



# **FFT Analysis of THD in Distribution System with Grid Connected RES**

Avinash Kumar Tiwari<sup>1</sup>, A.K.Jhala<sup>2</sup>

PG Scholar, Department of EE, RKDF College of Engg, Bhopal, M.P., India<sup>1</sup>

Head, Department of EE, RKDF College of Engg, Bhopal, M.P., India<sup>2</sup>

**ABSTRACT:** To preserve the conventional fuels for the long time and to reduce the other environmental issues it is important to use the non-conventional energy sources/renewable energy sources in large extent for electrical power generation. The use of the power electronic converters is important, when the renewable sources connecting to distribution system (3-phase 4-wire). This system is most economic and reliable when there are maximum benefits from grid interfacing inverters. This grid interfacing inverters thus can be utilized multifunction device as-

- 1) Power converter to supply generated power from RES to grid, and
- 2) Shunt active power filter for compensating distort current, harmonics at load side, reactive power support for load, load neutral current.

These multifunction's may be either accomplished individually or simultaneously. With the use of this technique grid interfacing inverters and 3-phase 4-wire, linear or non-linear unbalanced load combination at point of common couple (PCC) appears as a balanced linear load to the grid. This control technique is to be simulated in MATLAB.

**KEYWORDS:** Active power filter, FFT Analysis, distributed generation (DG) system, point of common couple (PCC), power quality (PQ), and non-conventional energy

## **I.INTRODUCTION**

Fossil fuel resources are our main sources of energy and they are depleting. Fossil fuels are non renewable and environmentally damaging. Due to increasing pollution of air, universal warming concerns, diminishing fossil fuels and their increasing cost have made it necessary to look towards renewable sources as a future energy solution. There are many Renewable Energy Sources (RES) such as wind, solar, tidal power, biomass etc. Solar energy has great potential to supply energy with minimum impact on the environment, since it is clean and pollution free. In finding solutions to overcome a global energy crisis, the Photo Voltaic (PV) system has attracted significant attention in recent years. The government is providing incentives for further increasing the use of grid-connected PV systems. Usually, grid connected photovoltaic energy conversion systems are composed of an inverter.

Renewable Energy Sources are more and more integrated at the distribution level due to increase in load demand which utilize power electronic converters. The widespread use of power electronic devices causes disturbances on the electrical deliver system. The instability are due to the using of non-linear devices. These will introduce harmonics in the power system thereby causing equipment overheating, damage devices, EMI related problems etc. Harmonics is considered as one of the most essential problem in electrical power systems. Harmonics in power delivery system are current or voltage that are integer multiples of fundamental frequency.

Distributed generation (DG) is termed as renewable energy source (RES) included at distribution level. The utility is concerned due to the high saturation level of intermittent RES in delivery systems as it may pose a hazard to network in terms of strength, voltage regulation and power-quality (PQ) problems. Consequently, the DG systems are required to fulfill with strict technical and regulatory frameworks to guarantee secure, reliable and efficient operation of overall system. Due to the innovation in power electronics and digital control technology, the DG system can now be actively controlled to improve the system operation with enhanced PQ at the PCC. Nevertheless, the widespread use of power electronics based equipment and non-linear loads at PCC produce harmonic currents, which may weaken the quality of power. Usually, the current controlled voltage source inverter is of choice to interface the irregular RES in distributed system. In recent times, only some control strategies for grid coupled inverters incorporating PQ solution have been proposed. Inverter operates as active inductor at a definite frequency to absorb the

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harmonic current. Except the exact calculation of network inductance in real-time is difficult and may decline the control performance.

## II. SYSTEM MODEL AND DESCRIPTION

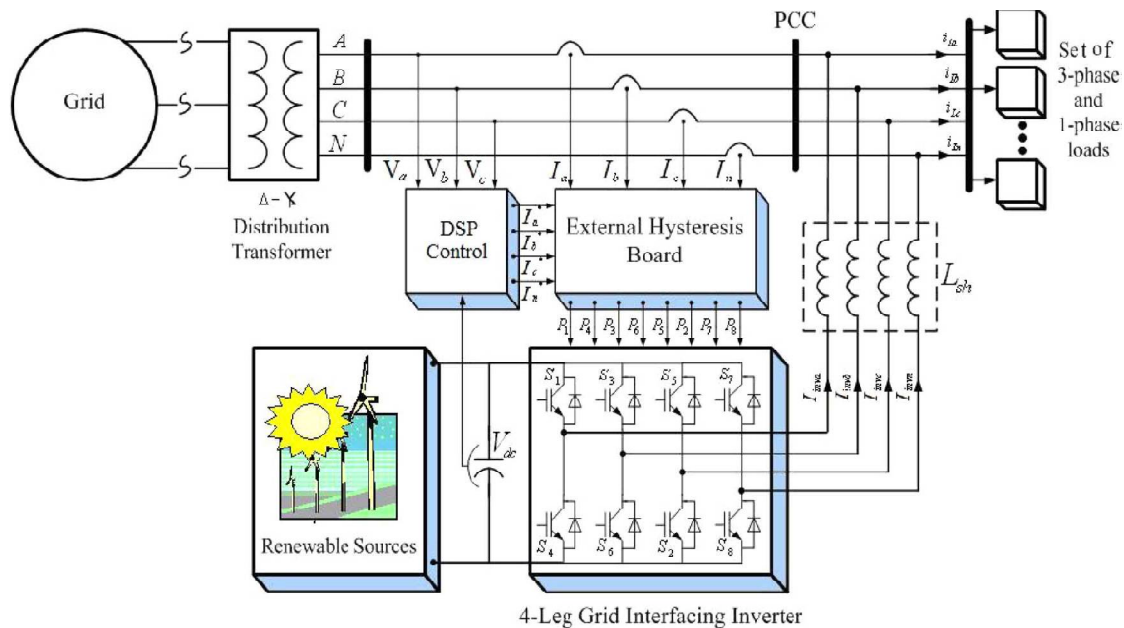


Fig. 1. Schematic of proposed distributed generation system

The parallel approach which includes a shunt active filter, acts as active conductance to damp out the harmonics in distribution network is proposed. The control strategy for non-conventional sources interfacing inverter based on – theory is proposed i. This technique includes both load and inverter current sensing to compensate the load current harmonics.

However, because of the increased popularity of electronic and non linear loads, current and voltage waveforms become distorted. This deviation from a perfect sine wave can be represented by harmonic components having a frequency that is an integral multiple of the fundamental frequency. Thus, a pure voltage or current sine wave has no distortion and no harmonics and a non sinusoidal wave has distortion and harmonics, thus lead’s a serious PQ problem in the power system. To compensate these load current harmonics and unbalance in load at distribution level use of active power filter is of great importance. But this results in an additional hardware cost. However, in this paper the features of APF are included in the, conventional inverter interfacing renewable with the grid, not including any extra hardware cost.

cost. Here, the grid interfacing inverter can be effectively utilized to perform following important functions as-

- 1) transfer of active power from the renewable resources.
- 2) reactive power support to load;
- 3) compensation of current harmonics at PCC; and
- 4) unbalance and neutral current compensation in case of 3-phase 4-wire structure.

The PQ constraints at the PCC can be therefore strictly maintained within utility standards without additional hardware cost. With such a control the combination of grid interfacing inverter and the 3-phase 4-wire linear or non-linear unbalanced load at point of common coupling appears as the balanced linear load to grid side.

## III. PROPOSED CONTROL TECHNIQUE

The dc link voltage,  $V_{dc}$  is sensed at a regular interval and is compared with its reference counterpart  $V_{dc}^*$ . The error signal is processed in a PI-controller. The output of the PI controller is denoted as  $I_m$ . The reference current templates ( $I_a^*$ ,  $I_b^*$ , and  $I_c^*$ ) are obtained by multiplying this peak value ( $I_m$ ) by the three-unit sine vectors in phase with the three source voltages. These unit sine vectors are obtained from the three sensed line to neutral voltages. The reference grid

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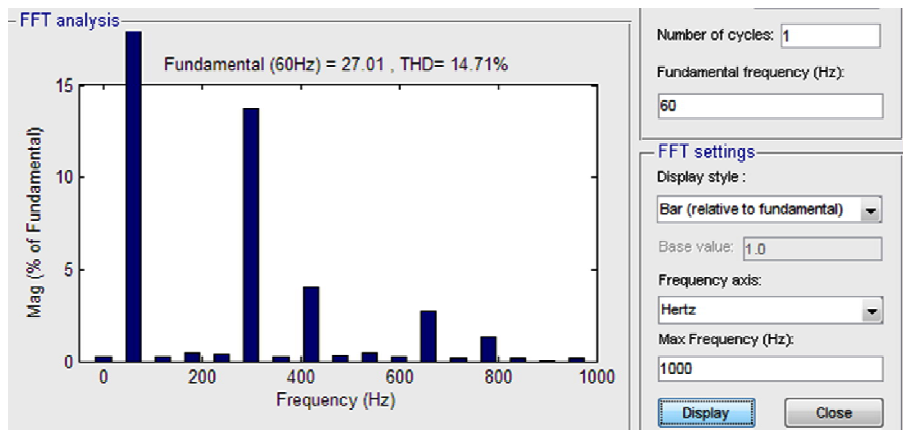
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neutral current ( $I_n^*$ ) is set to zero, being the instantaneous sum of balanced grid currents. Multiplication of magnitude  $I_m$  with phases three-unit sine vectors results in the three phase reference supply currents ( $I_a^*$ ,  $I_b^*$ , and  $I_c^*$ ). The grid synchronizing angle obtained from phase locked loop (PLL) is used to generate unity vector template. The reference grid currents ( $I_a^*$ ,  $I_b^*$ ,  $I_c^*$  and  $I_n^*$ ) are compared with actual grid currents ( $I_a$ ,  $I_b$ ,  $I_c$  and  $I_n$ ) to compute the current errors. These errors are given to hysteresis current controller then generate the switching pulses for six IGBTs of the grid interfacing inverter.

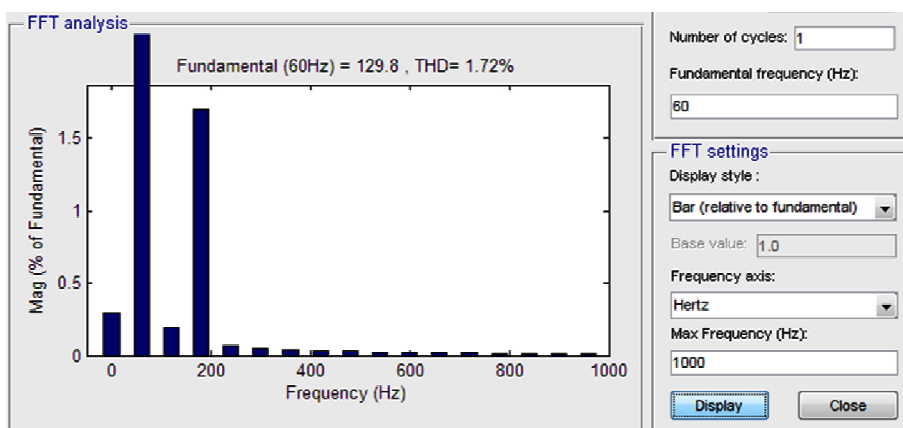
## IV. RESULT AND DISCUSSION

Use of 4- leg grid interfacing inverter it is found that reducing THD in the supply currents for various load conditions. THD at different i.e. phase a, phase b, phase c, are calculated with the help of FFT analysis.

### THD at phase A before inverter act as multifunction:



### THD at phase A after inverter act as multifunction:

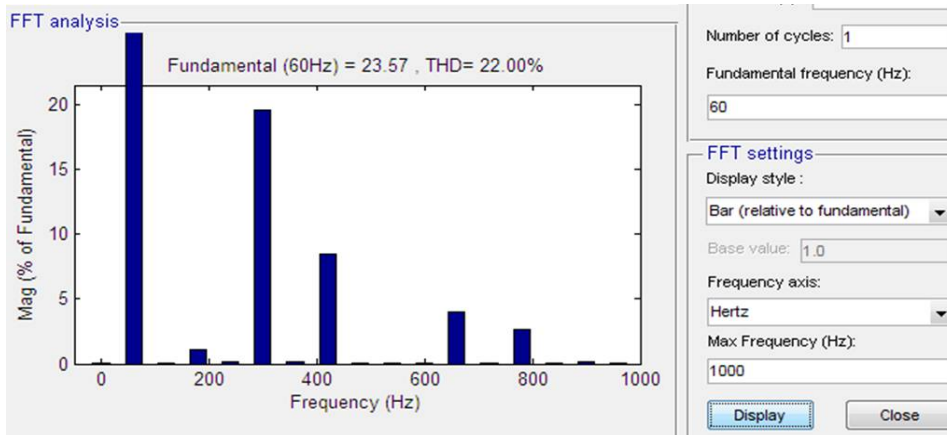


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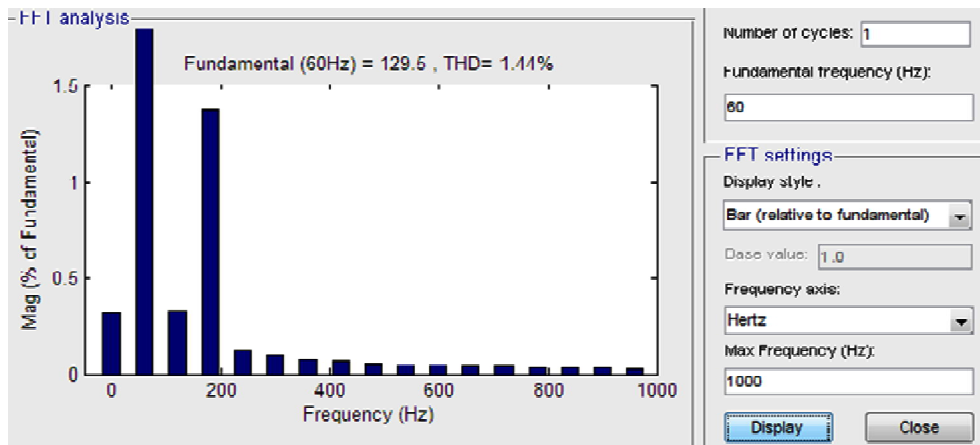
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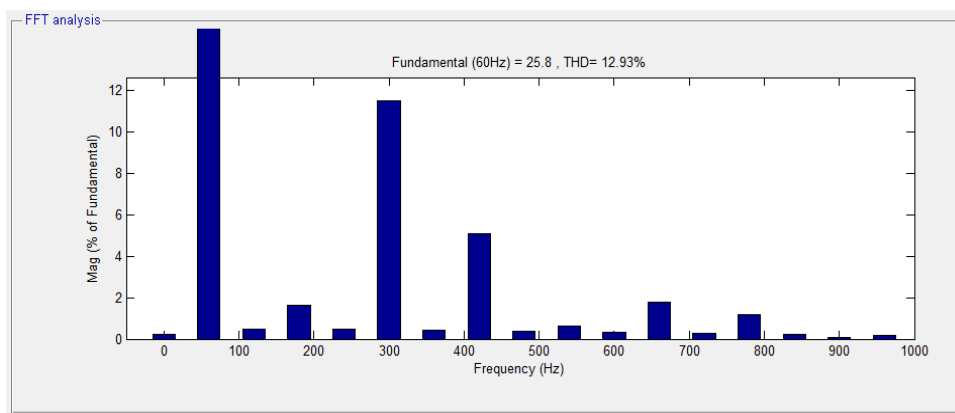
**THD at phase B before inverter act as multifunction:**



**THD at phase B after inverter act as multifunction:**



**THD at phase C before inverter act as multifunction:**



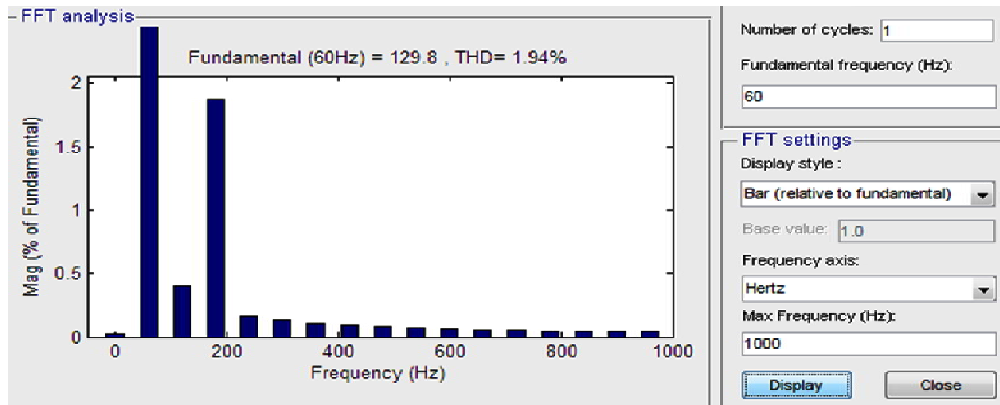


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**THD at phase C after inverter act as multifunction:**



Harmonic distortions at phase a, phase b and phase c currents at point of common coupling before inverter is in operation are observed as 14.71%, 20%, 12.93% respectively. This THD % at phase a, b, c, are much more according to IEEE standard. After inverter is in operation, it is observed that highly unbalanced grid currents, after inverter acting as active power filter, appear as pure sinusoidal balanced set of currents on grid side. And grid current side THD's are reduced to 1.72%, 1.44%, 1.94% for a, b and c phases respectively.

## V. CONCLUSION

From the results, it can be concluded that the grid interfacing inverter is functioning as a conventional inverter as well as an Active Power Filter. It can also be concluded that the grid interfacing inverter is maintaining sinusoidal source current under various load conditions. It is also reducing THD in the supply currents for various load conditions.

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