Assessment of Grid Integration Impact of Photovoltaic System in HD Modelling

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Abstract: This article examines the harmonic performance of grid-connected photovoltaic systems at different levels of penetration. The considered system was modelled in the MATLAB Simulink environment. Voltage and current profile were examined as a percent of total harmonic distortion (THD) under different photovoltaic scenarios. As a result, it has been shown that grid bound photovoltaic generates different harmonic distortion depending on the photovoltaic transmission level fed into the grid. Currents due to harmonics were computed with this typical model from photovoltaic systems connected to distorted as well as undistorted grids. Conclusion of this paper based on results in MATLAB simulation our system.

Keywords: Photovoltaic Grid Integration, Grid Interactive Photovoltaic System, Harmonics, MVDN, Resonance, HD

1. Introduction

Photovoltaic (PV) technology has recently become best ever solution in renewable energy because it can generate electricity without any pollution. Given the strong state support from most developed countries, the price of photovoltaic systems has dropped steadily over the last few years, especially for grid-connected photovoltaic systems. This has led to the quick growth of the photovoltaic market in recent years in the global level.

The main cause of harmonic generation is non-linear loading. Non-linear loads change their impedance in response to the applied instantaneous voltage. This causes non-sinusoidal current to flow when the applied voltage is zero. In other words, this type of load does not have a constant ratio of current to the voltage during switching. Power electronics used in power converters cause problems with power quality such as harmonic distortion. The performance of photovoltaic systems with respect to power quality is highly dependent on the use of the inverter, the amount of solar radiation, and the temperature, which can affect the generated power, voltage and current profiles. In this study, we examine the effects of solar radiation on a clear day to investigate the effect of this phenomenon on the overall distortion performance of a photovoltaic system.

The DC output of the photovoltaic array should be converted to AC in the power system grid. Under this condition, the inverter needs to convert direct current to alternating current. Switch mode inverters use switching devices such as commutating thyristors that can control the turn-on timing but not the turn off time itself. Shutdown must be performed by reducing the circuit current to zero using additional circuitry or power. On the contrary, the self-excitation inverter is characterized by using a switching element capable of freely controlling the on state and the off state, for example, an IGBT or a MOSFET. The self-excited inverter can freely control the voltage and current waveforms on the AC side, adjust the power factor, and suppress harmonic currents. He is very resistant to network confusion. With the advancement of switching devices, most inverters use distributed power supplies such photovoltaic power generators which is now self-commutated inverters.

As a result, two goals are achieved, with the goal of developing an essentially improved photovoltaic model (1 and 3 phases) and repeating the study of the harmonic generation of "Medium Voltage Distribution Network (MVDN)" using the proposed model. The proposed model can be called Norton equivalent circuit model in harmonic domain (HD) of the photovoltaic system.

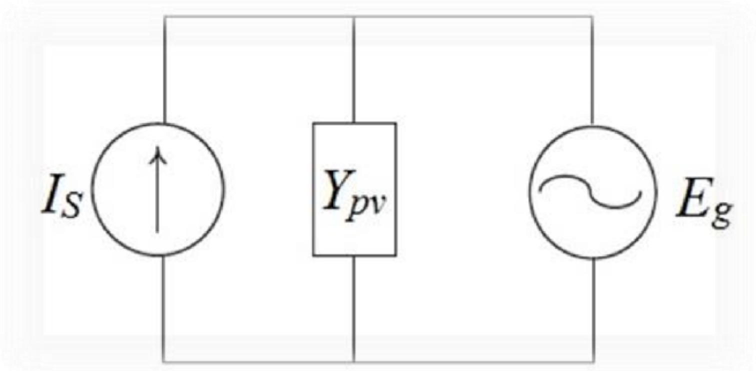

Figure 1. Model of Single-Phase Photovoltaic System In HD

The HD method helps to explain the interface between the photovoltaic system and the grid network, which operates under voltage-free conditions. This model is modelled using Norton's theorem. In addition, this model is suitable for the proposed investigation of harmonic power flow (HPF) using techniques developed in harmonic domain. To conduct the study of MVDN resonance, grid parts such as transformers, loads and capacitors are extruded as in harmonic domain model. The standard IEEE 13-bus system was revised and utilized for the simulation. Technical and insightful results will be shown and elaborated here.

2. Photovoltaic System Modelling

Practical scale photovoltaic systems inherently include photovoltaic arrays, power conditioners, filters, control circuits, protection devices (eg, circuit breakers), and connection transformers. Fig. 2 and Fig. 3 are schematic diagram of single and three phase photovoltaic systems respectively. Inverter circuit of PV system is modelling depends on IGBT switching technology. Such a scheme gives the inverter section as a complete black box based on its operation. The output voltage and the input voltage are associated with equation (1).

$$Vinv\ (t) = G(\omega t)Vdc \qquad (1)$$

In this study, a bipolar switching process is assumed, which is lower to the single pole strategy used here. This is because the previously generates harmonics more than the later. Fourier series representation has also been used, but it is intensive calculations and not easy to integrate with other components of the photovoltaic system filter.

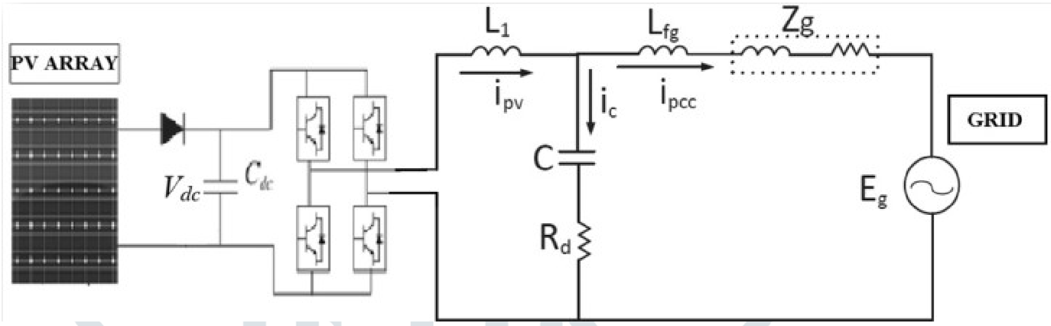

Figure 2. Schematic of Single-Phase Photovoltaic System

By applying the Norton circuit theorem the result of the mathematical model is shown. Note that the model is first displayed in the time domain (TD) and then converted to the harmonic domain (HD).

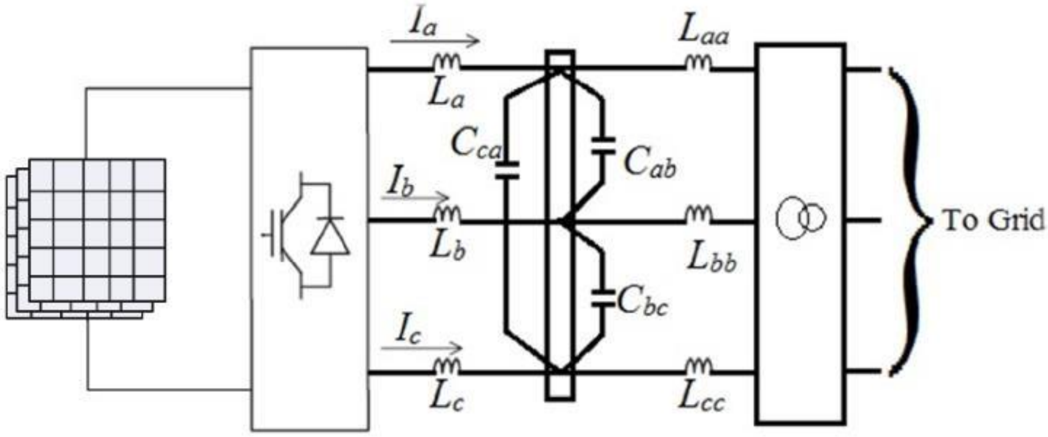

Figure 3. Schematic of Three Phase Photovoltaic System

3. Proposed Model Validation

To use the proposed model to quantify and characterize the harmonics of a photovoltaic system coupled to a various system under power distribution system in that a systematic process follows, which is illustrated by the flow chart of fig.4. Distribution system is modelled using the classic Carson equation. With HD technology, anyone can model TransCore saturation. Such models require more data for analysis than other systems. A specimen of such required data is the transformer current flow graph. However, HPF studies need to consider the effects of core saturation to improve accuracy. The test system used in this study used a harmonic model of the transformer in the form of HD because it did not provide useful information about the transformer's current-to-flux ratio.

Second, the interpretation of harmonics between the photovoltaic system and nonlinear components (e.g. transducers with saturation) or loads (e.g. Induction Motors) can be fully evaluated in the proposed CMS analysis model, unlike the time interval approach of a phase that separates the interactions. From this point of view, our model can also easily detect possible cancellations between photovoltaic harmonics and the network. Therefore, no assumption about the instability of the phase angle of the harmonics is required.

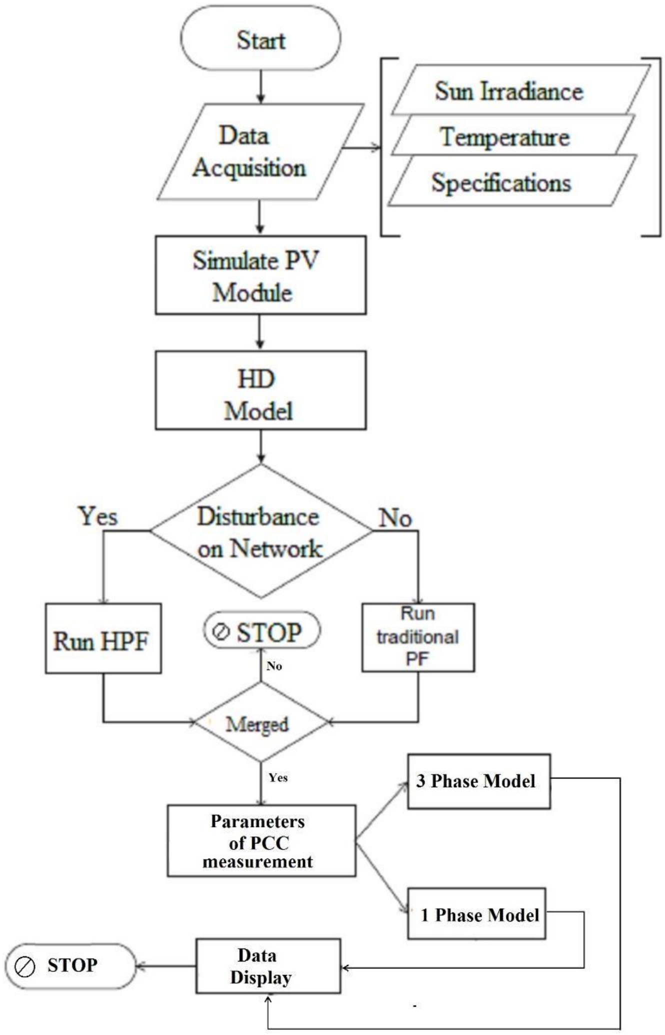

Figure 4. Harmonic Prediction Algorithm Using Proposed Model

The resonance test performed with the model endorses the influence of resistance inhibition as well as negative charge on the inhibition of resonances that are affected by the interface between the grid network and the LCL filter from inverter side. After validating our model, it must be made vibrant that our model in this document is the first harmonic domain reference frame (HDRF) model of the photovoltaic system.

4. MATLAB Simulation

Fig.5 shows the MATLAB simulation diagram for this project which includes IEEE 13-Bus system. photovoltaic System is connected to one of the bus in that IEEE 13-Bus system. Fig.6 shows photovoltaic system diagram. This system is constructed on 50Hz supply frequency. After compilation of this system, we get different waveforms and result of THD in FFT analysis.

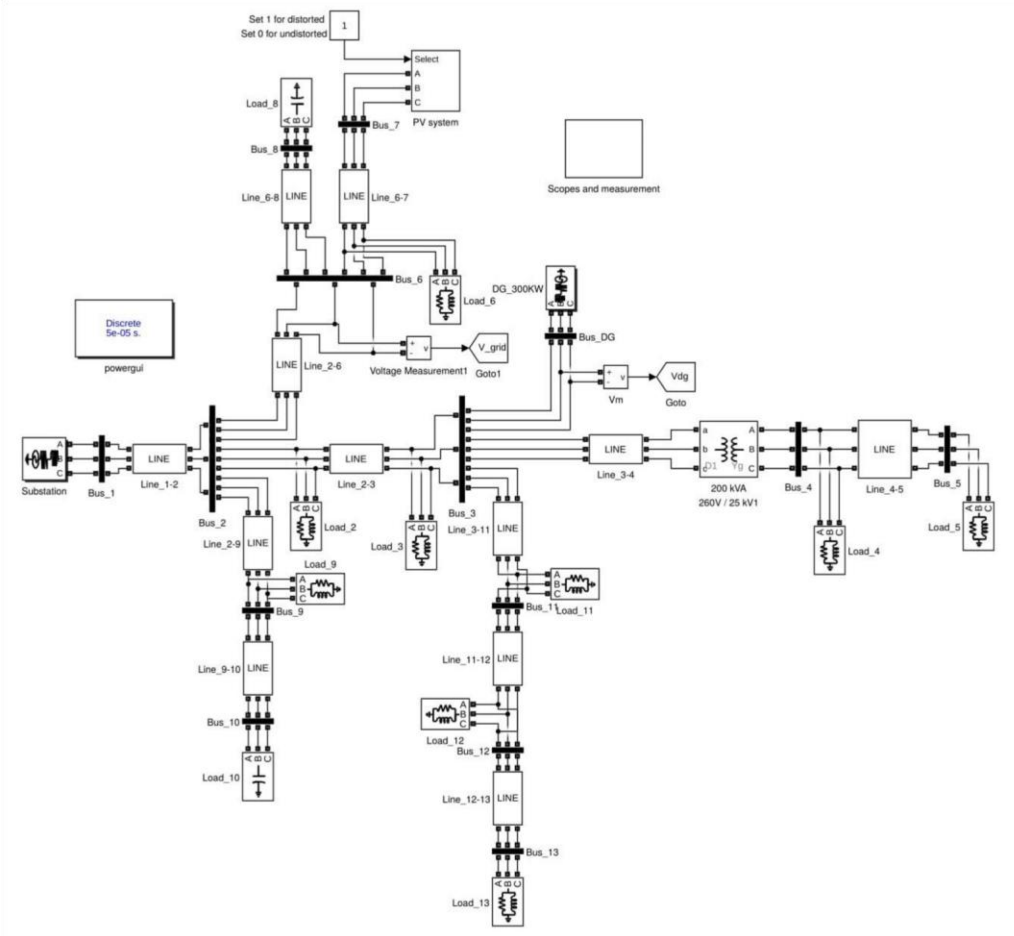

Figure 5. IEEE 13-Bus System with Photovoltaic System

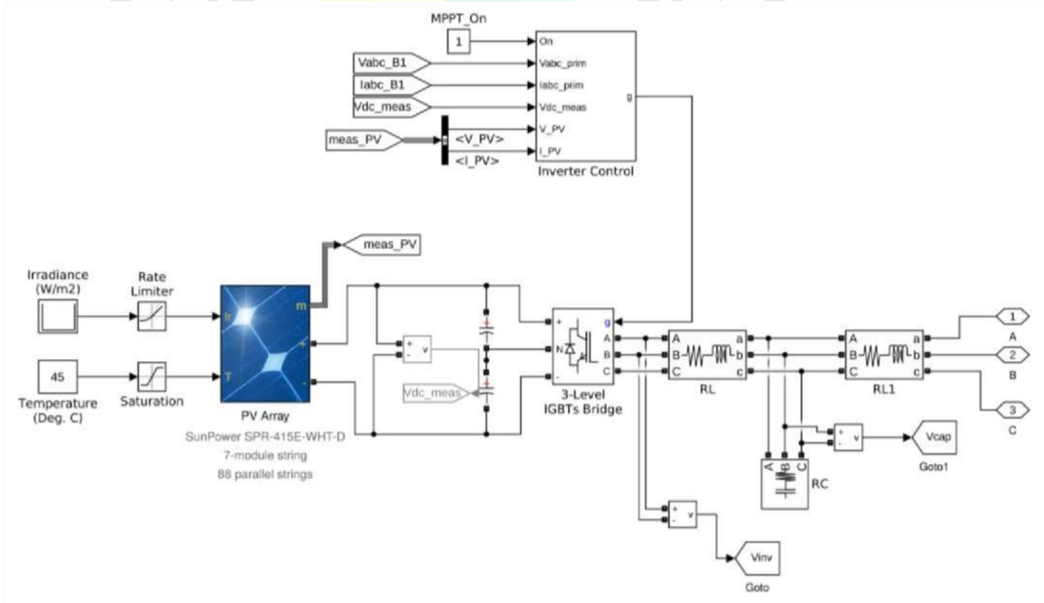

Figure 6. Photovoltaic System in MATLAB Simulation

5. Results of MATLAB Simulation

We shows here only three waveforms and three FFT analysis that is Waveform of Vpcc in distorted grid, Vdg in distorted grid, Vdg in undistorted grid and FFT analysis of the same. Fig.7 shows Waveform of Vpcc in distorted grid. Fig.9 shows Waveform of Vdg in distorted grid. Fig.11 shows Waveform of Vdg in undistorted grid. Fig.8 shows FFT Analysis of Vpcc in distorted grid. Fig.10 shows FFT Analysis of Vdg in distorted grid. Fig.12 shows FFT Analysis of Vdg in undistorted grid. Table.1 shows THD Comparison of Vpcc, Ipcc Vdg.

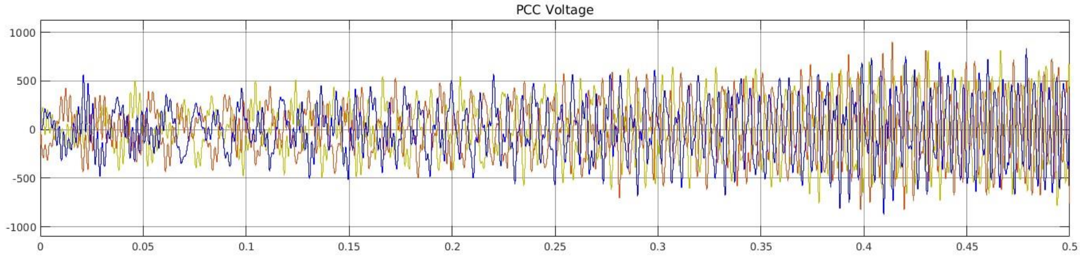

Figure 7. Waveform of Vpcc in Distorted Grid

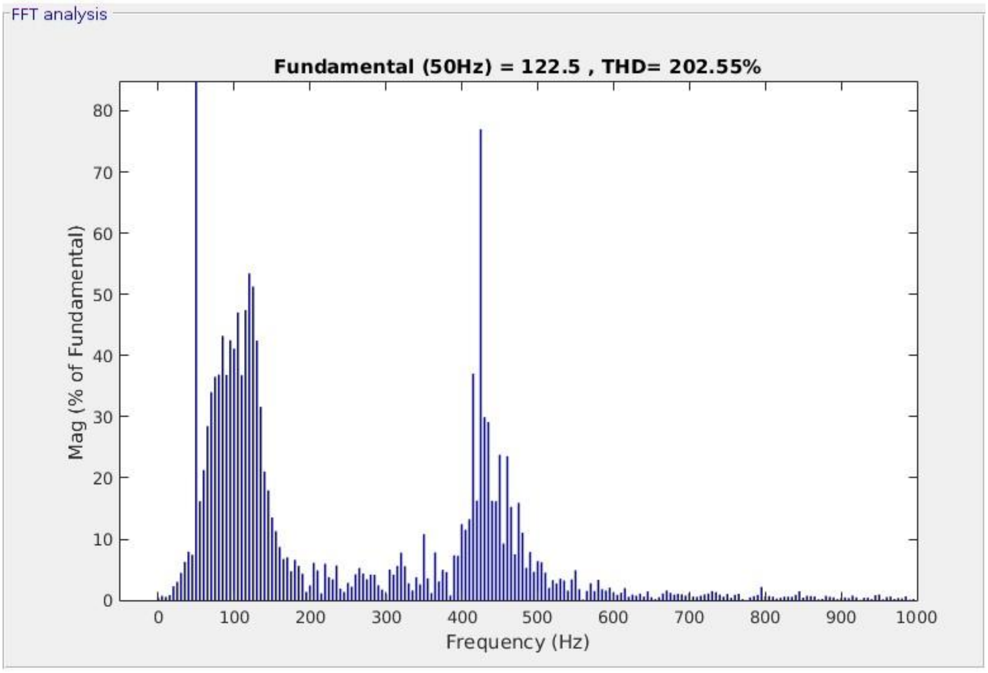

Figure 8. FFT Analysis of Vpcc in Distorted Grid

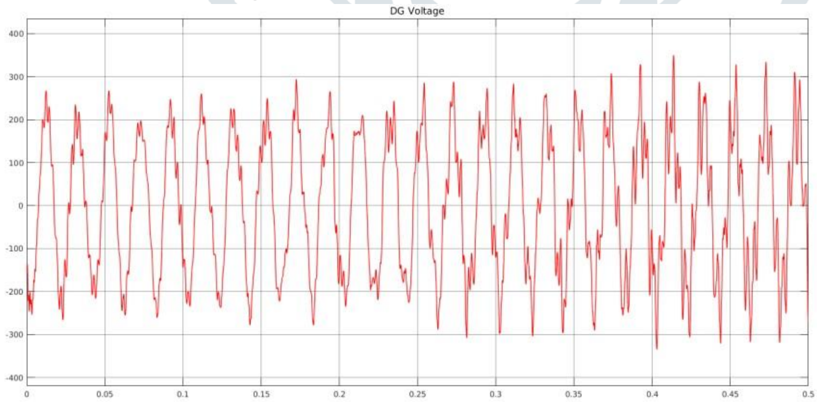

Figure 9. Waveform of Vdg in Distorted Grid

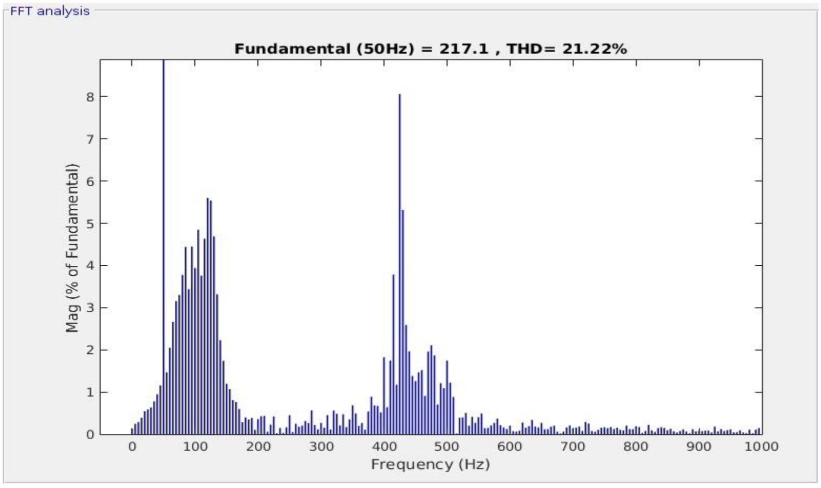

Figure 10. FFT Analysis of Vdg in Distorted Grid

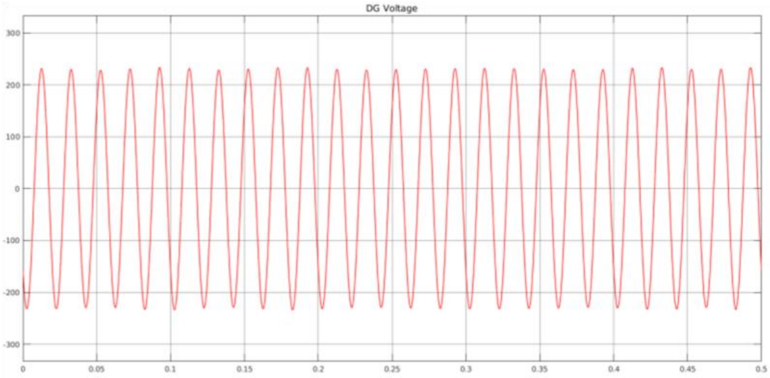

Figure 11. Waveform of Vdg in Undistorted Grid

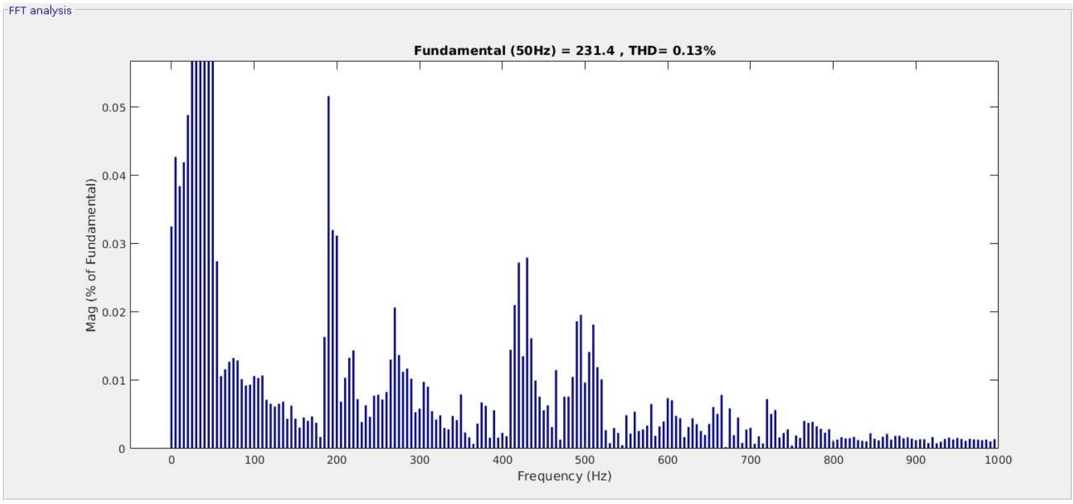

Figure 12. FFT Analysis of Vdg in Undistorted Grid

Table 1.THD Comparison of Vpcc, Ipcc Vdg

Distorted grid			*Undistorted grid*		
Vpcc THD	*Ipcc THD*	*Vdg THD*	*Vpcc THD*	*Ipcc THD*	*Vdg THD*
202.55	*130.24*	*21.22*	*0.59*	*14.46*	*0.13*

6. Conclusion

In this study, we proposed a complete HDRF system model for photovoltaic-VSC system for interactive single-phase and three-way interactive system. These HD models were used to evaluate and measure the interaction between the power and the network harmonics of a photovoltaic system. Simulation results show a common interaction between the harmonic current of the optoelectronic device and the background distortion of the network.

In addition, the MVDN resonance of the three-phase photovoltaic system was investigated using a preceding model. The results confirm that resonant excitation is conceivable due to precise impedance dealings with the photovoltaic filter capacitor. Well-known buffers of chain resistance can prevent phase A and C resonances, but phase B parallel resonances are not completely avoided. This is consistent with different degrees of negative charge for different levels. At the same load, all three phases were wet, suggesting that the PCC's negative charge was causing significant damping of the resonance. Therefore, a detailed assessment is recommended. Also, to distinguish the effects of real harmonics caused by photovoltaic integration and harmonic performance of the network before and after photovoltaic integration.

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