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A Three-Phase Grid Connected Photovoltaic System with Modified MPPT Method

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Abstract - In this study, a three-phase grid-connected Photovoltaic system is demonstrated. A photovoltaic (PV) system that is connected to the grid, provides several benefits, including a topology that is simple, high efficiency and so on. Considering control scheme difficulty greatly enhanced because of all the regulatory requirements, which are maximum power point tracking (MPPT), coordinated with the supply voltage, harmonic drop as a current output, must be addressed at the same time. The DC/DC converter, solar panels, DC-link, three-phase voltage source inverter (VSI) on the grid, as well as output filters are all detailed representations of the essential components of the system in this model. Line current harmonic distortion should be reduced. A sophisticated control strategy with two PI controllers and MPPT is purposed in this paper to stabilize DC voltage. A robust phase-locked loop (PLL) synchronizes a grid-connected voltage source inverter with three phases. The simulation and practical findings reveal that the stability as well as efficiency of a three-phase grid connected PV system are high.

Keywords- solar energy, grid-connected inverters, photovoltaic (PV), maximum power point tracking (MPPT).

I. Introduction

The global need for energy has been constantly increasing. Renewable energy sources' intermittent and unpredictable character could be correctly modelled to minimize the system's detrimental influence on system stability [1-2]. In the previous two decades, the rapid advancement of photovoltaic (PV) technology has exploded suggests that PV generating will emerge as one among the most popular appealing renewable sources of energy in large-scale application areas in the medium to long future [3]. The fact that the production for the solar energy has increased is evidence of this. Every year, the company has increased by more than 20% [4].

Solar energy systems are known as Photovoltaic (PV) system that provide direct energy to electrical devices or energy that is fed further into the public electricity network. Photovoltaic are usually thought to be an expensive technology [5]. However, photovoltaic are most cost-effective choice in some scenarios. The advancement of techniques in photovoltaic, the use in grid-connected photovoltaics (PV) system has increased dramatically. This demonstrates that photovoltaics are highly appealing alternative for producing power that is good for the environment for a diverse range of applications [6].

The (MPPT) maximum power point tracking controller is time-varying yet nonlinear circuit. The perturb and observe approach is one of the MPPT strategies that have been developed. When radiation changes, the P&0 approach (MPPT) is used to limit volatility and the risk of direction loss system. Under fast changes, in radiation, gradually reaching around 12% [7-8].

The boost converter is installed between the inverter and solar panel to control the step-up voltage of the photovoltaic output. A voltage source inverter (VSI) gets its name emphasized by the fact that it generates three phase voltages and currents from a DC voltage source that is relatively continuous [9-10].

The phase locked loop control method is characterized by output signals that are precisely synchronized with a frequency and the phase analysis of the input signals. This solution totally eliminates VSI output synchronization issues and allows the supply grid to be readily incorporated without circulating current concerns. The sources create DC output which is then transformed power into AC power. This transmission is carried out using sinusoidal pulse width modulation (SWPM) and pulsed PLL coordinated voltage source inverter (VSI) connected to the electrical network. [11-15]. The strategies used for control have been described in the literature. The derived model's recommended system architecture is shown in figure 1.

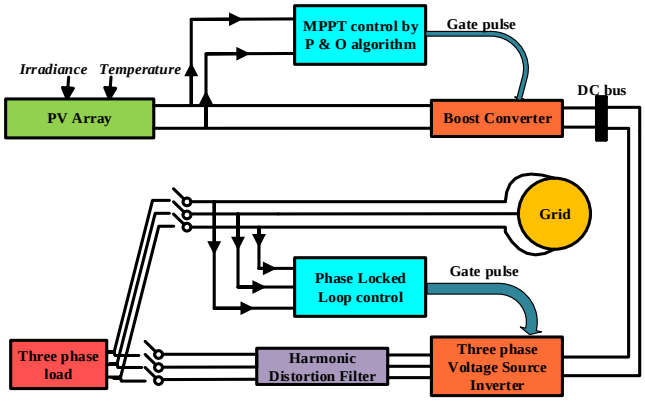

Fig. 1. Basic circuit diagram of MICRO GRID

II. PHOTOVOLTAIC MODELLING

A PV panel is a series and parallel arrangement of PV modules, while a PV module is a solar cell connected in series. Each photovoltaic (PV) module is made up of multiple interconnected PV cells. The cells convert solar energy into direct-current electricity. The figure 2, illustrates a customized network of solar PV cell. When light shines on a solar cell the voltage is generated, the generated voltage across the solar cell drives the current in an external circuit which deliver the power.

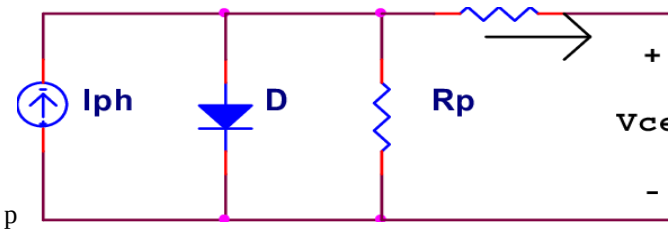

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Fig. 2 A circuit with the similar modification of PV cell

The current of solar cells in PV array is defined as follows:

$$I = I\text{ph} - I\text{o,cell}\,[\exp(\frac{qv}{\alpha kT}) - 1] - \frac{V+IR_s}{R_{sh}} \qquad (1)$$

Where,

*i*ph -is the current of the incidental light,

iD - current inside the Shockley diode

*I*sh - is the saturated current in reverse

q -is equal to the charge of an electron

K - is constant of boltzmann

Temp. -is equals to the temperature in Kelvin.

v -refers to the voltage at output

*R*sh - the resistance of the PN junction diode

Rs - to the resistance of the contact series

The quantity of electricity a photovoltaic panel module generates fluctuations substantially based on its operational parameter temperature and varying irradiance. As a result, it's critical to focus on the developed power curve and to maintain solar panel output voltage where almost all the power is harvested. Maximum power point tracking is the term for this procedure.

The relationship between current and power as a function of figure 3 which depicts voltage as a function irradiance, while figure 4 depicts voltage as a function of PV cell heating temperature. Various algorithms can be tracked the maximum power point. The perturb and observe (P&O) technique was applied in our build system shown in figure 5.

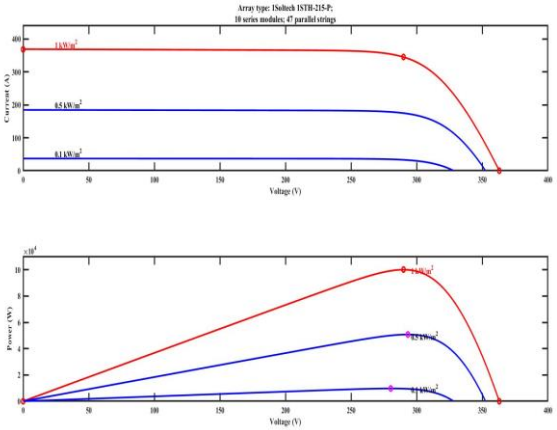

Fig.3 PV cell output characteristics as a function of Irradiance

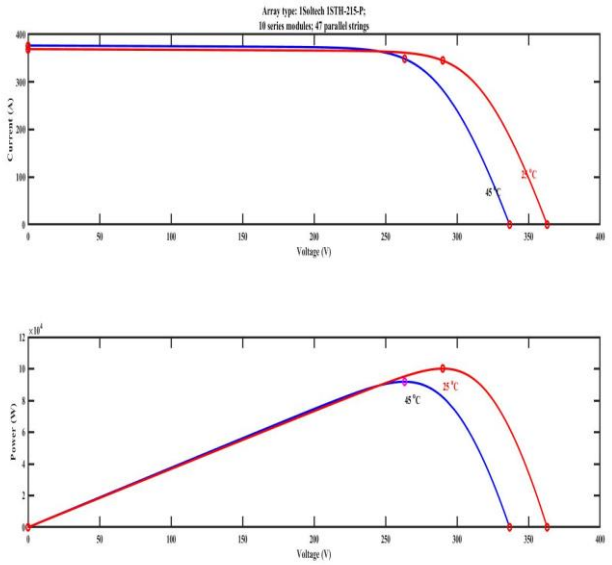

Fig. 4. PV cell output characteristics as a function of temperature

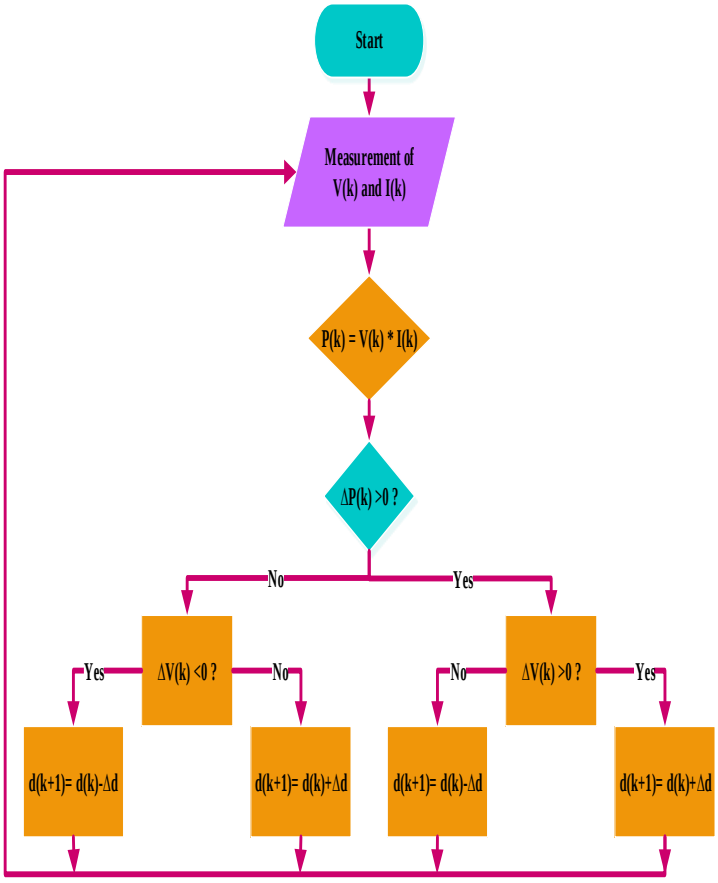

Fig. 5. The perturb and observe (P&O) method is depicted in the flow chart

III. DC-DC BOOST CONVERTER

A DC-DC converter is designed to modify the panel inductive reactance to matched the load resistor by changing the duty cycle, frequency. The DC-DC boost converter was used to extract the maximum power from the PV array arrangement while simultaneously raising the output voltage to a safe level for utility disturbance. Figure 6 depicts design of the converter.

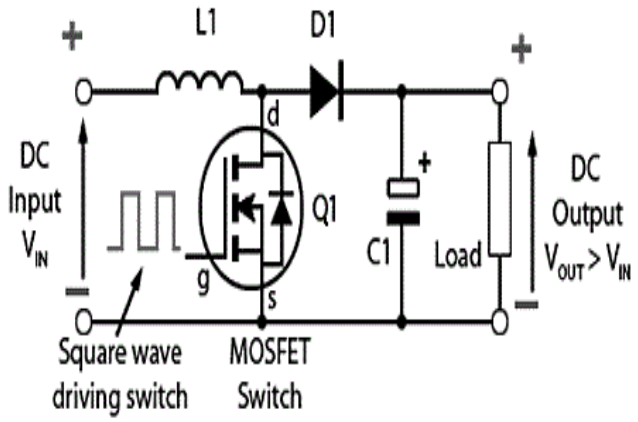

Fig. 6. Circuit diagram of boost converter

Physical components such as inductance, power supply, diode and capacitor collaborate in the power generation process. Although even most of the electronic switches utilised here are power MOSFET investigation shown that IGBT can also be used for switching. The P&O and MPPT based boost converter described in figure 7 as shown below.

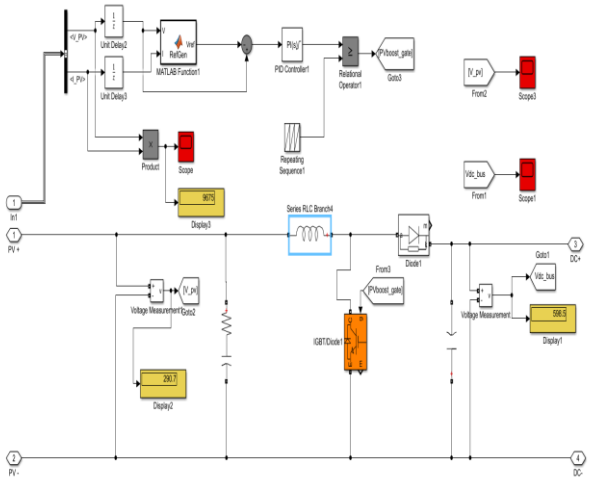

Fig. 7. A MATLAB model of DC boost converter that includes an MPPT controller

IV. THREE-PHASE INVERTER

A voltage source inverter is employed to designed to transform the PV array DC output to AC current. Figure 8 &9 illustrate schematic design of the purposed voltage source inverter (VSI) with its matched filter circuit model is shown. A three-phase inverter is required to convert a DC supply into three-phase power supply output. Three-phase voltage power converter source is made up of three-phase bridge circuit design. combination. The voltage source inverter gives the fast pace current output will be discharged into the power system in a grid connected Photovoltaic system. The inverter power outcome must be in same phase with the utility grid voltage and both have same frequency pulse.

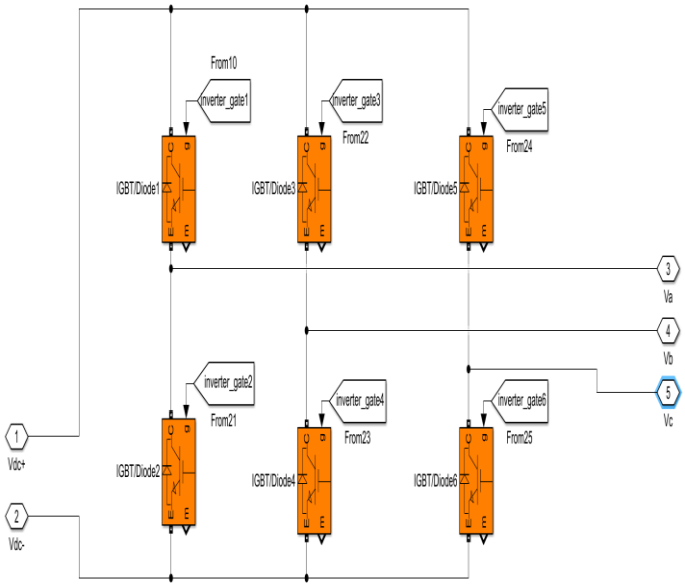

Fig. 8. Inverter mode with a voltage source

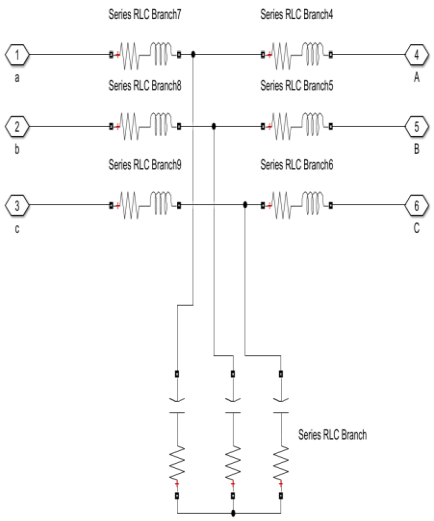

Fig. 9. Combination of filters

A closed loop feedback controller is phase locked loop (PLL) circuit that tracks and changes the speed and frequency of the

domestically generated output pulse in reference to the input .

System	Parameter	Values
Photovoltaic array	Per module cell count	(N_{cell}) = 60.0
	Each module fault current	(i_{sc}) = 7.84 Amp.
	Per module open loop circuit voltage	(V_{oc}) = 36.3 Volt
	Current at MPP	(I_{mp}) = 7.35 Amp.
	Voltage at the maximum power point	(V_{mp}) = 29 Volt
	Strings that are parallel	= 47
	Each string has a series connected module	= 10
	Maximum power output in total	= (7.35*47) (29*10)
	(at I=1000W/m^2 &T=25^{0}C) ≈ 100k watts	100, 180.5W
Boost circuit	Series inductor	(L_1) = 1.45 mH
	Shunt capacitor	(C_1) = 3.227µF
Filtering circuit	Inductance in series	(L_f) = 500µH
	Capacitance in parallel	(C_f) = 100µF
	=	
Supply of AC Volt	Voltage on the grid	(V_{rms}) = 400
	The frequency of the grid	(freq.) = 50Hz

PARAMETER TABLE 1

pulse. As shown in figure 10, below bases conversion development of phase locked loop (PLL) approach explains (VSI) control strategy.

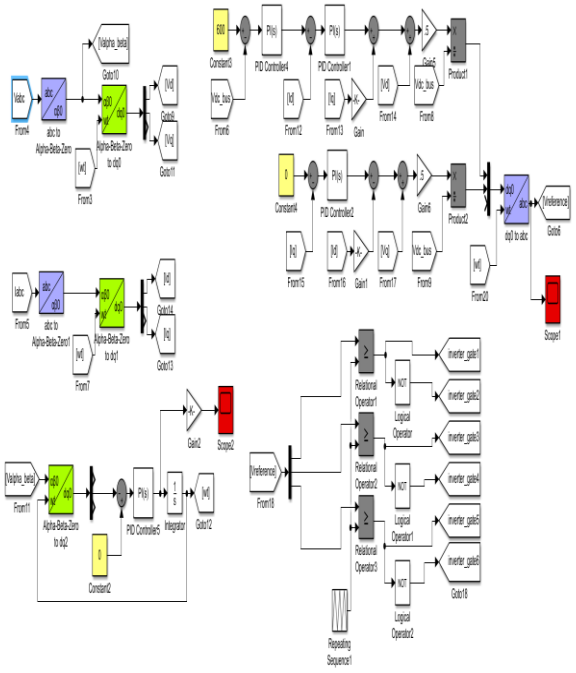

Fig.10 MATLAB model of PLL

Figure. 11, shows the suggested control structure for a three-phase grid-connected PV system made up of PV panels.

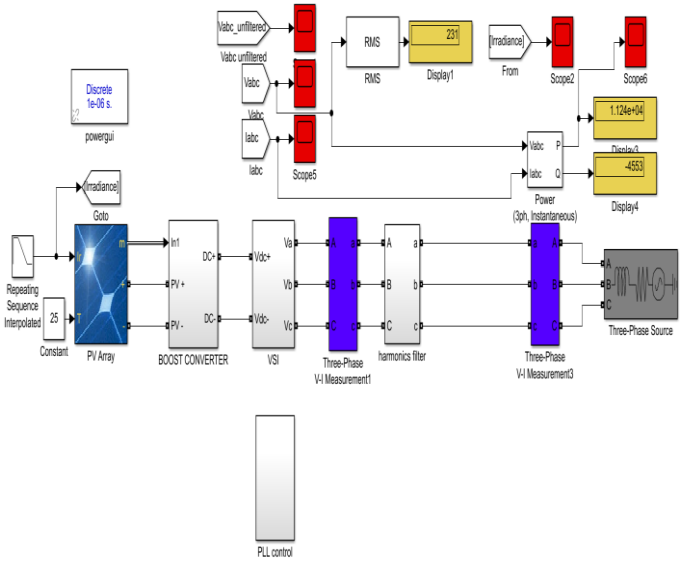

Fig. 11. A three-phase grid-connected PV system control framework proposed

The waveforms of the simulated waves are displayed in figures 12-22. The simulation results show that the proposed control strategy performs exceptionally well. The boost converter performance shown in figure 13 as being consistent. The unadulterated non-sinusoidal output of the developed voltage source inverter and filtered circuit voltage output shown below in figures 14 and 15, respectively. Figure 16 depicts the variation in VSI output current as a function of solar irradiance that occurred on the Photovoltaic array in figure 17. Figure 19 and 20 shows frequency tracked by PLL model, respectively. Figure 21 and 22 illustrate the detailed analysis of voltage total harmonic distortion and percentage of total harmonic distortion using FFT.

V. SIMULATION RESULTS

The specification of simulation model are listed in Table 1

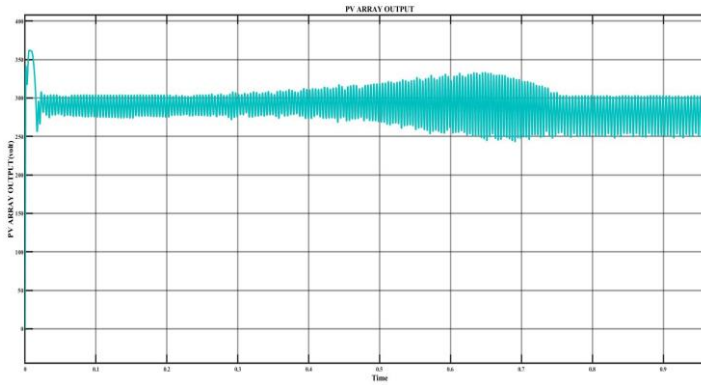

Fig. 12. PV array output

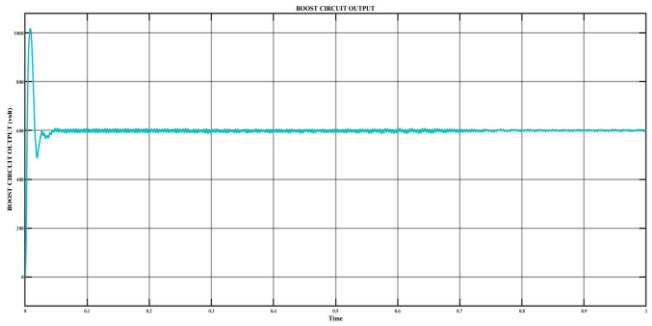

Fig. 13. The boost converter electrical output

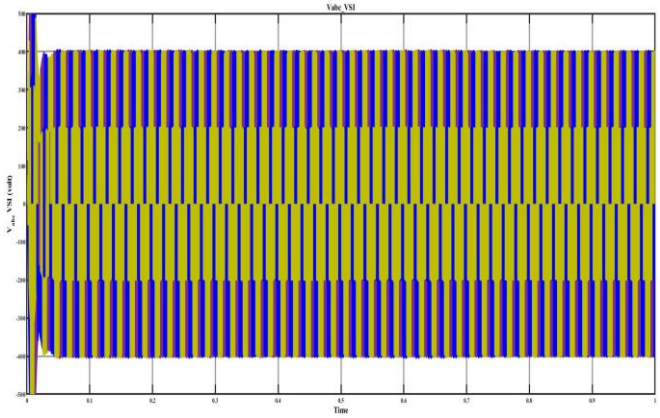

Fig. 14. The voltage source inverter produced output

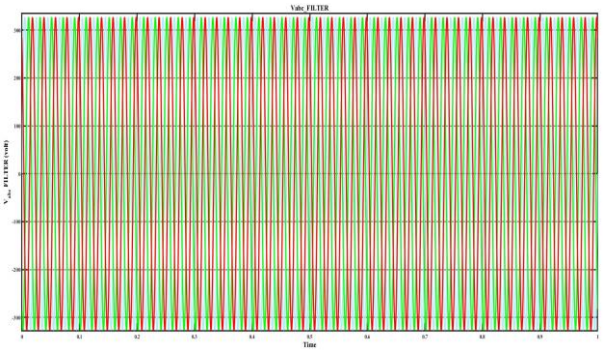

Fig. 15. The designed filter circuit output

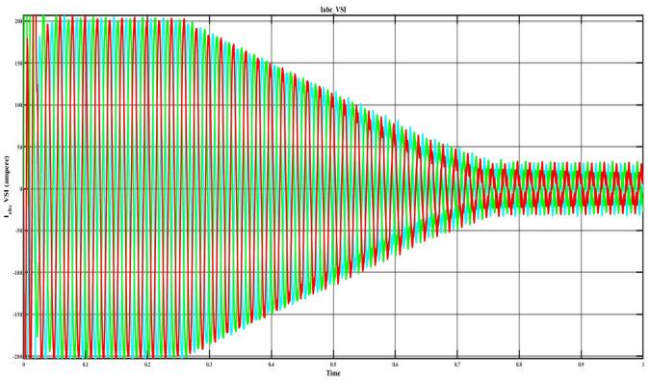

Fig. 16. Line current

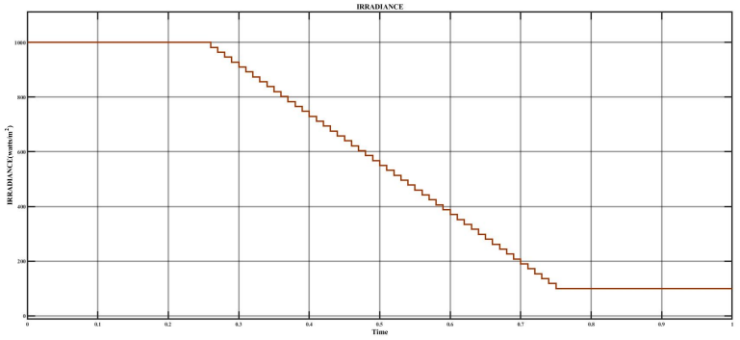

Fig. 17. Irradiance of the heat

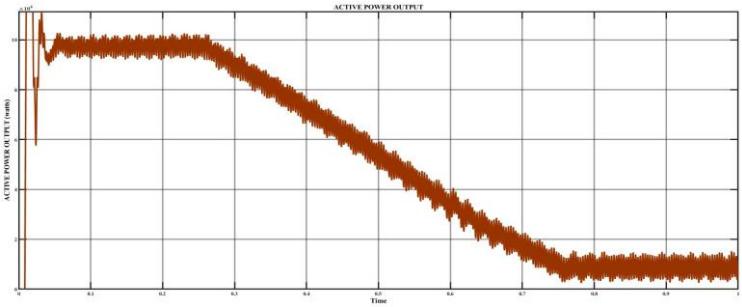

Fig. 18. Supply of active power

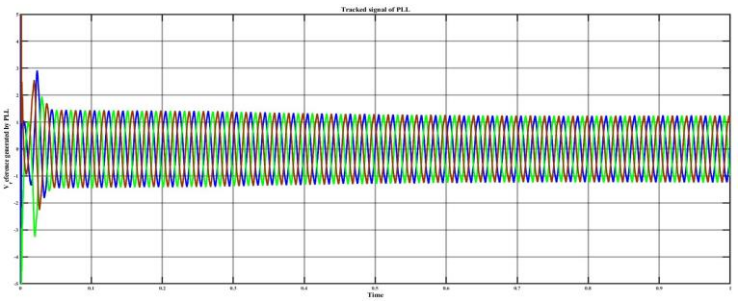

Fig. 19. PLL pulse monitored in three phases

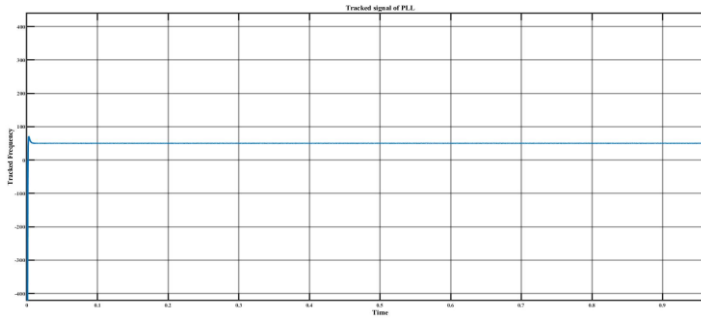

Fig. 20. PLL tracked signal frequency

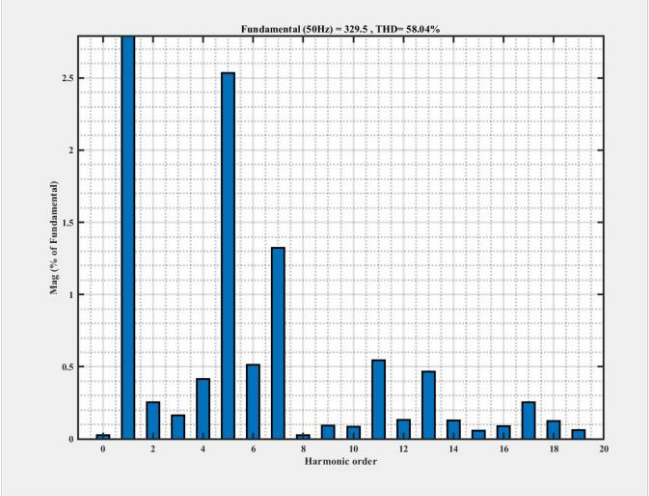

Fig. 21. Total harmonic distortion of the VSI output power voltage

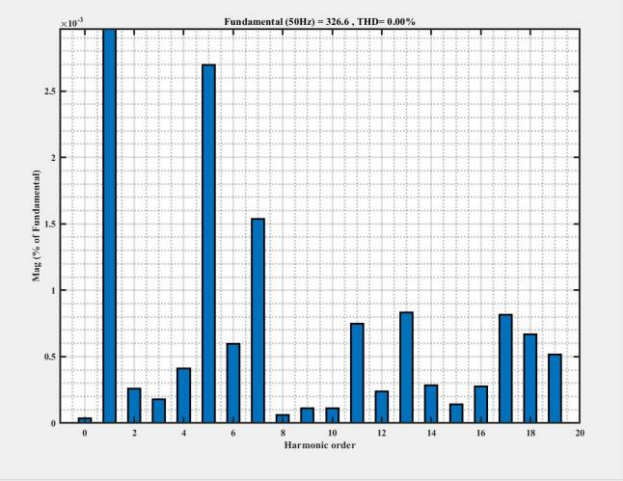

Fig. 22 Total harmonic distortion of filtered output power voltage

VI CONCLUSION

The control technique for grid-connected photovoltaic array system was given in this paper. The main goals were to maximize the PV array power output while also injecting to transport the electricity slightly elevated AC current is fed transported to the load. The VSI filtering and unprocessed load results show a significant increase in total harmonic distortion (THD). The addition of stronger and more efficient controlling algorithms, as well as control of more objects could be part of the model future growth renewable energy producers, as well as number of additional features.

REFERENCES

[1] Alam, Md Shafiul, Fahad Saleh Al-Ismail, Aboubakr Salem, and Mohammad A. Abido. "High-level penetration of renewable energy sources into grid utility: Challenges and solutions." *IEEE Access* 8 (2020): 190277-190299.

[2] Kumar, G. V., Ratnam Kamala Sarojini, K. Palanisamy, Sanjeevikumar Padmanaban, and Jens Bo Holm-Nielsen. "Large scale renewable energy integration: Issues and solutions." *Energies* 12, no. 10 (2019): 1996.

[3] Al-Shetwi, Ali Q., M. A. Hannan, Ker Pin Jern, M. Mansur, and T. M. I. Mahlia. "Grid-connected renewable energy sources: Review of the recent integration requirements and control methods." *Journal of Cleaner Production* 253 (2020): 119831.

[4] Gandhi, Oktoviano, Dhivya Sampath Kumar, Carlos D. Rodríguez-Gallegos, and Dipti Srinivasan. "Review of power system impacts at high PV penetration Part I: Factors limiting PV penetration." *Solar Energy* 210 (2020): 181-201

[5] Du, Wenjuan, Haifeng Wang, and L-Y. Xiao. "Power system small-signal stability as affected by grid-connected photovoltaic generation." *European Transactions on Electrical Power* 22, no. 5 (2012): 688-703.

[6] Libo, Wu, Zhao Zhengming, and Liu Jianzheng. "A single-stage three-phase grid-connected photovoltaic system with modified MPPT method and reactive power compensation." *IEEE* Transactions on Energy Conversion 22, no. 4 (2007): 881-886.

[7] Libo, Wu, Zhao Zhengming, Liu Jianzheng, Liu Shu, and Yuan Liqiang. "Modified MPPT strategy applied in single-stage grid-connected photovoltaic system." In 2005 International Conference on Electrical Machines and Systems, vol. 2, pp. 1027-1030. IEEE, 2005.

[8] Abdelwahab, Saad A. Mohamed, Abdallah Mohamed Hamada, and Walid SE Abdellatif. "Comparative analysis of the modified perturb & observe with different MPPT techniques for PV grid connected systems." *International journal of renewable energy Research* 10, no. 1 (2020): 55-164

[9] Martins, Denizar Cruz. "Analysis of a three-phase grid-connected PV power system using a modified dual-stage inverter." *International Scholarly Research Notices* 2013 (2013).

[10] Pathak, Pawan Kumar, Anil Kumar Yadav, and Pravendra Tyagi. "Design of three phase grid tied solar photovoltaic system based on three phase VSI." In *2018 8th IEEE India International Conference on Power Electronics (IICPE)*, pp. 1-6. IEEE, 2018.

[11] Gautam, Shivansh, and Seema Agrawal. "Performance analysis of Grid Interactive PV system with PLL Controlled Three Phase Inverter." In *2021 International Conference on Smart Generation Computing, Communication and Networking (SMART GENCON)*, pp. 1-6. IEEE, 2021.

[12] Dua, Surendra Singh, Ruchi Sharma, and Raghavendra Patidar. "Using Improved MPPT Charge Controller Improvement Functioning Efficiency of Power Grid Connected Solar Photovoltaic System." In *IOP Conference Series: Materials Science and Engineering*, vol. 1099, no. 1, p. 012083. IOP Publishing, 2021.

[13] Le Minh Phuong, Phan Quoc Dzung, and Nguyen Minh Huy. "A THREE-PHASE GRID-CONNECTED PHOTOVOLTAIC SYSTEM WITH REACTIVE POWER CONTROL."

[14] Khatua, Pradeep K., Vigna K. Ramachandaramurthy, Jia Ying Yong, and Jagadeesh Pasupuleti. "Decoupled control of three phase grid connected solar PV system." *Int J. Eng. Adv Technol* (2019).

[15] Khawla, El Malleh, Dhia Elhak Chariag, and Lassaad Sbita. "A control strategy for a three-phase grid connected PV system under grid faults." *Electronics* 8, no. 8 (2019): 906.

[16] Jain, Kritika, Annapurna Bhargava, and Bulbul Mewara. "Power quality enhancement using unified power flow controller in

standalone grid connected solar pv system." In *2018 International Conference on Inventive Research in Computing Applications (ICIRCA)*, pp. 709-713. IEEE, 2018.

[17] Schonardie, Mateus F., and Denizar C. Martins. "Solar grid-connected three-phase system with active and reactive power control and input voltage clamped." In *2007 14th IEEE International Conference on Electronics, Circuits and Systems*, pp. 463-466. IEEE, 2007.

[18] Khalifa, Ahmed S., and Ehab F. El-Saadany. "Control of three phase grid connected photovoltaic power systems." In *Proceedings of 14th International Conference on Harmonics and Quality of Power-ICHQP 2010*, pp. 1-7. IEEE, 2010.

[19] Gautam, Shivansh, and Seema Agrawal. "Performance Analysis of Three Phase Grid Connected PV Array with ANN Controlled SAPF." In *2021 2nd Global Conference for Advancement in Technology (GCAT)*, pp. 1-6. IEEE, 2021.

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