Load Sharing and Power Quality Improvement in Solar PV Connected Microgrid

Ashutosh Barua

Asst. Professor, Electronics and Communication Engineering Department
Amity University Madhya Pradesh, Gwalior (M.P), India

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Abstract - *As the power demand in industry as well as domestic area is sharply increasing day by day resulting in the growing emission of harmful gases by the diesel generators which is polluting our environment. Modern world's enhanced commercial activities and rapid growing industrialization are increasing the peak of electricity demand in a significant way. As most of the power generation in India is based on coal which emits lots of co_2 and other harmful gases. These gases are the major sources of various environmental problems like climate change, ozone layer depletion, melting of glaciers, global warming and its associated consequences. This paper discusses the power sharing by the solar Photo Voltaic (PV) panel of a microgrid with help of HOMER legacy software and also discusses the power quality of the system.*

Key Words: HOMER, PV, Solar PV, Load Sharing

1. INTRODUCTION

Microgrid is interconnected system of generators and electrical load for a local area it provides viable solution for villages and remote areas, where the grid connectivity is not proper and cost of electricity per Kwh generated by diesel generator is very high and also the fuel is non renewable, therefore there is a requirement to switch from diesel generator to renewable energy sources like solar Photo Voltaic (PV)[1,8].PV Connected microgrid modelling is done.

1.1 PV CELL Model

The components of a PV system depend on the type of application (stand-alone or grid). The main element of these installations is the PV module, which consists of a set of photovoltaic cells that produce electricity from the light that strikes them.

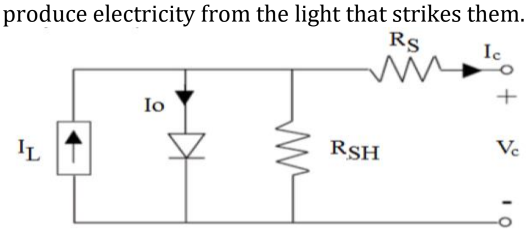

Fig -1: PV cell Model

Photovoltaic is a method of generating electrical power by converting solar Radiation Into direct current electricity using semiconductors that exhibit the photovoltaic effect [2]. There are input parameters to determine PV Component in PSCAD model. First, the weather condition Includes (solar Irradiance and Temperature). In this paper the weather data used for Malanpur area of Madhya Pradesh measured in December from International Weather for Energy Calculation.

1.2 PV Array Model and Microgrid Design

the default parameters that determine the Electrical Data for PV module for central inverter [3], and subsequently, the Performance of PV-Array is shown in Figure 2. The output power for one module is 200 watt and the nameplate capacity for PV Array1 ≈ 20 KW with total number of modules 100. A microgrid is designed using software as shown in Figure.3.

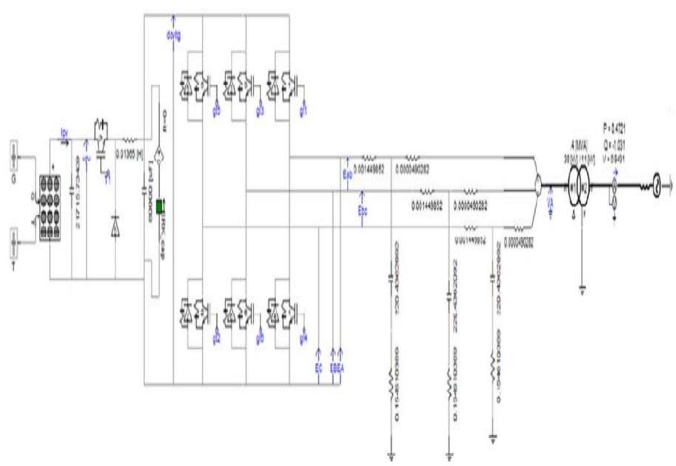

Fig -2: PV Array Model

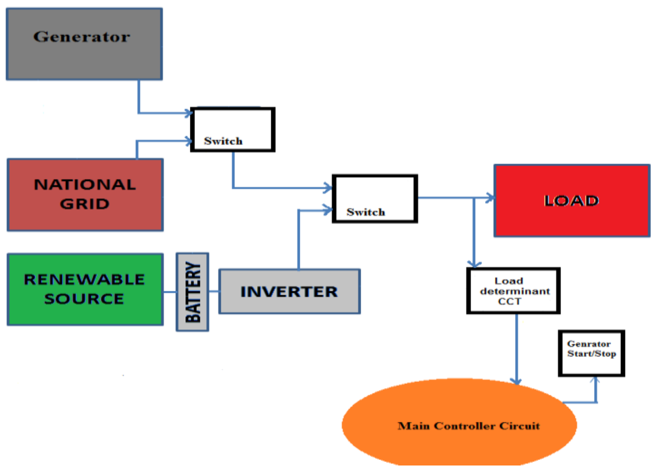

Fig-3: Microgrid Design

In this paper a comparison is done between (central and string) inverter as shown in Figure5 When all PV modules are connected to single inverter this is central inverter[4,5], As for string inverter, there are many numbers of inverters and each one is responsible for certain number of PV modules with its own MPPT control [6]. String inverter is the best choice when PV system subjected to shading condition because certain number of PV modules affected by shading condition In contrast Central inverter all PV modules affected by Shading and output power decrease [7].

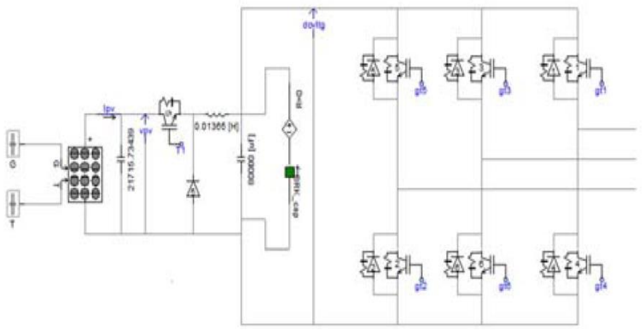

Fig-4: Central inverter configuration

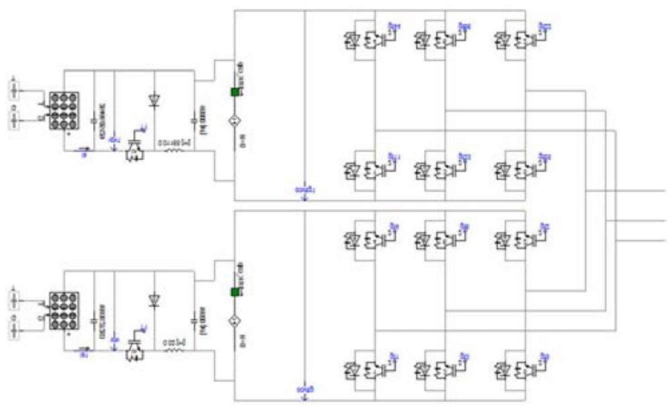

Fig-5: String inverter configuration

2. TOTAL DEMAND DISTORTION AND TOTAL HARMONIC DISTORTION ANALYSIS

Sinusoidal terms (harmonics) whose frequencies are whole multiples of the fundamental frequency. In order to connect PV system to grid utility using inverter which is responsible for add harmonic distortion to grid that degrade power quality of it. For better performance of PV system connected to grid with good power quality there are standards that organize and regulate this problem. One standard is IEEE Std.929- 2000 “IEEE Recommended Practice for Utility Interface of Photovoltaic (PV) Systems” which ensures compatible operation of photovoltaic (PV) systems that are connected in parallel with the electric utility [8].

It is recommended by the previous standard that the harmonic distortion at the Point of Common Coupling (PCC), which is the point at which the PV system is tied with the grid, should comply with IEEE Std 519-1992 [9,10]. PCC lies between the transformer and the grid [11]. IEEE 519-1992 standard sets specific limits for allowable current and voltage harmonics in power systems.[9]

In order to explain the power quality problems that occur in the PV grid-tied system, there are several tests of central and string inverters using sinusoidal pulse width modulation controlling method and space vector modulation controlling method. Then, the results are analyzed from different point of views related to types of inverter configuration and the effect of them on Power quality of grid and efficiency of system, and also related to two pulse width modulation control and effect of them on each inverter.

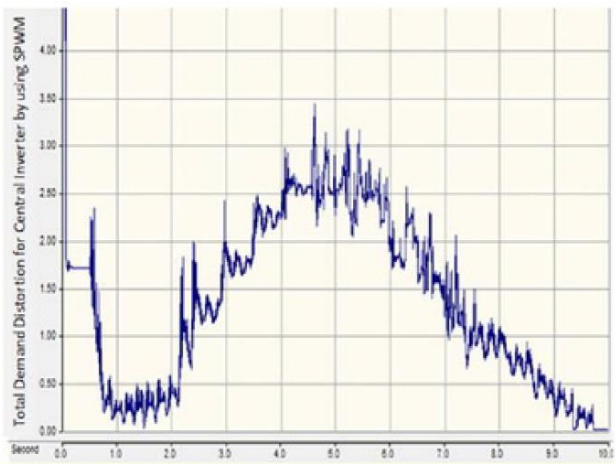

Fig-6: TDD % of the current at PCC of central inverter using SPWM

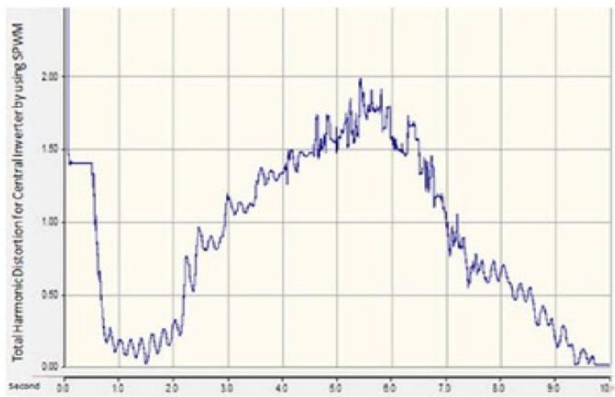

Fig-7: THD % of the Voltage at PCC of central inverter using SPWM.

Fig-8: output voltage of central inverter using SPWM.

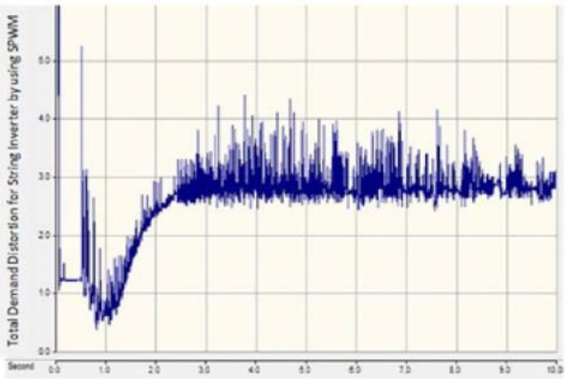

Fig-9: TDD % of the current at PCC of string inverter using SPWM.

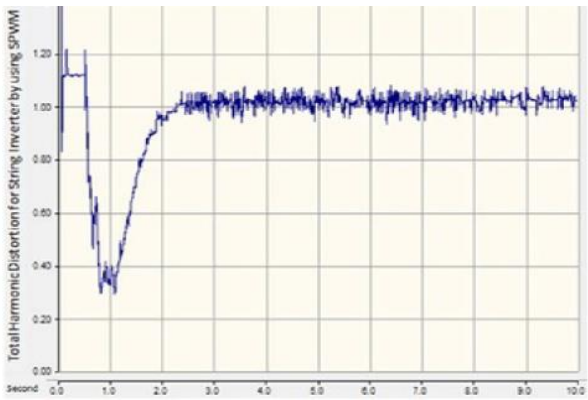

Fig-10: THD % of the Voltage at PCC of string inverter using SPWM.

2.1. RMS Output Voltage

In Figure (6, 7, 9, and 10) are shown the TDD of the current and THD of the voltage in phase A at PCC for Central and String Inverter by using SPWM and SVM. It is observed that TDD &THD of central inverters are less than string inverter and this is rational because Central Inverter has only one Converter and String Inverter has more than one. But String inverter has good performance than central inverter as shown in Figure (11, 12, 13, 14, and 15) that Illustrates RMS output voltage of string inverter higher than central inverter. TDD, THD, individual current and voltage harmonic amplitude for central and string inverter.

Fig-11: TDD % of the current at PCC of central using SVM.

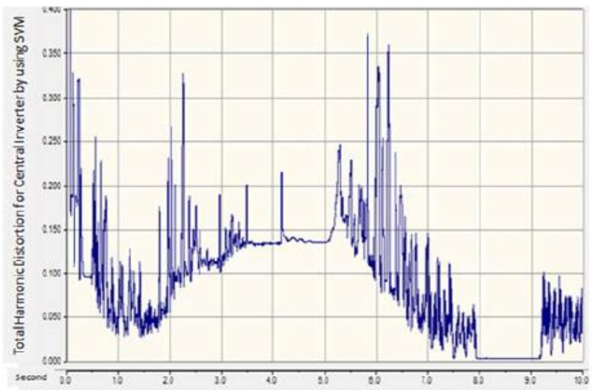

Fig-12: THD % of the current at PCC of central inverter using SVM.

Fig-13: RMS-output voltage of central inverter Using SVM.

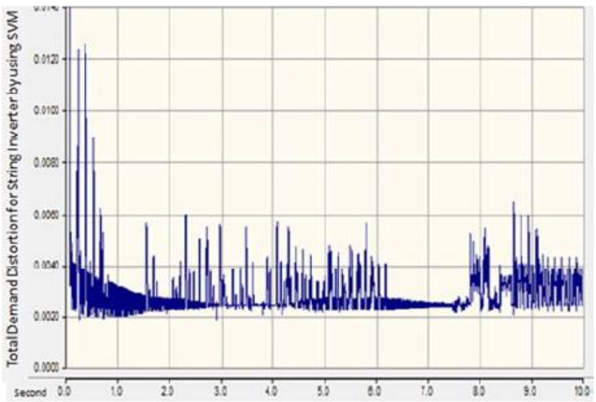

Fig-14: TDD % of the current at PCC of string inverter using SVM.

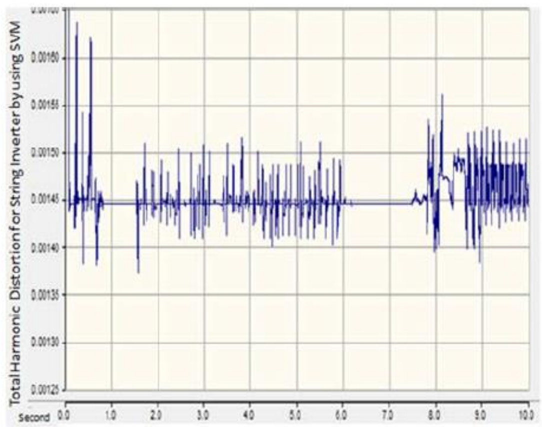

Fig-15: THD % of the current at PCC of string inverter using SVM.

Fig-16: RMS-output of string inverter using SVM.

3. MICROGRID SIMULATION

MICROGRID simulation using software Homer v2.68, and a comparative study is done. The meteorological data of Solar Radiation, hourly wind speed has taken for Malanpur, M.P, India (Longitude 78°10'12" East and Latitude 26°13'50" (North). Various combinations of PV array, diesel generator were taken into account to get optimum economic solution that would meet a given load in some residential houses of Gwalior. Details of the system data is given in table-1.

Table.1.System data

Parameter	Value
Total load	11.54kW (Peak)
Average Load	6.52 kW
Load factor	0.5649
Generator size	17kW
Size of PV panel	13kW
Battery Ah	300
No. of Battery	20
Battery voltage	12
Inverter efficiency	84%
Inverter size	17kW
PV panel derating	82

Average monthly electric production and hourly generator output profile of a diesel generator without SPV is considered.

Table.2. Emissions data comparison with and without SPV.

Pollutant	**Emissions Without SPV (kg/yr)**	**Emissions With SPV (kg/yr)**
Carbon dioxide	32145	18457
Carbon monoxide	83.8	57.6
Unburned hydrocarbons	9.4	6.28
Particulate matter	8.07	6.59
Sulfur dioxide	70.3	42.7
Nitrogen oxides	868	542

4. CONCLUSIONS

This paper focuses PV system tied microgrid power sharing by solar and its power quality problem. Investigates PV inverter configuration such as Central and string with two pulse width modulation methods (SPWM-SVM) and the effect of them on power quality from view point of Harmonic. Lastly the power sharing by the PV is determined. By referring the table no.2 We can conclude that a large portion of the power demand can be met by using solar PV. Not only in the power demand is met but also the harmful gases emissions is reduced like Nitrogen oxides, carbon monoxide, cabon dioxide, Particulate matter and Sulphur dioxide is reduced.

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