Simulation Study Using SIMULINK/MATLAB on THD for PV Grid Connected System

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Abstract

Total harmonic distortion (THD) is a measurement of the harmonic distortion and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency. The purpose of this paper is simulation study on THD for photovoltaic (PV) grid connected. A scale-down less than 1kW system will be developed and established for the study. The impact on THD will be assessed to simulate the real network environment by varied motor loads and the utility grid also will be measured. The motor is connected to Adjustable Speed Drives (ASDs) as the load. The simulation is done by using MATLAB/Simulink software and the simulation results will be collected and analyzed.

Keywords- Photovoltaic, Adjustable Speed Drives (ASDs), Grid Connected, MATLAB/Simulink simulation

1. Introduction

The usage of grid connected Photovoltaic (PV) systems has become popular in many parts of the world. More numbers of grid connected PV generators that connected to a distribution network through PV inverters are potentially able to cause harmonic problems. Harmonic problem can be defined as a particular disturbance, which is created by the presence of non-linear components in the electrical system. It determines a permanent modification of the voltage and current sinusoidal wave shapes in terms of sinusoidal components at a frequency different from the fundamental. In a grid-connected photovoltaic power system, the direct current (DC) output power of the PV array should be converted into the alternating current (AC) power of the utility power system. Under this condition, an inverter to convert DC power into AC power is required. Inverters used in the simulation circuit affect the harmonic levels. [1].

In this paper, it focus on performance of PV grid connected system. The system components and power control scheme were modeled in terms of performance behavior. The proposed models were implemented in MATLAB/Simulink.

2. System Modeling and Control

The proposed system consists of a PV Array, DC to DC converter (chopper), a common DC capacitor, DC to AC converter (inverter), load and grid connected as shown in Fig.1. The measurement are placed at both input and output sides of the inverter, loads and at the utility grid. The connected load at point of common coupling (PCC) is a motor load. Proposed power control scheme of the PV grid connected system is modeled by using MATLAB/Simulink.

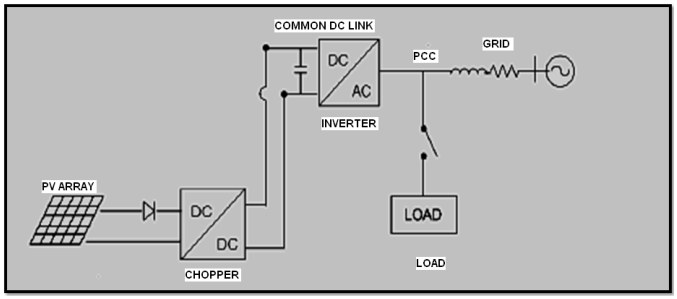

Figure1. Block diagram of PV grid connected system

2.1 PV Array

Numerous PV cells are connected in series and parallel circuits on a panel for obtaining high power, which is a PV module. A PV array is defined as a group of several modules electrically connected in series-parallel combinations to generate the required current and voltage. Fig.2 indicates a simplified equivalent circuit model of a PV module and converter at PV system that used in the study, which consists of a current source in parallel with a diode and in series with a series resistor.

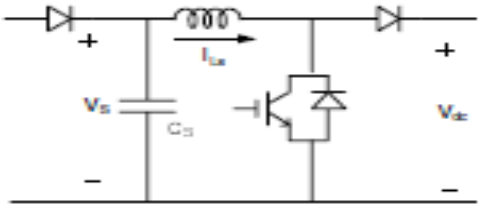

Figure 2. Equivalent circuit of PV module

2.2 *Chopper*

DC-DC converters boost step-up the PV voltage to the level of the allowable maximum line voltage and to the stable required dc level without storage elements as battery. DC to DC converter is controlled to track maximum power point of the PV array.

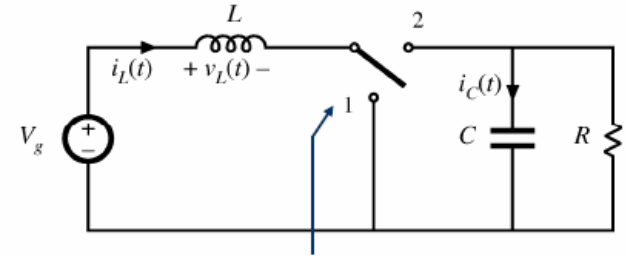

Figure 3. Boost converter with ideal switches [2]

2.3 Inverter

An inverter is use as power converter in order to convert the DC power from the panel into AC form. The inverter topologies can divide with two types that are single and multi stage inverter. The single stage inverter topologies have the advantage such as low cost, high efficiency, robust performance, high reliability and simple structure. In other hand, the multi stage inverter accept a wide range of input voltage variations, high cost, low efficiency, complicated structured and isolated topologies with high frequency transformers can extract power from the source even when the input dc voltage is very low. Fig.4 illustrates the introduction of circuits and control of a DC-DC converter and a single-phase DC-AC inverter then, Fig.5 shows the single stage inverter and multi stage inverter is depicted at Fig.6.

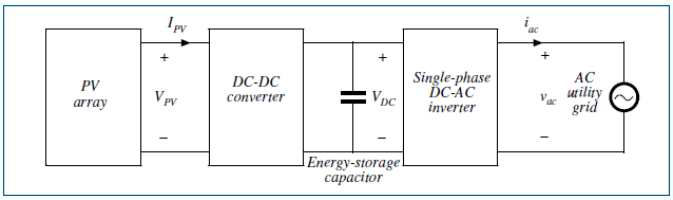

Figure 4. Introduction to circuits and control of DC-DC converter and a single phase DC-AC inverter [2]

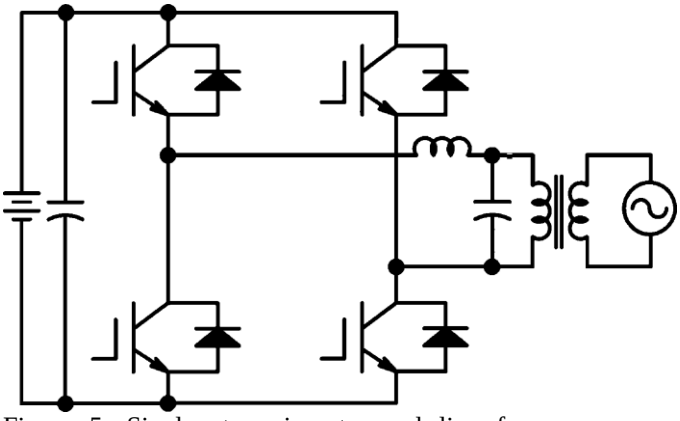

Figure 5. Single stage inverter and line frequency transformer [3]

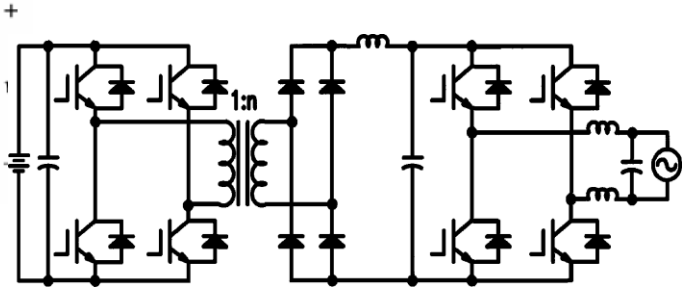

Figure 6. Multi stage inverter with high frequency transformer [3]

3. Result and Discussion

This project was done by using MATLAB/Simulink in order to observe the performance of PV grid connected system. Fig.7 illustrates the overall model of PV system in MATLAB/Simulink. The system of PV is single phase and connected with three phase varied motor load. The THD was obtained by analyzed the voltage and current at grid system.

The PV system has been connected to 415V distribution feeder and the frequency is varried to 30Hz, 40Hz and 50Hz. The data of voltage,current,Total Harmonic Distortion Voltage (THDv) and Total Harmonic Distortion Current (THDi) are showed from Fig.10 to Fig.15.

Fig.7 is showing the modelling of PV grid connected system using MATLAB/simulink. While Fig.8 and Fig.9 show the voltage and current that was measured at grid system. The voltage produced Vpp=600V and the current is Ipp=5A. The voltage and curent is not in smooth sinewave waveform because of the harmonic distortion occured at grid connected system.

Fig.10 and Fig.11 present the THDv and THDi that measured at Point of Common Coupling (PCC) connected system. In this situation, the fixed motor load is used. The frequency is 50Hz and normal speed during this condition is 1500rpm. The THDv produced 0.28% and THDi was producing 5.69%. The current waveform does not resemble the applied voltage waveform because of the using of electronic devices in inverter.

Fig.12 depict the THDv and Fig.13 represent the THDi. The frequency is adjusted to 40Hz and normal speed during this condition is 1300rpm. THDv connected resulted 0.03% and THDi is 5.82%. The value of THDi is high compared to the THDv. Regarding on this simulation, when the speed decreased, the THDv decreased and THDi increased. Keeping the low THD values on a system will further ensure proper operation of equipment and a longer equipment life span [4].

Fig.14 and Fig.15 show the THDv and THDi respectively when the frequency is adjusted to 30Hz, and normal speed during this condition is 1200rpm. THDv connected produced 0.01% and THDi is 11.00%. The value of THDv is low compared to the THDi. Regarding on this simulation, when the speed decreased to 1200rpm, the THDv more decreased and THDi more increased.

As a conclusion for this simulation results, when the speed decreased, the THDv become decreased but the THDi increased. It show that the speed of motor load is influence the result of THDv and THDi.

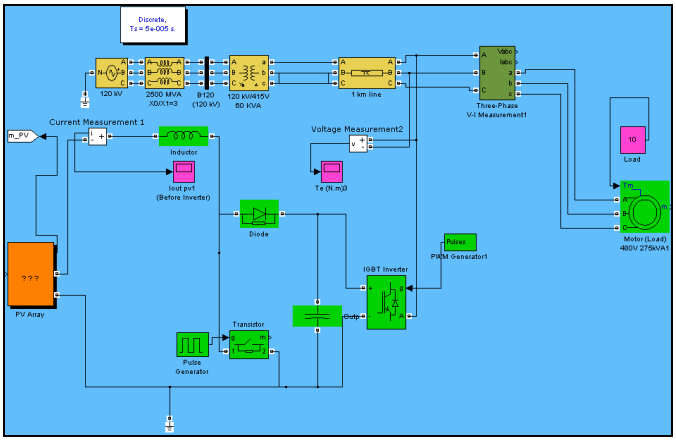

Figure7. Model of PV grid connected system

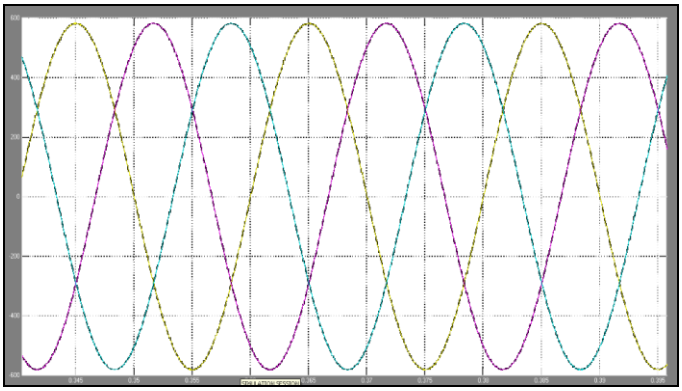
Figure8. Voltage at grid

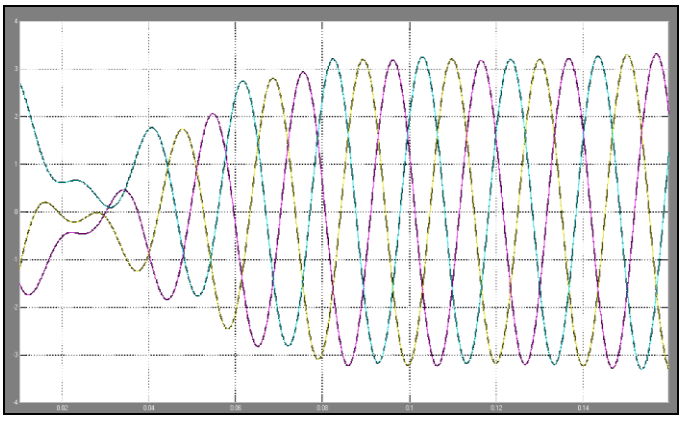
Figure9. Current at grid

3.1 Motor Frequency=50Hz, Motor Speed=1500rpm

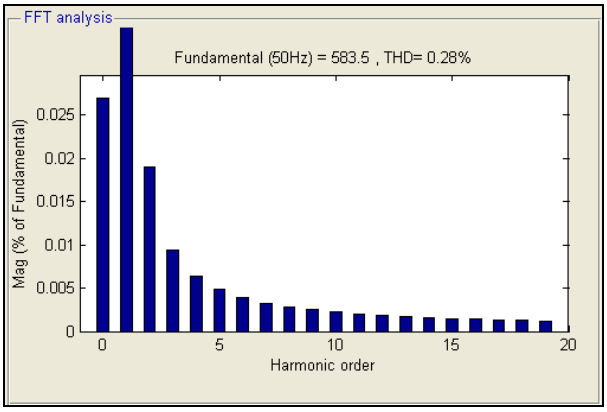

Figure10. Total Harmonic Distortion for voltage

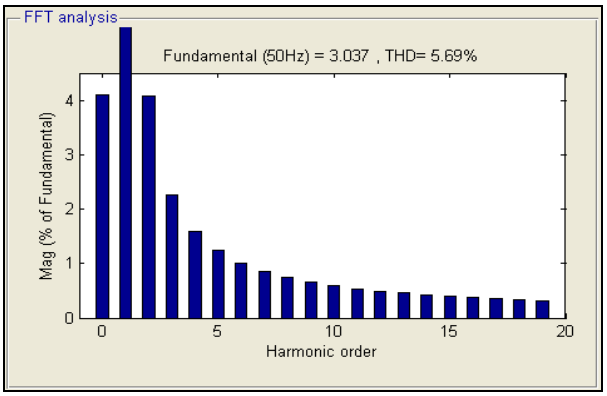

Figure11. Total Harmonic Distortion for current

3.2 Motor Frequency=40Hz, Motor Speed=1300rpm

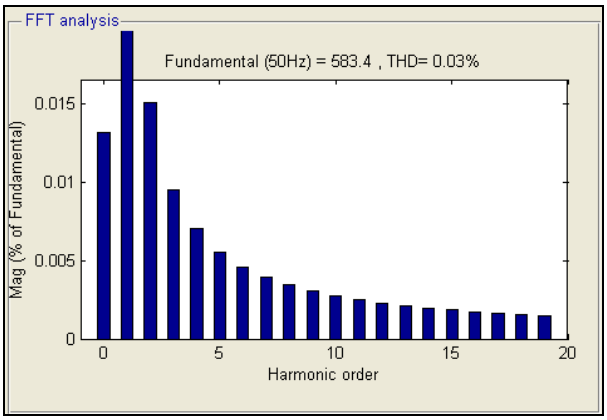

Figure12. Total Harmonic Distortion for voltage

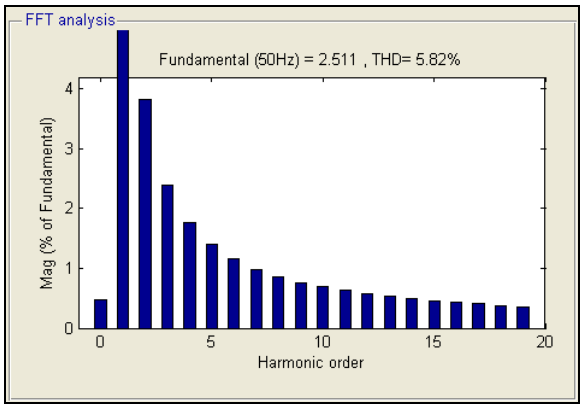

Figure13. Total Harmonic Distortion for current

3.3 Motor Frequency=30Hz, Motor Speed=1200rpm

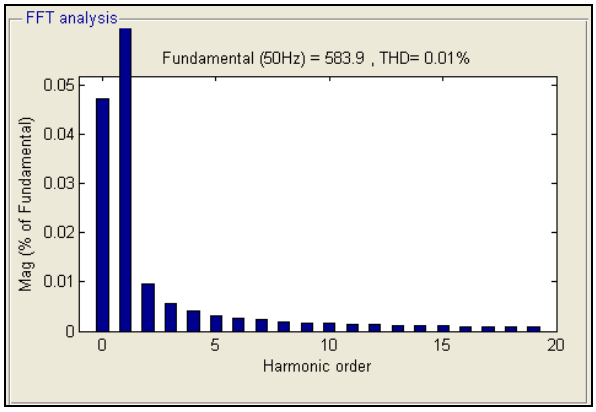

Figure14. Total Harmonic Distortion for voltage

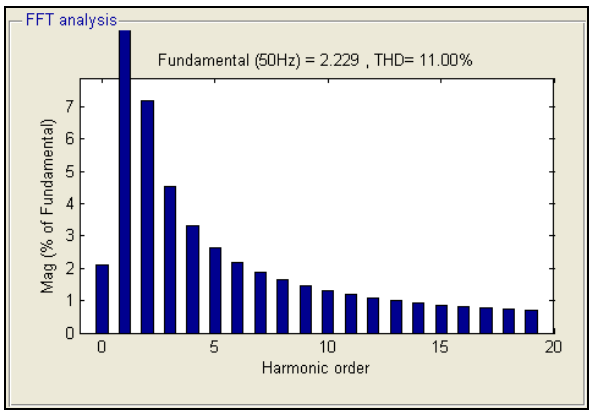

Figure15. Total Harmonic Distortion for current

4. Conclusion

The simulation results show the excellent performance on THD in PV grid connected system. The THD of PV grid-connected system has been analyzed under influence of load conditions. The inverter of harmonic currents is affected not only by the grid conditions but also by using of electronic components. The simulation shows the different THD for voltage and current. As a conclusion, when the speed decreased, the THDv become decreased but the THDi increased. It show that the speed of motor load is influence the result of THDv and THDi.

References

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[3] Topologies of Single-Phase Inverters for Small Distributed Power Generators: An Overview Yaosuo Xue, Student Member, IEEE, Liuchen Chang, Senior Member, IEEE, Søren Bækhøj Kjær, Member, IEEE, Josep Bordonau, Member, IEEE, and Toshihisa Shimizu, Senior Member, IEEE

[4]http://www.aspowertechnologies.com/resources /pdf/Total%20Harmonic 20Distortion.pdf