Abstract

In this paper, comparative study of Firefly algorithm based on Intelligent controller (Fuzzy Logic controller) Diode bridge Boost PFC converter with PI, PID controller is proposed. Main aim of the proposed method to compensate the harmonic current generated by the Diode Bridge rectifier which shunted with Boost PFC converter, so as to achieve a Power Factor nearer to unity and to get improved efficiency, regulated DC voltage. Merits of the proposed converters include higher power density, simpler control strategy, less harmonic control contents, nearly unity power factor and unidirectional power flow. Principle, design analysis and conditions achieving for the proposed converters are described.

Keywords: Power factor correction, AC to DC Converter, Efficiency, Firefly algorithm, PID, PI, Intelligent Controller, Fuzzy Logic.
1 INTRODUCTION

Converters have been extensively employed with the generation of the power electronics. In addition, they are utilized for the DC loads in commercial, industrial and residential applications. Normally, there are diverse phases involved in conversions though there are two kinds of universal conversions available such as the AC to DC conversion and DC to AC conversion. In a large majority of the cases, these conversions depend invariably on the state the of conversion applications. Normally, an AC to DC converter is also called the rectifier which arranges the line supply or the parallel AC sources as input and provides a regulated DC output voltage. With a particular range of voltage values the corresponding controlled DC voltage may be changed with the help of an independent boost or buck or a blend of the DC/DC conversions [1-2].

The fundamental control is offered by the AC to DC converters with the sparkling advantages of low price and simplicity. Conversely, the innate defects are such that the power factor (PF) tends to decrease when the ring angle goes up and the ripples are present in the output DC voltage. The most important difficulties and may create problem such as, harmonic, Low Power factor, high investment cost, low efficiency, and low dependability, which hold back their extensive use. On other hand, these rectifiers perform as nonlinear loads and draw line current harmonics which twist the mains voltage [9-12]. Other sensitive tools linked in the similar network may get badly affected by these current harmonics. However, the size and cost of a converter is based on its optimal control which should as high as feasible. Nevertheless, higher frequencies result in the raise of transistor switching losses, and hence, the converters efficiency gets restricted [11-12]. In existing works, many controller topologies such as PI, PID, fuzzy logic controller (FLC), are involved for PFC of the power converter. But these methodologies are struggles to find the optimal controlling performance based on the load.

As compared to simple rectifiers, Boost converter more expensive but efficiently improves the power quality in the applications.
Intelligence controller FFA based Fuzzy scheme has been introduced. Fuzzy logic system is based on a change in power input and power changes with respect to the input voltage changes. However, fuzzy can determine the size of uninterrupted voltage required to maintain the constant voltage. Many intelligent optimization methods have been offered and used like neural networks, genetic algorithms, swarm intelligence, ant colony optimization, optimization Big Bang Big Crunch and others have been proposed to automatically generate fuzzy rules from numerical data. This paper proposes a new method Firefly Algorithm (FA) by finding points of membership functions of FLC for boost controller. Firefly algorithm standard a, and coefficient [13]-[15], [16]. Features FFA in every iteration step to achieve faster convergence. The proposed algorithm is firefly algorithms to tune fuzzy logic controller to obtain the optimal solution for diode bridge boost converter. Intelligence controller FFA based Fuzzy scheme has been introduced. Fuzzy logic system is based on a change in power input and power changes with respect to the input voltage changes. However, fuzzy can determine the size of uninterrupted voltage required to maintain the constant voltage. The main advantage of the proposed FLC-FA is more efficient and accurate than the still fuzzy logic controller standard. In this proposed work, a comparative study of PI, PID controller and Fuzzy Logic controller with optimisation of FFA [Fire Fly Algorithm] for AC to DC converter is for the regulation of the input power factor[3] and the related power quality challenges. With regard to the power factor rectification, output DC voltage control and good efficiency, the presentation of the innovative optimal control algorithm for AC to DC converter is carried out. The precise version of the novel power converters topology model and control algorithm is illustrated below.

2 DIODE BRIDGE BOOST POWER FACTOR CONVERTER

To make power factor unity, in order to make the input current sinusoidal and in phase with input voltage by varying the duty cycle. Here the operation of the boost PFC converter which is
simple and low cost circuit. Here the below circuit Fig 1 show the operation of boost PFC converter circuit

![Fig 1 Modes of operation of Boost PFC converter](image)

Mode I:
Switch S1 is Closed, when the supply is ON, Inductor is being energized through the supply main and the inductor current will increased. The anode Diode Dpfc is connected to ground through S1, then Diode becomes reverse biased. Then the Energy is provided to the load by the capacitor.

Mode II:
Switch S2 is Open, when the supply is ON, at this time inductor get de-energized. Current decreases and supplies energy to the load and the capacitor again get recharge.

By continuous switching of Switch S1, that maintain a constant output voltage and controls the average inductor current. The duty cycle determines the amount of time the inductor increases verse decreases, then the inductor current can be adjusted. From this we can improve the power factor and Efficiency.

### 3 DIODE BRIDGE BOOST POWER FACTOR CONVERTER WITH CONTROLLER

In a Closed-loop control system, is needed to ensure that the output voltage is maintained and the AC current is sinusoidal and in phase
with the AC voltage. This research mainly concentrating on the PWM generation for boost switch.

![Diode Bridge Boost PFC converter circuit with controller](image)

Fig 2. Diode Bridge Boost PFC converter circuit with controller

The control system shown in Fig 2 requires to measure the following:

- Measurement of the output voltage (Vdc) to maintain at the reference level (Vref)
- Measurement of the AC voltage to provide a reference for the inductor current
- Measurement of the Average inductor current to tracks the rectified AC voltage.

4 PROPORTIONAL INTEGRAL (PI) CONTROLLER

Industrial application, most widely used controller is PI controller, due to its simple structure, easy to design and low cost, but in case of uncertainty in load and non linear, the PI controller fail. The controller output in this case is

\[ u(t) = K_p e(t) + K_i \int e(t) dt \]
5 PROPORTIONAL INTERGAL DERIVATIVE (PID) CONTROLLER

PID controller is most commonly used algorithm for controller design and it is most widely used controller in industry. The PID controller algorithm utilized for is design velocity algorithm, it is also called incremental algorithm. In the industry, PID controllers are the most common control methodology to use in real applications.

\[ u(t) = K_p e(t) + K_i \int e(t) dt + k_d \frac{de(t)}{dt} \]

PID is mainly suitable for constant parameters, If the system is modelled near a nominal point, then the parameters and the disturbance are constant. If there is any variation in the system parameter the result produced by the PID controller is worst, for these reason we are introducing the intelligent controllers Fuzzy controller which based on Firefly algorithm for boost converter which lead the system for robust control and good performance under any variation in the system.

6 FFA BASED FUZZY LOGIC CONTROLLER

6.1 PROPOSE ALGORITHM

This paper proposes a Fire fly algorithm for Boost converter for Power factor correction. This algorithm was designed by a mathematical X.S. Yang. FFA was formulated by mimicking the flash mating activity of fireflies. As compare to other optimization algorithm such as Artificial Bee Colony optimization and Ant colony optimization and Particle swarm algorithm Firefly algorithm is simple and faster computing in seeking membership functions (MF) fuzzy logic controller (FLC).

Fireies are small insects, which are capable of producing light to
attract a prey (mate). They release small rhythmic light ashes. The light intensity attraction 'I' of reies decreases with the distance 'r'. Hence, most reies are visible only up to several hundreds of meters. To execute this algorithm the fitness function is articulated based on the fluorescence light behavior of reies. For simplicity, it is imagined that light intensity attractiveness of rey is determined by its brightness 'I' which is in turn connected with the fitness function.

Attractiveness and light intensity

At a particular position 'r', the brightness 'I' of a rey can be chosen as I(r), proportional to the fitness, for a maximization problem. So the I(r) varies according to the well known inverse square law.

\[ I(r) = \frac{I_0}{r^2} \quad \text{.........(1)} \]

Fireflies attractiveness \( \beta \) is proportional to the I(r) seen by surrounding reies can be dened as

\[ \beta = \beta_0 e^{-\gamma r^2} \quad \text{.........(2)} \]

where \( \gamma \) is the light absorption coefficient.

Distance

The distance between any 2 fireflies is estimated using the distance formula.

\[ r_{ij} = \sqrt{\sum_{k=1}^{d} (x_{ij} - x_{jk})^2} \quad \text{.........(3)} \]

Firefly 'i' is moved towards brighter firefly 'j' and its movement is calculated by

Movement

Basic movement of fireflies can be calculated using the equation as follows:
\[ X_{i+1} = x_i + \beta_0 e^{-\lambda r^2} - A_i (x_j - x_i) + \alpha \epsilon_i \ldots (4) \]

where, \( r \) is the distance between any two fireflies, \( \beta_0 \) is the attractiveness at \( r = 0 \), \( \gamma \) is fixed light absorption coefficient, \( x_i \) is spatial coordination fireflies to \( i \), \( x_j \) is spatial coordination fireflies to \( j \), \( a \) is the parameter randomization, \( \epsilon_i \) is the value of the vector of random values between 0-1.

The pseudo code for rey algorithm is given below

1. Generate the initial population randomly.
2. Calculate the fitness of initial population based on light intensity of fireflies.
3. While (termination criteria is satisfied)
   4. For \( i = 1:p \) (p fireflies)
      5. For \( j = 1:p \)
         6. Calculate light intensity (I) using Eq. (1).
         7. Distance between two fireflies is calculated using Eq. (3).
         8. If (I(i) < I(j))
            9. Firefly \( i \) is moved towards firefly \( j \) using Eq.(4).
            10. Determine new solutions.
         Else
            12. Firefly \( i \) is moved randomly towards \( j \)
      EndIf
   Endfor \( j \).
   Endfor \( i \).
4. Endwhile
17. Sort the fireflies according to light intensity values of the new solution.
7 RESULT

Performance Comparison of PI, PID, Fuzzy Logic Controller with Firefly Algorithm

<table>
<thead>
<tr>
<th>S.No</th>
<th>Controllers</th>
<th>Power Factor</th>
<th>Efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PI Controller</td>
<td>0.9349</td>
<td>99.88</td>
</tr>
<tr>
<td>2</td>
<td>PID Controller</td>
<td>0.95</td>
<td>99.34</td>
</tr>
<tr>
<td>3</td>
<td>Fuzzy Logic Controller with FFA</td>
<td>0.9987</td>
<td>99.994</td>
</tr>
</tbody>
</table>

Table. 1. Results comparison between PI, PID and Fuzzy controller

8 CONCLUSION

In this paper the unity power factor correction of single phase boost converter by employing Proportional-Integral, Proportional-Integral-Derivative and Fuzzy Logic controllers with Firefly algorithm controller loop is discussed. The techniques were employed because of their robustness and efficiency. The proposed methods, gives comparative the better efficiency and improved power Factor for Diode Bridge Boost Converter.

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