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Fuzzy Logic Controller Based On Power Factor Corrections with Combination of Shunt Filter and Tcr

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ABSTRACT

Power Factor Correction (PFC) provides well-known benefits to electric power systems. These benefits include power factor correction, poor power factor penalty utility bill reductions, voltage support, release of system capacity, and reduced system losses. The performance of fuzzy logic controller only depends on the selection of membership function and Inference of fuzzy rules, fuzzy logic controllers have an advantage in coping with the time varying non-linearity of switches. The Proportional & Integral controllers (PI) controller design requires an accurate mathematical model of the plant. Also it fails to perform satisfactorily performance under various parameters such as voltage variations, nonlinearity, load disturbance, etc. The paper presents an advanced PFC technique by using Thyristor controlled rectifier TCR. The PFC strategy uses PI controllers to correct the input current shape and fuzzy controller to control the output voltage. A model for Power Factor Correction has been formed by using the MATLAB software. The produced model has also been simulated by using fuzzy logic tools. The simulation results show that the fuzzy controller for output voltage can achieve better dynamic response than its PI counterpart under lager load disturbance and plant uncertainties.

Keywords- Thyristor controlled rectifier TCR, Fuzzy inference systems, Fuzzy rules, Membership function.

Harmonics and reactive power regulation and guidelines are upcoming issues and increasingly being adopted in distributed power system and industries. Vital use of power electronic appliances has made power management smart, flexible and efficient. But side by side they are leading to power pollution due to injection of current and voltage harmonics. Harmonic pollution creates problems in the integrated power systems. The researchers and engineers have started giving effort to apply harmonic regulations through guidelines of IEEE 519-1992. Very soon customers have to pay and avail the facility for high performance, high efficiency, energy saving, reliable, and compact power electronics technology. It is expected that the continuous efforts by power electronics researchers and engineers will make it possible to absorb the increased cost for solving the harmonic pollution.

The thyristor controlled reactors of various network configurations are widely used in industries and utility systems for harmonic mitigation and dynamic power factor correction. These thyristor controlled reactor operate as a variable reactance in both the inductive and capacitive domains. By means these two parameters two types of problems are normally encountered. The first problem is the reactive power (Var) that leads to poor power

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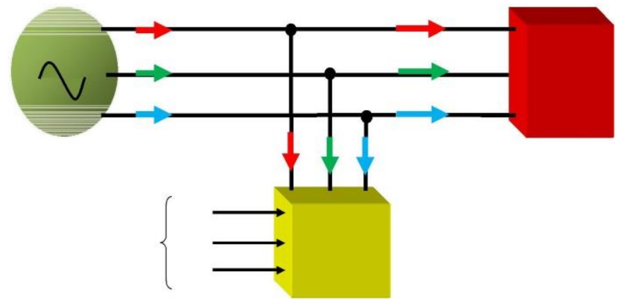
factor and the harmonics appears due to presence of power converter devices and nonlinear loads for example, electrics machines, fluctuating industrial loads, such as electric arc furnaces, rolling mills, power converters etc. These types of heavy industrial loads are normally concentrated in one plant and served from one network terminal, and therefore, can be handled best by a local compensator connected to the same terminal.

The main emphasis of the investigation has been on compactness of configurations, simplicity in control, reduction in rating of components, thus finally leading to saving in overall cost. Based on these considerations, a wide range of configurations of power quality mitigators are developed for providing a detailed exposure to the design engineer in selection of a particular configuration for a specific application under the given constraints of economy and the desired performance. Fig 1.1 shows a classical shunt passive filter is connected the power system through common coupling point (PCC). Because of using non-linear load, the load current is highly non-linear in nature. The compensating current which is the output of the shunt passive filter is injected in PCC, by this process the harmonic cancellation take place and current between the sources is sinusoidal in nature. The passive filter is popular in cancellation of harmonic current in power system. To control this process, there are two ways i.e.



(i)Harmonic extraction technique
(ii)Current modulator

Harmonic Extraction

The harmonic extraction is the process in which, reference current is generated by using the distorted waveform. Many theories have been developed such as p-q theory (instantaneous reactive power theory), d-q theory, P-I controller, adaptive controller etc. Out of these theories more than 60% research works have been consider p-q theory and d-q theory due to their accuracy, robustness and easy calculation.

Current Modulator

Current modulator mainly provides the gate pulse to the ac-dc converter. There may be many techniques used for giving the gate signals to PWM VSI or CSI such as sinusoidal PWM, triangular PWM etc.

The above described two control techniques (harmonic extraction technique and current modulator technique) are main research foci of many researchers in recent years. It may be noted that either harmonics extraction technique or the current modulator can be used individually or both at a time. Apart from these two techniques, most of the research works are directed also in dealing with multi-level rectifier control problems.

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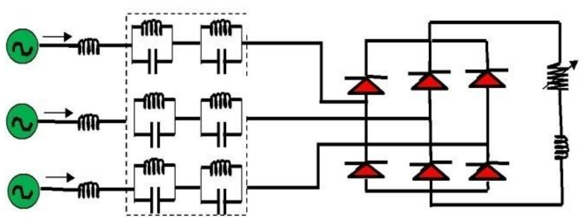
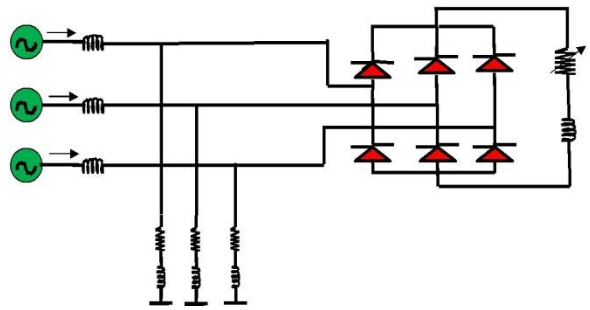
Passive Hybrid Filter

The use of passive shunt filter creates the problem of voltage regulation at light loads. It also increases the dc voltage ripple and ac peak current of the rectifier. On the other hand, passive series filter suffers from lagging power factor operation as well as the voltage drop across the filter components both at fundamental frequency as well as harmonic frequencies. To overcome these drawbacks, a combination of both these configurations is presented as passive hybrid filter. This configuration is able to supplement the shortfalls of both these passive filters and simultaneously it results in improvement in harmonic compensation characteristics for varying load condition even under stiff and distorted ac mains voltage.

Schematic diagram of a ac-dc converter with R-L load and passive series filter at input



Schematic diagram of a six pulse ac-dc converter with R-L load and passive shunt filter at input



Design of passive filters

Various issues involved with the design of the passive filters are considered here. The design procedure of passive filter is explained

Filter design constraints

There are various issues in the design of a passive filter for its proper functioning in harmonic reduction. The key issues are mentioned here:

Minimizing harmonic source current

The prime objective of the filter design is to minimize the harmonic current in ac mains. This is ensured by minimizing the filter impedance at the harmonic frequencies so that the harmonic filter acts as a sink for the harmonic currents.

Minimizing fundamental current in passive filter

To ensure that the installation of passive filter does not cause the system loading, the fundamental current in the passive filter is minimized by the maximizing the passive filter impedance at the fundamental frequency. Environment and ageing effect The capacitors with metalized film construction lose capacitance as they age. Similarly the manufacturer tolerance of the harmonic filter reactor may result in tuned frequency higher than the nominal. An IEEE Standard 1531[45]

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recommends that the passive filters are tuned at 6% below the rated frequency so that it will exhibit acceptable tuning at the end of its 20 year life

Design of Passive Shunt Filter

The passive shunt filter consists of first order series tuned low pass filters for 5^{th} and 7^{th} order harmonics. For the series tuned low pass filters, the impedance is given by Where Q_{sh} is the reactive power provided by the passive filter, h is the harmonic order of the passive filter; X_L is the reactance of inductor. X_c is the reactance of the capacitor at fundamental frequency. The reactive power requirement may be initially assumed around 25% of the rating of the load [44]. It may be equally divided among different filter branches. The values of series tuned elements may be calculated from eqn. (2.5). The quality factor for low pass filter (defined as $QF = X_L/R$), is consider as 30 in this work to calculate the value of the resistive element.

FUZZY LOGIC CONTROLLER

Fuzzy logic has rapidly become one of the most successful of today's technologies for developing sophisticated control systems. The reason for which is very simple. Fuzzy logic addresses such applications perfectly as it resembles human decision making with an ability to generate precise solutions from certain or approximate information. While other approaches require accurate equations to model real-world behaviors, fuzzy design can accommodate the ambiguities of real-world in human language and logic. Although genetic algorithms and neural networks can perform just as well as fuzzy logic in many cases , fuzzy logic has the advantage that the solution to the problem can be cast in terms that human operators can understand, so that their experience can be used in th design of the controller. This makes it easier to mechanize tasks that are already successfully performed by humans.

In a broad sense, fuzzy logic refers to fuzzy sets - a set with unsharp boundaries. Examples of fuzzy sets are “hot,” “tall,” “medium,” etc. In a narrow sense, fuzzy logic is a logical system that aims to formalize approximate reasoning .In fuzzy logic a fuzzy symbol can take any truth values from the closed set [0, 1] of real numbers thus generalizing the Boolean truth values. As the technology was further embraced, fuzzy logic was used in more useful applications.

PROGRAMMING THE FUZZY LOGIC

"Fuzzy logic allows a generalization of conventional logic”. It provides for terms between "true" and "false" like "almost true" or "partially false". Therefore, fuzzy logic cannot be directly processed on computers but must be emulated by special code. Fuzzy tech provides you with all the tools to design and test a fuzzy logic system**.** Once designed, fuzzy tech stores your work as an FTL format file. FTL stands for "Fuzzy Technology Language", and can be considered "the programming language of fuzzy logic". Fuzzy Tech provides an all-graphical user interface fuzzy Tech converts this FTL description to code that can be used on your target hardware that is, the hardware where your fuzzy logic solution finally shall run on.

PROCEDURES FOR FUZZY CONTROL

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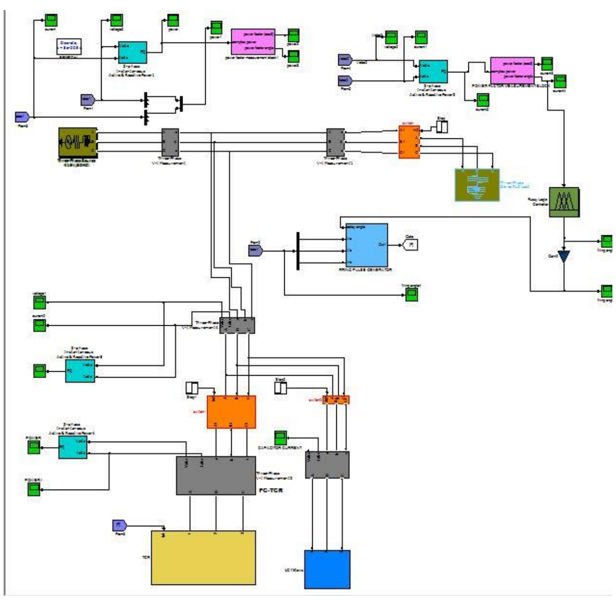
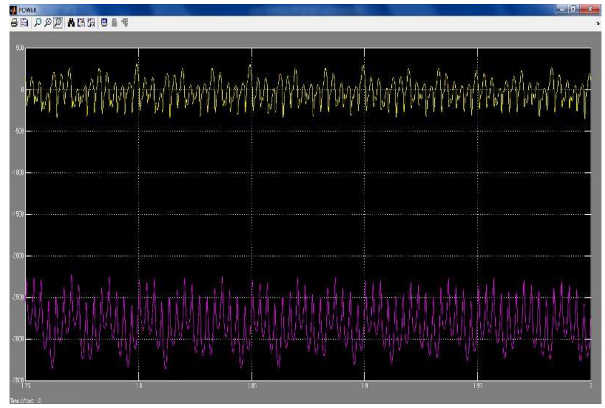
Fuzzy logic makes it possible to express a control system with a set of fuzzy rules. A fuzzy rule is an "IF-THEN" statement of a desired control action using human language variables. An example of a fuzzy rule would be:

- If the temperature is a little above the set point and rising at a medium rate, then increase cooling slightly.
- If the temperature is somewhat below the set point, but the present amount of cooling is a lot less than what the normal amount has been, then wait a while to change cooling.

SIMULINK MODEL PASSIVE FILTER WITH TCR



SIMULATION OUTPUT



CONCLUSIONS

The main objective of this investigation has been to evolve different power quality improvement techniques for improving various power quality indices at ac mains as well as on dc bus in ac-dc converter with R-L load. It has also intended to determine the extent of improvement in different power quality indices in various techniques for application. This research work has been on developing configurations suitable for retrofit applications, where presently a six pulse diode bridge rectifier is being used. The obtained results of various circuit configurations of front end ac-dc converters in preceding chapters have demonstrated successfully fulfilling these objectives.

The effect of multiple harmonic sources can be investigated by applying the superposition principle.

The SVC harmonic generation modeled by positive-, negative-, and zero-sequence
Harmonic sources.

The system represented by linear models at each harmonic frequency.

The precise evaluation of harmonic distortion must have accurate load modeling.

Hence the TCR-TSC combination is better in SVC.

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