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Enhancing the Performance of Luo Converter using ANFIS Controller for PV System

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***Abstract* — In** this paper a system consists of **PV power module** which feeds an isolated load through **LUO CONVERTER** was proposed. The output voltage of PV module depends on the solar irradiance which is variable in nature. The fluctuating output is rectified and kept constant by means of a LUO Converter. A **Neuro Controller** and a **Fuzzy Logic Controller** are designed for closed loop control which replaces the use of PI Controller used in conventional model that produces noise and harmonics in output voltage of Converter. Both controllers having their pros and cons, which can be eliminated by the combination of both. The required accuracy of output voltage can be achieved by using **ANFIS controller**. The comparison of these three designing of controller is given in this work. The proposed system has been demonstrated using **MATLAB Simulink** based Simulation.

Keywords—*LUO converter; PV (photovoltaic); artificial neural network; fuzzy controller; ANFIS controller; MATLAB*

I. INTRODUCTION.

DC-DC Power electronic converters are periodic time-variant systems because of their switching operation. The performance of the DC-DC converter is influenced by uncertainties, which are usually circuit parameters variations, line and load disturbances and nonlinear dynamics of the system. Nonlinear control, variable structure system control, adaptive control, optimal control and the robust control have been developed for the DC-DC converter. In the application of such techniques, development of mathematical model is necessary. Since the effect of parasitic elements limits the output voltage and power transfer efficiency of DC-DC converters, the voltage lift technique can lead to improve circuit characteristics. Luo converter is developed using the voltage lift technique. Luo converter is a highly nonlinear system used for DC-DC voltage regulation, reducing harmonic distortion and power factor correction in switch mode power supplies. The on linear characteristic of the converter is due to the continuous opening and closing of a switch. The control of these converters has become a challenging issue. Traditional design techniques are based on the mathematical model of the converter. Therefore, in recent years soft computing techniques are used as a tool to control the DC-DC converter when there are changes in the input voltage and the load, resulting minimum overshoot and settling time. Hence the purpose of this research work is to develop an ANFIS controller for Luo converter. The back propagation algorithm has been used to realize the learning mechanism. . Analysis, design and simulation of the proposed controller for Luo converters have been discussed.

II. PV SYSTEM

Photovoltaic offer consumers the ability to generate electricity in reliable way. Photovoltaic systems are comprised of photovoltaic cells, devices that convert light energy directly into electricity. Because the source of light is usually the sun, they are often called solar cells. The photovoltaic process is "producing electricity directly from sunlight." Photovoltaic are often referred to as PV. PV cells convert sunlight directly into electricity without creating any pollution. PV cells are made of at least two layers of semi-conductor material. One layer has a positive charge, the other negative. When light enters the cell, some of the photons from the light are absorbed by the semiconductor atoms, freeing electrons from the cell's negative layer to flow through an external circuit and back into the positive layer. This flow of electrons produces electric current.

The stand-alone photo-voltaic energy system requires storage to meet the energy demand during period of low solar irradiation and night time. Battery storage in a solar system should be properly controlled to avoid catastrophic operating condition like overcharging or frequent deep discharging. Storage batteries account for the most PV system failures and contribute significantly to both initial and the eventual replacement cost. The LUO DC-DC converters are used to match the output of a PV generator to a variable load. LUO converters allow the charge current to be reduced continuously in such a way that the resulting battery voltage is maintained at a constant value.

III. BLOCK DIAGRAM

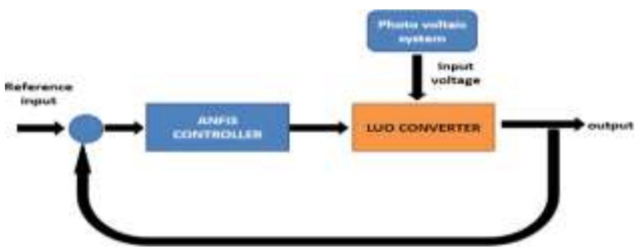

Fig. 1 BLOCK DIAGRAM OF PROPOSED SYSTEM

The system consist of various unit's such as photo voltaic system, controller, and converter. Output voltage from the photo voltaic system is given as an input to the Luo converter. The function of the controller unit is to ensure the constant flow of the output voltage to the system. The training algorithm is to train the controller by several iterations under supervised learning technique. Controller output signal is given as an input for Luo converter. Comparator is used to compare the reference input voltage and the output voltage from the Luo converter to get the constant output voltage. By changing the duty cycle in a controller the constant flow of output voltage is achieved.

IV. CIRCUIT AND OPERATION OF LUO CONVERTER

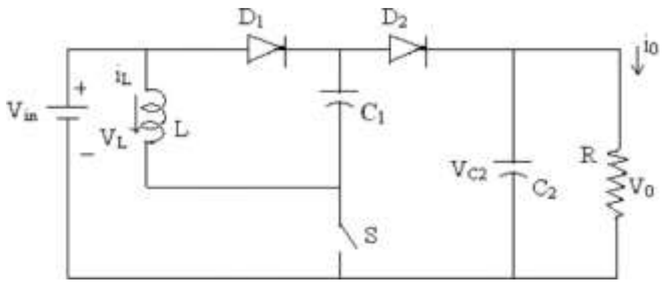

Fig. 2 CIRCUIT DIAGRAM OF LUO CONVERTER

The circuit diagram of the Luo converter is shown in fig. 2. The advantage of Luo converter is High efficiency and High output voltage with small ripples. In the circuit, S is the power switch, the energy storage passive elements are inductors L, Capacitor C_1,load resistance be R, the output terminal voltage and current value will be always positive. It operates two modes.

MODE 1:

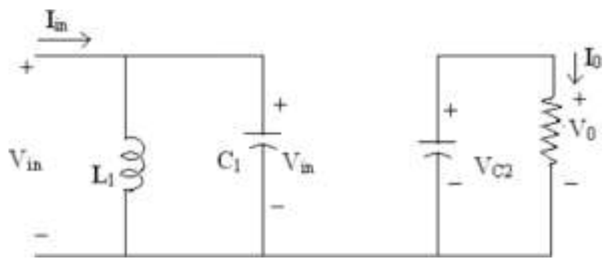

FIG. 3 MODE 1 OPERATION

The switch s is on state. Diode D_1 is in conduction mode. Diode D_2 is off.the inductor l to be charge. And the capacitor C_1 is charged to V_{in} when switch s is in on position the current will increases with voltage V_{in}. Capacitor $c_2$supplies to the load.

MODE II:

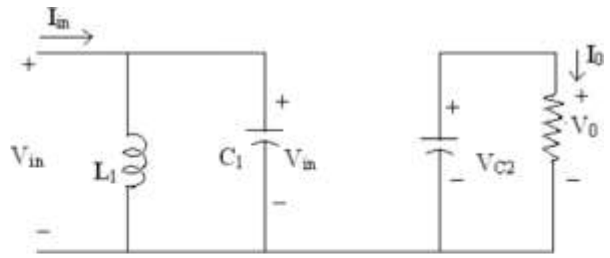

FIG. 4 MODE II OPERATION

The switch s is off state. Diode D_1 is in conduction mode. Diode D_2 is off. The stored energy from the inductor and capacitor is discharged and supplies to the load. Capacitor c_2 charged due to inductor current.

The current iL2 increases during switch are in ON Period DT. And it decreases during switch are in OFF period (1-DT).

The output voltage is given by

$$v = \frac{(2-D)}{(1-D)} v_{in} \quad - \tag{1}$$

The output current is given by

$$_{o}I = \frac{(1-D)}{(2-D)} I_{in} \tag{2}$$

Duty ratio

$$D = \frac{T_{ON}}{T} \tag{3}$$

The transfer function of Luo converter is derived from the state space averaging method is,

$$\frac{V_0(S)}{D(S)} = \left\{\frac{-SL\left(\frac{2-D}{(1-D)^2}\right)+R}{S^2LRC_1+SL+R(1-D)^2}\right\} \tag{4}$$

By applying the values of parameters,

$$\frac{V_0(S)}{D(S)} = \frac{-2.16\,S + 3600}{0.000002s^2+0.01\,s+25} \tag{5}$$

V. SIMULINK MODEL OF LUO CONVERTER

The simulation has been performed on the positive output Luo converter for PV system with parameters listed in Table1

Parameters name	Symbols	Value
Input voltage	VI	12volts
Output voltage	Vo	100 volts
Inductors	L1	16.66Mh
Capacitors	C1	220µf
Capacitor	C2	220µf
Switching frequency	Fs	100Hz
Load resistance	R	100Ω
Duty ratio	D	0.8636

TABLE 1 PARAMETERS LIST

The MATLAB/Simulink simulation model is shown in Fig.5.

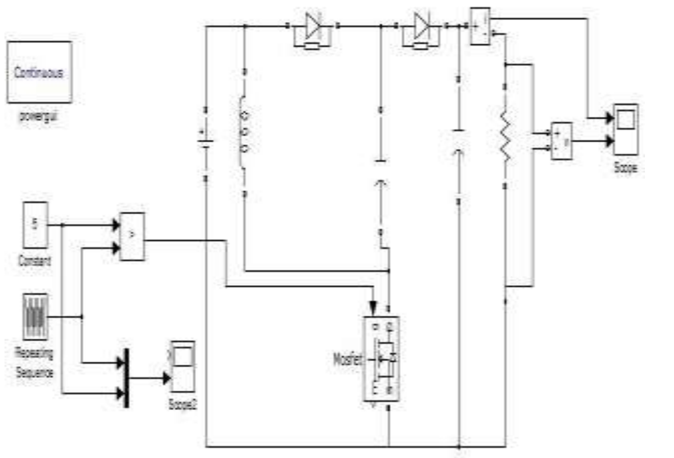

FIG. 5 Simulink model of Luo converter

The positive output elementary Luo converter is designed and simulated using MATLAB/Simulink and the output voltage from converter is shown in Fig 6.

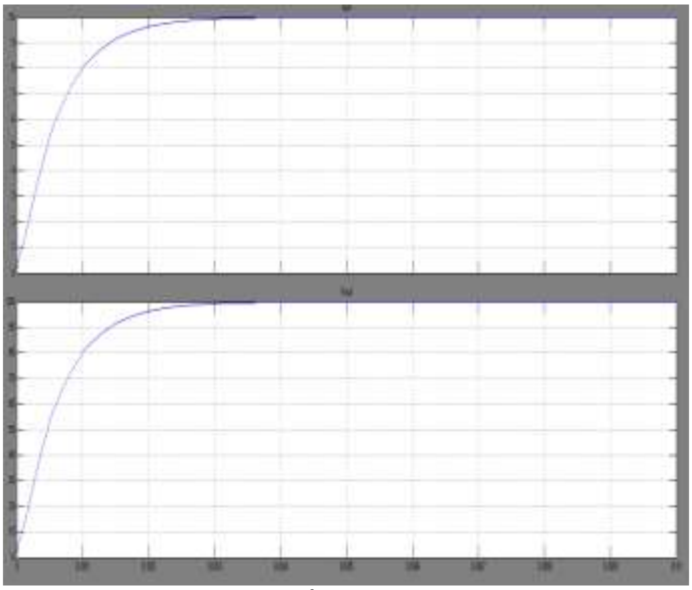

Fig 6 output of Luo converter

Switching circuit

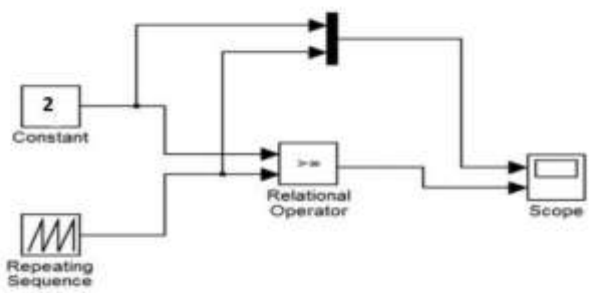

Fig 7 simulation model switching circuit

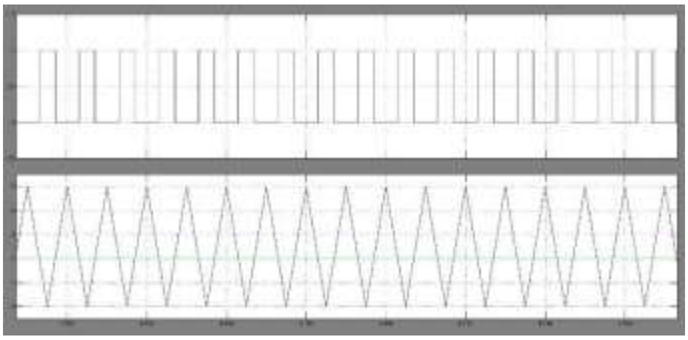

Fig 8 simulation output of switching circuit

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VII. DESIGN OF CONTROLLERS

PI CONTROLLER

Most of the control techniques for DC motor controller in industrial applications are embedded with the Proportional-Integral-Derivative (PID) controller. PI control is one of the oldest techniques. It uses one of its families of controllers including P, PI and PID controllers.

A proportional integral controller (PI Controller) is a generic control loop feedback mechanism widely used in industrial control system. A PI is most commonly used feedback controller. Over 90% of the controllers in operation today are PI controllers this approach is often viewed as simple, reliable and easy to understand. Controllers respond to the error between a selected set point and the offset or error signal that is the difference between the measurement value and the set point. Optimum values can be computed based upon the natural frequency of a system. Too much feedback (Positive feedback cause stability problems) causes increasing oscillation.

With proportional (gain) only control the output increases or decreases to a new value that is proportional to the error. Higher gain makes the output changer larger corresponding to the error. Integral can be added to the proportional action to ramp the output at a particular rate thus bring the error back toward zero. Derivative can be added as a momentary spike of corrective action that tails off. Derivative can be a bad thing with a noisy signal.

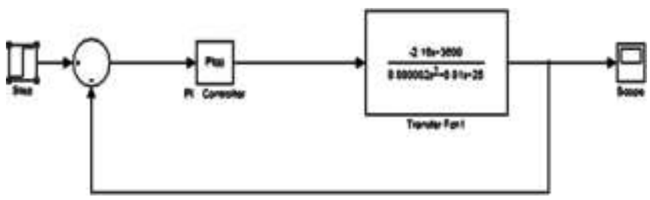

Fig 9 simulation model of PI controller

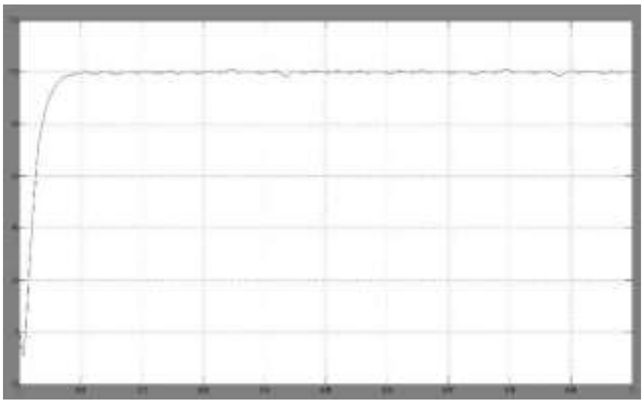

Fig 10 output of PI controller

The drawback of PI controller is unable to adapt and approach thebest performance when applied nonlinear system.it will suffer from dynamic response, produce overshoot longer rise time and setting time.

ARTIFICIAL NEURAL NETWORK

A neural network (also called an ANN or an artificial neural network) is a sort of computer software, inspired by biological neurons. A neural circuit is a population of neurons interconnected by synapses to carry out a specific function when activated. Biological neural networks have inspired the design of artificial neural networks. The neural network itself is not an algorithm, but rather a framework for many different machine learning algorithms to work together and process complex data inputs. Biological brains are capable of solving difficult problems, but each neuron is only responsible for solving a very small part of the problem. This is one method for creating artificially intelligent programs (or) loading the data. There are different learning techniques presented in an artificial neuron network in this project supervised learning technique is used to train the controller.

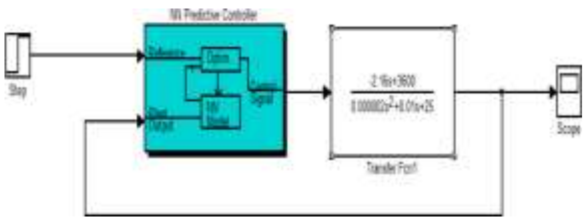

Fig 11 simulation model of ANN

Supervised learning is a type of system learning technique in which both input and reference output data are provided. Supervised learning is used to train the controller by several iterations by comparing the input and output data's.

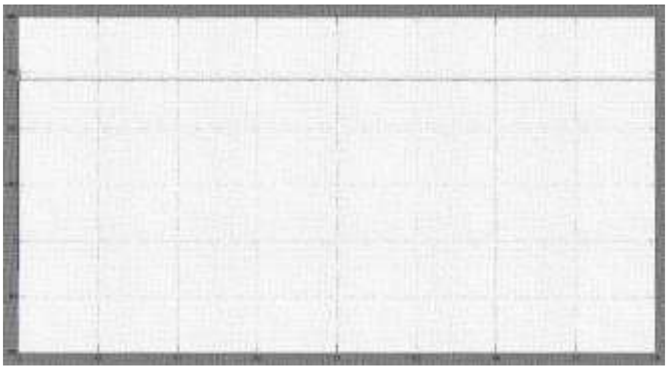

Fig 12 output of fuzzy controller

FUZZY LOGIC CONTROLLER

The main objective of this work is to investigate the stability of artificial intelligent system (Fuzzy Logic Controller) for validating the proposed PV system under variable climatic conditions. Neural Networks are data based whereas Fuzzy Logic model is based on expert knowledge. The Fuzzy optimization technique used here is Back Propagation. The fig.8 shows the architecture of Fuzzy logic controller. In order to obtain the modelled, predicted and optimized PV system, due to its non-linearity which is influenced by variable climatic conditions like solar irradiance and ambient temperature, the Fuzzy was validated with several test data by minimizing mean square error. Fuzzy logic method is the only way to get solution for uncertain conditions. The fig.13 shows the developed Fuzzy model.

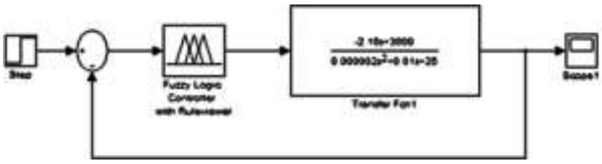

Fig 13 simulation model of fuzzy controller

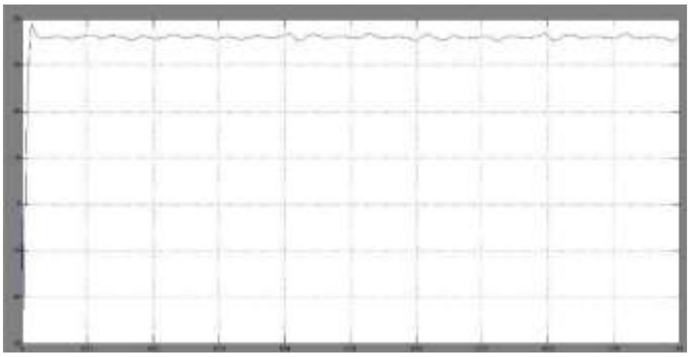

Fig 14 output of fuzzy controller

ANFIS CONTROLLER

In proposed system used here is adaptive network based fuzzy inference system. ANFIS is a simple data learning technique. It is the combination of fuzzy logic and neural network. Both method combined as single technique and improve the quality of output.in order to obtain the optimized PV system output voltage due to its non-linearity this is influenced by variable climatic conditions. For the corresponding to mamdani type fuzzy inference, the MAX-MIN composition and result can be obtained by means of CENTER OF GRAVITY defuzzification method for output. Updating of the adjustment parameters in the ANFIS architecture is only possible with back propagation algorithm method. The ANFIS was validated with several test data by minimizing mean square error.

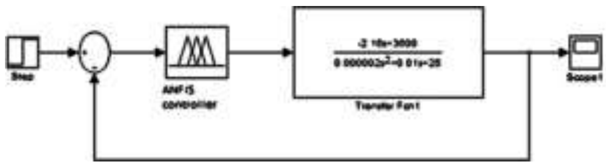

Fig 15 simulation model of ANFIS Controller

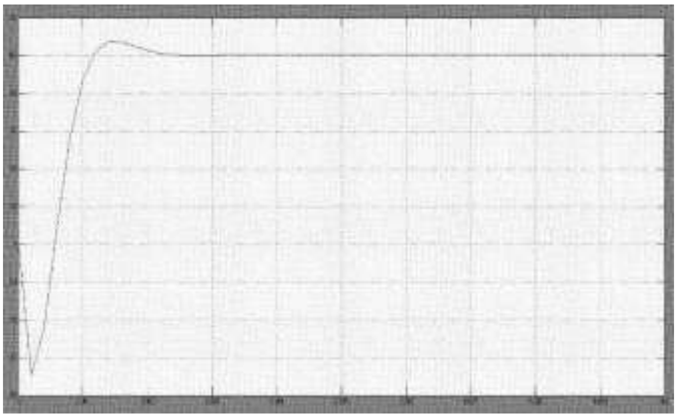

Fig 16 output of ANFIS controller

The satisfactory performance of ANFIS proves that it can be used for the prediction of the optimal configuration of the PV system

VI. CONCLUSION

In this paper presents the supervisory control system using soft computing techniques. Modeling of elementary Luo converter has been done using state space averaging method and circuit averaging technique and is simulated using MATLAB Software. The dynamic response of Luo converter was analyzed for line and load variations are controlled effectively. The PI, ANN, FUZZY and ANFIS controllers are designed with the help of MATLAB and the simulation results are compared. The simulation results proves that the ANFIS controller is gives the proper output regulation minimum value for steady state error, settling time and peak overshoot.

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