IMPROVEMENT OF POWER QUALITY IN STANDALONE MICROGRID BY DVR USING SRF THEORY

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ABSTRACT: Power quality plays a vital role in today's power system. It is one of the most important areas to be improved to get better performance of the system and to attain system stability. Microgrid is one among the widely used areas in which improvement of power quality is to be done. Microgrid is a small scale version of utility grid which can operate independently (Standalone mode) as well as in conjunction with main grid. Microgrid involves use of renewable energy sources like solar, wind, fuel etc. This paper involves reduction of load harmonics in standalone microgrid designed with solar and wind with DVR using SRF theory.

Keyword : Microgrid, Solar, Wind, Power quality, DVR, SRF.

1.INTRODUCTION

Electric Power quality is basically termed as the waveform of normal sinusoidal voltage or current source without any deviation in it. Usually power quality refers to maintaining the bus voltage waveform purely sinusoidal at rated voltage and frequency. The waveform of electric power at the generating level is purely sinusoidal and is free from distortion. Many of the power consumption equipments are designed to function under pure sinusoidal voltage waveforms. With increase in power demand it is clearly seen that the use of fossil fuels is getting increased and if this increases at the same rate then there might be greater scarcity of non-renewable resources. These days people are showing interest towards renewable energy sources because of their abundancy and also they are nature friendly. Renewable sources include solar, wind, fuel, tidal etc.,. Solar energy is most abundantly available year long and wind is also one of the widely used sources of energy.

But these energies are intermittent in nature i.e., they are not available at same quantity throughout the year. So the issue now is if we employ these in power generation they may damage the connected loads as the loads are set to operate at certain operating voltage and frequency. So to minimize these kind of issues several control techniques have been employed in order to make the outputs from these renewable sources feasible.

In this paper a standalone microgrid is employed with solar and wind as sources and the performance of this grid is studied. Particularly load harmonics of both voltage and current are reduced. To reduce the load side voltage and current harmonics a facts device called dynamic voltage restorer(DVR) is employed. The theory employed in the DVR is synchronous reference frame (SRF) theory.

2.MICROGRID

2.1. About Microgrid

As electric distribution technology steps into the next century, many trends are coming into existence that will change the requirements of energy delivery. These modifications are being driven from both the demand side where higher energy availability and efficiency are desired and also from the supply side.

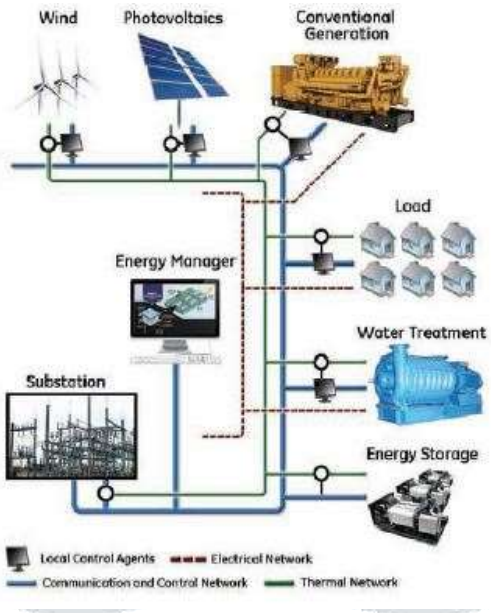

Fig1.Microgrid power system

Microgrid is an integrated system. The integration of the Distribution energy resources connected to microgrid is a bit critical. Also there is an additional problem regarding this control, grouping and control of distribution energy resources in an efficient and reliable manner. Integration of wind turbines and photovoltaic systems with grid leads to grid instability. One of the solutions to this problem can be achieved by the implementation of microgrid.

2.2. PV ARRAY

A photovoltaic array (PV system) is an interconnection of modules which in turn is made up of many PV cells connected in series or parallel. The power produced by a single module is not enough to meet the requirements of commercial applications, so modules are connected to form array in order to supply the load. In an array the connection of the modules is same as that of cells in a module. The modules in a PV array are generally first connected in series to obtain the desired voltages; the individual modules are then connected in parallel to allow the system to produce more current.

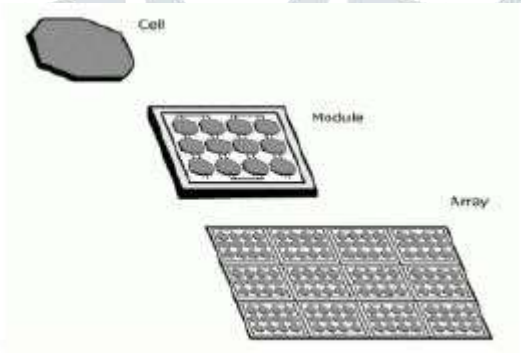

Fig.2.Photovoltaic system

2.2.1. Modeling of PV panel

The photovoltaic system can generate direct current electricity without any environmental impact when is exposed to sunlight. The basic building block of PV arrays is the solar cell, which is basically a p-n junction that directly converts light energy into electricity. The output characteristic of PV module depends on the

cell temperature, solar irradiation, and output voltage of the module. The figure shows the equivalent circuit of a PV array with a load.

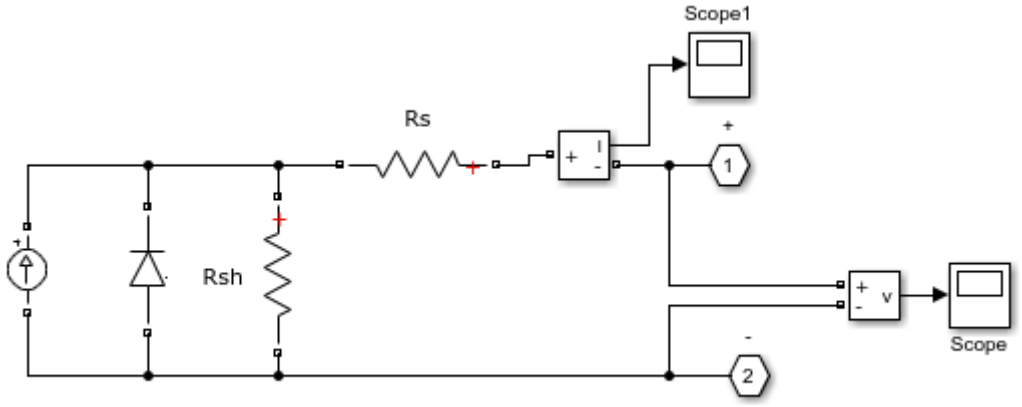

Fig 3. Basic pv model

Usually the equivalent circuit of a general PV model consists of a photocurrent, a diode, a parallel resistor which expresses a leakage current, and a series resistor which gives an internal resistance to the current flow. The shunt resistance Rsh of the cell is inversely related with the shunt leakage current to the ground. A small variation in series resistance Rs will significantly affect output power of PV cell.

3.WIND TURBINE

A wind turbine is a device that converts kinetic energy from the wind, also called wind energy, into mechanical energy; and this process is known as wind power. If the mechanical energy is used to produce electricity, then the device may be called as a wind turbine or wind power plant. Today's wind turbines are manufactured in a wide range of vertical and horizontal axis types.

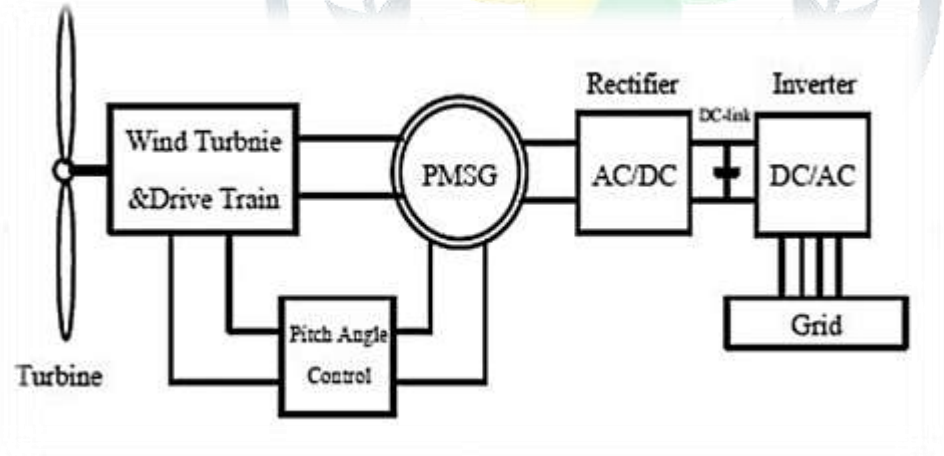

Fig.4. General working principle of Wind Energy System.

4.HYBRID MICROGRID

Here in this paper it is explained about hybrid micro grid operated in standalone mode. This Hybrid microgrid is a combination of solar and wind.

4.1. OPERATION

Hybrid grid consists of solar and wind operated in standalone mode. Here the load harmonics of both voltage and current are calculated. These harmonics(total harmonic distortion) are reduced using a facts device called DYNAMIC VOLTAGE RESTORER(DVR). This DVR is implemented in series with the grid and the load harmonics are reduced. Synchronous reference frame theory (SRF) is used in DVR.

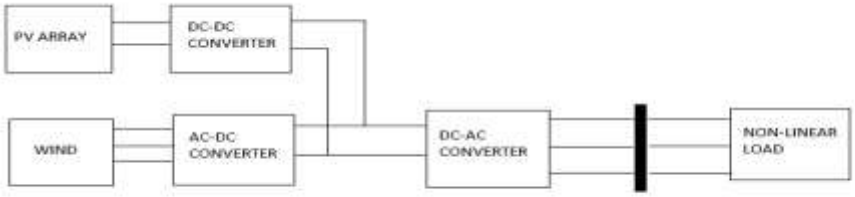

Fig.5.Block diagram of hybrid grid without DVR

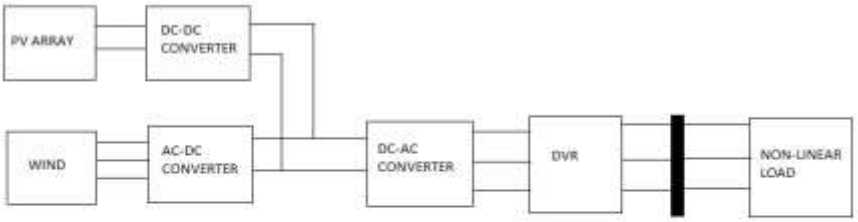

Fig.6. Block diagram of hybrid grid with DVR.

4.2. COMPONENT PARAMETERS OF HYBRID GRID

1.AC current source = 450volts

2.frequency = 60hertz

3.solar shunt resistance, Rsh = 1e3ohms

4.solar series resistance, R = 1ohm

5.capacitor across DC link = 9000e-6farads

6.Transformer ratio(n1/n2) = 500 500

5.DYNAMIC VOLTAGE RESTORER(DVR)

The DVR is a power quality device. It has an immense role in protecting industries against disturbances such as voltage sags related to remote system faults ,harmonic mitigation. The basic operation principle of the DVR is to inject an appropriate voltage in series with the supply through an injection transformer. Also DVR is widely used device to mitigate voltage sag To mitigate voltage sag, DVR has been considered as an effective sag mitigation equipment and also many research works have been carried out focusing in the design and control of DVR. And also Power transfer ability, transient stability and damping of power oscillation is improved by using DVR in transmission system. And also it is capable of generating or absorbing real and reactive power at its ac terminals. The basic principle of a DVR is simple ,by inserting a voltage of desired magnitude and frequency, in order to restore the load-side voltage balanced and sinusoidal. In this proposed model synchronous reference frame theory(SRF) is applied.

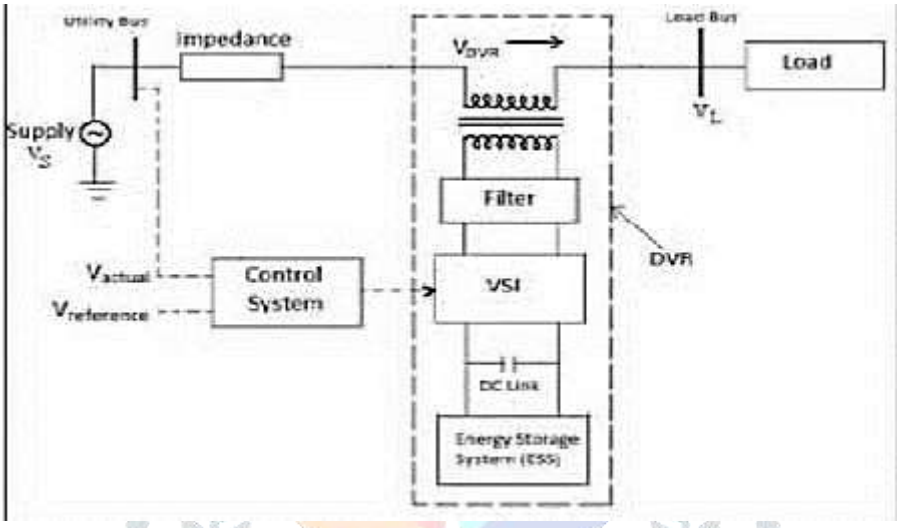

Fig.7. Basic block diagram of DVR

6.SIMULATION AND OBSERVATIONS

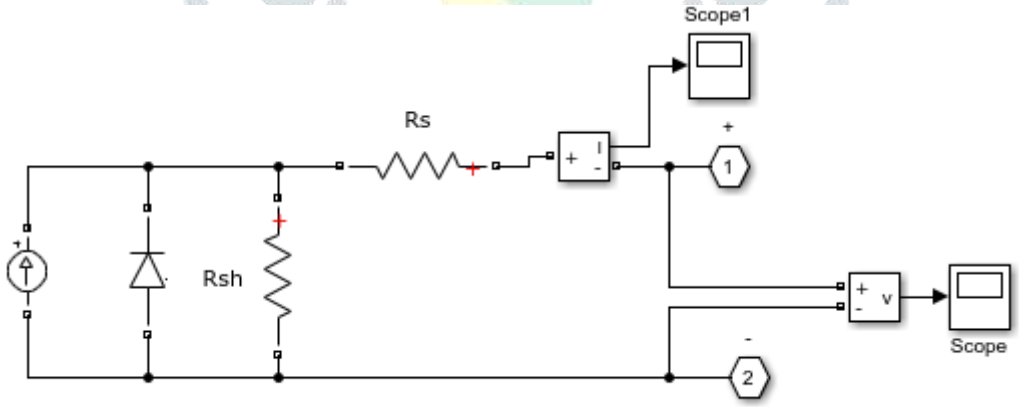

Fig.8.Basic Solar PV array

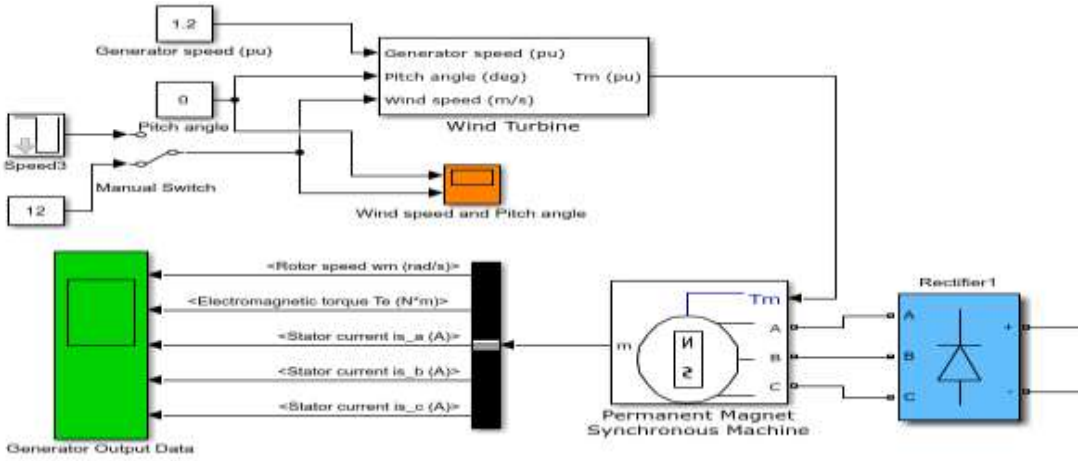

Fig.9.Basic wind turbine

The above shown diagrams are basic figures of solar and wind used in hybrid microgrid. This grid is operated and the voltage and current waveforms are seen and its harmonics are calculated.

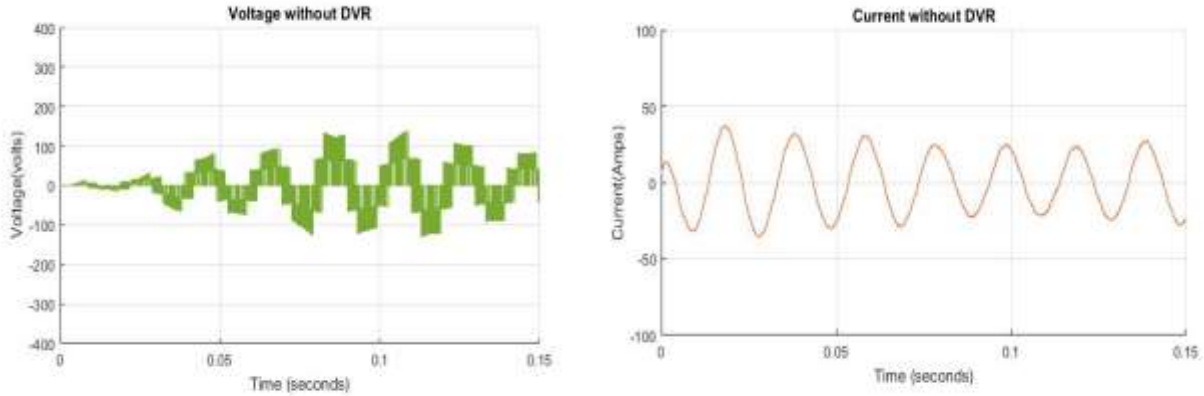

Fig.9. load voltage and current waveforms of microgrid without DVR

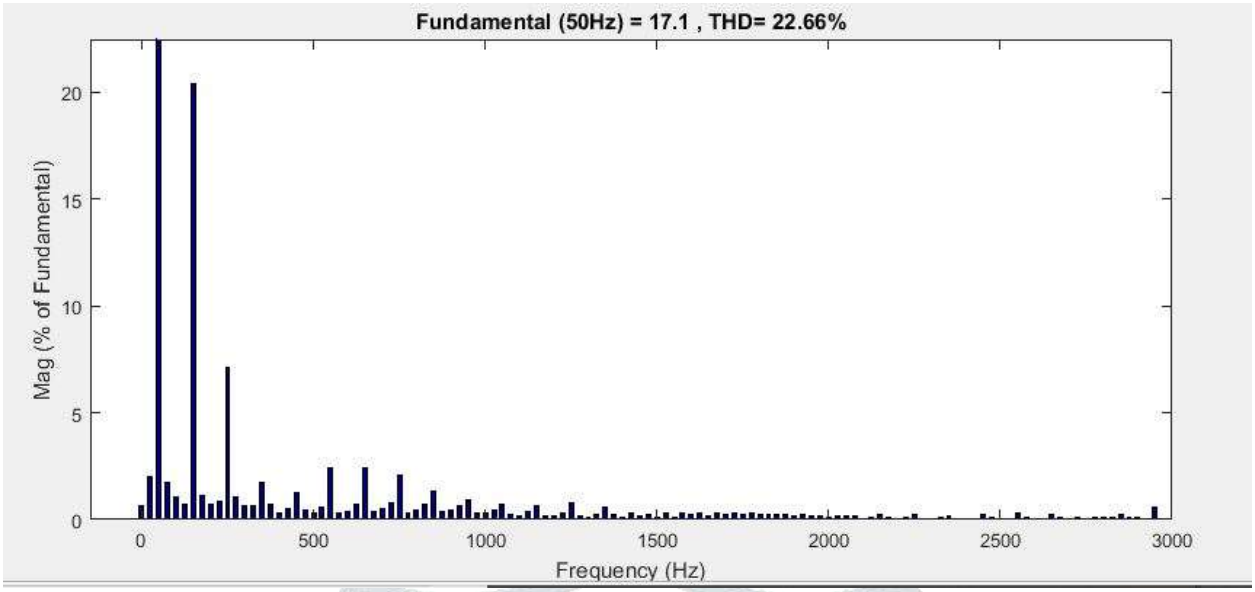

Fig.10. FFT analysis of load current without DVR

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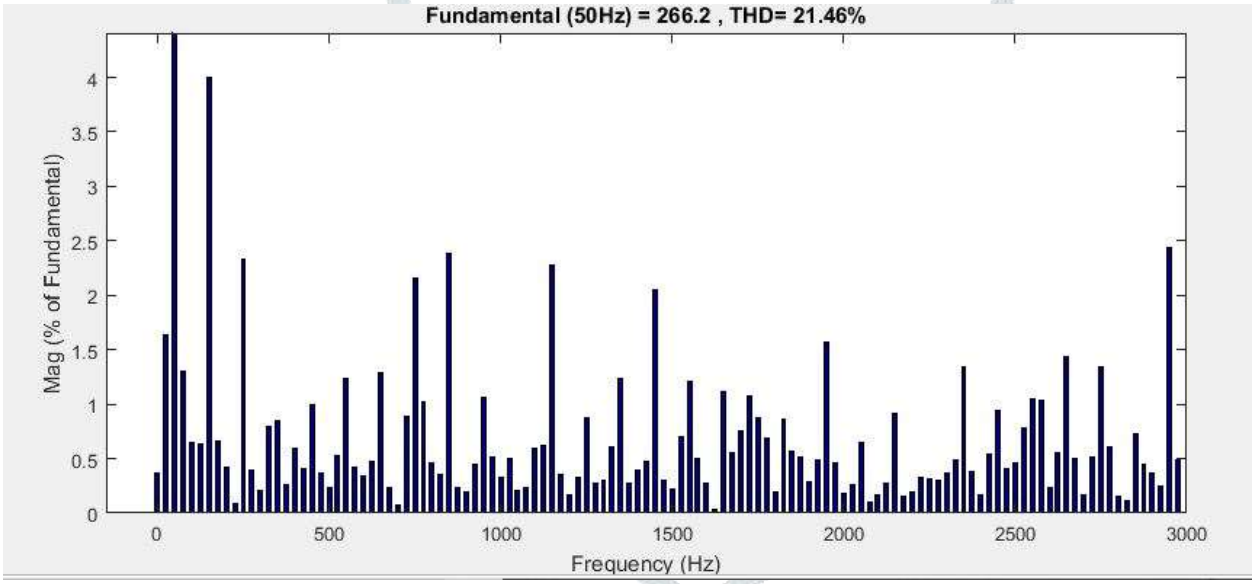

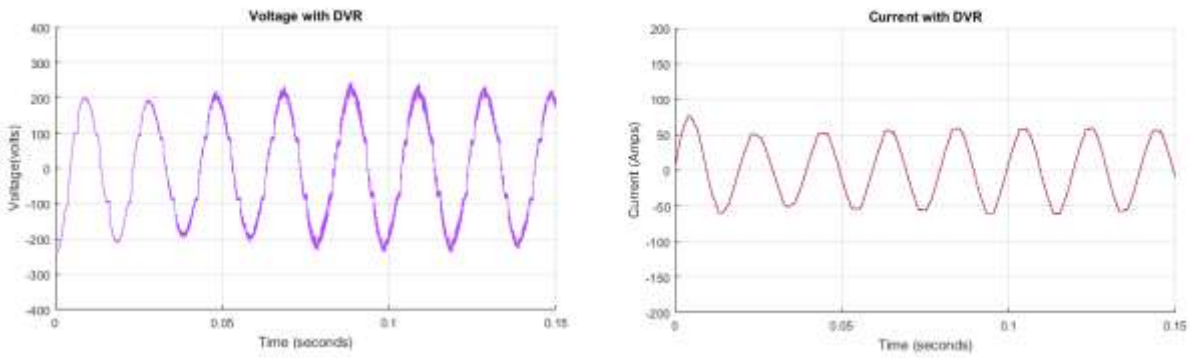

Fig.12. load voltage and current waveforms of microgrid with DVR.

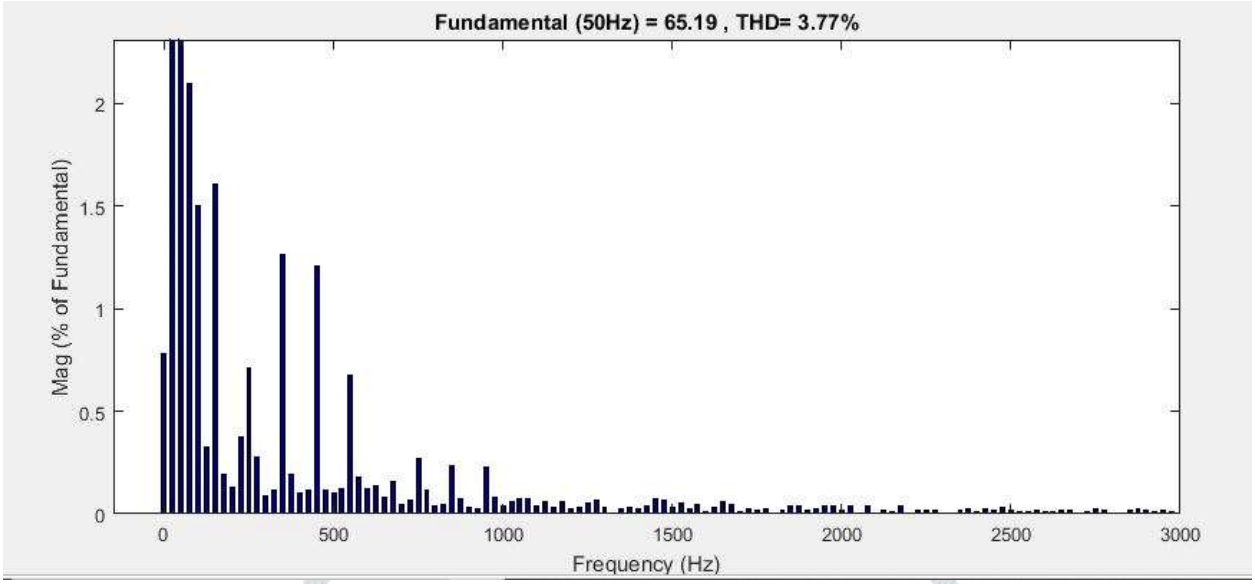

Fig.13. FFT analysis of load current with DVR

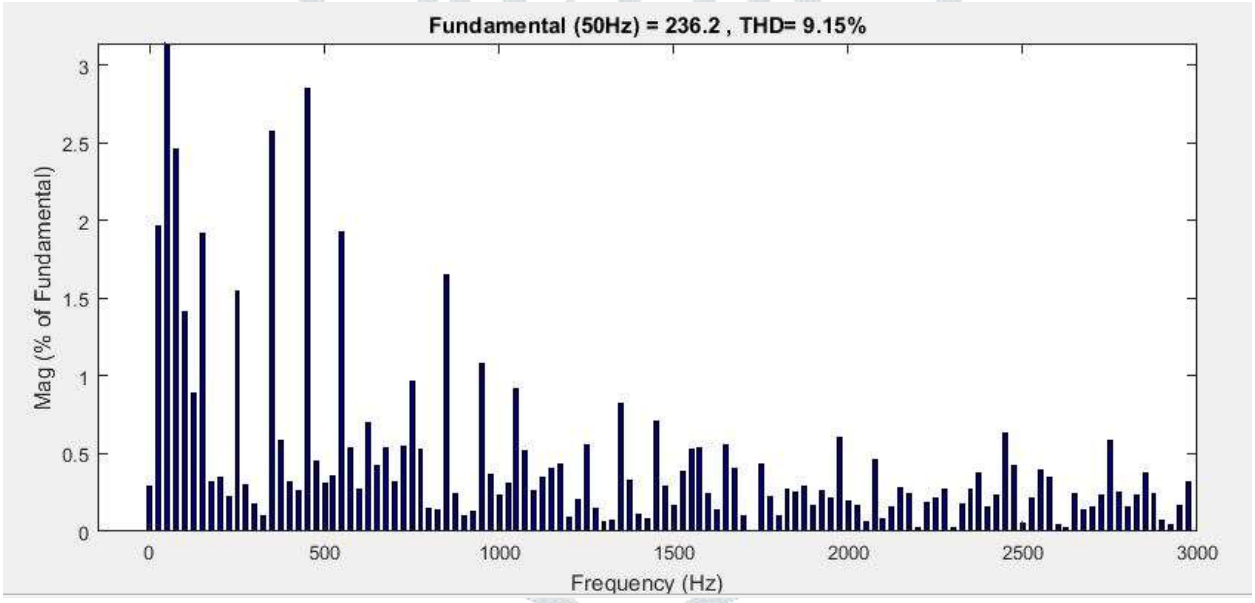

Fig.14.FFT analysis of load voltage with DVR

5.1.OBSERVATIONS TABLE

	LOAD VOLTAGE THD(%)	LOAD CURRENT THD(%)
WITH OUT DVR	21.46	22.66
WITH DVR	8.91	3.02

6.CONCLUSION

In this paper, the hybrid grid system configuration is done in MATLAB/SIMULINK environment. FACTS devices are one of the best methods to improve the power quality in a system. Here in this paper load side system voltages and currents are calculated and the harmonics are reduced using Dynamic Voltage Restorer with synchronous reference frame theory. The hybrid grid may also be feasible for some small isolated industrial plants with both PV system and wind turbine generator as the major power supply. The ability of MG to island generation and loads together has a potential to provide a higher local reliability than that provided by the power system. Among various techniques reviewed and considering future scope, more case studies of actual sites of MG can be done and some extended emphasis should be laid on issues of micro grid like protection issues, power system stability and further the implementation of FACTS devices in existing micro grid can help to maintain power quality and better power flow and all of these can be analyzed in MATLAB.

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