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AN INNOVATIVE HYBRID APPROACH TO THE FLC-BASED PHOTOVOLTAIC MODULE LEVEL POWER ELECTRONICS; SOLAR OPTIVERTER

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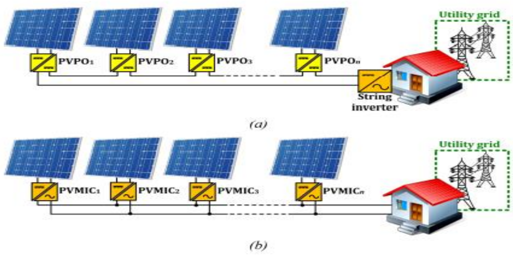
Abstract: Here, the Optiverter, a brand-new kind of photovoltaic (PV) module-level power electronics device, is examined. Direct AC connectivity, an ultrawide MPPT voltage window, and intrinsic safety are all features of this latest generation of solar microinverters. Shade-tolerant MPPT and multi-mode control with variable DC-link enable successful PV module energy harvesting under different shade situations. The inclusion of fuzzy logic controllers (FLCs) in this control strategy boosts system performance and decreases DC voltage 'overshoots'. Simulating the proposed system results is done in MATLAB/SIMULINK using the environment.

Keywrods: Fuzzy logic controller for solar panel MPPT (maximal power point tracking) (FLC)

I.INTRODUCTION

Solar PV system owners and installers have been more interested in MLPE over the last decade since it enables each PV module to function at its maximum power point. PV MLPE systems may be divided into two categories depending on how much electricity they convert: partial and complete. The latter has an advantage over the former in this respect because of the broad variety of operating circumstances associated with PV installation. PV power optimizers (PVPOs) and microinverters are used extensively in current MLPE systems (PVMICs). Connecting solar panels in series with PVPOs is common practise (Fig. 1a). A PVPO is installed in the junction box of the PV module before the string inverter acquires a enough DC voltage from the array. [3] When using PVPOs, non-isolated DC/DC converters are often utilised to keep the string voltage constant independent of the string's properties or operating conditions[3]. One of the most important advantages of PVPOs is that they may be utilised with a broad variety of solar panels, including 72- and 96-cell modules and thin film panels. ' String arrangements with PVPO need a minimum of six to eight PV modules even if they are basic since the PVPO cannot be larger. Low-component PVPOs may achieve efficiencies of more than 98 percent [4].



PVPOs and PVMICs grid-connected solar panels are shown in Figure 1 (left) and (right).

Because of the worry about a single point of failure, the string inverter supplying PV power into the AC grid might likewise become a "elbow." More dangerous than fires caused by arcing in a controlled setting is the high-voltage DC arc between PV modules and the string-inverter. As a result, it is essential to implement additional safety precautions, such as detecting arcs and disconnection of the solar power plant immediately. The PVMIC's ability to maximise output voltage is one of numerous other features that make it ideal for use in homes and businesses. A minimum number of PV modules is no longer required since the PVMICs are connected to the grid in tandem. Increase or reduce the PV system's capacity as required by adding or removing PV modules and the PVMICs that support them. As a result of the PVMIC's increased component count, its reduced cost per watt may be countered by poorer multi-stage power conversion efficiency. [5] There are more components and a higher operating temperature (up to 60 °C) in the PVMIC that might jeopardise the system's long-term reliability. The cheap cost, great efficiency, and long-term dependability of PVMICs need an MPPT voltage range that is restricted. The Optimizer, a brand-new kind of PV MPLE system, is debuted in this paper (PVOPT). The PVMIC's broad range of MPPT voltages and direct AC connection may benefit all applications. This list of characteristics includes solar panel level monitoring and cut-offs, installation flexibility, and the size of a PV power system. Before the entire presentation of PVOPT's suggested technology, comparisons are made. For Shade-Tolerant MPPT, the hardware and software principles are then outlined (ST-MPPT). We used a 300 W PVOPT with experimental electronics for our demonstration.

II.PROPOSED SYSTEM

A)PHOTOVOLTAIC OPTIMIZER

There are Optimizer MLPE systems that bridge the gap between PVPO and PVMIC MLPE systems. In comparison to PVPOs, PVMICs have the greatest possible MPPT voltage range and the shade-tolerant performance because of their direct AC connection and inherent safety. An inverter with grid connected full-bridge arrangement and multi-mode control is built into the Optimizer's front end buck-boost DC-DC converter. As a result of the PVOPT's better multimode control, its MPPT voltage window is four times the PVMIC's. All of the PVOPT's 60 and 72-cell PV modules, including those with severe opaque shading (two of the three substrings), could be harvested with its low starting voltage. Figure 2 shows PVOPT's generalised power circuit diagram. Using a two-stage building procedure, the PVOPT's broad MPPT voltage window and ability to monitor global maximums were accomplished. The qZSSRC is the better front-end DC-DC converter even for MLPE applications. MPPT and voltage matching between the PV module and the high-voltage DC connection are taken care of in this scenario. Topologies for the boost half bridge [4] and the PWM boost converter [15] are two examples of high performance DC-DC converters used in front-end system design. When it comes to gaining DC voltage, the QZSSRC offers an amazing input voltage regulation capability of 6.7 to 50 [16]. PVOPT's design has concentrated on the integrity and hybridization of its primary components, which have drawn special attention because of its cost-performance trade-off. The TX transformer in the qZSSRC, for example, helps resonance and allows In order to enable continuous switching, voltage step-up and galvanic isolation are required for semiconductors. It is possible to get complete ZCS of the VDR diodes and, depending on operating mode, ZVS or ZCS of primary-side MOSFETs using the transformer TX's leakage inductance Llk and the capacitors C1 [18] and C2 [19]. For the S5, S6, S7, and S8 legs of the grid-tied inverter, full-bridge Si and SiC MOSFETs are used in a basic design. In the context of the tale, it may be observed. graphic that an LCL filter was used to remove switching noise and provide a sinusoidal waveform at the PVOPT's output. It is displayed in Figure 6 and its essential parameters are presented in Table 2 from a top-down perspective. In order to keep costs down, we used generic components wherever we could. When using RM14 ferrite cores, LqZS coupled inductor and TX hybrid isolation transformer were employed to link all components. Thermal pads and vias for a PVOPT PCB were created using natural convection cooling.

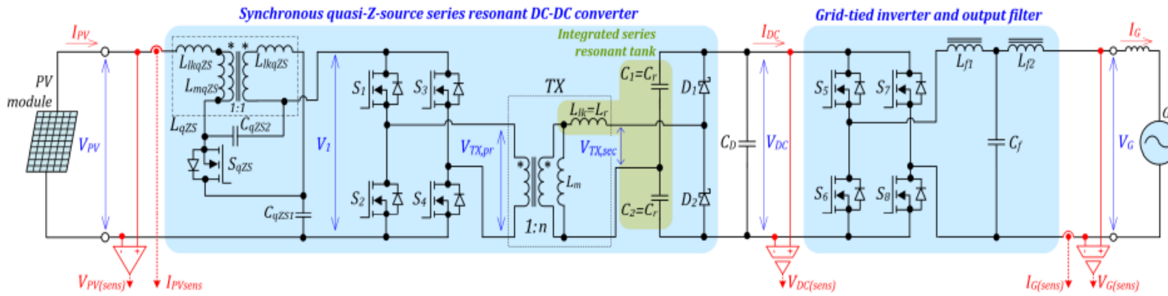
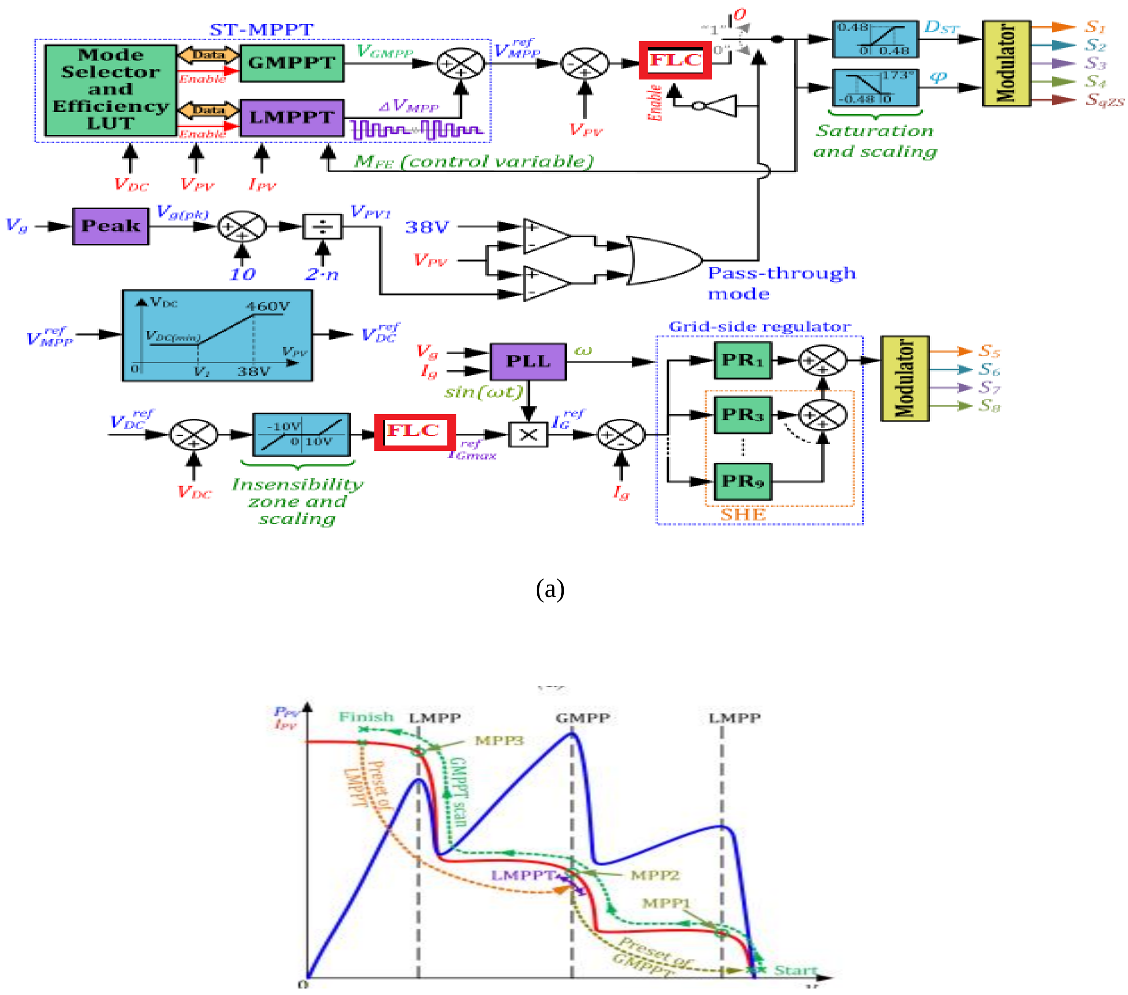


Fig.2 The photovoltaic Optiverter general power circuit diagram (PVOPT)

B) MAXIMUM POWER POINT TRACKING WITH TOLERANT SHADE (ST-MPPT)

The grid-tied inverter (PI1) and qZSSRC (PI2) PI controllers are included in the PVOPT's control system, as shown in Figure 3a (PI2). A negative PI1 output initiates the buck mode, while a positive PI1 output initiates the boost mode. As long as a PR controller and a SHE block are used, the grid current may be measured properly. The grid current IG is controlled by a device known as PR1 to guarantee that it matches the reference current (IGref). Each odd harmonic in the grid-side regulator has its own PR controller in the SHE. The controllers PR3, PR5,...,PR9 will be used to eliminate the third and fifth harmonics. Figure 3a shows how the amplitude of the reference grid current is set by the fuzzy controller (IGref). In PTM mode, PI2 is utilised for MPPT, whereas both FLC controllers are used in the other two modes. The ST-MPPT Algorithm will be discussed in detail in this section. It is favoured over PVMICs under partial and opaque shadowing because of its MPPTs that are powered by sunlight (ST-MPPT). Fig. 3b shows the ST-MPPT system, which incorporates GMPPT and MPPT components (LMPPT). The design of the Si PV modules includes three substrings and three bypass diodes. Scanning of the P-V curve may be used to identify both localised and globalised MPPs. Once the GMPPT (GMPP) has been activated with the input variables, the LMPPT takes action to disturb the operational point in order to maximise MPPT efficiency. The control system. Figure 4 depicts the ST-MPPT method. This is seen in Fig. 2a, where the ST-MPPT is utilised to raise PVOPT voltage up to a reference voltage established by the control system, and this voltage is then maintained by the controller.



(a)

(b)

Fig.3 APVOPT-controlled and ST-MPPT algorithm-controlled system

Once every 30 minutes or when the PV power varies by 10% or more, a GMPPT rescan is performed. The qZSSRC comes with a pre-set configuration. Until the qZSSRC receives its maximum input voltage or step-down ratio, the preset will not be terminated. In order to drop the reference voltage as low as possible, the PV module is switched off. To complete the GMPPT postprocessing operation, the stored data must be subjected to the PVOPT efficiency determined using a look-up table. PVOPT may function with two MPPs of equal power running at separate voltages when operating at higher voltages and greater output powers. Higher voltages reduce system reliability because they produce fewer heat cycles.

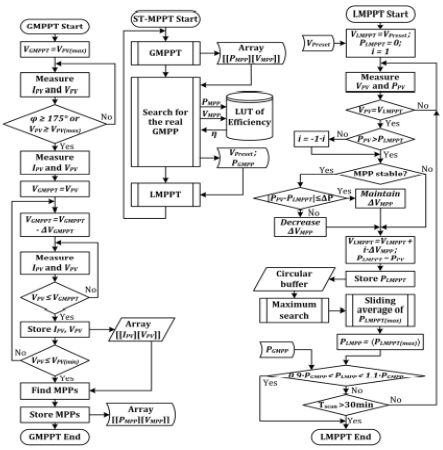


Fig.4 The ST-MPPT routine's workflow

III. PROPOSED FUZZY LOGIC CONTROLLER

The fuzzy method consists of three key phases

(1) Level of input,

(2) Stage and processing

(3) Stage of Output.

The Fuzzy controller receives input in the form of an error signal. An error signal is reduced by using membership and truth values during processing. After processing, a defuzzifier removes any lingering doubts about the signal's loudness.

Four components of a fuzzy logic controller configuration :

1) Running.

2) Basis of the law

3) Method of inference

4) Defuzzification.

The PI controller is the most popular choice for industrial applications because of its cheap cost and ease of design. The advantages of PI controllers are clear, but if the object is too unpredictable, they fail. The benefits of a PI-style control system may be easily maintained when designing a fuzzy logic controller. The control output of this situation is

$$K_p \Delta u_f + k_i \int e\, dt \qquad (1)$$

The FLC output values in this example are kp and ki, which are identical to the PI controller values.

Fuzzification

Fluzzification may be achieved by comparing input parameters to fuzzy variables. Each member of a fuszified variable serves a specific purpose. As seen in Fig. 4, inputs and outputs may be floated in fluids of the positive (P), zero (Z), and negative (N) kinds. The fuse controller receives inputs from errors and their derivatives.

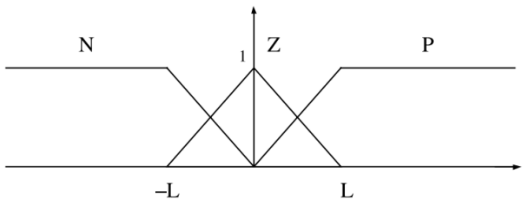


Figure 5 shows the fuzzy controller's membership functions in action.

What it means to be part of a great crowd

$$\mu_p(x_i) = \begin{cases} 0 & xi < 0 \\ \frac{xi}{L} & 0 \le xi \le L \\ 1 & xi > L \end{cases}$$

As a reminder, the controller's fuzzy input is xi. "Member-aggressive" is another word for this behaviour. As a reminder, the controller's fuzzy input is xi. "Member-aggressive" is another word for this behaviour.

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$$\mu_N(x_i) = \begin{cases} 1 & xi < -L \\ \frac{-xi}{L} & -L \leq xi \leq 0 \\ 0 & xi > 0 \end{cases} \quad (7.2)$$

And there is no option for membership:

$$\mu_Z(x_i) = \begin{cases} 0 & xi < -L \\ \frac{xi+L}{L} & -L \leq xi \leq 0 \\ \frac{-xi+L}{L} & 0 < xi \leq L \end{cases} \quad (7.3)$$

0 $\quad x_i > L$

Inference

The variable factors are considered while making control choices. Decisions on manufacturing are based on a body of knowledge. The controller's rule set is shown in Table 1. The min–max technique of inference may be used to analyse output variables. Iconography. Fuzzy controllers are an option. Proposed.

Table 1 of the Fuzzy Controllers

$\dot{e}[k]$	$e[k]$ $\Delta u_f[k]$		
	N	Z	P
N	N	N	Z
Z	N	Z	P
P	Z	P	P

Defuzzification

The output variables of the fuzzy inference approach must be translated in order to provide numerical results. Use Zadeh operating rules and a generic defuzzifier for fuzzy controller output.

$$\Delta u_f(k) = \frac{\sum_{i=1}^{9} \mu c(\mu f)\mu f}{\sum_{i=1}^{9} \mu c\,(\mu f)} \quad (7.4)$$

IV.SIMULATION RESULTS

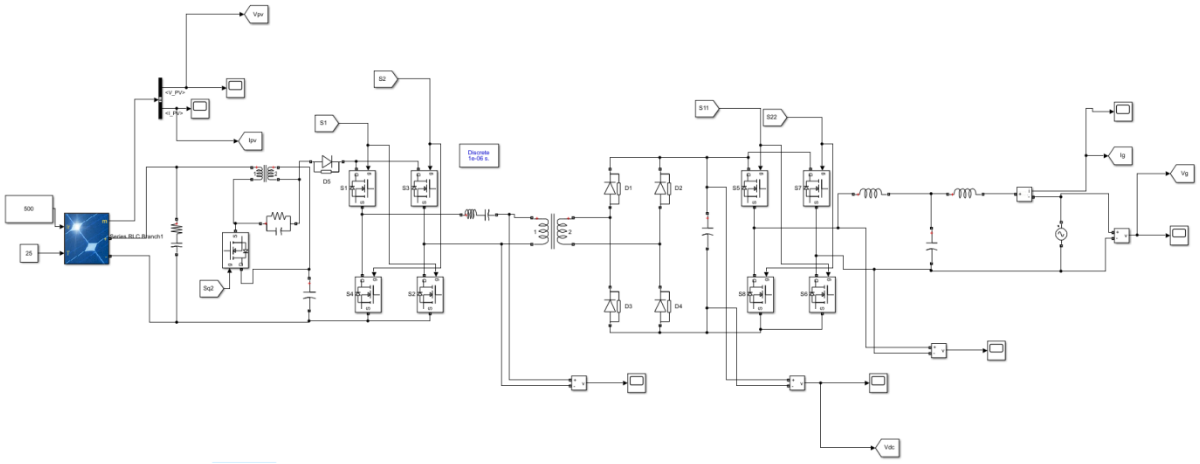

Fig.6 MATLAB/SIMULINK circuit of the proposed system

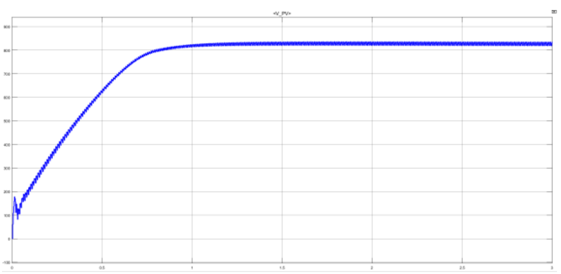

Fig.7PV voltage (Vpv)

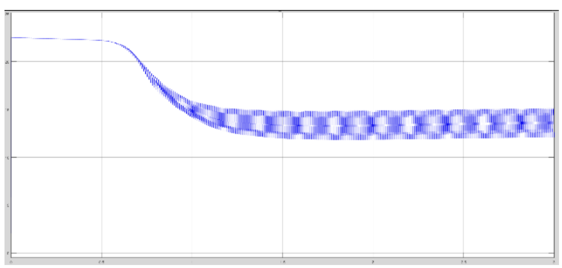

Fig.8 PV current (Ipv)

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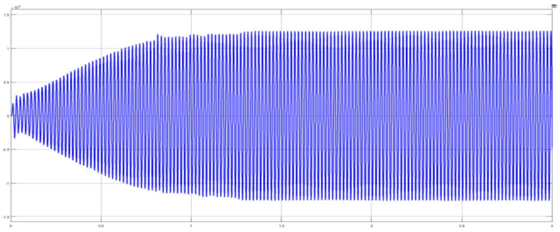

Fig.9 Inverter voltage

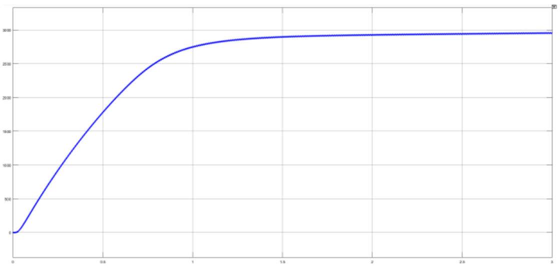

Fig.10 Rectifier output voltage

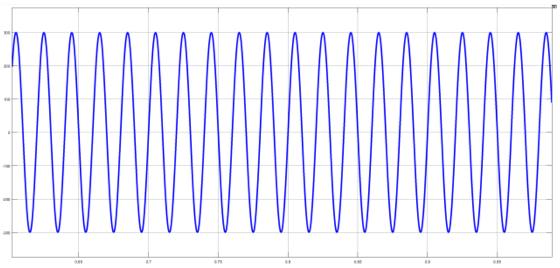

Fig.11Grid voltage (Vg)

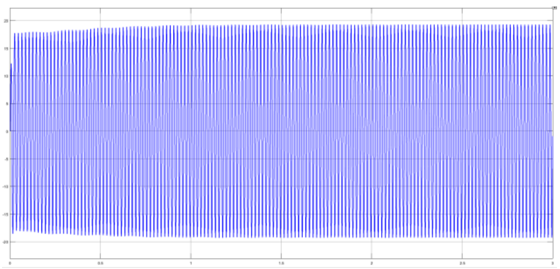

Fig.12 Grid current(Ig)

Fig.13 Grid current THD%

CONCLUSION

The PV Optiverter may be used with a broad range of PV modules and voltages, making it suitable for both small commercial and residential PV systems. When conventional microinverters fail to gather any power due to strong opaque shading, they cannot keep up with the MPPT's shade tolerance... The improved power rating and contemporary, high-power PV modules minimise power clipping. To this end, the galvanic isolation of the converter as well as the unique control system with a variably set differential capacitor voltage may be credited. P-V curve scanning may be used to trigger the shade-tolerant MPPT. A smaller solar power system cannot do better than the PV Optiverter. Installation and shipping costs, as well as staff training, are all reduced when many PV modules are stored in a single storage unit. DC-DC converters with equivalent performance may be built using a variety of different designs, including the qZSSRC. Using a fuzzy logic controller also enhances the system's performance and reduces the DC voltage "overshoot" (FLC). The efficiency of an Optiverter might be affected by the fact that it is designed to function with a broad variety of voltages. Modulated cycle skipping and programmable rectifiers with high DC voltage gain have the potential to enhance performance at low loads.

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