RENEWABLE ENERGY BASED BIDIRECTIONAL DC – DC CONVERTER WITH ZVS IN DC MICROGRID OPERATION

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***Abstract:**Hybrid power system is able to reduce energy storage needs. There is increasing require for the use of alternate or renewable energy sources to accomplish clean and low cost electricity for Residential Application. This document intend a novel integrated converter topology for interfacing between the dc bus for a residential micro grid application The renewable resources like solar energy, wind energy, fuel cells, biomass energy, etc. are interconnect using various power electronics converters.This paper presents integration of solar energy, wind energy, fuel cells resources for distribution level using Bidirectional DC – DC converter and its control strategy to attain the voltage outline of scheme. Generally the powers produced from these renewable sources are integrated by a variety of converters facing between dc-link. The key factor of a distributed generation voltage is Bidirectional converter as it interface to renewable energy source to the grid and distributes the generated power. This concept of interconnection of solar, wind, Fuel cell energy is designed and simulated in MATLAB-Simulink for non-linear load. Keywords: DC bus interconnection, micro grid, dc–dc converter, power converter integration.*

***Keywords:** Microgrid, ZVS, Renewable energy, Bidirectional DC-DC converter, Grid.*

I. INTRODUCTION

The diffusion of renewable energy in present power system, micro grid has urbanized into an admired application worldwide. In this paper bidirectional DC –DC converters for AC and DC hybrid micro grid purpose are proposed as a well-ordered interface. In the direction of achieve high performance operation and Boost up bidirectional converter with dc-bus voltage regulation and power compensation in Ac-micro-grid utilize.

RES are included at distribution level is named as distributed generation (DG). A Bidirectional DC to DC converters are used for conversion of power to standard bus voltage and its control strategy to achieve the voltage profile of the system. Bidirectional DC to DC converters have the advantages of the low total harmonic distortion (THD) due to increase in level of converters. There is a benchmark current loop for dissimilar modes of function to simplicity the conversion among different modes. A power distribution system desires a bi-directional converter to manage the power flow among dc bus and ac grid, and to control the dc bus to certain range of voltages.

To attain dependable zero-voltage switching change in the whole operational range of a standard non-isolated bidirectional dc–dc converter that uses synchronous rectification is anticipated. The advance is based on operation in the discontinuous conduction mode with a constant reversed current of satisfactory amplitude, which is attained by load-dependent dissimilarity on switching frequency.

II. PROPOSED SYSTEM

The proposed system contains RES linked to the dc link of a grid-interfacing converter as exposed in Figure 1. This arrangement is fit for the stand-alone hybrid power system used in Micro-Grid. Before reaching towards Micro-Grid, the conversions of electricity from wind, solar, fuel cell are carried out. The Three energy sources are connected in parallel to a common DC bus line. Then such a DC power is boost up with Bidirectional DC – DC converted and is converted back to AC power using three phase inverter.

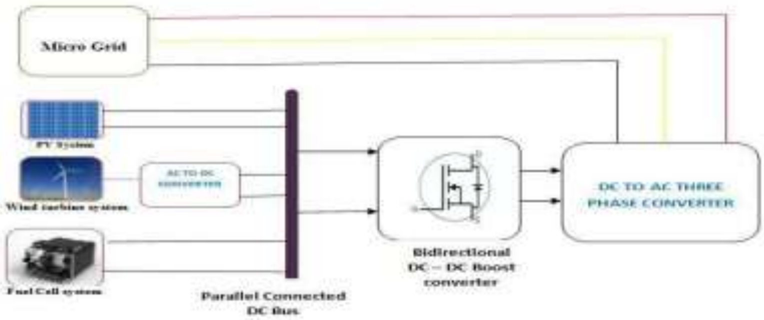


Figure 1: Grid interconnection of RES

The bidirectional DC to DC converter is a key factor interface of renewable energy source to the grid and produces the generated power. In case of photo voltaic system generated power is at very low DC voltage while wind turbine generates power at AC voltage.

A. Modelling of PV System

The photovoltaic cell generates DC electricity when sunlight falls in solar cells. PV cell is extremely related to that of the standard diode with a PN junction produced by semiconductor material. When the junction takes up light, the energy of absorbed photon is shifted to the electron-proton system of the material, developed charge carriers that are divided at the junction. The charge carriers in the junction area appear a potential gradient acquire speed up in the electric field, and flow as current during an external circuit. To obtain elevated power, many cells are linked in series and parallel circuits on a panel; the solar array is a collection of a several modules electrically linked in series parallel arrangement to generate the vital current and voltage.

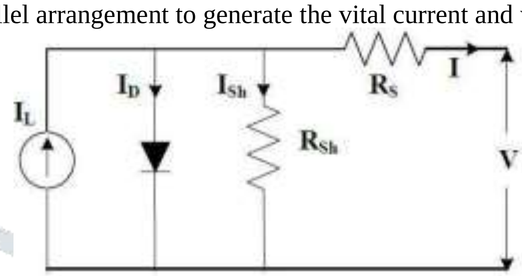


Figure 2: Photo-Voltaic model

As shown in Figure 2, a solar cell can be represented by a current source parallel with a diode, a high resistance and series with a tiny resistance. The above model consist of one diode, current source, internal shunt resistance (R_{Sh}) and a series resistance (R_S) that signifies the resistance in every cell of module. The total current (I) which is given by solar panel is the difference between the photo current and the normal diode current (I_D).
Photo-Voltaic cell is a P-N junction. When light happening lying on P-N junction of solar cell, electron gap pair off is produced in the depletion layer of solar cell. So if a load is connected to the terminal of solar cell, the overload charges i.e. a current flow through the load.

B. Modelling of Wind system

Wind is normal observable fact connected to group of air loads effects mainly with the disparity solar heat of the earth's shell. The wind turbine confines the wind kinetic energy in a rotor contains two or extra blades automatically together to an electrical generator. A significant factor in how greatly your wind turbine will create is the stature of its loom therefore turbine be mounted on

a tall tower to improve the energy capture for input to wind generator i.e. asynchronous machine.

$^{P}\text{mech}^{=}$ (1)

Where *ρ* is the air density, *at* is the area swept out by the turbine blades, *Vω* is the wind velocity, and *CP* is the power coefficient and symbolized the efficiency of the wind turbine.

C. Modelling of Fuel Cell System

A fuel cell is an electrochemical device which changes the chemical energy of a fuel and an oxidant directly into electrical power. The basic material structure of a single cell contains an electrolyte layer get in touch with a permeable anode and cathode on both sides. In a representative fuel cell, fizzy fuels be complete incessantly to the anode and an oxidant (i.e., oxygen from air) is supplied incessantly to the cathode (positive electrode) section; the electrochemical reactions occur at the electrodes to produce an electric current (Fig. 3).

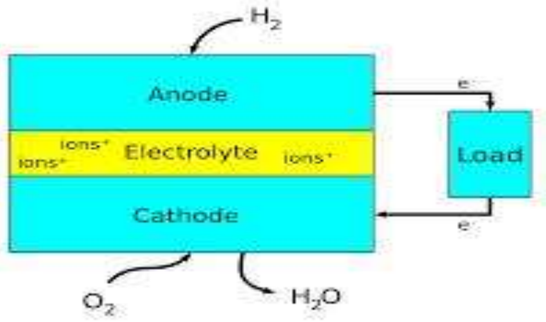


Figure 3: Modelling of Fuel Cell System

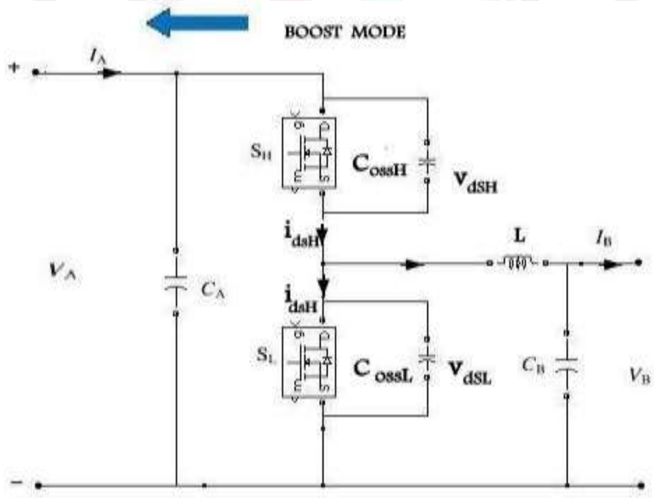
In the case of a fuel cell with an acid electrolyte the electrochemical reactions are:

Anode reaction: $H^2 \rightarrow 2H^+ + 2e^-$
Cathode reaction: $1/2O_2 + 2H^+ + 2e^- \rightarrow H_2O$
Overall reaction: $H_2 + 1/2O_2 \rightarrow H_2O$ + heat (exothermic reaction=-286 kJmol^{-1})

A fuel cell, while having components and characteristics similar to individuals of a typical battery, differs in several respects. The battery is an power storage device and the available energy is find out by the chemical reactant stored within the battery itself. The battery will finish producing electrical energy when the chemical reactants are addicted. In a secondary battery (fuel cell), the reactants are incessantly full from an external source.

III. BIDIRECTIONAL DC – DC CONVERTER

These converters over usual single-switch buck or boost converters is in the lesser transmission losses got by reinstate the freewheeling diode with a power transistor.



This operation focuses on switching transitions in zero voltage condition in a DCM-operated synchronous dc–dc converter. On the stands of a detailed analysis, it gives guidelines for determining the required reversed current and dead time duration for ensuring ZVS capability in the entire effective choice of the converter.

To achieve ZVS in a conventional dc–dc converter that operates synchronous rectification is by operating the converter in the DCM. The converter shown in Fig. 4. Two operating modes, depends on the direction of the main energy flow. While the standard inductor current $I_{L,avg}$ flow in the direction from V_A to V_B, the converter works in buck mode, in which SH perform main-FET and SL as a sync-FET. If $I_{L,avg}$ flows in the opposite direction, the operation of two transistors in the circuit are exchanged shown in Figure 4.

A. Zero Voltage Switching In DCM

S_H is twisted OFF, the main transition period begins. Assume to facilitate the dead time is extended as much as necessary, the inductor current I_L totally discharges C_{ossL}, while C_{ossH} is concurrently stimulating to the input voltage V_A. Once the drain-to-source voltage v_{dsL} crosswise S_L falls to zero, the diode of the sync FET gets over current. In the next phase, the sync FETSL is naturally turned on at zero voltage in both CCM and DCM. The anti-parallel body diode of the main FETS$_H$ does not take over any current during this transition and therefore the absence of reverse recovery effect in the main-FETs of the synchronous dc–dc converters.

B. Zero-Voltage Turn-On of the Main-FET

An adequately extended dead time, i.e., time interval among turn-off the main FET and turn-ON the sync FET. As the main FET is twisted OFF at the pinnacle inductor current, which charges its scrounging output capacitance to the voltage V_A and discharges the scrounging capacitor across the sync FET in a slightly small instance, a secure to smallest necessary dead time for stopping immediate transference of equally transistors is enough for attain zero-voltage switch on of the sync FET. Additionally, an extreme dead time does not stand for a risk of trailing ZVS, as there is no device that would source the upturned procedure of renews the parasitic capacitor transversely the sync FET after it is once discharged. An extreme dead time simply source a small enlargement in overall conduction losses caused by a longer conduction period of the main FET's body diode.

IV. SIMULATION MODEL

A. Simulink Model of PV Model

Figure 5 explains the simulation model of PV system this clarifies detail about the every PV cell characteristic. Output of the PV cell is connected to parallel with other renewable sources and fed to the constant DC Bus.

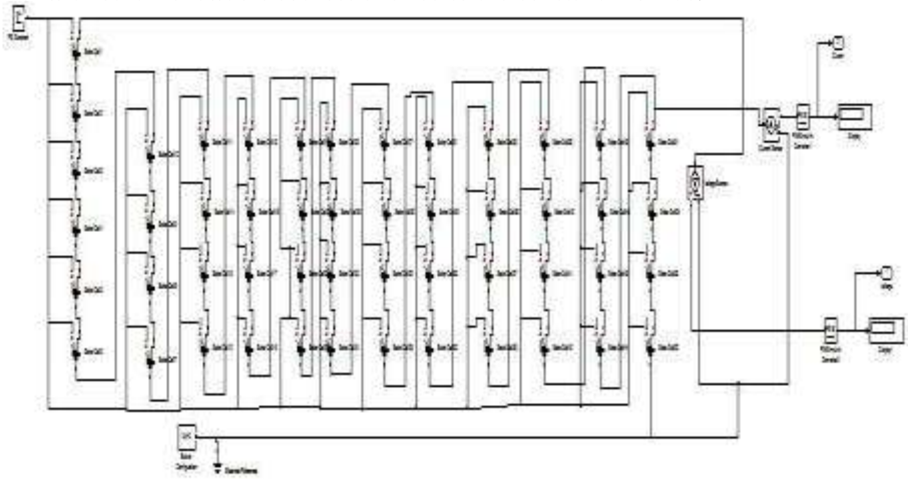


Figure 5: Simulation model of PV system

B. Simulink Model of Wind Turbine

Figure. 6 shown the simulation model of wind turbine. Turbine is main component of wind energy generation system. Design of turbines coverts the wind energy into the mechanical power. This mechanical power is distributed to the rotor of asynchronous generator which coverts it into the electrical form. Output of this system is AC and supply to the bridge rectifier to convert into DC form for constant DC bus voltage.

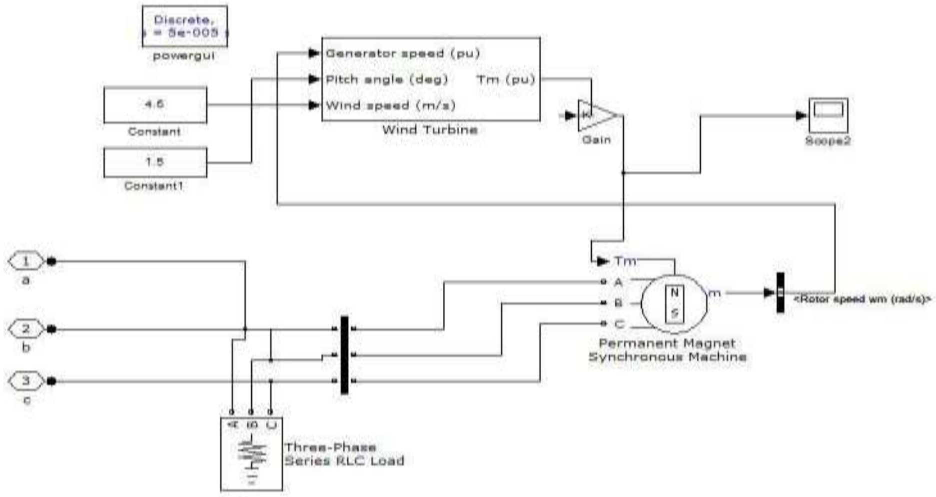


Figure 6: Simulation model of Wind system

C. Simulation Model Of Fuel Cell Model

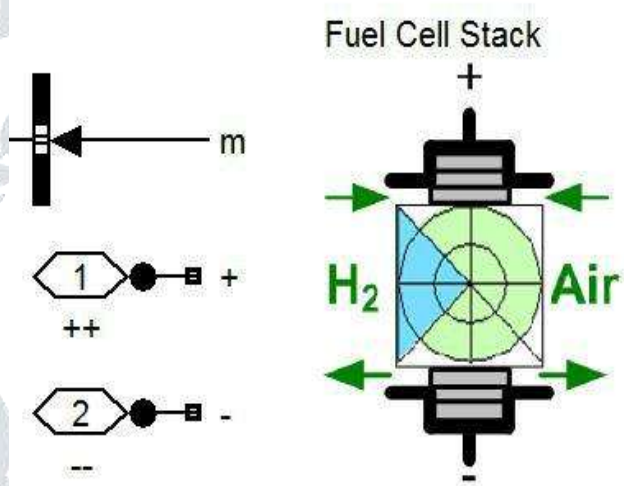


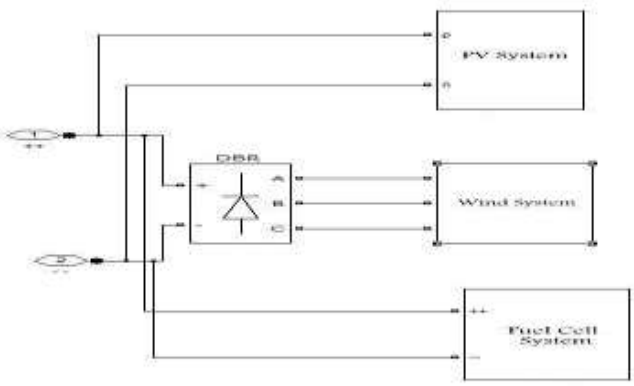
Figure 7: Simulation Model of Fuel Cell system

Figure 7 explains the simulation model of Fuel Cell system. This explains detail about the Fuel Cell characteristic. Output of the Fuel Cell is connected to parallel with other renewable sources and fed to the constant DC Bus.

D. Hybrid Renewable System

The hybrid unit has three total generating plants, a PV solar cell plant, and wind-turbine and fuel cell system. These sources are connected in parallel to a 420V DC line. The wind system output is connected to an AC/DC Rectifier. The overall project arrangement is given in Figure 8.

Figure 8: A simple hybrid solar, wind & Fuel cell system



E. Simulink Model of Proposed Hybrid System

Figure 9 shows the simulation model of hybrid system. Three renewable system output is parallel given to the DC – DC bidirectional converter. This output is fed to three phase converter with PWN technique. Three phase converter output is fed to Micro Grid through a L – C Filter Circuit breakers are used for protection.

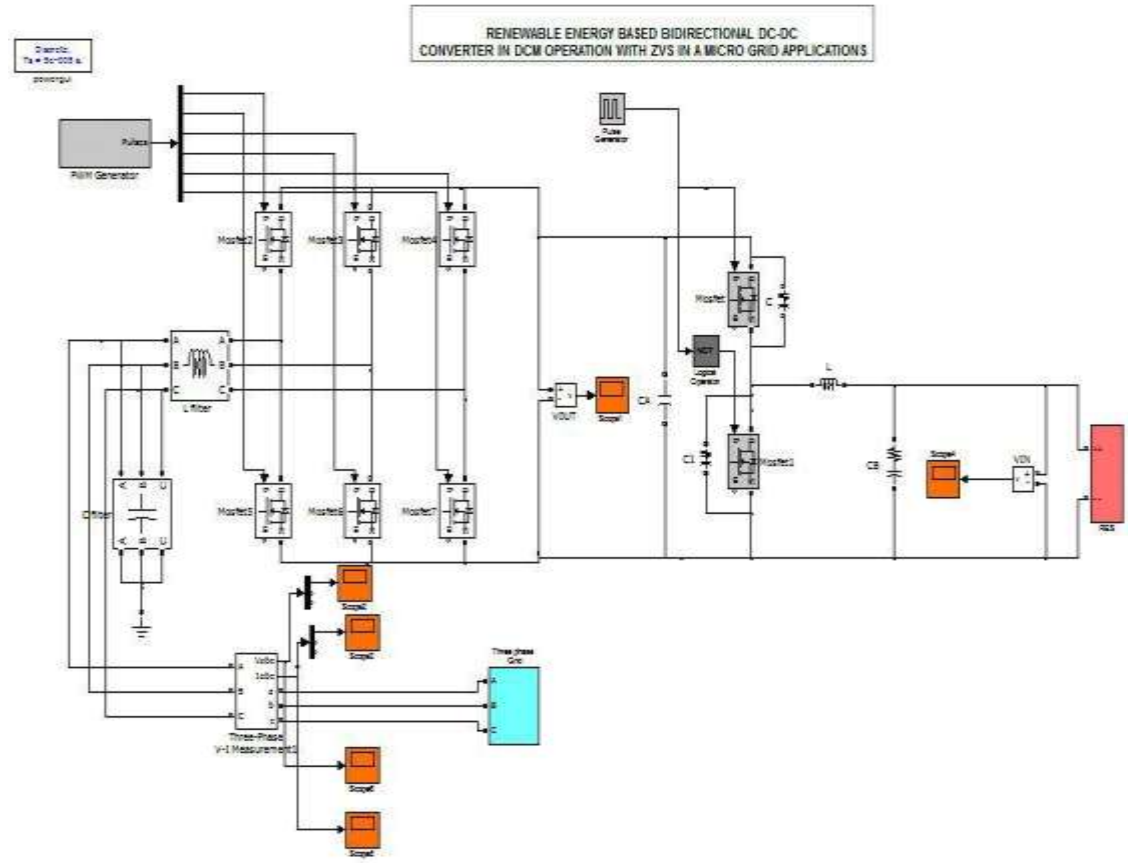


Figure 9: Simulation model of hybrid system

V. SIMULATION RESULTS

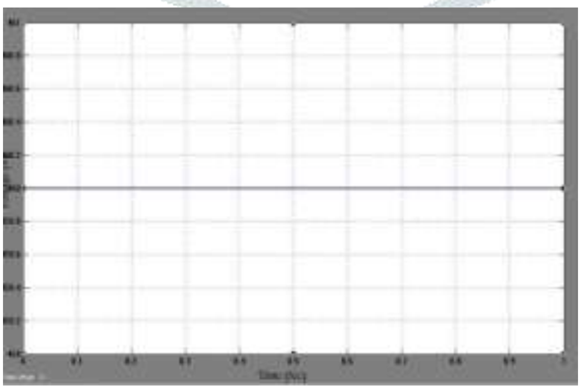


Figure 10: Output voltage (460 V DC) from hybrid system

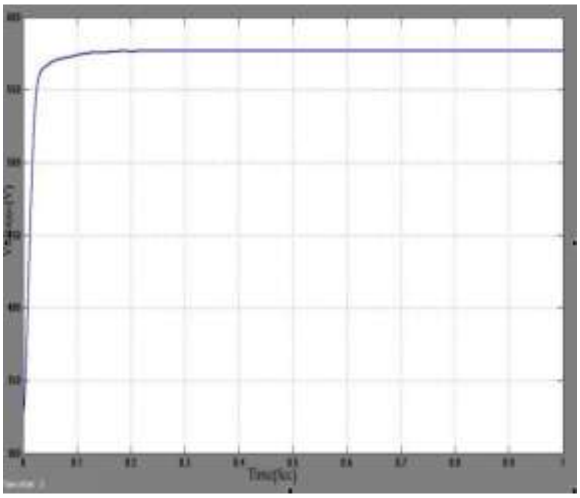


Figure 11: Output voltage (580 DC V) from Bidirectional DC – DC converter (Boost Mode)

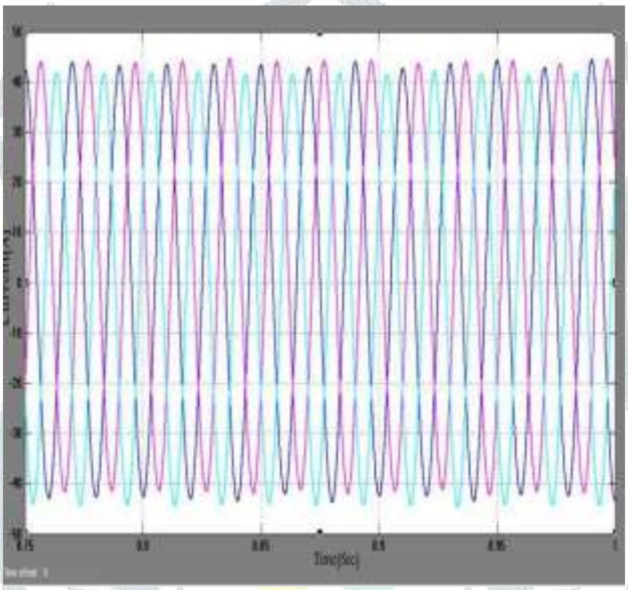


Figure 12: Output three phase current from three phase inverter is connected to Micro grid

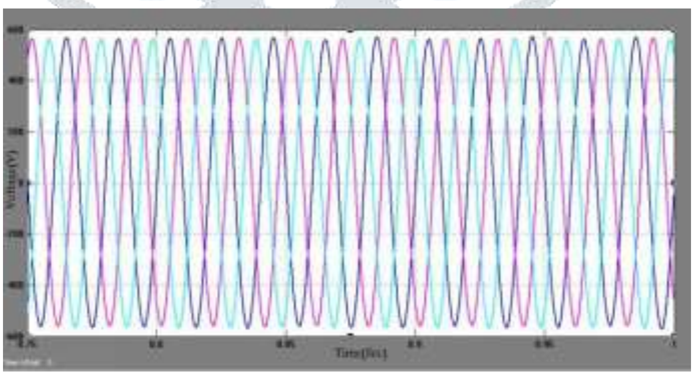


Figure 13: Output three phase voltage (580 V AC) from three phase inverter is connected to micro grid

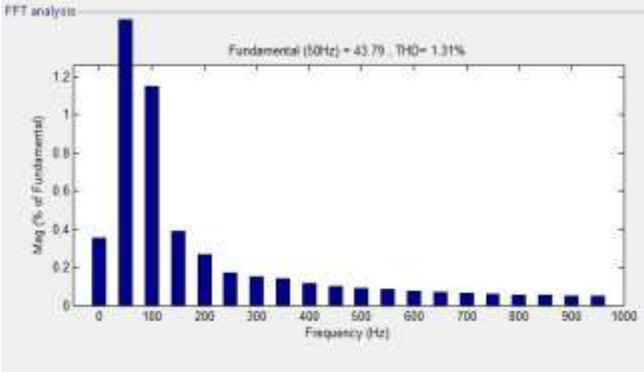


Figure 14: FFT Analysis of Renewable energy based Bidirectional DC–DC DCM (1.31%)

VI. CONCLUSION

[1] wind-photovoltaic-fuel cell hybrid energy system for stand-alone operation is proposed in this paper. The plan and investigation of this revelation type ultra-low emission energy system are offered. System dynamic modelling, simulation, and design of controller are reported in this work. All system models were described through mathematical aspect. Results show that the effectiveness of this hybrid energy system. Such a system shows its ability to supply a variable load without interruption. The system is more reliable in comparison to a wind-fuel cell hybrid system, because of three systems in parallel and their different characteristics. It is more economical to supply the load by this hybrid energy system because it doesn't need the fuel cell to work all day long. The system performance can satisfy the user in all perspectives. It could regulate the output power properly while its transients were damped very quickly.

REFERENCES

[1] D.-Y. Jung, S.-H Hwang, Y.-H Ji, J.-H Lee, Y.- Jung and C Won, "Soft-switching bidirectional dc/dc converter with a LC series resonant circuit," IEEE Trans. Power Electron., vol. 28, no. 4, pp. 1680–1690, Apr. 2013

[2] J. Baek, W. Choi, and B. Cho, "Digital control of synchronous buck converter with multi-mode for wide load range," in Proc. 7th Int. Conf Power Electron Motion Control Conf., Jun. 2012, vol. 4, pp. 3028–3032.

[3] Stankovic, L. Nerone, and P. Kulkarni, "Modified synchronous-buck converter for a dimmable hid electronic ballast," IEEE Trans. Ind. Electron., vol. 59, no. 4, pp. 1815–1824, Apr. 2012.

[4] D. Sable, F. Lee, and B. Cho, "A zero-voltage-switching bidirectional battery charger/discharger for the NASA EOS satellite," in Proc. 7th Annu. Appl. Power Electron. Conf. Expo., Feb. 1992, pp. 614–621.

[5] L. Huber, B. Irving, and M. Jovanovic, "Effect of valley switching and switching-frequency limitation on line-current distortions of DCM/CCM boundary boost PFC converters," IEEE Trans. Power Electron., vol. 24, no. 2, pp. 339–347, Feb. 2009.

[6] R. W. Erickson and D. Maksimovic, Fundamentals of Power Electronics, 2nd ed. Norwell, MA, USA: Kluwer, 2001.

[7] J. Arrigo, "Input and output capacitor selection," Texas Instrum., Dallas, TX, USA, Appl. Rep. SLTA055, 2006.

[8] (2015). Magnetics Powder Cores: High Flux Cores. [Online]. Available: http://www.mag-inc.com/products/powder-cores/high-flux-cores

[9] X. Zhou, M. Donati, L. Amoroso, and F. Lee, "Improved light-load efficiency for synchronous rectifier voltage regulator module," IEEE Trans. Power

[10] K. Zhang, S. Luo, T. Wu, "New insights on dynamic voltage scaling of multiphase synchronous buck converter: IEEE Trans. Power Electron., vol. 29, no. 4, pp. 1927–1940, Apr. 2014.