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Flc Based Mppt Operation of Sepic Converter For Maximum Power Point Tracking

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Abstract: The solar photovoltaic power has received great attention and experienced impressive progress all overthe 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 performance of the proposed FLC-based MPPT operation of SEPIC converter is compared to that of the conventional proportional–integral (PI)-based SEPIC converter.

I. INTRODUCTION

The single -ended primary inductor converter (SEPIC) acts as a buck-boost dc–dc converter, where it changes its output voltage according to its duty cycle. The selection of a proper dc–dc converter plays an important role for maximum power point tracking (MPPT) operation. Due to its output gain flexibility. Among known converters, the SEPIC, conventional buck–boost, and Cuk converters have the ability to step up and step down the input voltage. Hence, this converter can transfer energy for all irradiation levels. Another desirable feature is continuous output current, which allows converter output parallel connection, or conversion to a voltage source with minimal capacitance. The buck or boost converters are not preferable, due to the lack of output voltage flexibility. The SEPIC is chosen because the output voltage can be higher or lower than the input voltage. Also the input and output voltages are dc isolated. The isolation is provided by the series capacitor c, which blocks the dc from the supply side to the output side [1].An auxiliary switch and a clamp capacitor are connected. A coupled inductor and an auxiliary inductor are utilized to obtain ripple-free input current. The voltage multiplier technique and active clamp technique are applied to the conventional SEPIC converter to increase the voltage gain, reduce the voltage stresses of the power switches and diode. Moreover, by utilizing the resonance between the resonant inductor and the capacitor in the voltage multiplier circuit, the zero-current-switching operation of the output diode is achieved and its reverse-recovery loss issignificantly reduced. Both the SEPIC and the Cuk converter provide the choice to have either higher or lower output voltage compared to the input voltage.

The MPPT algorithm represents optimal load for PV array, producing opportune voltage for the load. SEPIC converters can have a low input current ripple, which is one of the advantages of SEPIC converters. However, a bulk inductor should be used to minimize the current ripple. Input current ripple becomes one of important requirements due to the wide use of low voltage sources such as batteries, super capacitors, and fuel cells. The PV panel yields exponential curves for current and voltage, where the maximum power occurs at the curve's mutual knee. The applied MPPT uses a type of control and logic to look for the knee, which in turn allows the SEPIC converter to extract the maximum power from the PV array. The tracking method used, i.e., perturbs and observe (P&O).A tracking method based on parabolic function is proposed to perform the photovoltaic maximum power point tracking. With the proposed method, the maximum power calculation is made from a parabolic convex function. Then a systematic scheme is developed to adjust the concavity and optimal region of the approximate parabola for ensuring the iterative convergence of the proposed method. In order to confirm the effectiveness of this proposed design, the approach has been applied to investigate different atmospheric scenarios. Among different intelligent controllers, fuzzy logic is the simplest to integrate with the system. Recently, the fuzzy logic controller (FLC) has received an increasing attention to researchers for converter control, motor drives, and other process control because it provides better responses than other conventional controllers. The imprecision of the weather variations that can be reflected by PV arrays can be addressed accurately using a fuzzy controller. In order to take 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.

II. EXISTING SYSTEM

The PI controller is designed well where it isoptimized to produce minimum error signal. However, it clearlyappears that the output signal cannot follow the reference signalin Fig. 1 fast. Furthermore, the output voltage does not lie onthe maximum power curve. Moreover, large amount of powercan be lost due to the PI controller. The reason behind thisthat the PI controller addresses two main issues: the steadystate error and the maximum overshoot. If one need focus ontime, the derivative controller must be added to become thePI–derivative (PID) controller, but this causes instability in thesteady state. Therefore, the PI controller cannot follow accuratechanges in reference signal effectively.

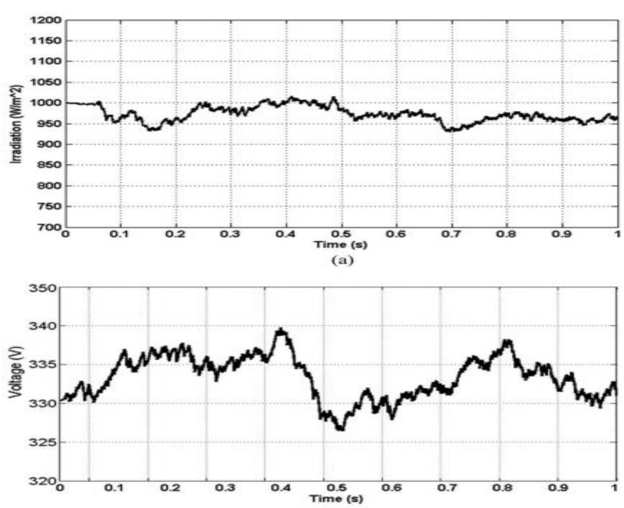

Fig. 1. (a) Irradiation(W/m2). (b) Reference voltage tracks the maximum power.

The drawback of most of the fuzzy-based MPPT algorithmsis that the tracking point is located away from the maximumpower point when the weather conditions change. However,a drawback of P&O technique is that, at steady state, theoperating point oscillates around the maximum power pointgiving rise to the waste of available energy, particularly in casesof constant or slowly varying atmospheric conditions. This canbe 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 sizedecreases. However, accuracy leads to slow response whenthe environmental conditions change rapidly. Larger step sizemeans higher speed for the MPPT operation, but this will leadto inaccuracy and larger intrinsic oscillations around the maximum power point in steady state. Step sizes should, thus, bechosen well to achieve high speed and accuracy.

III. PROPOSED SYSTEM

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 depending on the maximum power. Furthermore, the controller changes the voltage level by changing

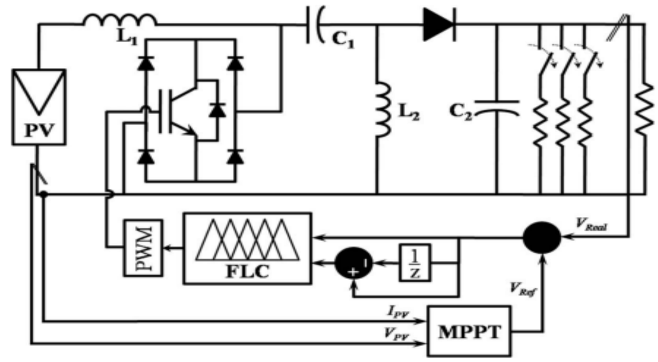

Fig. 2. Circuit diagram of the SEPIC converter for the FLC-based MPPT scheme.

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. Another reference signal is used to compare the SEPIC's output, to achieve the maximum power. This reference signal is adaptive, changing its shape according to weather conditions. The

SEPIC's output signal is, thus, compared with the adaptive reference signal, to feed the inverter with the most suitable power. The inverter's input signal should be as smooth as possible, but the SEPICMPPT generates a non-smooth signal, owing to its tracking of maximum power. This problem is notas big, since the non-smooth signal can be enhanced by the inverter's fuzzy controller and the low-pass filter connected to the inverter. Hence, although the input signal is not smooth, the exploitation of the maximum power is possible, as well as the creation of a smooth output signal.

Fig. 1 is the circuit diagram of the SEPIC dc–dc converter together with the MPPT and the fuzzy controller. The design of the fuzzy controller was done using Mamdani's method for both the converter and the single-phase inverter. The selection of the membership functions will be discussed in the next section. The PWM changes its duty cycle according to the control signal, configuring a feedback from the output signal represented in voltage, current, and power to get the reference signal, which is unpredictable and adapts itself depending on the maximum power achieved by the duty cycle's changes. 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.

In Fig. 1, the SEPIC converter can use single switch. However, for PV applications, the dc–dc converter can be used to supply the inverter, as well as to charge the batteries instandalone systems, hence using bidirectional switch.

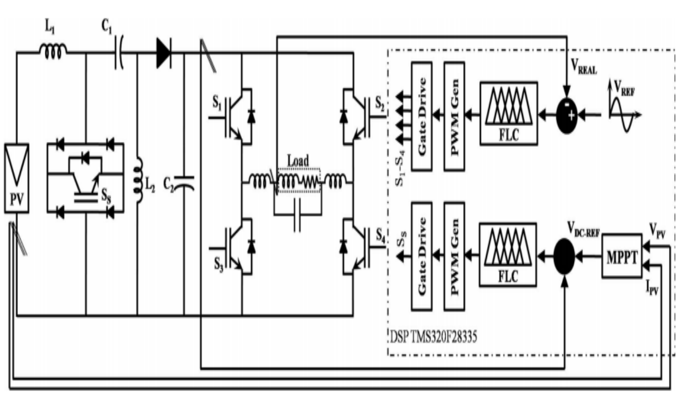

Fig. 3. Overall control scheme for the proposed FLC-based MPPT scheme for the SEPIC converter.

The fuzzy control systems are based on expert knowledge that converts the human linguistic concepts into an automatic control strategy without any complicated mathematical model. Simulation is performed in buck converter to verify the proposed fuzzy logic controllers.The overall control scheme of the proposed system is shownin Fig. 2. In FLC design, one should identify the main controlvariables and determine the sets that describe the values of eachlinguistic variable.

IV. SIMULATION RESULTS

Simulation was applied on MATLAB/Simulink to verify the practical implementation of the proposed SEPIC fuzzy controller for the single-phase inverter. Fig. 1 presents thereference signal for the SEPIC's output, where it tracks themaximum power. The results introduced in Fig. 4 belong tovoltage and current signals of the conventional PI controller.The PI controller is selected for comparison because of itssevere use in industry applications.

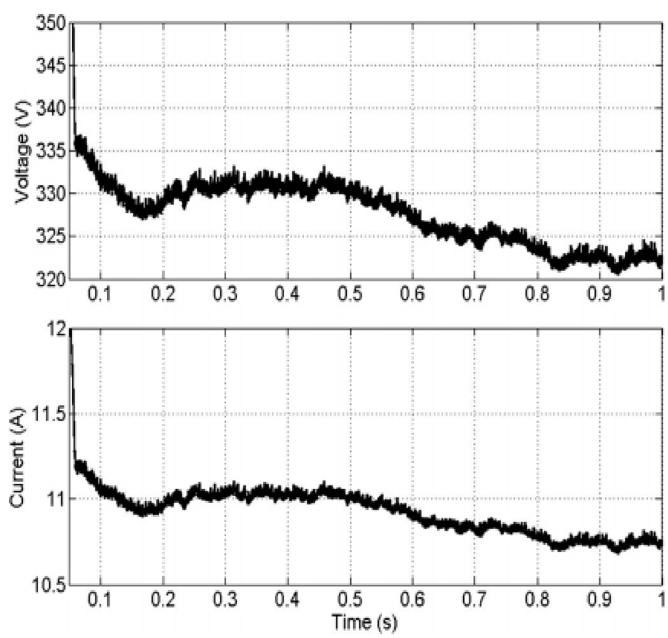

Fig. 4. Output (top) voltage and (bottom) current waveforms of the SEPIC converter with the conventional PI control scheme.

The output voltage and current signals of the proposed FLCbased MPPT at constant load condition are shown in Fig. 5. Itis noticeable that the signals were not smooth; on the contrary,they carried a component of the maximum power betweenvoltage and current. The voltage range changed from 320 to340 V. The voltage signal in Fig. 5 is similar to the referencesignal in Fig. 1, where the error signal approached zero asFig. 6 proves this.

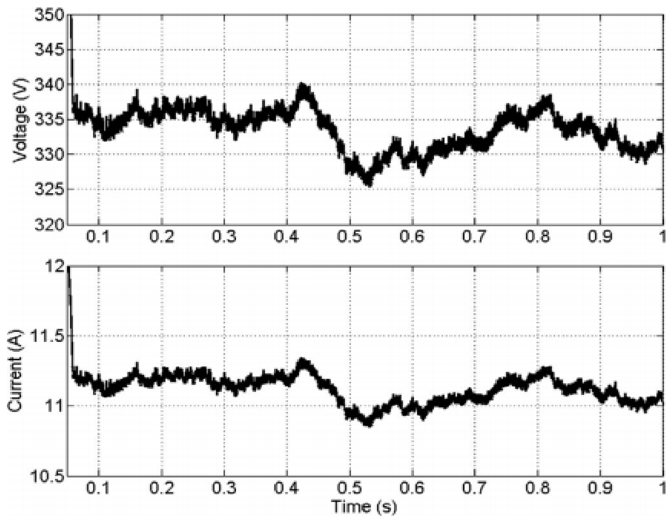

Fig. 5 Output (top) voltage and (bottom) current waveforms of the SEPIC converter with the proposed FLC-based MPPT scheme.

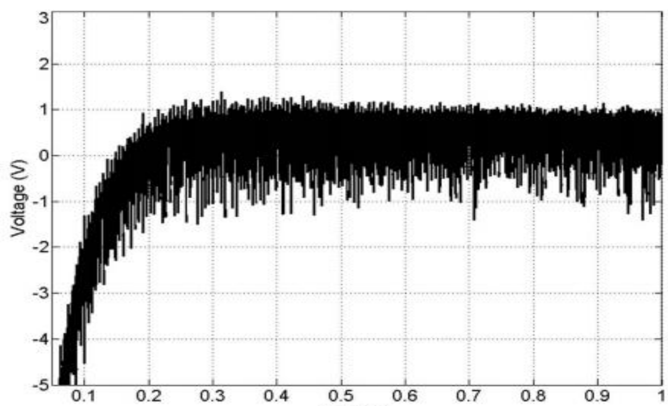

Fig. 6. Inverter current, voltage, and voltage error signals with lagging power factor load for the proposed FLC-based SEPIC and inverter system.

V. CONCLUSION

An FLC-based MPPT scheme for the SEPIC converter andinverter system for PV power applications has been presentedin this paper. A prototype SEPIC converter-based PV invertersystem has also been built in the laboratory. The performanceof the proposed controller has been found better than that of theconventional PI-based converters. Furthermore, as comparedto the conventional multilevel inverter, experimental resultsindicated that the proposed FLC scheme can provide a betterTHD level at the inverter output. Thus, it reduces the cost of theinverter and the associated complexity in control algorithms.Therefore, the proposed FLC-based MPPT scheme for theSEPIC converter could be a potential candidate for real-timePV inverter applications under variable load conditions.

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