ENHANCING THE CAPABILITY OF INTERHARMONICS IN SOLAR FED GRID CONNECTED SYSTEM WITH MPPT MODOFICATION

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ABSTRACT: In this research, we present a new grid-connected solar power system based on fuzzy logic controllers. Grid-connected photovoltaic (PV) systems are facing new power quality issues due to interharmonics. Maximum Power Point Tracking (MPPT) is one of the primary drivers of interharmonics, and previous research and field tests have validated the evidence of interharmonic emission from PV inverters. In this sense, the interharmonic feature of the PV system is significantly influenced by the MPPT parameters, such as their sampling rate. When choosing the sample rate of the MPPT algorithm, there is typically a trade-off between the interharmonic emission and the MPPT performance. More precisely, using a faster MPPT sample rate will raise the interharmonic emission level while simultaneously increasing the MPPT efficiency. This research proposes a novel FLC-based mitigation approach for interharmonics in PV systems to address this problem. In order to choose the sampling rate at random between the fast and slow values, the suggested solution alters the MPPT algorithm. By doing this, the frequency spectrum distribution can effectively reduce the interharmonics in the output current. However, the suggested method's MPPT performance can be kept comparable to that of using a fast MPPT sampling rate. MATLAB/SIMLINK settings have demonstrated the efficacy of the suggested interharmonic mitigation on a single-phase grid-connected photovoltaic system.

KEYWORDS: FLC controller, MPPT, sampling rate, Interharmonics.

I.INTRODUCTION: Over the past ten years, difficult problems relating to grid integration have emerged as photovoltaic (PV) systems have become more widely used. Interharmonics, or frequency components that are non-integer times of the fundamental frequency, are one of the new power quality issues for grid-connected PV systems [1]. According to recent research, PV inverters may be the cause of interharmonic emissions for PV systems, which have been seen in field measurements as well as in laboratory testing environments [2]–[6]. The interharmonics can result in flickering, grid voltage fluctuations, and inadvertent disconnection of PV systems, even if the interharmonics standard pertaining to the emission limit is still being developed. Therefore, mitigations are required and interharmonic emissions from PV systems should be minimized[7].

According to the previous studies [3]–[6], the Maximum Power Point Tracking (MPPT) operation is one of the main causes for interharmonics in PV systems. In particularly, the perturbation of the PV arrays voltage during the Maximum Power Point (MPP) searching inevitably induces power oscillations at the dc side, especially during the steady-state operation. This power oscillation contains a series of low-order frequency components, which is reflected in the frequency components of the amplitude of the output current |ig|. When multiplying the amplitude of the output current |ig| with the phase angle sin(θg), the output current ig will contain a certain amount of interharmonic frequencies due to the amplitude modulation following the control diagram in Fig. 1.

Characteristic in PV systems has been proposed in [8], where the results from the interharmonic model agree well with the field observation in [6]. It has been demonstrated in [8] that the interharmonic characteristic is strongly dependent on the MPPT algorithm parameters such as the perturbation step-size step and the sampling rate MPPT. As discussed in [8], the interharmonic emission can be effectively alleviated by reducing the sampling rate of the MPPT algorithm. However, this will inevitably slow down the tracking performance of the MPPT algorithm [9], which may reduce the MPPT efficiency and thus the PV energy yield, especially during changing environmental conditions (e.g., solar irradiance and ambient temperature). Thus, there is a trade-off between the interharmonic emission and the MPPT efficiency when selecting the sampling rate of the MPPT algorithm. With the above motivation, a new mitigating solution for interharmonics in PV systems is proposed in this paper. The proposed method randomly switches the operation between a fast and slow sampling rate of the MPPT algorithm. By doing so, the interharmonics in the output current can be effectively reduced due to the distribution of the frequency spectrum. On the other hand, the MPPT performance of the proposed method can be maintained similar to the case when employing a fast MPPT sampling rate.

II.PROPOSED SYSTEM:

A. System Configuration

The experimental test in this paper is conducted based on the single-stage single-phase PV inverter shown in Fig. 1, where the system parameters are given in Table I. In this configuration, the PV inverter is employed to control the power extraction from the PV arrays and convert it to the ac power delivered to the grid [10]. In order to maximize the PV energy yield, the operating voltage of the PV arrays (i.e., corresponding to the dc-link voltage vdc) is determined by the MPPT algorithm during the operation. The dc-link voltage vdc is regulated through the control of the output current ig by a current controller, where the phase angle of the output current sin(θg) is obtained using a Phase-Locked Loop (PLL).

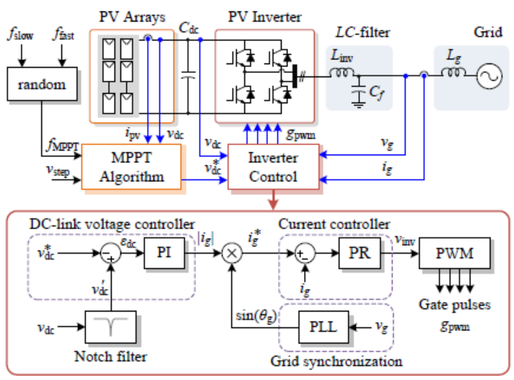

Fig. 1. System diagram and control structure.

TABLE I
PARAMETERS OF THE SINGLE-PHASE GRID-CONNECTED PV SYSTEM.

PV rated power	3 kW
DC-link capacitor	C_{dc} = 1100 μF
LC-filter	L_{inv} = 4.8 mH, C_f = 4.3 μF
Grid-side inductance	L_g = 2 mH
Switching frequency	f_{inv} = 8 kHz
Controller sampling frequency	f_s = 20 kHz
Grid nominal voltage (RMS)	V_g = 230 V
Grid nominal frequency	f_g = 50 Hz

B. Maximum Power Point Tracking

The MPPT algorithm is essential for the PV system in order to maintain the operating point of the PV arrays close to the MPP and thus maximize the energy yield during the operation. In this paper, the Perturb and Observe (P&O) MPPT algorithm is employed [9], where the perturbation step-size v_{step} and the MPPT sampling rate f_{MPPT} are the MPPT parameters. One important characteristic of the P&O MPPT algorithm (and also other hill-climbing MPPT methods) is the power oscillation during the steady-state operation [9]. This behavior is shown in Fig. 2, where the PV inverter operates under constant solar irradiance condition. Two MPPT sampling rates of 2.5 Hz and 5 Hz are employed to demonstrate the performance of the PV system with different MPPT sampling rates. Comparing the operating condition with two times difference in the sampling rate can clearly demonstrate their impact on the interharmonic characteristics. It can be seen that the PV arrays voltage oscillates within three operating points, which correspond to the "top of the hill" in the power voltage characteristic of the PV arrays. This is achieved when the sampling rate is properly selected below the PV-power settling time as discussed in [11]. Notably, the frequency of the oscillation is proportional to the MPPT sampling rate. the oscillation is proportional to the MPPT sampling rate.

The below table 2 represents the rule base of fuzzy logic controller with 5*5 =25 rule base represents.

	Error (E)					
Change in Error (CE)		NB	NS	Z	PS	PB
	NB	NB	NB	NS	NS	Z
	NS	NB	NS	NS	Z	PS
	Z	NS	NS	Z	PS	PS
	PS	NS	Z	PS	PS	PB
	PB	Z	PS	PS	PB	PB

Table 2 Fuzzy logic rule base table

Where:

PB=Positive big

PS= Positive small

Z = Zero

NS= Negative small

NB= Negative big

NS= Negative small

E = Error

CE= Change in Error

1. If error is NB and change in error is NB then the resultant is NB
2. If error is NB and change in error is NS then the resultant is NB
3. If error is NB and change in error is EZ then the resultant is NS
4. If error is NB and change in error is PS then the resultant is NS
5. If error is NB and change in error is PB then the resultant is EZ
6. If error is NS and change in error is NB then the resultant is NB
7. If error is NS and change in error is NS then the resultant is NS
8. If error is NS and change in error is EZ then the resultant is NS
9. If error is NS and change in error is PS then the resultant is EZ
10. If error is NS and change in error is PB then the resultant is PS
11. If error is EZ and change in error is NB then the resultant is NS
12. If error is EZ and change in error is NS then the resultant is NS
13. If error is EZ and change in error is EZ then the resultant is EZ
14. If error is EZ and change in error is PS then the resultant is PS
15. If error is EZ and change in error is PB then the resultant is PS.

16. If error is PS and change in error is NB then the resultant is NS
17. If error is PS and change in error is NS then the resultant is NS
18. If error is PS and change in error is EZ then the resultant is EZ
19. If error is PS and change in error is PS then the resultant is PS
20. If error is PS and change in error is PB then the resultant is PB
21. If error is PB and change in error is NB then the resultant is EZ
22. If error is PB and change in error is NS then the resultant is PS
23. If error is PB and change in error is EZ then the resultant is PS
24. If error is PB and change in error is PS then the resultant is PB
25. If error is PB and change in error is PB then the resultant is PB.

III.SIMULATION RESULTS:

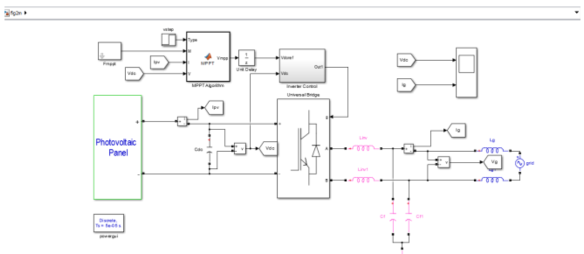

FIG.3 PROPOSED SIMULINK DIAGRAM

CASE 1: Sampling Rate At 2.5HZ

Fmppt-2.5HZ

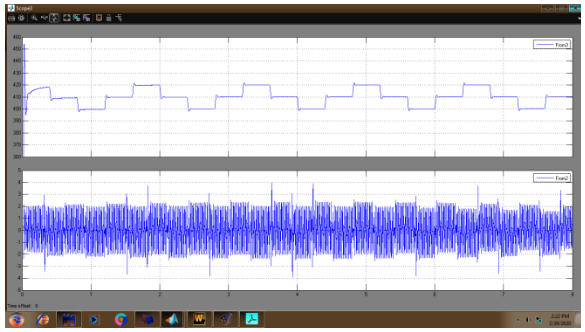

FIG 4. DC VOLTAGE AND GRID CURRENTS

CASE 2 SAMLING RATE Fmppt-5HZ

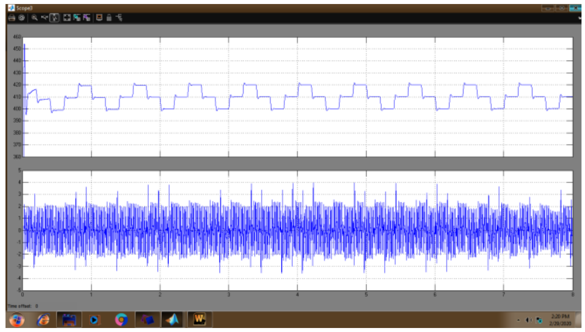

FIG 5. DC VOLTAGE AND GRID CURRENTS

CASE 3 : PROPOSED SYSTEM(RANDOMLY SELECTED SAMPLING RATE)

Fmppt-Random

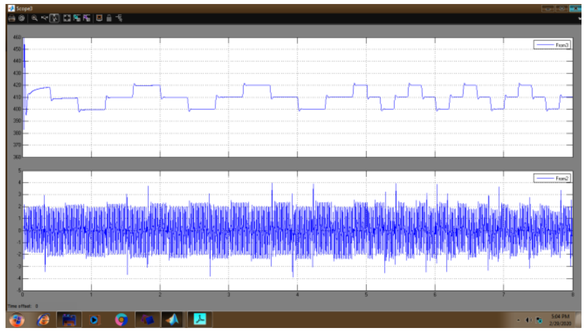

FIG 6. DC VOLTAGE AND GRID CURRENTS

Efficiency

Fmppt=2.5HZ

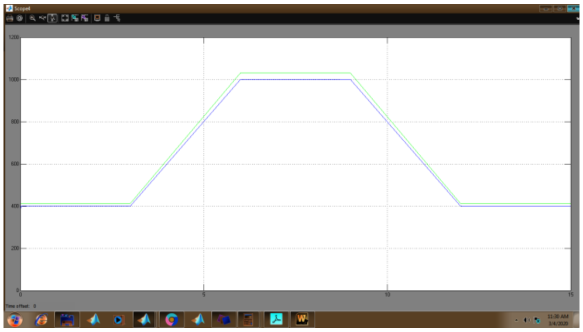

FIG 7 EFFICIENCY OF SAMPLING RATE AT 2.5HZ

Fmppt=5HZ

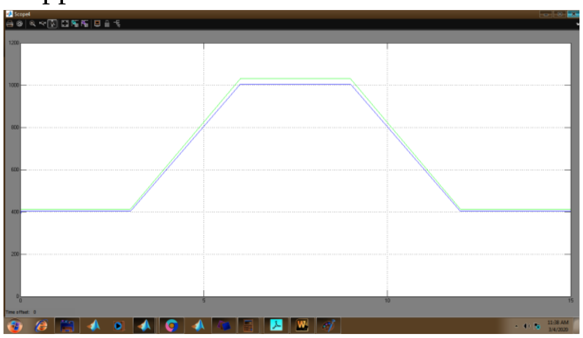

FIG 8 EFFICIENCY OF SAMPLING RATE AT 5HZ

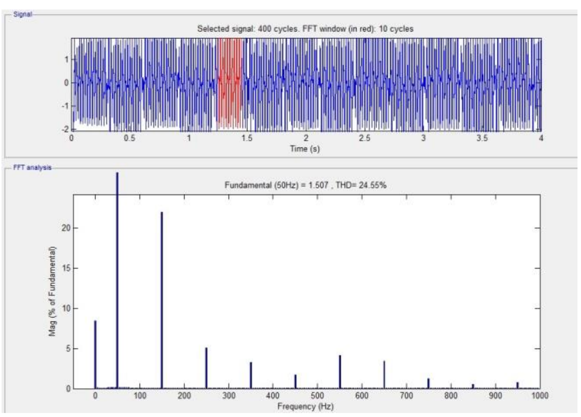

FIG.9. % THD OF GRID CURRENT WITH PI CONTROLLER

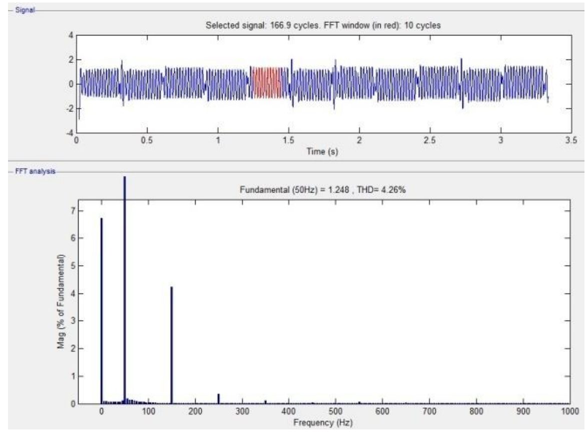

FIG 10 % THD PROPOSED FUZZY LOGIC CONTROLLER

IV. CONCLUSION

In this study, we present a solar-fed microgrid based on FLC. When choosing the sample rate of the MPPT algorithm in the traditional MPPT implementation, the interharmonic emission and the MPPT efficiency are traded off. This study suggests a novel mitigation technique for the interharmonics in PV-based FLC systems in order to address this problem. By choosing the MPPT algorithm's sampling rate at random throughout the operation, the suggested solution alters the MPPT algorithm. By doing this, the amplitude of the dominant interharmonics can be greatly decreased and the output current's frequency spectrum can be smoothed. Furthermore, with a fast MPPT sampling rate, the suggested mitigation solution's MPPT performance may be kept near to the traditional MPPT operation, achieving comparable tracking efficiency under dynamic operating conditions. The effectiveness of the suggested approach has been confirmed in MTLAB/SIMULINK for both dynamic and steady-state (such as interharmonics) operations (e.g., MPPT efficiency).

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