

- The objective of work is to control the system in case of under load and over load situations.
- The objective of work is to define a robust system that will not be affected with the smaller variations in the parameters.

**Why this one better** The presented work is the improvement over the existing work under following respects

- In this presented work, an effective Bee Colony Optimization approach is defined to achieve the system stability in case of network fault as well as unequal load. Whereas the existing work is defined only specific to the load based system stability.
- In existing system, the system stability is been achieved in about 2-3 seconds whereas in this present work, the system stability is achieved in about 1.5 seconds.
- In existing system, the stability is defined for single area it means the power system is not much complex. But in this work, a hybrid system is defined with 3 different areas and effective stability is achieved in all areas.

**How it works Step1:** This is the Initialization Step i.e. it initializes the population of the solution/feature/food source. In this step we will place employed bee on each food source.




**Step 2:** This step includes the quality assessment of food source. In this we will evaluate the food source using normalized correlation coefficient c (x, y). Correlation is termed as template matching.

**Step 3:** In this step onlookers do the greedy selection. In this step for all food source we calculate probability of values.

$$p_i = \frac{c_i}{\sum_{n=1}^{N} c_n}$$

Where

- $i = \{1,2,3 \ldots \ldots, N\}$ Where N= total number of food source.
- $p_i$ =Probability of ith food source
- $c_n$ = Correlation Value

**Step 4:** In this step we do selection of features. Now we have to calculate average of correlation value obtained by each onlooker bee for a particular food source.

For example: Consider a Single machine connected to infinite bus system with a simple exciter, having the parameters $K_1$, $K_2$, $K_3$, $K_4$, $K_5$ and $K_6$ [1]. The following table describes all the different combinations of parameters and loading explored with this system.

**Step 5:** In this step we do the reselection of features. In this we will produce the candidate food position from the old one in memory, which may have been abandoned while feature extraction.

**Step 6:** In this step we calculate fitness value. If the fitness value is less than or is equal to 1, then we will continue face recognition otherwise no image found and we will exit.

Then the onlooker bee will select the maximum $p_i$ and will follow the employed bee to the selected food source.

Note: - step 2 will repeated for all onlooker bees and will calculate probability for each onlooker bee.

The machine constants that were used are:

| | **Hydro** | **Steam** |
|---|---|---|
| $X_d$ | **1.14** | **1.6** |
| $X_d$’ | **0.24** | **0.32** |
| $X_q$ | **0.66** | **1.55** |
| **Tdo’** | **12** | **6** |

Where

$X_d$ is representing Direct axis armature winding synchronous reactance.

$X_d$’ is representing Direct axis armature winding transient reactance.

$X_q$ is representing Quadrate axis armature winding synchronous reactance.

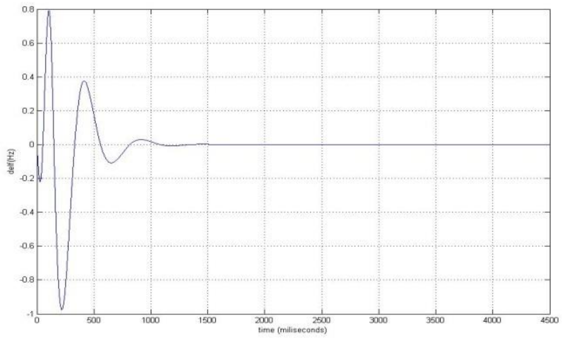
Tdo’ is representing Direct axis armature winding transient open circuit time constant.

Consider a synchronous machine connected to an infinite bus bar though an external reactance with a simple exciter with operated at a load of P+JQ=0.9+j0.3. Parameters of the system are as fallows.

$K_1$ = 0.7643, $K_2$ = 0.8649, $K_3$ = 0.3230. $K_4$ = 1.4187, $K_5$ = -0.1463, $K_6$ = 0.4168, H=3.

The result in the form of graph is achieved as




**Conclusion & future work**: In this presented work, the problem of fault is been covered by using the ABC based optimization model. The fault is associated with the bus line. In general case, as the fault occur the voltage, complete voltage distribution over the system is affected and overall voltage in the system set to 0. In this presented system, a ABC improved stability model is been presented to achieve the stability over the system.

But in this presented system, an effective model is presented to achieve the signal stability. The presented system provided the stable voltage distribution as fault occur over the system. The obtained results shows that the power stability is been achieved by the system.

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