INTRODUCTION

Power quality determines the fitness of electrical power to consumer devices. Synchronization of the voltage frequency and phase allows electrical systems to function in their intended manner. The term is used to describe electric power that drives an electrical load and the load's ability to function properly. Without the proper power, an electrical device (or load) may malfunction, fail prematurely or not operate at all. Power is simply the flow of energy and the current demanded by a load is largely uncontrollable. Active filtering of electric power has now become a mature technology for harmonic and reactive power compensation in two-wire (single phase), three-wire (three phase without neutral), and four-wire (three phase with neutral) ac power networks with nonlinear loads. This paper presents a comprehensive review of active filter (AF) configurations, control strategies, selection of components, other related economic and technical considerations, and their selection for specific applications. It is aimed at providing a broad perspective on the status of AF technology to researchers and application engineers dealing with power quality issues. Solid state control of ac power using thyristors and other semiconductor switches is widely employed to feed controlled electric power to electrical loads, such as adjustable speed drives (ASD’s), furnaces, computer power supplies, etc. Such Controllers are also used in HV dc systems and renewable electrical power generation [1] [2] [3]. In general industry and consumers both are responsible for the increasing deterioration of the power system voltage and current waveforms. Fig.1 presents a power system with sinusoidal source voltage ($v$ After fuzzy reasoning we have a linguistic output variable which needs to be translated into a crisp value. The objective is to derive a single crisp numeric value that best represents the inferred fuzzy values of the linguistic output variable. Defuzzification is such inverse transformation which maps the output from the fuzzy domain back into the crisp domain. Some defuzzification methods tend to produce an integral output considering all the elements of the resulting fuzzy set with the corresponding weights. Other methods take into account just the elements corresponding to the maximum points of the resulting membership functions.

Operating with linear and nonlinear loads. The non linear load current ($iL1$) contains harmonics and is non sinusoidal. The resulting harmonics in the source-current (is) produces a nonlinear voltage drop (v) in the line impedance, which distorts the load voltage ($yL$). Since load voltage is distorted, even the current at the linear load ($iL2$) becomes non sinusoidal. The presence of harmonics in power lines result in low power factor, low efficiency, increased power losses in the distribution system and interference problems in communication systems [4]. Sometimes this leads to the failures of electronic equipments, which are very sensitive to voltage and current distortions [19],[6]. Passive filters can be used to compensate these power quality problems to some extent, but they have limited operation range and solve/reduce the problem for the specific frequencies they are tuned for.

Fuzzy Logic Controller

Most commercial fuzzy products are rule-based systems that receive current information in the feedback loop from the...
device as it operates and control the operation of a mechanical or other device. A fuzzy logic system has four blocks as shown in Fig. 2. Crisp input information from the device is converted into fuzzy values for each input fuzzy set with the fuzzification block. The universe of discourse of the input variables determines the required scaling for correct per-unit operation. The scaling is very important because the fuzzy system can be retrofitted with other devices or ranges of operation by just changing the scaling of the input and output. Those are combined and converted to crispy values with the defuzzification block. The output crisp value can be calculated by the center of gravity or the weighted average.

**Fuzzification**

Fuzzification is the process of decomposing a system input and/or output into one or more fuzzy sets. Many types of curves can be used, but triangular or trapezoidal shaped membership functions are the most common because they are easier to represent in embedded controllers. Fig 3 shows a system of fuzzy sets for an input with trapezoidal and triangular membership functions. Each fuzzy set spans a region of input (or output) value graphed with the membership. Any particular input is interpreted from this fuzzy set and a degree of membership is interpreted. The membership functions should overlap to allow smooth mapping of the system. The process of fuzzification allows the system inputs and outputs to be expressed in linguistic terms so that rules can be applied in a simple manner to express a complex system. Suppose a simplified implementation for an air-conditioning system with a temperature sensor. The temperature might be acquired by a microprocessor which has a fuzzy algorithm to process an output to continuously control the speed of a motor which keeps the room in a “good temperature,” it also can direct a vent upward or downward as necessary. The figure illustrates the process of fuzzification of the air temperature. There are five fuzzy sets for temperature: COLD, COOL, GOOD, WARM, and HOT.

**Defuzzification**

After fuzzy reasoning we have a linguistic output variable which needs to be translated into a crisp value. The objective is to derive a single crisp numeric value that best represents the inferred fuzzy values of the linguistic output variable. Defuzzification is such inverse transformation which maps the output from the fuzzy domain back into the crisp domain. Some defuzzification methods tend to produce an integral output considering all the elements of the resulting fuzzy set with the corresponding weights. Other methods take into account just the elements corresponding to the maximum points of the resulting membership functions.

**Proposed Design Of Parallel Converter Scheme**

In this paper the objective is to improve the power quality of unregulated non linear loads such as diode bridge rectifiers feeding resistive or inductive loads. In order to achieve this, a parallel processing scheme of converters as shown in Fig., is proposed. In this scheme a single phase Synchronous Link Converter (SLC) is used as an auxiliary converter (it replaces the shunt active filter) in parallel with diode bridge rectifier with DC capacitor supplying a resistive load, as main converter. The two converters are connected in parallel at the input and also at the output. Bulk amount of active power flows through the main converter, whereas the auxiliary converter takes care of the harmonic and reactive power requirements of the main converter. A power transformer with 2:1 turns ratio is used at the input of the auxiliary converter in order to match the DC output voltage of two converters. The SLC limits the total harmonics to acceptable levels and can adapt to the harmonic variations or even to the changes in the nonlinear load types. The paper will also focus on to the design and control strategy of this parallel power processing converter. The block diagram of parallel processing converters including non-linear load for a single system is shown in fig. 1.
Here, a single-phase uncontrolled diode bridge rectifier (main converter) with resistive load is taken as a non-linear load on a single phase ac mains. This draws non-sinusoidal currents from ac mains. Auxiliary converter (a synchronous link converter, SLC) is a single phase full bridge boost converter. It is basically a voltage source inverter having IGBT switches and an energy storage capacitor on DC bus. Due to its current reversibility characteristics the full-bridge inverter is connected in the parallel with the ac mains through a filter inductance $L_f$, and the DC side of the inverter is connected to a filter capacitor $C_f$. SLC overcomes the drawbacks of passive filters by using the switching mode power conversion to perform the harmonic current elimination. The main aim of the SLC is to compensate harmonics, reactive power and to eliminate the unwanted effects of non ideal ac mains so that it supplies only unity power factor sinusoidal currents. SLC is operated to improves the power quality of diode bridge rectifier non linear load by injecting a compensated current $i_a$ such that summation of input load current $i_L$ and auxiliary converter current $i_a$ makes the source current $i_s$ sinusoidal and in phase with the input source voltage.

This principle can be used in variety of nonlinear loads which are considered as sources of harmonics. Moreover, with an appropriate control scheme, SLC not only compensates the harmonic component of source current but also takes care of reactive power demand of non linear load. As the source voltage and source current becomes in phase with each other, hence overall power factor is also improved. In this way the power distribution system sees the combination of nonlinear load and auxiliary converter (SLC) as an ideal resistor. The auxiliary converter is controlled in such a way that sum of main converter input current and auxiliary converter input currents are sinusoidal and in phase supply voltage. Reference input current of auxiliary converter is derived using a feedback of output dc voltage of SLC and main converter which are connected in parallel, comparison of rms values subsequently compared with the actual output dc voltage to drive the reference for the input source current.

**Power quality Analysis with Linear load Application**

Simulink model is given to show power quality on linear load, theoretically as well as practical realization shows smooth current wave form, this result is basically provided to get a difference on power quality on non linear load application.

**Power quality Analysis with Non Linear Load Application**

During the load application on power supply in its various applications the quality of power becomes poor due to effect of non linear load (like electronic appliances), here a Simulink model is given to show the effect of non linear load (power rectifier) on power quality in terms of its harmonic distortions. The distorted current wave form is being depicted to show problem issue on application of non linear load.
A. Simulation results at non linear load

As now it is clear from above analysis, the addition of non linear load produces a very high Level of distortion in power quality that is shown in terms of percent THD. Finally a Simulink based model is proposed to reduce these harmonics from input current and hence to provide significant improvement in overall THD.

A. Simulation results at non linear load with proposed Scheme (SLC)

Figure 7 Simulink model of proposed control scheme

Power Quality Improvement on Nonlinear Load using SLC with Fuzzy Controller

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CONCLUSION

In this work an effort has been made to develop and implement a harmonic compensator for single phase diode bridge rectifiers AC to DC unregulated converter (main converter). The principle is based on parallel power processing. An auxiliary converter which is basically a synchronous link converter is connected in parallel to the main converter in order to compensate the harmonic and reactive power of the main converter. The above scheme has been simulated using MATLAB simulation software. Various simulation results are presented for the comparisons. This has the flexibility of PC based control. Using MATLAB software Fuzzy control is implemented in the digital environment. It is found that initially (with linear load) the waveform of source current was sinusoidal and in phase with source voltage thus having power factor unity. With the application of non linear load the waveform of source current became distorted having THD as 117% thus power quality becomes poor having power factor other than unity. As we apply SLC with Fuzzy controller and simulate the model with the help of MATLAB it was found that the waveform distortion of source current has been reduced to 5% thus the power quality is improved with power factor close to unity.

References

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