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A Review Article of Single-Phase Thd Reduction Using PSO-GWO Optimization Technique in Non-Linear Loads

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ABSTRACT: This paper introduces a Hybrid Shunt Active power filter that enhances power, response power, and harmonic offsetting under nonlinear load through a Hybrid Particle Optimization-Grey Wolf Optimization Proportional-integral-derivative Controller fractional order. To minimize Harmonics, the PSO-GWO method is used to accurately adjust the parameters of the controller. Comparing passive and active filters, it was found that the former was more bulky and complex in design, while the latter was not economical for high scores. Therefore, using MATLAB/Simulink and an experimental installation in real-time. An active and passive hybrid shunt system is developed. Inactive shunt filter compensation, methods such as (p-q) or IQ principle, only source stream is sensed, differentiated from predictable ones. In various operating conditions, including static, intermittent conditions as well as indices such as Total Harmonic Distortion, the performance of the proposed controller is assessed input P/F, Real and Reactive power are respectively. The hybrid PSO-GWO technique is used to optimize the parameters of the Fractional Controller and the Conventional PID Controller. The configured FOPIDC PSO-GWO outperforms the competitive outcomes in simulation and experimentation.

KEYWORDS: FOPIDC, PSO-GWO, THD, REACTIVE POWER AND POWER FACTOR IMPROVEMENT, SHUNT ACTIVE FILTER

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I. INTRODUCTION

Harmonics are voltages or currents generated by non-linear loads in an electric power system that are multiples of the system's fundamental frequencies. Harmonics are produced in power systems by non-linear loads. Non-linear loads include semiconductor devices such as transistors, IGBTs, MOSFETs, diodes, and so on. Popular office devices such as computers and printers, fluorescent lights, LED, battery chargers, and variable-speed drives are all examples of non-linear loads. Non-linear loads such as LED lamps and fluorescent lighting produce harmonics in low-voltage networks. Since inrush current has the greatest effect on the control factor of electrical networks, vendor derating instructions should be followed to prevent circuit-breaker tripping that is inconvenient (or causes trouble). In the electric loop, there is a harmonic. We need to mount a filter in the control system at the load end to eliminate the harmonics that are present. The filter can be attached to the power system network in two ways: series and shunt. This will be dependent on the relation to the power systems, so we'll go into the filter and how it works in great detail.

Series Connected Filter

This form of filter is related to the power system network in a series connection. It has a high impedance at the turning frequency, allowing only a few harmonics to flow through. However, the series-connected filter has a high cost. It can only compensate for lower-order harmonics since higher-order harmonics will necessitate a large number of series-connected filters. These are the series-connected filter's main flaws.

Shunt Connected Filter

One of the most common types of filter found in AC transmission systems; these filters are often connected to the power system in shunt or parallel. The key advantage of a shunt connected filter is that it can compensate for higher-order harmonics and is much less expensive than a series connected filter.

Active power filter

The active power filter for harmonic compensation is one of the most commonly used filters in industry. It will reduce harmonics via the reverse phase by adding active power to cancel an existing, harmonic section of the device due to non-linear loads.

Passive power Filter

The passive power filter consists of a resistor, inductor, and capacitor and does not have any active components such as transistors; nevertheless, it is incapable of providing dynamic harmonic compensation, so active filters are more widely used nowadays for harmonic compensation.

Working Principle of SAPF

This is the general block diagram of Shunt Active Power Filter:

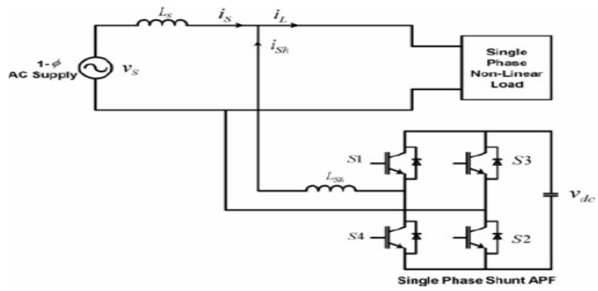

Fig: Single phase Shunt active filter.

In the electric power system, it generates the power given to the grid system, and the non-linear load is the key source of harmonics in the system. This non-linear load produces harmonics in the grid, and for this reason, the harmonics generated by nominal load must be balanced. A pulse, normally a FOPID for this type, is then added to an existing control unit so that SAPF can feed the filter current to commonly used coupled space. This filter current offsets the harmonics in the grid and controls the harmonic levels in the grid structure, which results in a perfect sinusoidal wave of optimal efficiency and at most zero harmonics in the system. This is the theory of operation of the most popular application of the SAPF. This dilemma involves a range of non-linear loads. Traditional methods for controlling basic energy qualities for the efficient compensation of SAPF such as current harmonics, reactive intensity which load imbalance, and are governed by FOPID.

II. LITERATURE REVIEW

The Area of **NON-LINEAR** system is fascinating in the 1997 FABIANA POTTKER AND IVO BARBI [1] has conducted Research and used a single-phase power factor active control filter for non-linear load correction. In the research they found that latest average mode procedure that is the same as the pre-regulator boost is used in the modern control methodology, the paper focuses on modelling methods and the study of control strategy to ensure that the input current adjustment for individual and multiple nonlinear or linear loads and displacement phases is harmonic. An active filter is given for a single loan with a 1600-W corrective unit with condensers filter and a range of loads consisting of an 800-W corrective with condenser and an 800-W A-C chopper.

This research work was followed by M I ABUBAKAR [2] in year 2008, he has conducted Research and it was discovered that the effect of non-linear charges on the 3-stage distribution of the four-wire grid. These Experiments are carried out to monitor the various ranges and configurations of contemporary non-linear load fixed components that are sources of harmonic current. A further study is undertaken in three stages, the four wire structures similar which are specifically checked for the three separate loads, such as resistive, inductive and capacitive load. Even if the system is balanced, both simulation and experimental findings show that a decrease of the power factor in the power line and a sharp increase in the return current in the neutral line will induce the non-linear load, while the system is balanced.

In the same year CICED WANGKUI, GAUNSHUHUA, HOUQUAN, HOUYUANHONG, WU QINFANG [3] Claimed that large nonlinear loads contribute significantly to the harmonic distribution system. In the other hand, the prevalence of small non-linear loads, such as electrically shifted drives, will increase the harmonic distortion level in a distribution system considerably. In order to investigate harmonic distortion we use field tests for a variety of domestic devices. Field data from many urban loads of 0.4 VK shows that this non-linear load can have a major effect on performance and power factor deformation. In this paper, after a detailed study of the neutral and the phase current distortion levels in the functional control grid behind the low voltage transformer, we calculate the increase in losses due to nonlinear stress.

A significant development was fund in the year 2016 when GEORGE TOMY, DEVIKA MENON [4] has conducted Research and was discovered that Today's extensive use of non-linear loads has intensified harmonic current injection into the grid. The harmonic current is an important element in the depletion of grid power production. In a single or tri-phase way, a non-linear load can exist. The aim of this paper is to look at a control method for mitigating harmonics in a single-stage shunt active filter that uses the grid. The shunt active filter's reference signal is derived from instantaneous reactive power. The load is a resistive inductive load supplied with a diode rectifier. In a matt laboratory/similarly climate, a full control technique and analysis are applied.

In the same year KARUNANIKUM, RAKESH SAXENA AND ABHAYWAGH [5] published that Harmonics, fluctuation of voltage, low power and other conditions lead to poor performance. Voltage sag, swell, momentary interference, low voltage, overvoltage, noise, and harmonics are the most common disturbances caused by a lack of power quality. The study analyses absolute THD harmonic distortion measurement in new household equipment such as computers, power banks, cell loaders, CFLs and LEDs which are used for domestic loads.

In work was further carried by S M SALAM, M J UDDIN, SAIF [6] in year 2017 and they claimed about residence and business users using various load modes, most of which emit large harmonics. While the high cost of electricity means that most people use more energy efficient electrical equipment, they do not care for power usage. In order to determine the effect on the overall energy usage of the distributed network in various combinations of non linear cargoes, a systematic analysis is needed. The utilities have several power efficiency indexes to manage to ensure the efficient service of the supply network, which comprises turbines, drives and transformers. The paper concentrates on the development of an adaptive charging model that can dynamically adjust various types of charges, such that power efficiency parameters can be measured for any charge combination.

The latest work in this area is conducted by M SALAM, M. IFTEKHER UDDIN, M. RIFAT BIN MOINUDDIN [7] in year 2019 and they found that something new. Inefficient use of energy-efficient, non-linear lighting loads lead to high levels of harmonics, while light loads account for a limited proportion of the total load consumed by the distribution side. Wide harmonics can lead to voltage distortion and problems of power quality within a power system network. Power utilities must conform to a strict power quality standard for ensuring the smooth functioning of the distribution network, including output and transmission line installations. It is therefore important to identify the implications of energy-efficient devices for distortion of the power efficiency. This paper provides various case studies using the template base load modelling to determine the impact on the total resource consumption of a distributed network with these kinds of load combinations.

Then after used **PID CONTROLLER** system is fascinating in this year's 21 FEBRUARY 2017 IEEE, SANTOSH KUMAR VERMA, SHEKHAR YADAV [8] has conducted Research and was discovered that this paper outlines a new evolutionary approach to optimize fractional control parameters that are used to control two process types: time and higher order systems. Gray Wolf Optimizer is an evolved way to tune integer as well as fractional controls. The grey wolf optimizer searches for the right way to encircle, hunt, strike the prey then sequentially look for new beasts if one exists. Quality indexes such as integrated square error weighted time and integrated absolute error weights are minimized in order to certify these different methods to a minimum. The suggested algorithm is often analyzed compared to well-known approaches.

The most recent techniques are being used in this field, which is **PSO-GWO** in the year 2019 IEEE, WU CAO, MEMBER, IEEE, KANGLI LIU, MEMBER, IEEE, MUMU WU, SHENG XU AND JIANFENG ZHAO [9] has conducted research and discovered that The aim of this paper is to propose a new PSO-based current control system for lowering grid current THD and increasing the SAPF energy consumption ratio. The optimum limiting ratios of each harmonic order are determined in real time to achieve diverse and line-limiting power, which is a significant advantage. In addition, this paper uses a control scheme based on a qualitative and quantitative method for static error correction that includes selective harmonic detection under many rotating reference frames and a single PI current loop to provide an estimation of frequency response characteristics. Finally, simulation and research results affirm the viability of the new plan.

Then, nowadays, The latest work in this area is conducted by this year 17 APRIL 2020 IEEE JOURNAL, ALOK K. MISHRA , SOUMYA R. DAS, PRAKASH K. RAY, RANJAN K. MALLICK , ASIT MOHANTY, DILLIP K. MISHRA [10] has conducted research in this field and discovered that in this operation a three-phase three-wire device hybrid shunt active control filter was integrated. The prototype was created with the aim of eliminating loaded harmonics and increasing PF-to-unit input. The method that has been developed is economic, easy and fast to use to extract harmonics produced by load. Simulation and hardware experiments were also performed, which minimized the amount of harmonic and THD of the source present. In a wide range of operational scenarios, the proposed FOPIDC-based shunt hybrid PSO-GWO Power Filter offers greater harmonic compensation than the optimized PSO GWO HSAPF based on the FOPIDC.

III. PROBLEM IDENTIFICATION

Single-phase systems are also used for low-voltage energy generation. A low-tension 415/240V grid is used to power many office buildings and production facilities. Due to the rapid development of advanced power conversion machines, electronic equipment models, computers, office automation, air conditioning systems the existing distortion caused by harmonic has grown significantly, adjustable air velocity heating and other advanced power converters. The speedy increase of advanced Non-linear loads leads to the problem that single-phase systems have over-neutral current. Those neutral currents are dominated by the harmonic order 3rd, 9th, 15th, 21st, 27th, etc. For these harmonics, three harmonics are the word. The neutral wire will build up this harmonic current. This overwhelms the neutral pilot. Harmonic results in an electricity grid can boost cost control, quality regulation and energy usage while reducing energy efficiency.

• Transformer and power line overheating
• Circuit breakers tripping and fuses bursting
• Overloading and degradation of capacitors
• Interfering with telecommunication circuit and ripple control device caused by signal interference in converter equipment.
• Transmission losses have increased.
• An excessive amount of neutral current is flowing through the neutral cable.

IV. PROPOSED METHODOLOGY

Active Shunt power filters are supplied with the aid of the Gray Wolf Optimization Technique and the proportional-integral-derivative controller. Various methods are used for minimizing harmonics and improving the power factor operation.

FOPID Controller

The PID controller is a multifunctional input controller for various applications. It is also known as the Three Word Controller because its form has three parameters. The values of these parameters are defined by the corresponding output index. One of these output indices is the integral square error of the computed process variable with the objective fixed. The control system is designed to minimize square error integrity and thus to improve dynamic response. The values of the three acts' parameters can be shown in time: (P) forecast any future errors, (I) predict the errors of the past and (D) predict the latest errors. The PID controller comprises all three acts. Table shows the effect of each action parameter on the time response and stability of the device (I).

Table I. Effects of increasing the value of each parameter of conventional PID controller.

Parameter	Rise time	Overshoot	Settling time	Steady-state error	Stability
Kp	Decrease	Increase	small change	Decrease	Degrade
Ki	Decrease	Increase	Increase	Eliminate	Degrade
Kd	Minor change	Decrease	Decrease	No effect in theory	Improve if Kd smal

The block diagram of a single input-single output closed-loop control scheme with unity feedback is shown in Fig. (2),

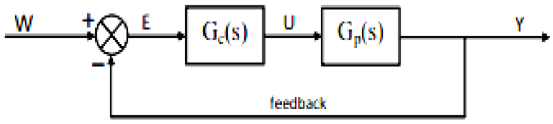

Fig. 2. The feedback control loop

where $G_c(s)$ is the controller's transfer function, $G_p(s)$ is the plant's transfer function, W is the necessary value, E is the error between the desired input and the actual output value, U is the control value, and Y is the real value of output.

The control function in the time domain is the number of these three acts.

$$u(t) = Kp\,e(t) + Ki \int e(t)dt + Kd\,\frac{de(t)}{dt}$$

In the s-domain, the PID controller's transition function is:

$$G_c(s) = \frac{U(s)}{e(s)} = K_p + K_i\frac{1}{s} + K_d\,s = (K_p s^2 + K_p s + K_i)/s$$

Podlubny suggested the FOPID controller for the first time in 1999. It's the extension to what's been done before.

Fractional calculus-based PID controller

When λ=1 and δ=1, it is a conventional PID controller; when δ=0, it is a PI controller; and when λ=0, it is a PD controller. Figure 1 shows the block diagram of a closed-loop control mechanism with a single input and single output and a fractional (PID) controller (FOPID) Fig. (3)

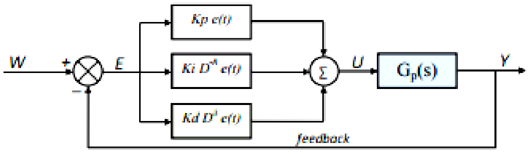

Fig. 3. Generic closed loop control system with the fractional order ($PI^{\lambda}D^{\delta}$) controller (FOPID)

The PID controller's differential equation is as follows:

$$U(t) = K_p\,e(t) + K_i D^{-\lambda}\,e(t) + K_d D^{\delta}\,e(t)$$

In this case, and are fractional orders. The controller equation becomes; by using Laplace to transform the above equation.

$$U(s) = K_p\,e(s) + K_i\,s^{-\lambda}\,e(s) + K_d\,s^{\delta}\,e(s)$$

The PID controller is a subset of the PID controller, with λ = δ =1. The fractional PID controller is extended to plane, while the conventional PID controller is expressed by four points (P, PI, PD, and PID). This expansion provides more stability and precision, as seen in Fig. (4).

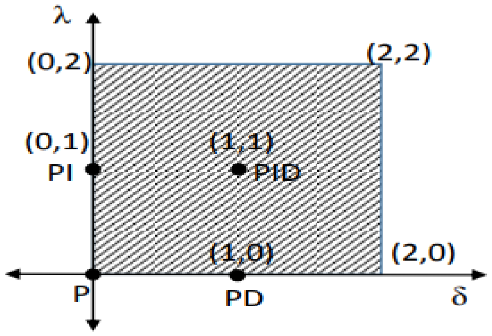

Fig. 4. Generalization of FOPID Controller: From point to plan

Grey Wolf Optimization Techniques: Genetic Algorithms Based Grey Wolf Optimization Techniques:

The genetic algorithm for optimization and search problems is a local research technique. Genetic algorithms are a type of developmental algorithm that uses techniques such as heritage, mutation, selection and crossover based on evolutionary biology (also called recombination). There's a group of abstract representations of candidate optimization solutions (called chromosomes) for better solutions to genetic algorithms used as computer simulations. Evolution takes place in the years and starts from a group of humans who are mostly unrelated. The population's fitness is evaluated per generation and some individuals (based on their fitness), are randomly selected from the current population and modified to produce a new population (mutated or recombined). In the next version, the updated population is used. Today the following are discussed by Advanced Optimization Techniques, including Grey Wolf Optimization Techniques:

Grey Wolf Optimization:

Mirjaliali Mohammad and Lewis proposed it as a metaheuristic algorithm in 2014. Grey Wolves' social order and hunting technique have influenced GWO. The Grey Wolves lived in a very well-organized pack.

The size of the pack is approximately 5+12. They can even work together as a Pack. They have a strong leader. It can Male and Female Leaders.

The rank of Wolves in Pack

The **Alpha Wolf** is a Peck Leader that may be either male or female.

Decision-making on shooting, sleeping quarters, and waking time, among other things

Beta Wolf: A contender for the role of Alpha Wolf.

Giving Alpha feedback is your responsibility, and it will assist Alpha in making decisions.

Delta Wolf: Feed the pack and work for the pack if the pack is in danger.

Caretaker, Older Wolf scouts, and Hunter are **Omega Wolf's** roles.

Grey Wolf Algorithm for Optimization Working conditions:

The following are the key steps of grey wolf hunting:

Searching: I'm on the lookout for the Prey.

Tracking, Catching, and Approaching the Prey are all steps in the pursuit.

Encircling and Harassing the Prey: Encircle and harass the prey until it stops moving.

Attacking the Prey is an assault.

V. EXPECTED OUTCOME

Using the grey wolf optimization technique, a shunt active power filter was analyzed. The utility of a shunt active power filter for harmonically removing warped source current. Two modes of load were considered in order to test the validity and versatility of the proposed scheme. The THD of the source present decreases in both cases. The use of non-linear loads has grown and the power factor in the grid has become harmonic and difficult. Many topologies may be used to exclude harmony from energy systems with THD reductions under IEEE standards being one of them, the Grey Wolf Optimization Methodology.

VI. CONCLUSIONS

Harmonics are generated by non-linear loads in low voltage networks. Although the injection current has the most effect on the electrical network control factor, it would recommend that disruption of the disorder is avoided. Through the deployment of many non-linear loads on a network, issues of harmonics can occur. However, additional Shunt active filters may be resolved, to compensate, respond, and stabilize the imbalance currents for the current harmonics of un-line led load. An active shunt filter detects the load current and injects the device to offset current or reactive load harmonics.

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