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A PHASE SHIFTING MPPT METHOD TO MITIGATE INTERHARMONICS FROM PV INVERTERS

[1]Mr.K.HARINATH REDDY, [2]B.VIJAYA DEEPTHI, [3]K.RANGANATH, [4]K.PAVAN KUMAR REDDY, [5]K.PAVAN KUMAR

[1]Asst.Professor, Department of EEE, AITS.

[2,3,4,5] Electrical and Electronics Engineering, Annamacharya Institute of Technology and Sciences

[1]harinathreddyks@gmail.com, [2]bandideepthi123@gmail.com, [3]ranganathkonanki45@gmail.com, [4]kottekumarreddy1718@gmail.com, [5]kadapalapavan143@gmail.com

Abstract— Inter-harmonics are emerging power quality challenges in grid-connected Photovoltaic (PV) systems. Previous studies and field measurements have confirmed the evidence of inter-harmonic emission from PV inverters, where the Maximum Power Point Tracking (MPPT) is one of the main causes for inter-harmonics. In that regard, the MPPT parameters such as their sampling rate have a strong impact on the inter-harmonic characteristic of the PV system. In general, there is a trade-off between the inter-harmonic emission and the MPPT performance when selecting the sampling rate of the MPPT algorithm. More specifically, employing a faster MPPT sampling rate will improve the MPPT efficiency, but it will also increase the inter-harmonic emission level. To solve this issue, a new mitigating solution for inter-harmonics in PV systems is proposed in this paper.

Index Terms: *Photovoltaic (PV) systems, inverters, maximum power point tracking (MPPT), inter harmonics, power quality.*

I. INTRODUCTION

With an increasing penetration level of Photovoltaic (PV) systems, challenging issues related to the grid integration have been arisen in the last decade. One of the emerging power quality problems for grid-connected PV systems is the interharmonics, which are defined as the frequency components that are non-integer times of the fundamental frequency [1]. Recent studies have reported that PV inverters are the potential source of interharmonics emission for PV systems, which have been observed both in the laboratory testing environment and the field measurements [2]–[6]. Although the interharmonics standard regarding the emission limit is still under development, the interharmonics can cause grid voltage fluctuations, flickering, and unintentionally disconnection of PV systems. Thus, the interharmonics emission in PV systems should be avoided and mitigations are needed [7].

The growing number of photovoltaic units based on power electronics (single-phase and three-phase) fed into the grid all over the world, it is essential to explore the power quality phenomena occurring on the grid and define the appropriate standards. The main power quality issues discussed so far are:

- Characteristic harmonics (odd harmonics up to 2 kHz for single-phase installations; odd nontriple harmonics for three-phase installations).
- Low order non-characteristic harmonics (also harmonics and interharmonics up to 2 kHz, even triple odd harmonics for three-phase installations)
- Rapid one-off voltage changes, flickering and other voltage amplitude changes over time scales of less than 10 minutes.
- Variations in supply voltage over time scales of 10 minutes and more.

There is currently limited literature investigating inter-harmonic emissions that originate from photovoltaic inverters. Compared to harmonics, problems related to interharmonics are relatively rare and the need to measure or mitigate interharmonics is rare, especially for photovoltaic systems. Interharmonics in mains current are a relevant research topic because interharmonics can cause voltage fluctuations and light flickering. Furthermore, with the introduction of energy efficient luminaries such as LED lamps, which could be sensitive to the presence of higher, order interharmonics [4], it is important to study the distortions in the mains current. MPPT control is likely the origin/cause of the interharmonic emissions transferred to the grid current. This becomes particularly pronounced in very low-power operating modes, due to the increased flatness of the P–V curve of connected panels [6].

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The interharmonics are shut to fundamental or integer harmonic is the reason for flicker. Therefore, detecting those interharmonics for flicker troubleshooting is desirable.

II. RELATED WORK

On the interharmonic emission of PV inverters under different operating conditions.

The aftereffects of exploratory assessment of entomb sounds delivered by PV inverters (PVInv) for a scope of various working conditions. To begin with, inborn entomb consonant age because of Maximum Power Point Tracking (MPPT) control is broke down. A short time later, age ofcurrent entomb sounds appraisal is broke down receiving the IEC61000-4-7 sub-bunch idea and their consequences for the stock voltage are assessed regarding transient glimmer list, Pst. At long last, the paper examines entomb symphonious flows delivered by PVInvs when sounds and entomb music are superimposed to the major inventory voltage.

Experimental-based evaluation of PV inverter harmonic and inter harmonic distortion due to different operating conditions

The aftereffects of complete testing and resulting point by point examination of the acquired test results, assessing consonant and inter harmonic exhibitions of photovoltaic inverters (PVInvs) for a scope of various working conditions. The exhibited outcomes show noteworthy power-subordinate changes in consonant and inter harmonic outflows of tried PVInvs for various inventory voltage conditions (nearness of voltage waveform bends and different source impedance esteems). To effectively evaluate and depict these changes in PVInv execution, this paper examines and applies estimation systems and measurements for assessing symphonious furthermore, inter harmonic emanation prescribed in existing gauges, just as some extra measurements and pointers.

For a few working conditions, tried PVInvs altogether increment both symphonious and inter harmonic emanations, and this paper moreover examines the effect of PVInv control (e.g., most extreme force point following control) as a potential beginning of the inter harmonic mutilation.

III. EXISTING METHOD

In existing System Field measurements have confirmed the evidence of inter-harmonic emission from PV inverters, where the Maximum Power Point Tracking (MPPT) is one of the main causes for inter-harmonics.

a) Drawbacks

- Where the inter-harmonics are presented because of only MPPT process.
- More Power losses are occurs.

IV. PROPOSED SYSTEM

The proposed method is PV inverter is employed to control the power extraction from the PV arrays and convert it to the ac power delivered to the grid. 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).

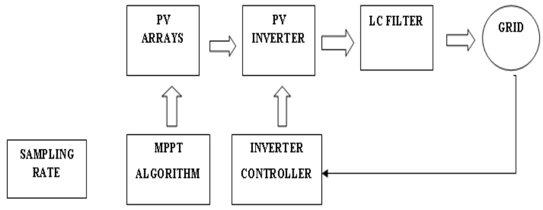

Figure – 1: Proposed Block diagram

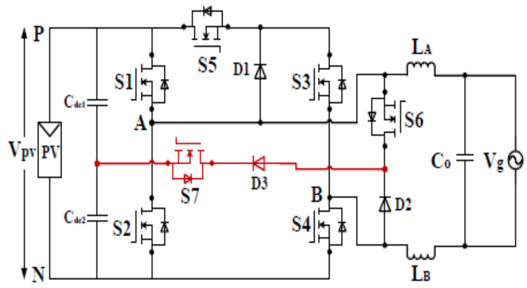

Figure – 2: Proposed Circuit Diagram

First, IGBT switches of the HERIC and H5 methods are replaced with MOSFETs and diodes to boost the efficiency.
Next, combine these two phase legs to derive new topology. By changing the position of the

freewheeling switches (S3 & D1), the family of the new topologies is derived.

Finally, to clamp the CM voltage at the half of the dc input voltage, a clamping branch consisting of a switch and a diode with a capacitor divider is introduced.

a) Circuit Operation

The family of the proposed transformerless PV inverter topology is depicted in Fig. 3 which is derived according to the derivation method described in the prior section, where S1, S2, S4, & S5 are high frequency switches, and S3 & S6 are low frequency freewheeling switches. The unidirectional clamping branch is constructed using switch S7 and diode D3 with a capacitor divider (Cdc1 & Cdc2) which clamps the CM voltage at the midpoint of dc link. LA, LB, and Co make up the LC type filter connected to the grid and Vpv represent the input dc voltage. The unipolar SPWM can be employed to the proposed topology with three-level output voltage. The MOSFET power switches are utilized as no reverse-recovery issues are required for the proposed configuration of the inverter for unity power factor operation. Consequently, the efficiency of the entire PV system is increased.

b) Interharmonics In photovoltaic Systems

Some of the possible and reported causes of interharmonic emissions in photovoltaic systems are: dynamic changes in solar irradiation caused by rapid passing of clouds and ramp speed events (especially in large photovoltaic plants), inefficiency of the control of Point detection strategy PV inverter maximum power (MPPT), reactive power management in inverters, active island techniques and interactions due to secondary emissions from other connected devices Identified challenges associated with measuring and analyzing interharmonic PV emissions are summarized and listed by following:

(i) frequency interharmonics with a frequency close to the fundamental or second harmonic component.

(ii) Brokerage of interharmonics with fundamentals and harmonics to create high and low frequency non-stationary interharmonics.

(iii) Interharmonics close to odd harmonics causing amplitude modulation in the fundamental or leading to modulation in the peak value.

(iv) Multiple sub harmonics at frequencies equally spaced between 0 and 50 Hz.

(V) The strong dependence of the frequencies and amplitudes of the interharmonics on the sampling frequency MPPT (manufacturer constant) or on the instantaneous disturbances caused by MPPT (if constant / random depending on the variations in solar radiation).

(vi) The strong dependence of the amplitude of the interharmonic emissions on the step change in the amplitude of the DC voltage and on the fluctuations in DC voltage caused by the MPPT control (the transient behavior is associated with the step change).

(vii) In some cases, there is an increase in interharmonic emissions, especially at low power levels. At low power levels, nonstationary interharmonics are of low amplitude with a low signal-to-noise ratio (SNR), which makes it difficult to set a threshold with respect to noise.

(viii) Interharmonics created due to the operation of different control strategies in different types of photovoltaic inverters intended for reactive power management to support the grid, island detection, MPPT, etc.

c) Maximum Power Point Tracking

The MPPT algorithms is essential for the PV system in order keep the working point of the photovoltaic fields close to MPP and thus maximize energy efficiency during operation. In this article, the MPPT Perturb and Observe (P&O) algorithm [9] is used, where the size of the perturbation step Vstep is the MPPT Sampling Rate fMPPT is the MPPT parameters. An important feature of the P&O MPPT algorithm (and other MPPT escalation methods too) is power oscillation during steady operation [9]. Where the photovoltaic inverter operates beneath to constant solar irradiance condition.

d) Mitigation 0f Interharmonics

Conventionally, the P&O MPPT algorithm is implemented with a fixed sample rate, where it

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offers a high sample rate and high MPPT efficiency during rapidly changing environmental conditions. One solution to reduce the dominant interharmonics in the output current is to use a random sample rate for the MPPT algorithm. This suggestion is similar to the Random Pulse Width Modulation (PWM) discussed in preceding study for reducing PWM switching harmonics [13]. However, in the proposed method, the random selection of the sample rate is applied to the MPPT algorithm. An easy way to implement this method is to randomly select the sample rate from the MPPT algorithm, high speed or low speed during operation, which can be summarized as:

$$f_{\mathrm{MPPT}} = \begin{cases} f_{\mathrm{fast}}, & \text{when} \quad X \leq 0.5 \\ f_{\mathrm{slow}}, & \text{when} \quad \text{otherwise} \end{cases} \tag{1}$$

In particular, there are others as well ways to randomly generate different sample rates during the operation, which is an interesting aspect for future research.

V. RESULTS

To further validate the effectiveness of the proposed method, experiments are also performed on a downscaled 2-cell gridconnected CHB PV inverter. A TMS320F28335 digital signal processor was employed to implement the control. Two Infineon FS50R12KT4_B15 IGBT modules were adopted to assemble the 2-cell CHB inverter. One Key sight E4360A PV simulator was used to provide the power supply for two DC buses (i.e., to emulate two separate PV strings).

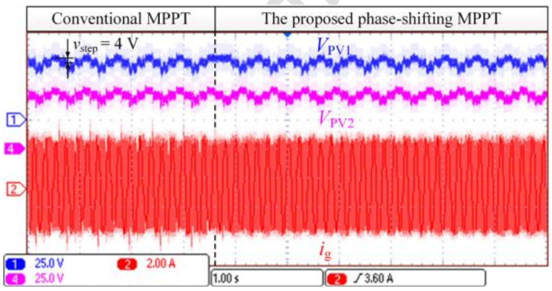

Figure-3: Experimental results of the PS-MPPT on a 2-cell CHB PV inverter, operated at 200 W/m2 and 25 °C, with the PV rated power being 300 W for each cell, and the grid voltage is 40 V(rms) (VPV1 [25 V/div] and VPV2 [25 V/div]: DC voltages for cell #1 and #2; ig [2 A/div]: grid current).

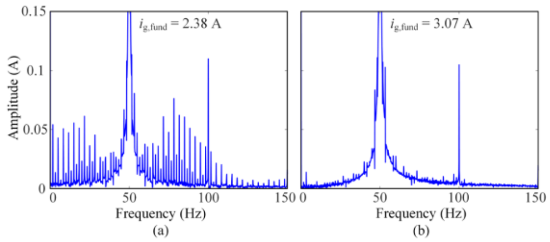

Figure-4: FFT analysis of the grid current ig shown in (a) with in-phase MPPT perturbations and (b) with the proposed PS- MPPT control.

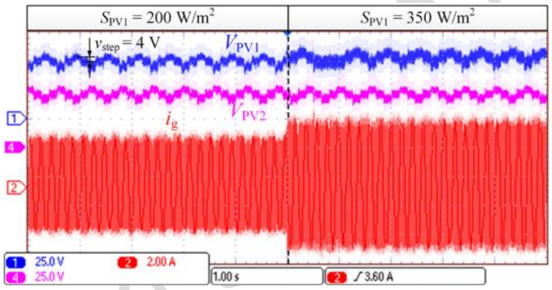

Figure -5: Experimental results of the PS-MPPT on a 2-cell CHB PV inverter under the irradiance change of PV #1: (VPV1 [25 V/div] and VPV2 [25 V/div]: DC voltages for cell #1 and #2; ig [2 A/div]: grid current).

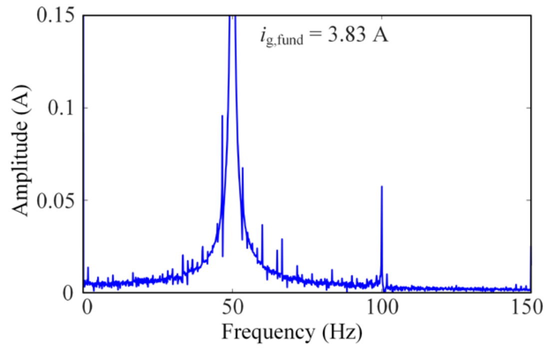

Figure-6: FFT analysis of the grid current ig

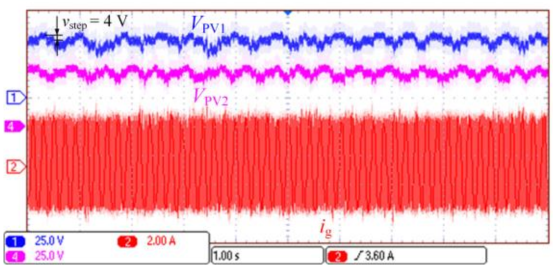

Figure-7: Experimental results of the random sampling-rate MPPT on a 2-cell CHB PV inverter, operated at 200 W/m2 and 25 °C: (VPV1 [25

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V/div] and VPV2 [25 V/div]: DC voltages for cell #1 and #2; ig [2 A/div]: grid current).

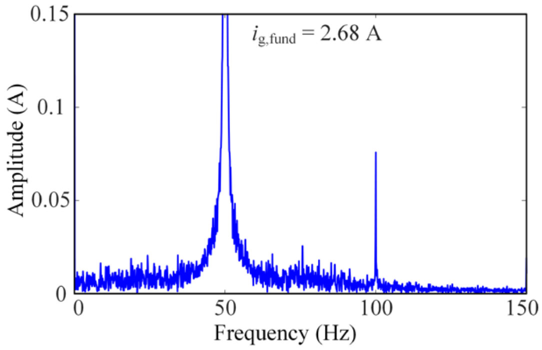

Figure-8: FFT analysis of the grid current

VI. CONCLUSION

With the conventional MPPT implementation, there is file compensation between interharmonic and MPPT emission efficiency when selecting the MPPT sample rate algorithm. To address this problem, a new mitigation solution for in this the interharmonic in photovoltaic systems has been proposed. The proposed method modifies the MPPT algorithm of random selection of the sampling frequency of the MPPT algorithm, during the operation. Thus, the frequency spectrum of the output current can be smoothed and amplitude of the dominant interharmonics can be greatly reduced, in addition, the MPPT performance of the proposed mitigation. The solution can be kept close to the conventional MPPT. Operation with a fast MPPT sample rate, if similar Monitoring of efficiency during a dynamic operating condition can be realized. The performance of the proposed method has it has been validated both in steady state (e.g. interharmonics) and dynamic operations (eg MPPT efficiency) using simulation results.

REFERENCES

[1] M. Aiello, A. Cataliotti, S. Favuzza, and G. Graditi, ―Theoretical and experimental comparison of total harmonic distortion factors for the evaluation of harmonic and interharmonic pollution of grid-connected photovoltaic systems,‖ IEEE Trans. Power Del., vol. 21, no. 3, pp. 1390–1397, Jul. 2006.

[2] T. Messo, J. Jokipii, A. Aapro, and T. Suntio, ―Time and frequencydomain evidence on power quality issues caused by gridconnected three-phase photovoltaic inverters,‖ in Proc. EPE, pp. 1–9, Aug. 2014.

[3] R. Langella, A. Testa, S. Z. Djokic, J. Meyer, and M. Klatt, ―On the interharmonic emission of PV inverters under different operating conditions,‖ in Proc. ICHQP, pp. 733–738, Oct. 2016.

[4] Kumar, N. Ashok, P. Nagarajan, Mr Neeruganti Vikram Teja, and Mr Raja Suresh. "Intelligent Greenhouse Monitoring and Controlling By Using Python on Raspberry Pi." EFFLATOUNIA-Multidisciplinary Journal 5, no. 2 (2021).

[5] P. Pakonen, A. Hilden, T. Suntio, and P. Verho, ―Grid-connected PV power plant induced power quality problems - experimental evidence,‖ in Proc. EPE, pp. 1–10, Sep. 2016.

[6] V. Ravindran, S. K. Rnnberg, T. Busatto, and M. H. J. Bollen, ―Inspection of interharmonic emissions from a grid-tied PV inverter in north Sweden,‖ in Proc. ICHQP, pp. 1–6, May 2018.

[7] A. Testa, M. F. Akram, R. Burch, G. Carpinelli, G. Chang, V. Dinavahi, C. Hatziadoniu, W. M. Grady, E. Gunther, M. Halpin, P. Lehn, Y. Liu, R. Langella, M. Lowenstein, A. Medina, T. Ortmeyer, S. Ranade, P. Ribeiro, N. Watson, J. Wikston, and W. Xu, ―Interharmonics: Theory and modeling,‖ IEEE Trans. Power Del., vol. 22, no. 4, pp. 2335–2348, Oct. 2007.

[8] A. Sangwongwanich, Y. Yang, D. Sera, H. Soltani, and F. Blaabjerg, ―Analysis and modeling of interharmonics from grid-connected photovoltaic systems,‖ IEEE Trans. Power Electron., vol. 33, no. 10, pp. 8353–8364, Oct. 2018.

[9] N. Femia, G. Petrone, G. Spagnuolo, and M. Vitelli, ―Optimization of perturb and observe maximum power point tracking method,‖ IEEE Trans. Power Electron., vol. 20, no. 4, pp. 963–973, Jul. 2005.

[10] S.B. Kjaer, J.K. Pedersen, and F. Blaabjerg, ―A review of single-phase grid-connected inverters for photovoltaic modules,‖ IEEE trans. Ind. Appl., vol. 41, no. 5, pp. 1292–1306, Sep. 2005.

[11] J. Kivim¨aki, S. Kolesnik, M. Sitbon, T. Suntio, and A. Kuperman, ―Design guidelines for multiloop perturbative maximum power point tracking algorithms,‖ IEEE Trans. Power Electron., vol. 33, no. 2, pp. 1284–1293, Feb. 2018.

[12] H. Schmidt, B. Burger, U. Bussemas, and S. Elies, ―How fast does an mpp tracker really need to be in Proc. EU PVSEC, pp. 3273–3276, Sep. 2009?

[13] F. Blaabjerg, J. K. Pedersen, and P. Thoegersen, ―Improved modulation techniques for PWM-VSI drives,‖ IEEE Trans. Ind. Electron., vol. 44, no. 1, pp. 87–95, Feb. 1997.