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MPPT USING FUZZY LOGIC CONTROLLER FOR SEPIC CONVERTER AND THREE PHASE INVERTER

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Abstract: The solar photovoltaic power has received great attention and experienced impressive progress all over the world in recent years because of more and more serious energy crisis and environmental pollution. The system consists of a photovoltaic solar module connected to a DC-DC Buck-boost converter. The system has been experienced under disturbance in the photovoltaic temperature and irradiation level. The fuzzy controller for the SEPIC MPPT scheme shows high precision in current transition and keeps the voltage without any changes, in the variable-load case, represented in small steady-state error and small overshoot. The proposed scheme ensures optimal use of PV array and proves its efficacy in variable load conditions, unity, and lagging power factor at the inverter output (load) side. The performance of the proposed FLC-based MPPT operation of SEPIC converter is compared to that of the conventional proportional–integral (PI)-based SEPIC converter. The system consists of a photovoltaic solar module connected to a DC-DC Buck-boost converter and towards three phase inverter.

Keywords: MPPT-maximum power point tracking, SEPIC-single ended primary inductor converter, FLC-fuzzy logic controller, PI-proportional integral, PV-photo voltaic.

I. INTRODUCTION

Energy has the great importance for our life and economy. The energy demand has greatly increased due to the industrial revolution. photovoltaic (PV) is the simple and reliable technology which directly convert solar energy into electricity which is the most convenient form of energy for utilization. The criteria for photovoltaic (PV) converter selection depend on many factors, such as cost, efficiency, flexibility, and energy flow. In this case, the flexibility represents the ability of the converter to maintain the output with the input varying, while the energy flow is assured by the continuous current of the converter . Various types of MPPT are available and they are depends on sensor, cost, speed etc., according to this they are classified into open circuit voltage, short circuit current method, perturb and observe (P&O), and incremental conductance (InCond). Conventional buck–boost, and Cuk converters have the ability to step up and step down the input voltage this converter can transfer energy for all irradiation levels. Feature is continuous output current, which allows converter output parallel connection, or conversion to a voltage source with minimum capacitance. This method compares the measured voltage (current) of the PV module with a reference voltage (current) to continuously alter the duty cycle of the DC-DC converter and hence operate the PV module at the predetermined point close to the MPP. There is no general agreement in the literature on which one of the two converters is better, i.e., the SEPIC or the Cuk. The limitations of the PI con-troller are well known because it is sensitive to parameter variations, weather conditions, and other uncertainties. There is need to apply a more efficient controller that can handle the uncertainties, such as unpredictable weather, for the PV system. The imprecision of the weather variations that can be reflected by PV arrays can be addressed accurately using a fuzzy controller. the advantages of the fuzzy logic algorithm, the MPPT algorithm is integrated with the FLC so that the overall control system can always provide maximum power transfer from the PV array to the inverter side, in spite of the unpredictable weather conditions.

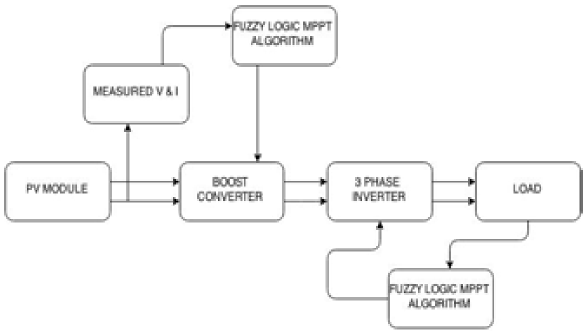

FIG 1 Block Diagram

This paper presents an FLC-based MPPT operation of the SEPIC converter for PV inverter applications As the proposed method always transfers maximum power from PV arrays to the inverter side, it optimizes the number of PV modules.

The PI controller has two main issues the steady state error and the maximum overshoot. If one need focus on time, the derivative controller must be added to become the PI–derivative (PID) controller, but this causes instability in the steady state.

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II. PROPOSED SYSTEM

A) PV Module

Photovoltaics (PV) is a method of converting solar energy into direct current electricity using semiconducting materials that exhibit the photovoltaic effect. A photovoltaic system employs solar panels composed of a number of solar cells to supply usable solar power. The number and size required is determined by the available light and the amount of energy required.

The amount of power generated by solar cells is determined by the amount of light falling on them, which is in turn determined by the weather and time of day. PV panels use the photovoltaic effect to , a solar thermal collector supplies heat by absorbing sunlight, for the purpose of either direct heating or indirect electrical power generation from heat.

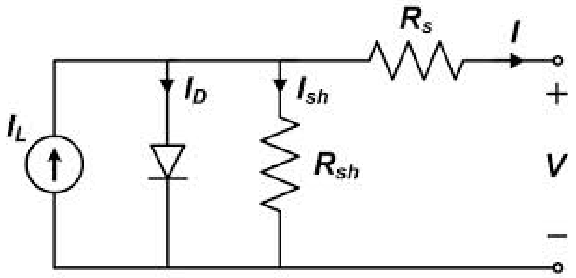

FIG 2 Equivalent circuit diagram

representing parasitic resistances. The change of voltage level fed to the inverter is the main function of the dc–dc converter. In this paper, the voltage level increases or decreases.

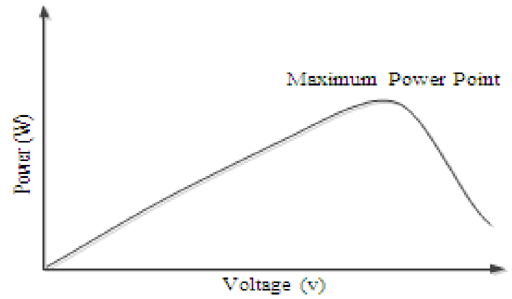

FIG 3 PV Characteristics Curve

The controller changes the voltage level by changing the duty cycle of the pulse width-modulated (PWM) signal, which tracks the reference signal. A sinusoidal reference signal is compared with the output signal to produce a supposedly zero error signal.

B) SEPIC CONVERTER

The single ended primary inductance converter (SEPIC) is a DC/DC converter topology that provides a positive regulated output voltage from an input voltage varies from above to below the output voltage. This type of conversion is handy when the designer uses voltages from an unregulated input power supply such as a low cost. Single-ended primary-inductor converter (SEPIC) is a type of DC-DC converter allowing the electrical potential (voltage) at its output to be greater than, less than, or equal to that at its input; the output of the SEPIC is controlled by the duty cycle of the control transistor. Buck and buck-boost converters have discontinuous input current, which causes more power loss due to input switching. The boost converter usually has higher efficiency than the SEPIC its output voltage is always larger than the input which causes inflexibility in maximum power extraction

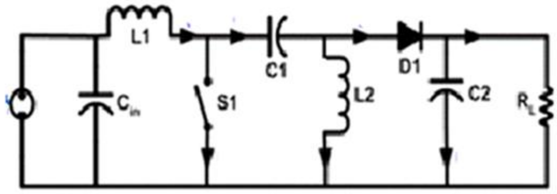

FIG 4 SEPIC Converter

The maximum power point can be achieved in case of a grid connected system, a full- load condition, or using battery charging in case of a standalone system. However, if the load need is lower than PV capacity, the PV voltage will move right in the PV curve, achieving the opportune power. This case happens even if the batteries of the standalone system are full and the load is lower than PV power. In grid-connected systems, the load is always there due to the huge number of clients. Therefore, the maximum power point can always be achieved subject to the load need. Perturbation and observation (P&O) method is an alternative method to obtain the maximum power point of the PV module.

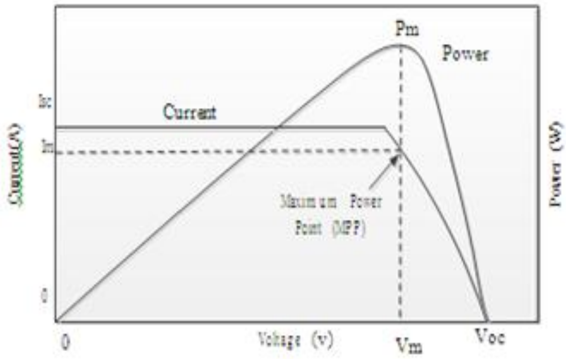

FIG 5 Maximum power curve

C) FLC Algorithm

In FLC design, one should identify the main control variables and determine the sets that describe the values of each linguistic variable. The input variables of the FLC are the output voltage error e(n) and the their is change of this error e_(n). The output of the FLC is the duty cycle of d(n) of the PWM signal, which Which regulates the output voltage. The triangular membership functions are Used for the FLC for easier computation. A five-term fuzzy set, i.e., negative big (N-II), negative small (N-I), zero (Z), Positive small (P-I), and positive big (P-II), is defined to describe each linguistic variable. The fuzzy rules of the proposed PV SEPIC dc–dc converter can be represented in a symmetric form.

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CE/E	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	NB	NM	NS	ZE	NS
NS	NB	NB	NM	NS	ZE	PS	PM
ZE	NB	NM	NS	ZE	PS	PM	PB
PS	NM	NS	ZE	PS	PM	PB	PB
PM	NS	ZE	PS	PM	PB	PB	PB
PB	ZE	PS	PM	PB	PB	PB	PB

FIG 6 Rule Table

In conventional rule based systems, inference means matching facts with rules, firing the matched rule, deriving new facts and repeating the cycles. The process is essentially the same in fuzzy logic, except that everything becomes a fact of degree with firing of matched rule pairs. A linguistic term is a member of linguistic variable set. A linguistic variable set typically contains three or more linguistic terms. Each linguistic term associated with a linguistic variable set has a degree of membership that ranges from zero to one both inclusive. A degree of membership one represents total membership in the linguistic variable set; a degree of membership of zero represents total exclusion from the linguistic variable set.

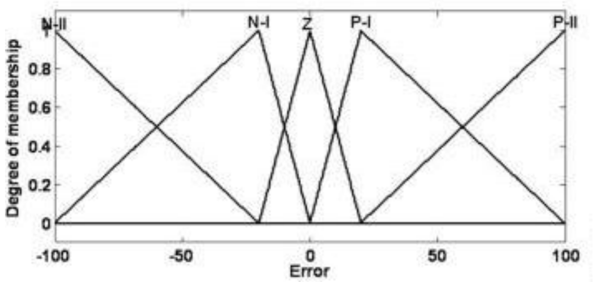

FIG 7 Rule Formation

The divergent distribution represents slow response for the system, whereas the convergent distribution represents fast response. As estimated, the error and the change of error are improved with increasing degree of convergence of membership functions. The value of convergent distribution cannot reach a high value because the response starts to be oscillated around the steady state.

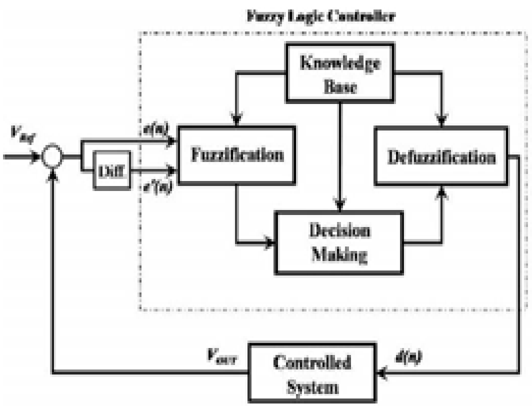

Figure 8 Structure of FLC

Fuzzification is a conversion process that converts real world crisp data measurements to fuzzy logic linguistic values. A membership function (a graphical plot of linguistic terms). defines the degree of membership for each specific crisp value. A fuzzified crisp value has a degree of association ranging from zero to one inclusive. The first step involved in fuzzy logic system is fuzzification i.e. a process of converting crisp (numerical) values to fuzzy set. Fuzzification of real value of an input device is done via input membership function. The membership functions are simple geometric figures such as isosceles triangle or trapezoid or any other shape.

III. PROPOSED MPPT BASED SEPIC CONVERTER

The fuzzy controller is applied to the SEPIC converter to mimic the new reference signal coming from the MPPT. The new duty cycle δ(k) of the SEPIC converter switch was adjusted either by adding or by subtracting the previous duty cycle δ(k− 1) with the duty cycle's perturbation step size. Equation (1) presents the relation between the present and previous duty cycles, where δ is the change in duty cycle, resulting from the change of reference signal. The MPPT control technique is applied to achieve a new ref-erence voltage for the fuzzy controller, which changes the duty cycle of the PWM signal for the SEPIC converter. The P&O al-gorithm has a simple structure and requires few parameters (i.e., power and voltage); that is why it is extensively used in many MPPT systems . In addition, it can be easily applied to any PV panel, regardless of the PV module's characteristics for the MPPT process. The P&O method perturbs the duty cycle and compares instantaneous power with past power. Based on this comparison, the PV voltage determines the direction of the next perturbation. P&O shows that, if the power slope increases and the voltage slope increases also, the reference voltage will increase; otherwise, it will decrease.The drawback of most of the fuzzy-based MPPT algorithms is that the tracking point is located away from the maximum power point when the weather conditions change. However, a drawback of P&O technique is that, at steady state, the operating point oscillates around the maximum power point giving rise to the waste of available energy, particularly in cases of constant or slowly varying atmospheric conditions. This can be solved by decreasing the step size of perturbation.The step size of the P&O method affects two parameters: accuracy and speed. Accuracy increases when the step size decreases. However, accuracy leads to slow response when the environmental conditions change rapidly.

IV. EXPERIMENT IMPLEMENTATION

Simulation was applied on MATLAB/Simulink to verify the practical implementation of the proposed SEPIC fuzzy controller for the single- phase inverter. presents the reference signal for the SEPIC's output, where it tracks the maximum power. The results introduced in belong to voltage and current signals of the conventional PI controller. The PI controller is selected for comparison

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because of its severe use in industry applications.The converter conditions used in the PI controller are the same as that used in the FLC. The PI controller is designed well where it is optimized to produce minimum error signal. Moreover, large amount of power can be lost due to the PI controller.. Therefore, the PI controller cannot follow accurate changes in reference signal effectively. At different operating conditions shows the experi-mental waveforms of the inverter's voltage and cur-rent for unity power factor load.

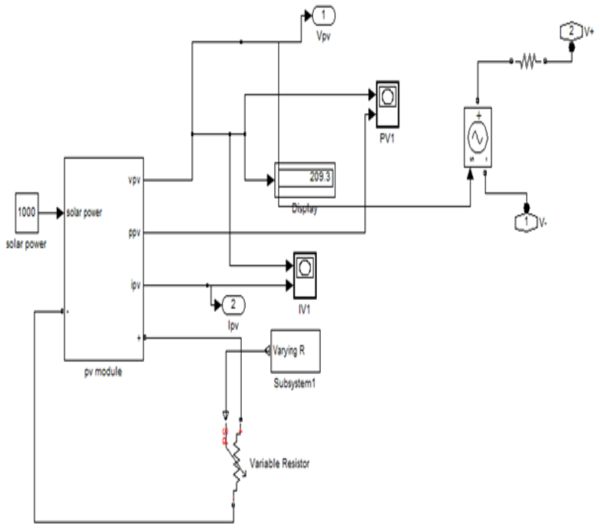

FIG 9 PV MODULE

Based on the PV module respective output voltage and, Current output waveform has been obtained.

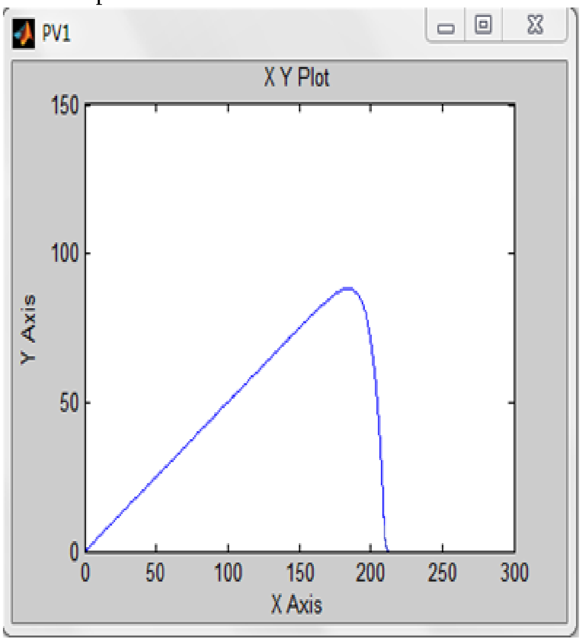

FIG 10 P-V Characteristics Curve

the voltage level increases or decreases depending on the maximum power. Fur-thermore, the controller changes the voltage level by changing. The following is he output waveform of PV array at different temperature and irradiance, while open circuit voltage increases in temperature.

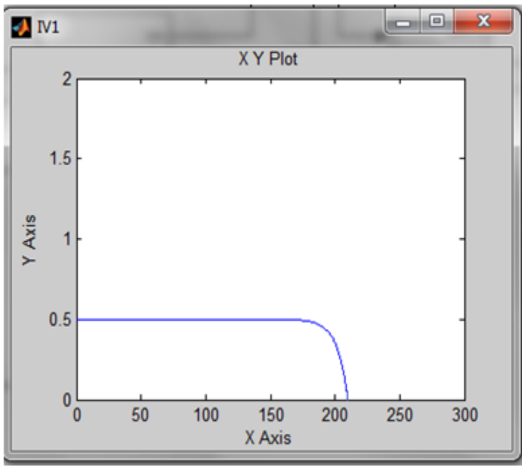

FIG 11 Characteristics Curve

The controlled FLC PWM signal can achieve two advantages to the inverter; first, it produces a smooth error-free sine wave, and second, it achieves a smooth transition for the current signal and constant (no) transition for the voltage signal (in the variable-load case). The smooth transition saves the load. Therefore, the FLC-based SEPIC MPPT converter can extract average power about 4.8% more than PI-based system.

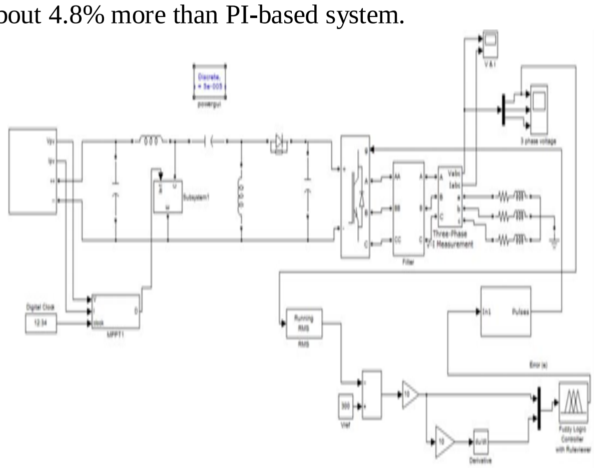

FIG 12 simulation of circuit diagram

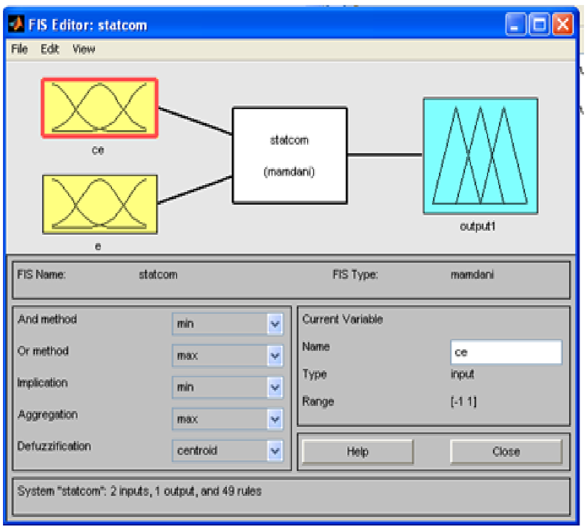

fig 13 adding input variables

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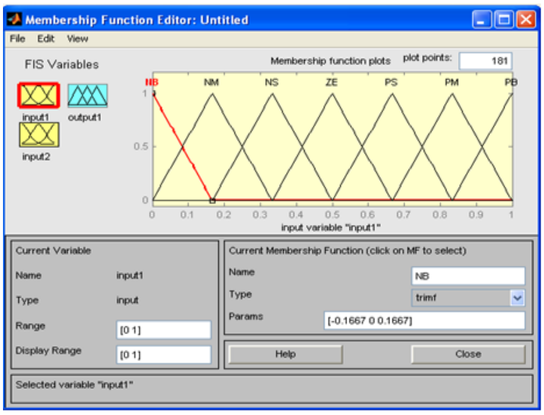

FIG 14 Adding Member Function For Input 1

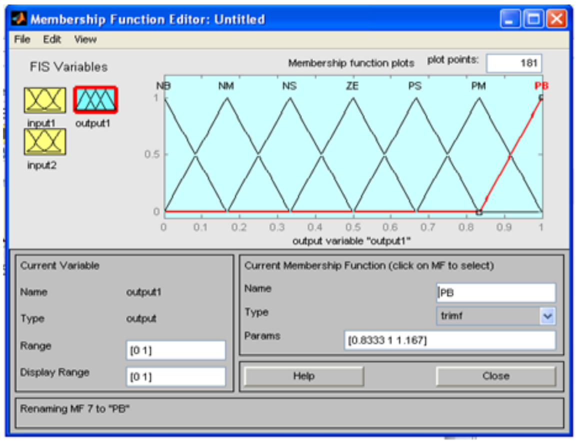

FIG 15 Adding Membership Function For Output

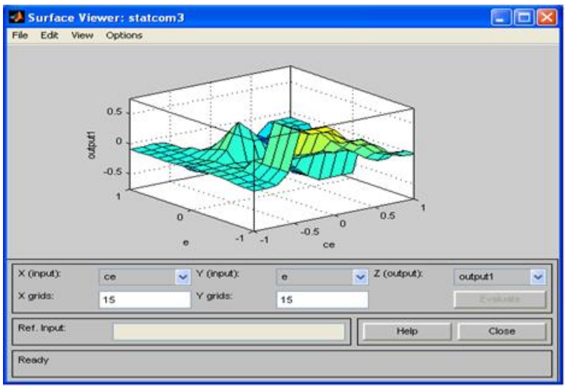

FIG 16 Surface View

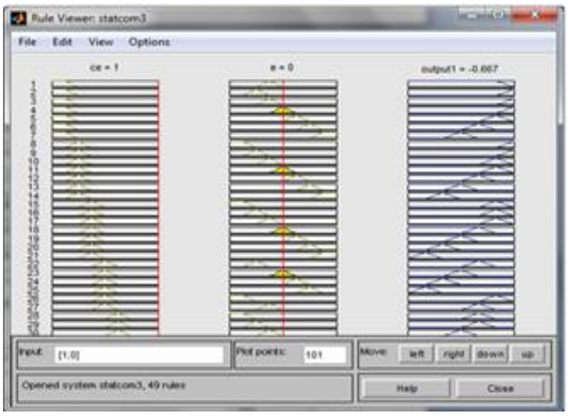

FIG 17 Rules View

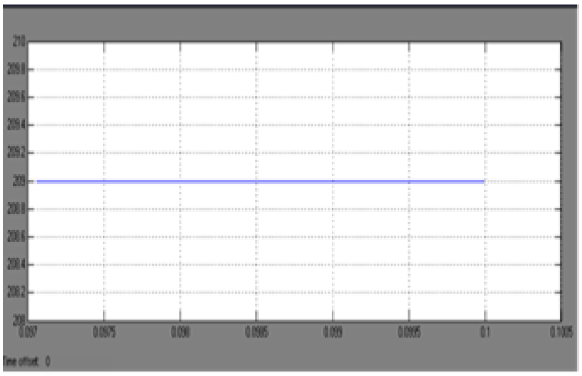

FIG 18 Input Voltage

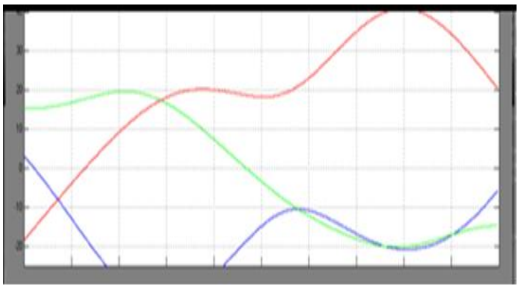

FIG 19 Output Voltage

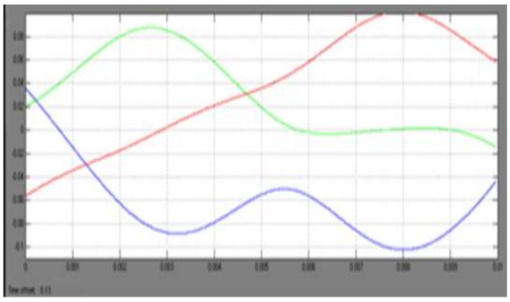

FIG 20 Output Current

V. CONCLUSION

An FLC-based MPPT scheme for the SEPIC converter and inverter system for PV power applications has been presented in this paper. A prototype SEPIC converter-based PV inverter system has also been built in the laboratory. The DSP board TMS320F28335 is used for real-time implementation of the proposed FLC and MPPT control algorithms. The performance of the proposed controller has been found better than that of the conventional PI-based converters. Furthermore, as compared to the conventional multilevel inverter, experimental results indicated that the proposed FLC scheme can provide a better THD level at the inverter output. Thus, it reduces the cost of the inverter and the associated complexity in control algorithms. Therefore, the proposed FLC-based MPPT scheme for the SEPIC converter could be a potential candidate for real-time PV inverter applications under variable load conditions.

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