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MPPT Using FLC For A PV Powered High Step-Up Boost Converter Using Coupled Inductor

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ABSTRACT: The paper proposes a high step up boost converter. The proposed converter has used a coupled inductor with switched capacitors. The capacitors were made to get charged in parallel and were made to get discharged in series by the configuration to achieve high step up voltage gain. And the voltage across the load is maintained constant by using a closed loop control.

The converter is being provided by a PV source instead of a fixed DC input voltage. The output of the PV system is then controlled by maximum power point tracking with fuzzy logic control. And the system is then implemented in MATLAB software to verify the proper performance of the converter and its control.

KEYWORDS: High step-up Boost Converter, PI Controller, MPPT, Fuzzy Logic Control.

I.LITERATURE SURVEY

Due to energy crisis and environmental issues such as pollution and global warming effect, photovoltaic (PV) systems are becoming a very attractive solution. Unfortunately the actual energy conversion efficiency of PV module is rather low. So to overcome this problem and to get the maximum possible efficiency, the design of all the elements of the PV system has to be optimised. In order to increase this efficiency, MPPT controllers are used. Such controllers are becoming an essential element in PV systems. A significant number of MPPT control schemes have been elaborated since the seventies, starting with simple techniques such as voltage and current feedback based MPPT to more improved power feedback based MPPT such as the perturbation and observation (P&O) technique or the incremental conductance technique [1-2]. Recently intelligent based control schemes MPPT have been introduced. Some converters operate at very high frequency with fast transient response. The main switch is fabricated from an integrated power process, the layouts can be changed to vary the parasitic, however design of switch layout is complex, fixed frequency and constant duty ratio must be maintained [5]. This converter provides high voltage gain and can be employed for high power applications however the duty ratio is limited to 0.85 [4]. In this, the energy of the leakage inductor is recycled to the output load directly, limiting the voltage spike on the main switch. To achieve a high step-up gain, it has been proposed that the secondary side of the coupled inductor can be used as boost and buck-boost converters [3-4].

II.INTRODUCTION

Boost converter has been a widely used device among the modern power applications. These electronic devices are used to increase DC electrical power efficiently from one voltage level to another. They provide smooth acceleration control, high efficiency, and fast dynamic response. There are FOUR main types of converter usually called the buck, boost, buck-boost and Boost converters. The buck converter step downs the voltage while the boost converter steps up it. The buck-boost and Cuk converters can do both step-down and/or step-up.

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The novel boost converter used consists of power semiconductor devices which are operated as electronic switches and classified as switched-mode DC-DC converters. Pulse Width Modulation is most frequently used among the various switching control methods. The previous work used proportional integral controller as the switch controller.
Different methods have been proposed for the improvement of the efficiency of the converter and to achieve high voltage gain, which is being done by using a switched capacitor and a coupled inductor for high gain by adjusting its turn ratio. Voltage spikes may occur due to the coupled inductor. For which we have used an active clamp circuit which avoids voltage spikes.

In this paper we have used a maximum power point tracking technique with fuzzy logic control for the control of switching of the converter. MPPT is used to track the maximum power from the Photo Voltaic system at the input of the converter. Maximum power point technique is very much used in energy conversion systems.

Fuzzy logic controller shows adaptive character in nature as it has robust response to a system with uncertainty, parameter variation and load disturbance. It is very much used to control an ill-defined, non-linear or imprecise system. It does not require accurate model. With this technique not only tight charging and discharging is achieved but fast dynamic response can also be achieved. Fuzzy logic controller uses membership functions assigned with some linguistic values and range in which they need to give output or to take input. They accept a set of rules for their functioning and processing of membership functions.

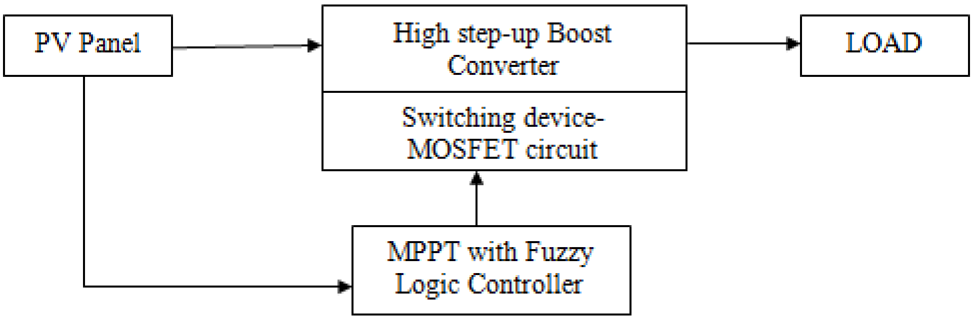

Figure 1 Proposed block diagram

Figure 1 shows the proposed model of the system, here the power from the PV panel is being tracked by the maximum power point tracking technique by the use of fuzzy logic control and the output is then made to produce PWM signal by comparing the output of the FLC with the repeating sequence. And the PWM signal controls the switching device which helps to maintain the load voltage and power.

III.SYSTEM MODEL AND ASSUMPTIONS

Figure 2 shows the configuration of the proposed circuit. The circuit consists of a boost converter with coupled inductor, switched capacitor and a clamp circuit. The equivalent circuit of the coupled inductor consists of a magnetizing inductor L_m, leakage L_k, and an ideal transformer. The leakage inductor energy of the coupled inductor is recycled to capacitor C_1, and thus the voltage across the switch S can be clamped. The voltage across the capacitors C_2, and C_3 can be adjusted by the turn ratio of the coupled inductor. For these reasons voltage of the switch is reduced significantly and low conducting resistance $R_{ds(on)}$ of the switch can be used. Thus high step-up voltage gain can be achieved.

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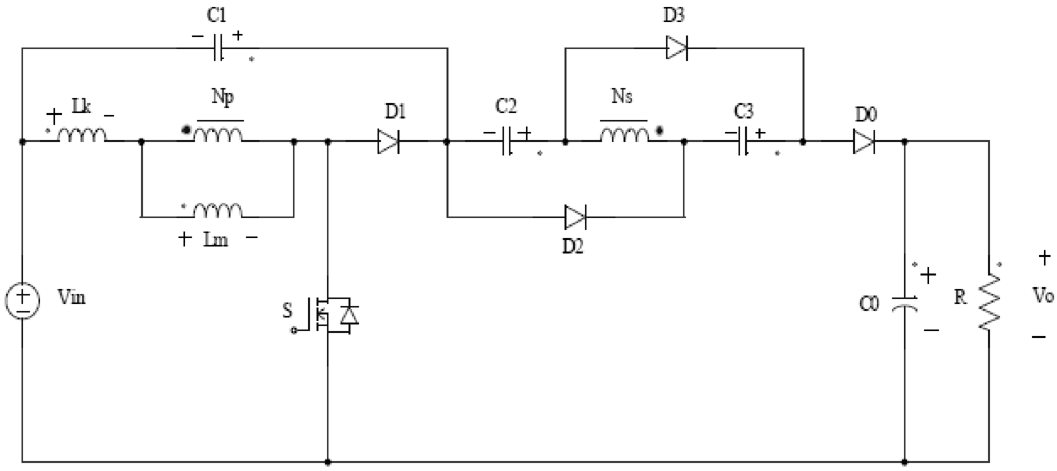

Figure 2 Circuit configuration of the proposed converter

IV.MODES OF OPERATION AND ANALYSIS

There are five operating modes in one switching period.

1) Mode I (t_0, t_1): This starts when the switch S is turned ON. Diodes D_1, D_0 are off, and D_2, D_3 are on. The current through L_k starts increasing linearly and the inductor L_m starts storing energy from the source voltage. Voltages V_{C2} and V_{C3} are connected in series to charge the output capacitor C_O which will then provide energy to the load. When current through D_0 becomes null this operating mode ends.
2) Mode II (t_1, t_2): Here switch will be kept ON. Diodes D_1, D_2, D_3 are off and D_0 is on. L_m starts charging due to the source voltage. Capacitors C_2 and C_3 also get charged due to the source via the coupled inductor. Capacitor C_0 discharges to the load to maintain the desired output voltage. Switch S is set off to end the mode.
3) Mode III (t_2, t_3): S is turned OFF. Diodes D_1, D_2, D_3 are off, and D_0 is on. Inductors L_k and L_m are discharge to the parasitic capacitor of the switch C_{ds}. Capacitor C_O kept discharging to provide energy to the load. Now the voltage across C_1 equals to V_{in}+V_{ds}, diode D_1 turns on to end the mode.
4) Mode IV (t_3, t_4): S remains OFF. Diodes D_1, D_0 are turned on and D_2, D_3 are off. Inductors L_k and L_m discharge to charge capacitor C_1. L_k discharges quickly. No current flows through the secondary side and L_2 charges capacitor C_0 and maintain the voltage across the load, which makes D_0 to switch off and mode ends.
5) Mode V (t_4, t_5): S continues OFF. Diodes D_1, D_2, D_3 are turned on and D_0 is turned off. Inductors L_k and L_m discharges to charge capacitor C_1. Making the voltage across the switch equals V_{in}+V_{C1}. And L_2 charges both the capacitors C_2 and C_3. The mode ends when the switch turns ON and makes the next switching period.

The operating modes given above are the operation of the converter at various switching and when the PV panel is connected to the converter, the switching of the converter is getting controlled by the output of maximum power point tracking with the fuzzy logic controller, where the PV output power is being checked and controlled by the controller to provide maximum input power to the converter.

V.SIMULATION RESULTS AND DISCUSSIONS

The fuzzy logic controller used in this converter control is having three stage of operation i.e. fuzzification, inference engine and defuzzification. The first step is to assign various linguistic values with their range set for various values of the input and output. The membership function are being assigned for the error value, change in error value and output value i.e. duty ratio.

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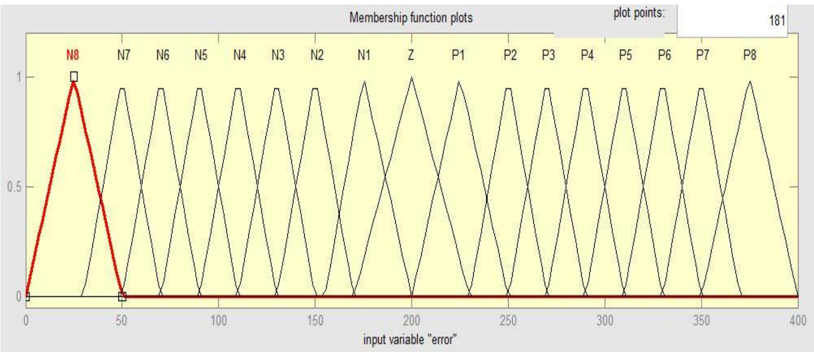

Figure 3 Membership Functions of Error.

Figure 3 shows the membership function given for the Error, i.e. the linguistic values or names given to the various range of input error. The error value is being taken by comparing the PV panel output power provided to the converter, tracking the maximum power of the PV panel.

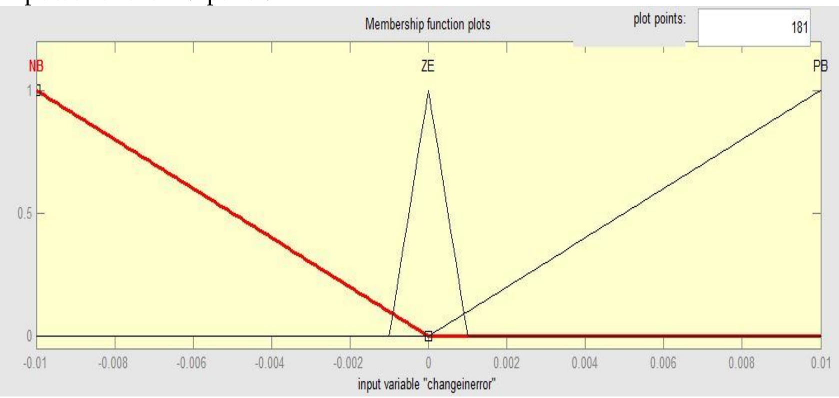

Figure 4 Membership Functions of Change in Error.

Figure 4 shows the membership function of the change in error, the value to change in error is given by the taking the difference of the error value and the error value after a unit delay. And the range of change in error is being set according to the need of control the output of the fuzzy logic control.

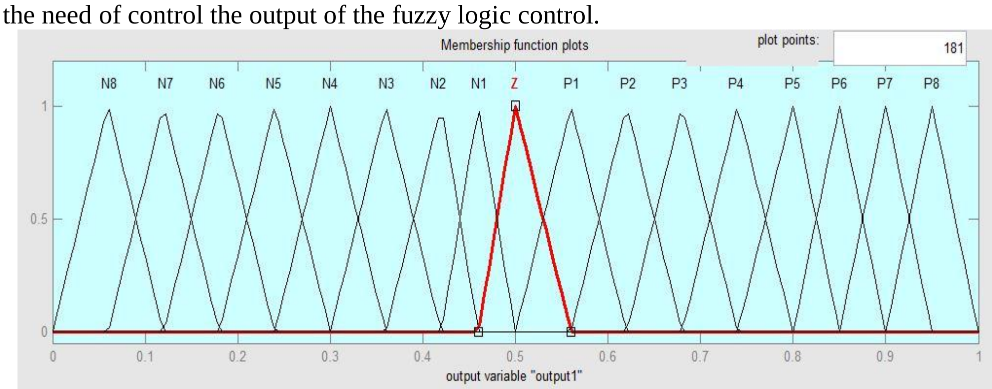

Figure 5 Membership Functions of Duty Ratio (D)

Figure 5 shows the membership functions given to the various values of the output i.e. duty ratio given as the MPPT output for the control of the switching device.

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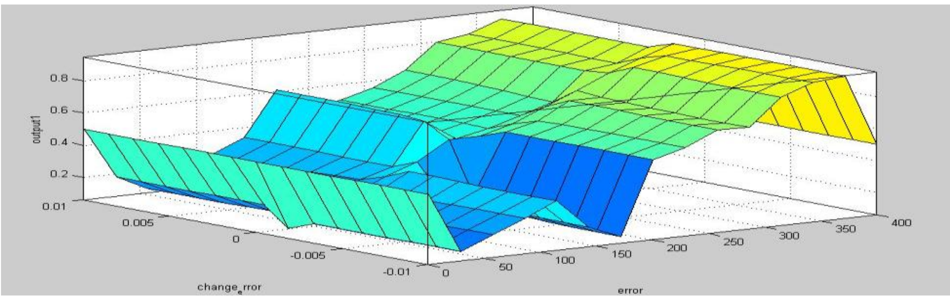

Figure 6 Surface view of Rules of FLC.

Figure 6 shows the surface view of rules given to the fuzzifier for the processing of the membership functions by the inference engine and finally passed to the defuzzifier to produce the relative output in terms of duty ratio. The various output values with respect to the both the inputs i.e. error and change in error can be understood here easily.

E \ E*	N	Z	P
N8	N7	N8	N6
N7	N6	N7	N8
N6	N5	N6	N7
N5	N4	N5	N6
N4	N3	N4	N5
N3	N2	N3	N4
N2	N8	N2	N3
N1	N8	Z	P2
Z	P1	Z	N1
P1	P2	P1	Z
P2	P3	P2	P1
P3	P4	P3	P1
P4	P3	P4	P3
P5	P6	P5	P5
P6	P7	P6	P5
P7	P8	P7	P6
P8	P8	P8	P7

Table 1 Rule Table for FLC

Table 1 shows the rules given to the fuzzifier for the processing of the membership functions by the inference engine and finally passed to the defuzzifier to produce the relative output in terms of duty ratio. The various output values with respect to the both the inputs i.e. error and change in error can be understood here easily.

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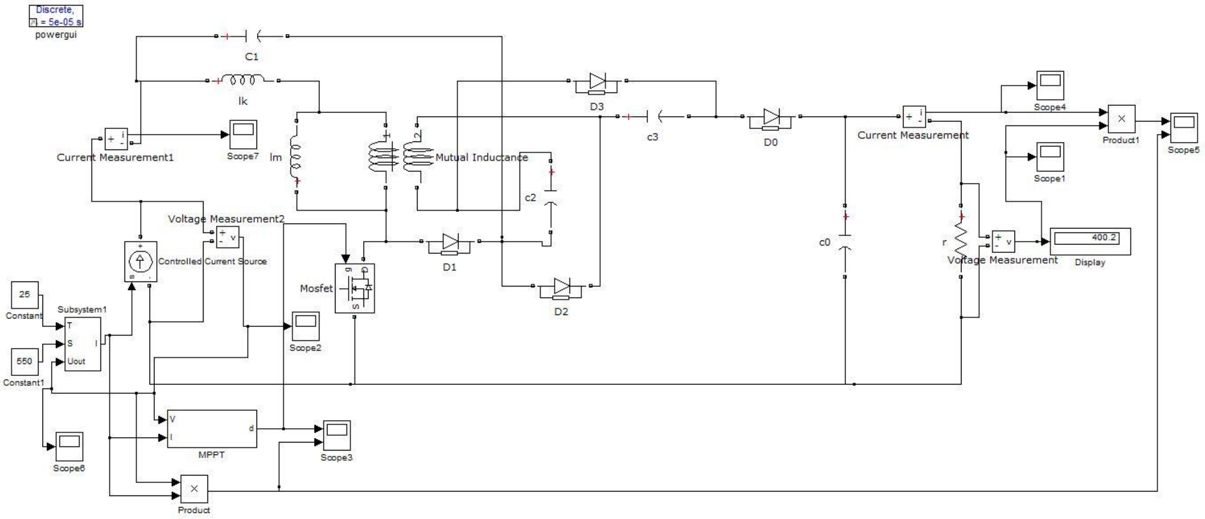

Figure 7 MATLAB Simulation Diagram of proposed converter

The converter has input source as the PV cell and being controlled at the input side for maximum input power. Figure 7 shows the MATLAB Simulation diagram of a high step-up dc-dc converter using coupled inductor for a PV system with MPPT. The duty ratio of the switch is adjusted by Fuzzy Controller to obtain the require output.

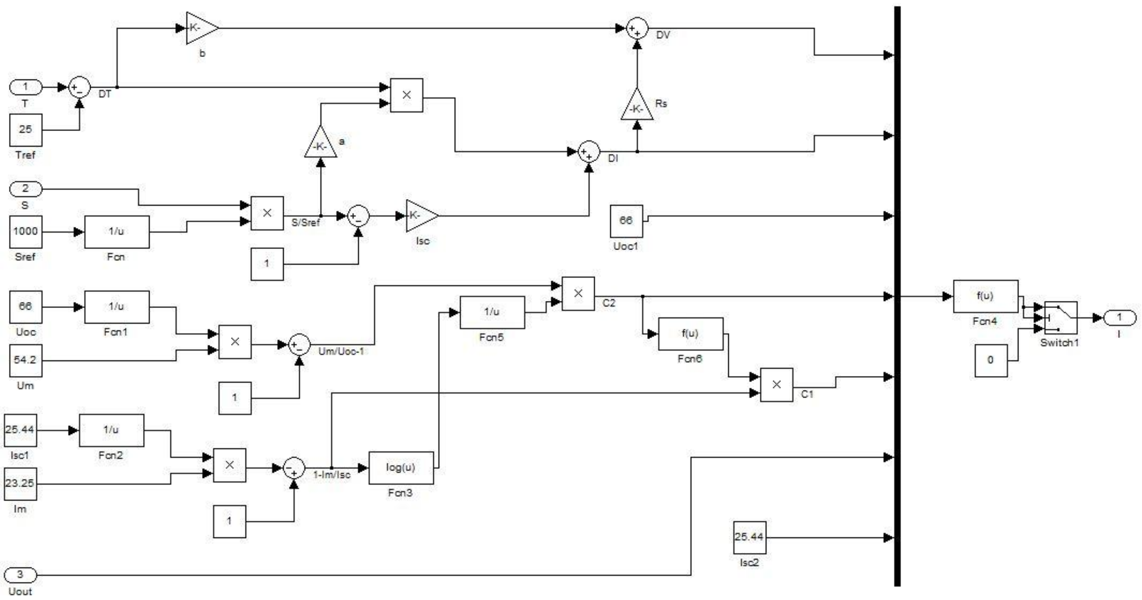

Figure 8 PV Sub-Block

Figure 8 shows the PV sub-block used in the controller in which the input shown is the temperature and the irradiance of the sun, the output of the PV system is the DC current behaving as the source to the converter circuit. The sub-block for the maximum power point tracking control by using the fuzzy logic controller, here the Fuzzy logic controller is independent of the controller and controls the switch of the converter just by comparing the output of the PV with the value given as reference to the FLC.

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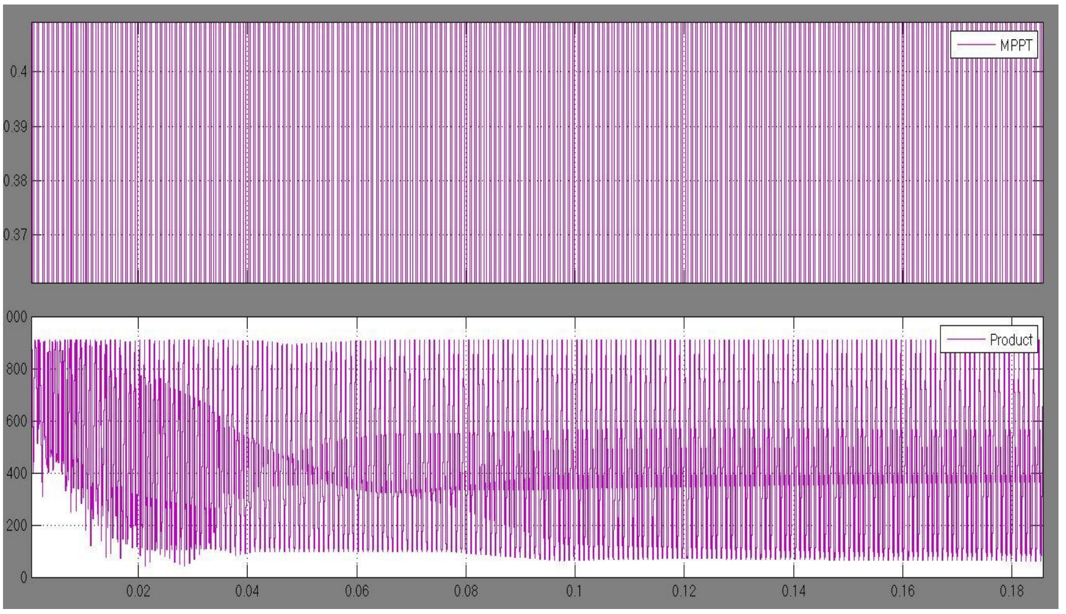

Figure 9 MPPT output to the MOSFET and Input Power to the converter from the PV

Figure 9 shows the gate signal generated by the MPPT block given to the switch. And the output power of the PV Cell for the converter which has been tracked by the controller.

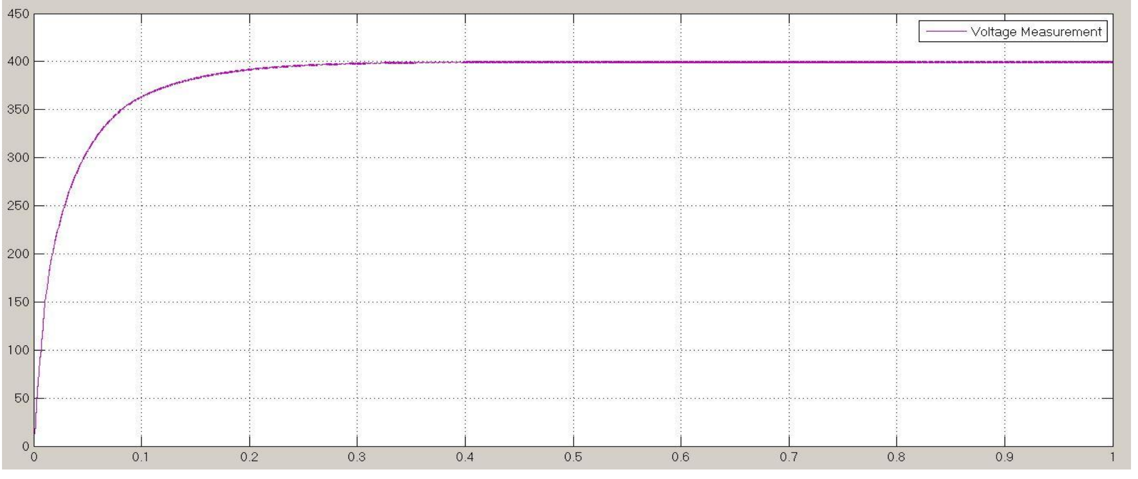

Figure 10 Output Voltage

Figure 10 shows the output voltage from the converter to the load, as for the most of the system the fixed output voltage is required. And for this system the main aim was to convert the input for the usable output voltage. The output of the PV system varies with system to system but the load of the converter cannot hold the voltage fluctuation, so the output voltage must be as stable as possible. And here we are getting the desired output voltage waveform by using MPPT with fuzzy logic controller for the PV input.

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VI.CONCLUSION

Here a PV powered high step-up boost converter using coupled inductor with fuzzy based MPPT control is simulated. By the capacitor charged in parallel and discharged in series by the coupled inductor, high step-up voltage gain of 400V is achieved. As the output voltage of the converter has minimum overshoot and steady state error, these studies could solve many types of problems regardless on stability because we know that fuzzy logic control is an intelligent and robust controller to their appliances and are non-model based controller.

Further it can be simulated with different types of other non model and hybrid control such as artificial neural network, genetic algorithm, fuzzy sliding mode, fuzzy PI and others can be used for advanced tuning and to check the constant output voltage with least ripple and to support different appliances with different voltage ratings.

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BIOGRAPHY

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