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INTELLIGENT CONTROL WITH FUZZY CONTROLLER FOR MINIMIZATION OF CURRENT HARMONICS

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ABSTRACT

Due to its simplicity, the discontinuous conduction mode boost rectifier is potentially the least expensive active line-harmonics reducing circuit. The line current however, shows considerable distortion when the peak input voltage is close to the output voltage. This research proposes a simple, low-cost method to reduce the line harmonics. A periodic voltage signal is injected in the control circuit to vary the duty cycle of the boost switch within a line cycle so that the third-order harmonic of the input current is reduced and the THD is improved. The proposed technique eliminates the additional harmonic generator, phase detecting and phase-locking circuits, which is proposed in the literature. Instead we can utilize the output voltage of the rectifier in the boost converter in order to modulate the duty cycle of the boost switch. As a result, the injected signal is naturally synchronized with line current. Simulation and experimental results are presented to confirm the validity of the method. An ac to dc converter consisting of a line frequency diode bridge rectifier with a large output filter capacitor is cheap and robust, but demands a harmonic rich ac line current. As a result, the input power factor is poor. Due to problems associated with low power factor and harmonics, harmonic standards and

guidelines, which will limit the amount of current distortion allowed into the utility, is introduced.

KEYWORDS: THD, FFT, FLC.

I. INTRODUCTION

Harmonics are one of the major concerns in a power system. Harmonics cause distortion in current and voltage waveforms resulting into deterioration of the power system. The first step for harmonic analysis is the harmonics from non-linear loads. The results of such analysis are complex. Over many years, much importance is given to the methods of analysis and control of harmonics. Harmonics present in power system also has non-integer multiples of the fundamental frequency and have a periodic waveform. The harmonics are generated in a power system from two distinct types of loads. First category of loads is described as linear loads. The linear time-invariant loads are characterized such that application of sinusoidal voltage results in sinusoidal flow of current. Non-linear loads are considered as the second category of loads. The application of sinusoidal voltage does not result in a sinusoidal flow applied sinusoidal voltage for non-linear devices. Harmonic current is isolated by using harmonic filters in order to protect the electrical equipment from getting damaged due to harmonic voltage distortion. They can also be used to improve the power factor. The active filters are normally available for low voltage networks. The active filters consist of active components such as IGBT-transistors and eliminate many different harmonic frequencies. Harmonic currents produced by nonlinear loads are injected back into power distribution systems through the point of common coupling.

II. Harmonic Frequencies of a Periodic Voltage or Current

Harmonics or harmonic frequencies of a periodic voltage or current are frequency components in the signal that are at integer multiples of the frequency of the main signal. This is the basic outcome that Fourier analysis of a periodic signal shows. Harmonic distortion is the distortion of the signal due to these harmonics.

II. Measuring Total Harmonic Distortion

Calculating theoretical THD can be a good exercise, but it can be a lot of work, and in practice, you aren't going to get an ideal signal (e.g., a perfect square wave) anyway. The outcome of these calculations can therefore only give an approximation for the THD that you might get for a given signal type. In practice, THD must be measured to obtain the RMS value of the fundamental frequency and all of the harmonics. This measurement can be done in a couple of ways.

Iii. Fuzzy Set Theory

The concept of the fuzzy set introduced by Zadeh is a set without precise boundaries. In contrast a classical set or a crisp set has boundaries that are known precisely. Elements of a fuzzy set belong to it with a certain degree, also called degree of membership, that ranges from 0 to 1 while in crisp set it is only 1 or 0 which means "belong to" or "does not belong to". The degree of membership is a result of mapping the input space also called universe of discourse using a membership function.

Iv. Artificial Intelligence (AI)

The ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings. The term is frequently applied to the project of developing systems endowed with the intellectual processes characteristic of humans, such as the ability to reason, discover meaning, generalize, or learn from past experience. Since the development of the digital computer in the 1940s, it has been demonstrated that computers can be programmed to carry out very complex tasks—as, for example, discovering proofs for mathematical theorems or playing chess—with great proficiency. Still, despite continuing advances in computer processing speed and memory capacity, there are as yet no programs that can match human flexibility over wider domains or in tasks requiring much everyday knowledge.

V. Objectives of Study

1. To recompense balanced and unbalanced nonlinear load currents with fuzzy logic controller.
2. To provide a sinusoidal supply current with low harmonic distortion.
3. To implement Fuzzy Logic Controller in MATLAB/Simulink software to reduce THD.

Vi. Proposed Algorithm

Fuzzy Logic Controller is used to control injected voltage into distribution line to compensate faults whether sag or swell. For this purpose IGBT controlled by pulse width modulator is used. The pulse width of PWM can be controlled and for this purpose some controllers like PI, fuzzy logic and BFO optimized fuzzy logic, are used here. Fuzzy logic algorithm's performance depends upon its membership functions and rule sets.

VII. METHODOLOGY

Fuzzy system methodology has been demonstrated to allow solving uncertain and vague problems, Example applications for power quality and power systems are included in this research, a fuzzy-logic is introduced. A fuzzy-logic-based approach is proposed to control the harmonic using fuzzy inference mechanism. The advantages of using a fuzzy system are simplicity, ease of application, flexibility, speed and ability to deal with imprecision and uncertainties. The proposed approach is tested for linear and nonlinear loads supplied from sinusoidal and/or non sinusoidal sources while considering lagging and leading power factor.

VIII. Input and Output Fuzzification

The displacement power factor, transmission efficiency power factor, and oscillation power factor are used to be inputs. The values of the displacement power factor and transmission efficiency power factor range between 0 and 1 while those of the oscillation power factor range between 0 and 0.816. We use the triangular form for the membership functions due to its simplicity to represent input variables, and three linguistic variables, Low, Medium, and High. The output are seven linguistic variables; Low, Moderately Low, Somewhat Low, Medium, Somewhat High, Moderately High, and High.

IX. Fuzzy Inference Mechanism

Fuzzy inference mechanism that is used here, is commonly used, in which the implication part is modeled by means of the minimum operator while the aggregation part is processed using the maximum operator.

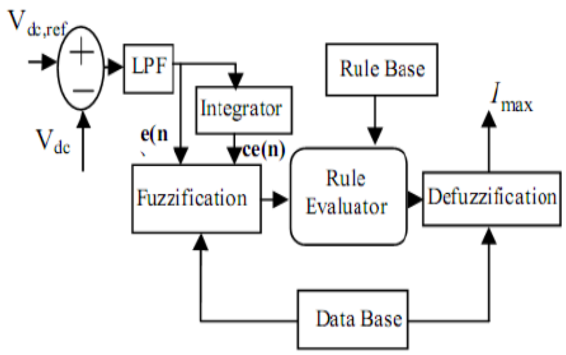

Fig. 1: Proposed diagram of Proposed Fuzzy logic controller.

X. Simulink

Simulink is a block diagram environment for multi domain simulation and Model-Based Design. It supports system-level design, simulation, automatic code generation, and continuous test and verification of embedded systems. Simulink provides a graphical editor, customizable block libraries, and solvers for modeling and simulating dynamic systems. It is integrated with MATLAB, enabling you to incorporate MATLAB algorithms into models and export simulation results to MATLAB for further analysis.

XI. RESULT AND DISCUSSION

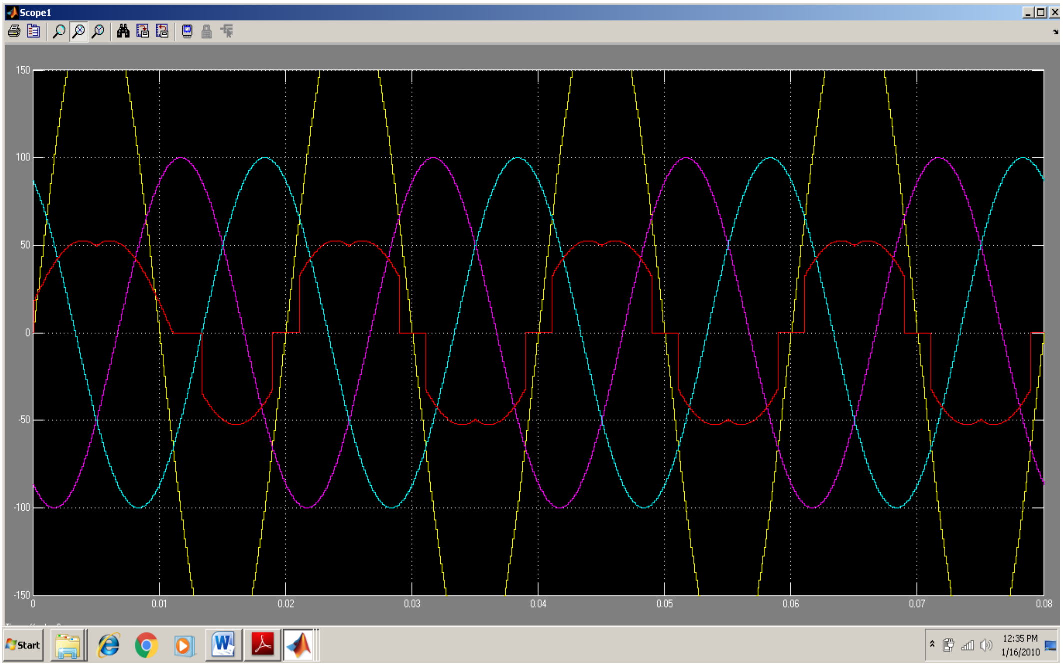

Fig. 2: Input Voltage (200) Performance in waveforms during Three-phase unbalanced Condition with source current using Fuzzy Logic Controller.

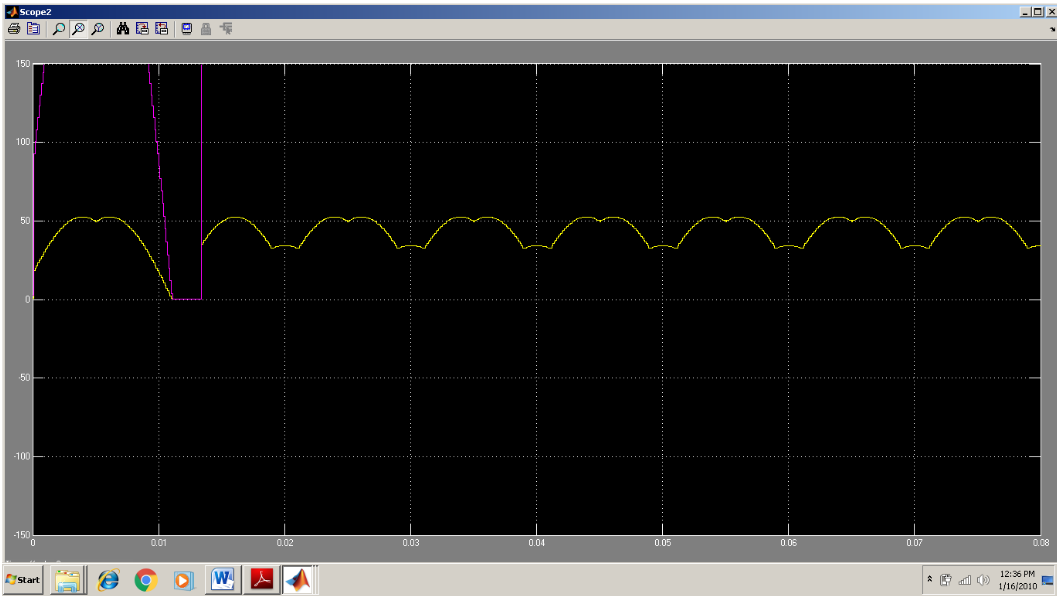

Fig. 3: Input Voltage (200) Performance in waveforms during Three-phase unbalanced Condition with Load Current using Fuzzy Logic Controller.

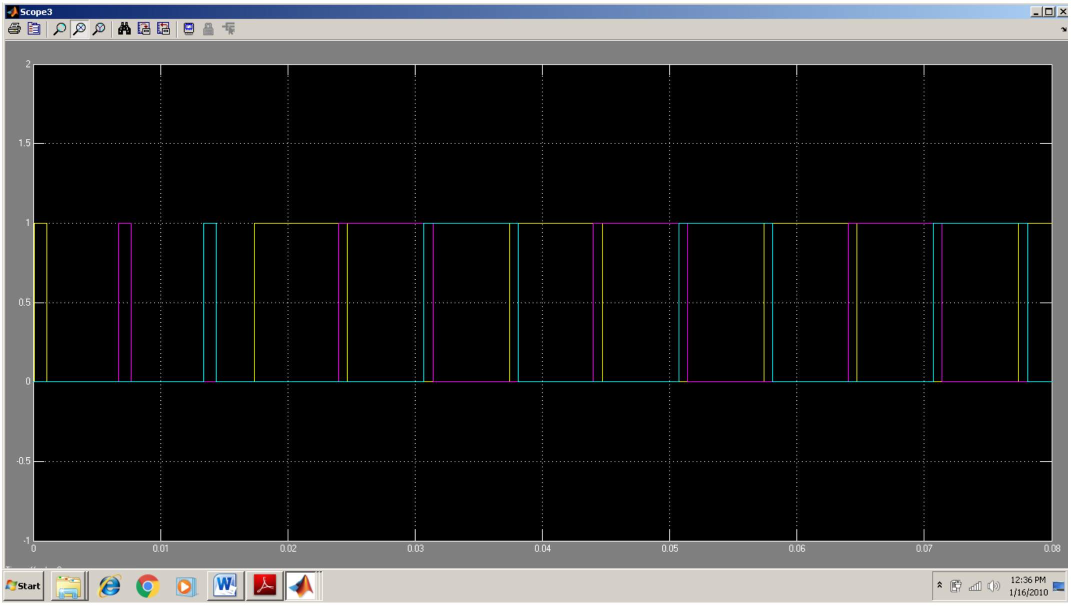

Fig. 4: Input Voltage (200) Performance in waveforms during Three-phase unbalanced Condition of Gate pluses using Fuzzy Logic Controller.

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Sampling time       = 0.0001 s
Samples per cycle   = 200
DC component        = 4.732e-007
Fundamental         = 130.2 peak (92.08 rms)

Total Harmonic Distortion (THD) = 9.28%

Maximum harmonic frequency
 used for THD calculation  = 4950.00 Hz (99th harmonic)

    0 Hz  (DC):         0.00%    270.0°
   25 Hz                0.00%    198.9°
   50 Hz  (Fnd):      100.00%      0.1°
   75 Hz                0.00%     53.2°
  100 Hz  (h2):         0.00%      0.0°
  125 Hz                0.00%    265.8°
  150 Hz  (h3):         7.55%      0.0°
  175 Hz                0.00%    114.8°
  200 Hz  (h4):         0.00%    175.9°
  225 Hz                0.00%      0.0°
  250 Hz  (h5):         1.45%      0.0°
  275 Hz                0.00%    163.2°
  300 Hz  (h6):         0.00%      0.0°
  325 Hz                0.00%      2.1°
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Fig. 5: THD after FFT analysis of sag introduced output 550 ohm with Fuzzy Logic Controller.

Table 1: Shows the input Load with TDH.

Load	Thd With Fuzzy Logic Controller (IN %)	Thd Without Fuzzy Logic Controller (IN %)
550 Load	9.28	41.76

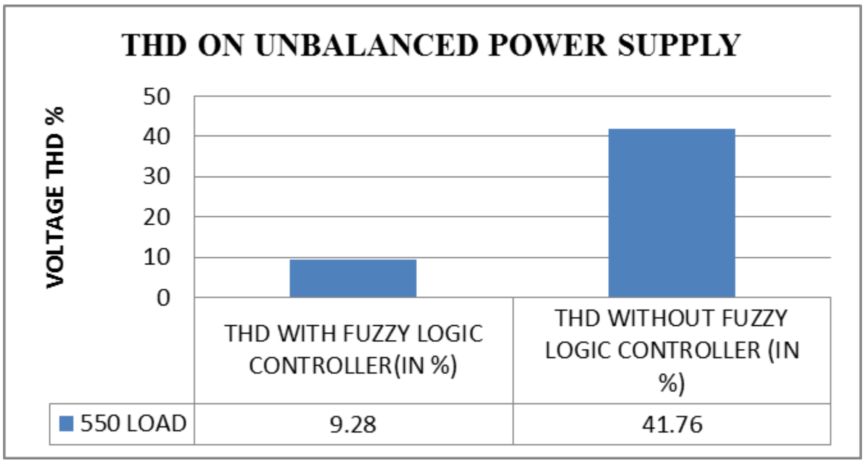

Fig. 6: Shows the Input load and minimizes the values of THD with & without Fuzzy Logic Controller on Unbalanced Supply.

XII. CONCLUSION

The results obtained by the fuzzy controller were well fit the results by balanced and unbalanced power supply. When the stages of the three phase are connected in parallel at low speeds, the efficiency is the highest among the other configurations. This shows that the fuzzy logic controller designed is much more suitable for three phase power as compared to already available model. The simulation is done in MATLAB/Simulink and the optimum solution is provided subsequently due to its fast iterative method. The results reveals that THD has been reduced from 41.76 to 9.28 % while 550 load and 750 load harmonics has been reduced from 42.06 to 7.23 % respectively.

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