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Photovoltaic Generators Reduce Harmonic Distortion in Micro Grids and Distribution Systems

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Abstract—— **These days, poor power quality is a big problem, hence the power sector has a study field dedicated to it. Technology advancements have made it possible to prevent issues with power quality in the power sector. The harmonics pertaining to power systems are the subject of this essay. Harmonic distortion of the voltage waveforms can lead to malfunctioning electronic devices, overheating of natural conductors and electrical distribution transformers, and distortion in communication networks. The use of photovoltaic generators to reduce harmonic distortion has been studied in this study. This research illustrates how lowering harmonics can enhance power quality in micro grids connected to the distribution system utilising photovoltaic generators.**

Keywords- Harmonics, PVG , Total Harmonic Distortion, FFT, SEPIC Converter Harmonics.

I. INTRODUCTION

Equipment having nonlinear voltages or currents tends to create harmonic distortions. Harmonic voltage decreases across the network's impedance are caused by harmonic current from various sources. Switching devices produce undesirable frequencies that have an impact on the supply voltage when used to manage loads and lower energy usage. Unwanted frequencies have a negative impact on the supply voltage in a number of ways, including the production of extra energy losses, the malfunction of regulating devices, signaling systems, protective relays, and telephone interference. Along with factors like overloading the power transmission and distribution network and overheating the components functioning as loads, malfunctions, additional losses, and overheating are also brought on. In micro grids, P & Q decomposition is used to manage the fluctuating power factor that results from the deployment of many renewable energy sources.

The power factor was improved using a single phase bridgeless SEPIC Power Factor Correction converter. It was discovered that the bridgeless SEPIC PFC outperforms the traditional SEPIC PFC in terms of harmonic reduction. [1] A double tuned filtering system results in a more effective voltage with fewer harmonics and lower power requirements. [2] They discovered via PSCAD that the LCL type filter's installation in PV Grid lessens the harmonic content brought on by the inverter.[3]. They discovered a solution to deal with harmonics by using a passive filter circuit to reduce harmonic distortions, however filtering results in a lower output voltage, therefore they utilised a DC-DC regulator. They utilised this to enhance their input current and the output voltage greater than the 90% of LCL type filter in PV Grid reduces the harmonic content caused by the inverter, using the PSCAD.[3] They discovered a solution to deal with harmonics by using a passive filter circuit to reduce harmonic distortions, however filtering results in a lower output voltage, therefore they utilised a DC-DC regulator. By doing this, they increased their input current and output voltage by more than 90%. [4] Making the load current sinusoidal and in phase with the source voltage minimises the harmonic distortions of micro grids and distribution systems. This was demonstrated by findings with MATLAB. [5] A good harmonic-free output is provided by a grid-connected PV system using a micro-inverter controlled by a PFC controller. [6] Utilizing the energy-storage reactor's third winding, The effectiveness of harmonic reduction is confirmed by the analysis of the rectifier diode and the soft switching operations and performances. [7] The output voltage has a lower THD due to the input adjusted carrier signals. An additional negative effect of this is greater switching frequency loss. Current distortion is possible using pulse modulation of an active filter with buck-boost connecting back-to-back to an inverter with priority switching [8]. [9] The shunt active power filter (SAPF voltage)'s source converter (VSC) uses synchronous reference frame theory to control and eliminate harmonics from the reference signals used in pulse width modulation (PWM). [10]

This study discusses the use of photovoltaic generators to reduce harmonic distortion. The essay is structured as follows: The introduction and the literature review are summarised in Section I. Section II discusses the impact of PV generators in micro grids. The findings of the simulations using a DC supply, PV generator, and boost/SEPIC converters are covered in Section III. The conclusions of the simulation results are presented in Section IV.

II. EFFECT OF PV GENERATORS IN MICRO GRIDS

In response to light, photovoltaic generators convert some of the light's energy into electricity. They have a wide range of benefits, including being clean, affordable, unreliable, economical, pollution-free, and low maintenance cost. The block diagram and the circuit diagram of the PV generators with SEPIC converters in micro grid is shown in Fig. 1 & Fig. 2 respectively.

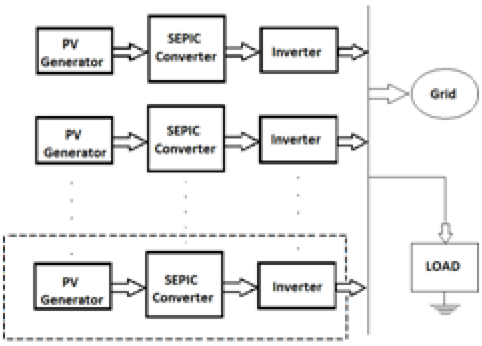

Figure 1. Block diagram of PV generator with SEPIC Converter in micro grid

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The voltage produced by PV generators is a variable quantity that is dependent on the light's intensity. SEPIC converters are employed to maintain the voltage generated as a constant. This converter can operate in step up or step down mode and is user-friendly. The SEPIC converter boosts the voltage if the input voltage is less than the necessary level and steps it down if the input voltage is more than the necessary rate. Our use of this SEPIC converter results in good efficiency and reliable operation.

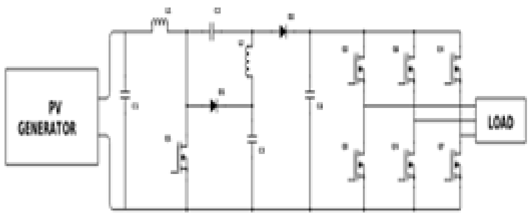

Figure 2. Circuit diagram of PV generator with SEPIC converter

A PV generator is connected to the load using the convertor and inverter system, as shown in figure 2. Using a SEPIC converter, the PV generator's variable DC voltage is increased or bucked to a constant voltage. Then, an inverter is used to transform the steady DC voltage into AC voltage. The resulting AC voltage is then put through an RL filtering circuit to remove the harmonic distortions, and the voltage with fewer harmonics is then supplied to the micro grid to improve power quality.

III. SIMULATION RESULTS AND DISCUSSIONS

The input power delivered from renewable energy sources to the micro grid should be devoid of harmonics in order to assure power quality in these systems. The harmonic distortion level of the voltage from PV generators must be examined in order to meet the aforementioned criterion. In this study, simulations of PV generators with SEPIC converters are performed using MATLAB R2013a SIMULINK. This outcome is contrasted with the simulation of a boost converter-equipped PV generator.

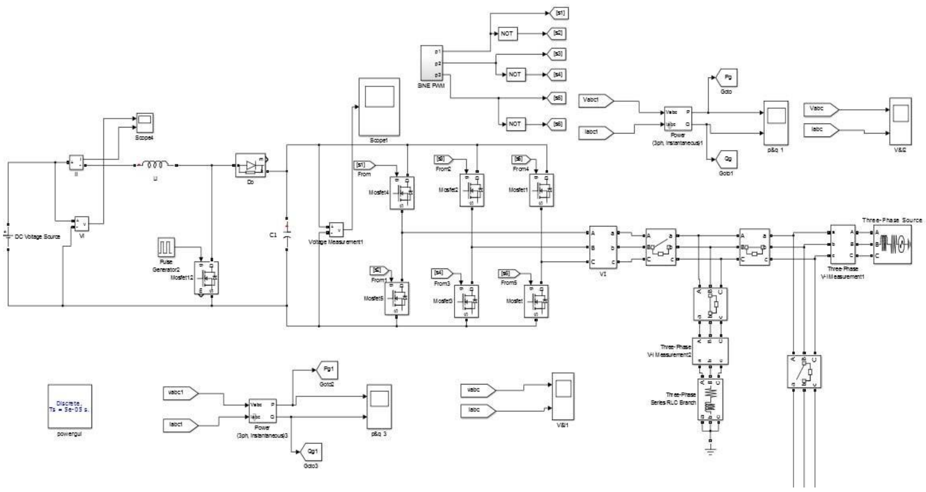

Figure 3. simulation circuit of DC source with boost converter

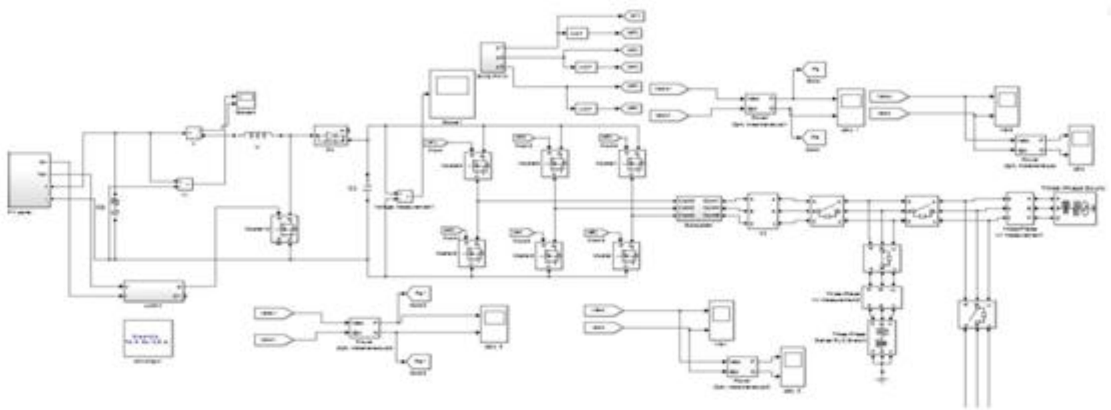

Figure 4. Simulation circuit of PV source with boost converter

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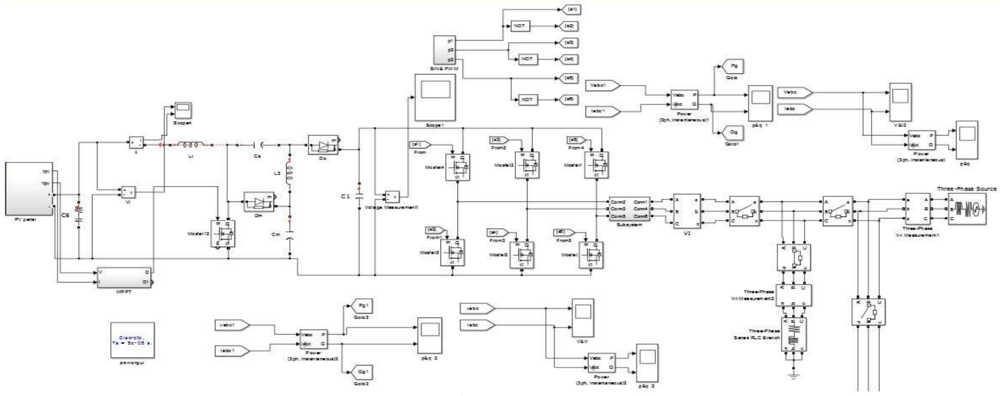
Figure 5. Simulation circuit of PV source with SEPIC converter

The simulation circuit in Fig. 3 makes use of an inverter and converter pair. A DC supply is used to power the boost converter. To provide non-linear loads, this is connected back to the micro grid through an inverter. The input is provided as the DC source.

Figure 6. Output voltage Waveform of DC sourced boost converter

The input is fed to the inverter, here the supplied DC source is inverted to AC and then the AC supply is further to the boost converter is supplied. The voltage is increased and provided to the filter circuit in this location. In distribution systems, or micro grids, harmonic distortions are filtered by the filter circuit. A DC source using a BOOST converter has a 200 v output voltage.

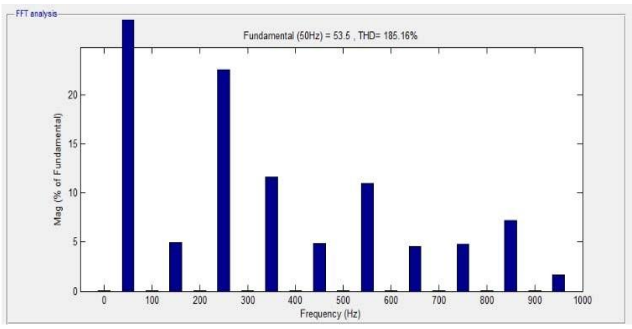

Figure 7. The Total Harmonic Distortion waveform of DC sourced boost converter

The Total Harmonic Distortion value for this system is 185. 16%.

According to the system in Fig 4, the DC source is replaced with the PV source namely PV generator. This system is taken as the maintenance cost is less compared to DC and there are no fluids using in this system. This PV generator is connected with the load system by means of an inverter and converter set. The PV generator is interfaced with boost converter and the voltage is boosted as for our requirements. The voltage boosted is further converted by using an inverter. The converted voltage is passed through the filters in order to remove the harmonics and fed to the grids from where it is been supplied to the distribution network.

Since the PV source can be used in a variety of ways, let's advance it by combining the boost convertor and SEPIC convertor. This has the benefit over boost in that it may be used in both modes, boost and buck, the latter of which is more advantageous. The procedure is quite similar to that in the boost convertor example, but employing the SEPIC convertor improves the output voltage and THD values.

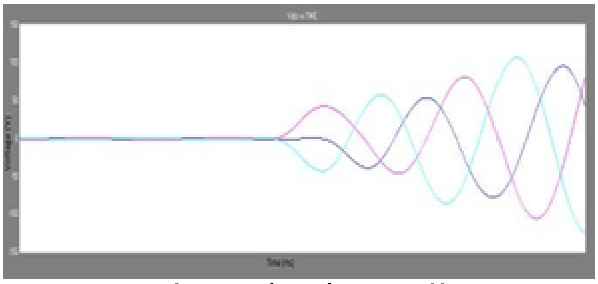
Figure 8. Output voltage waveform of PV sourced boost converter

Output voltage of a PV source with a BOOST converter is 400 v.

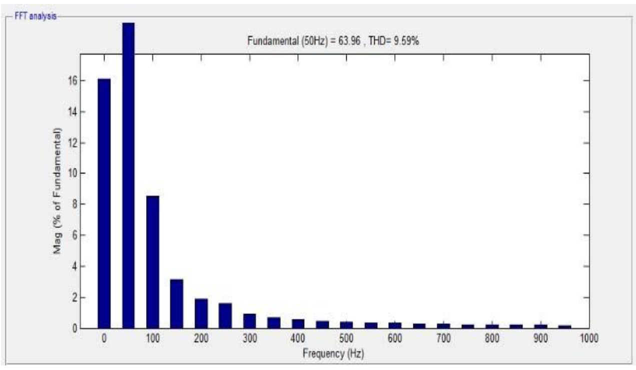

Figure 9. The Total Harmonic Distortion waveform of PV sourced boost converter

The Total Harmonic Distortion value for this system is 9.59%.

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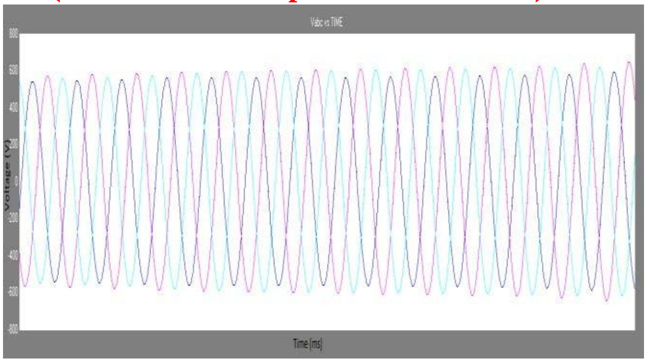

Figure 10. Output voltage waveform of PV sourced boost converter

Output voltage of a PV source with a SEPIC converter is 500 v.

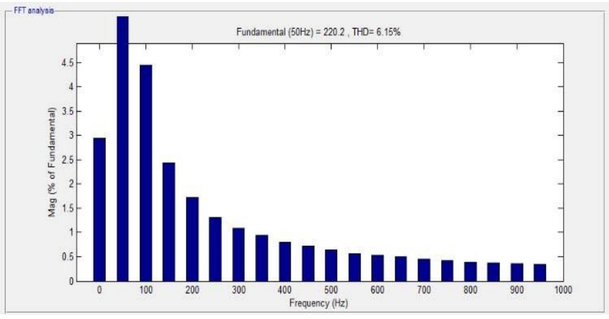

Figure 11. The Total Harmonic Distortion waveform of PV sourced boost converter

The Total Harmonic Distortion value for this system is 6.15%. The outputs are being tabulated according to their performances with different sources and converters.

TABLE-1 COMPARISION OF RESULTS

Sl.No	Type	Input voltage	Output voltage	THD Value
1	DC Source with BOOST Converter	65 V	200 V	185.16%
2	PV Source with BOOST Converter	65 V	400 V	9.59%
3	PV Source with SEPIC Converter	65 V	500 V	6.15%

IV CONCLUSION

In this paper the SEPIC converter is implemented to step up and step down when ever required and to make use of the clean , cheap , undependable and inexpensive means of energy. A continuous DC supply, a PV generator, a boost converter, a SEPIC converter, and the harmonic distortion are all compared. Results showed that using a SEPIC converter with a PV generator connected to a micro grid reduced total harmonic distortion by 3.44 percent. When using a SEPIC converter, the output voltage level is also boosted by 100 V.