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# Energy Management System Based On Dc-Dc Converter For Micro Grid Using Hybrid Energy Sources

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***ABSTRACT: This project presents a control of a micro-grid at an isolated location fed from wind and solar based hybrid energy sources. The machine used for wind energy conversion is doubly fed induction generator (DFIG) and a battery bank is connected to a common DC bus of them. A solar photovoltaic (PV) array is used to convert solar power, which is evacuated at the common DC bus of DFIG using a DC-DC Luo converter in a cost-effective way. The voltage and frequency are controlled through an indirect vector control of the line side converter, which is incorporated with droop characteristics. It alters the frequency set point based on the energy level of the battery, which slows down over charging or discharging of the battery. The system is also able to work when wind power source is unavailable. Both wind and solar energy blocks, have maximum power point tracking (MPPT) in their control algorithm. The system is designed for complete automatic operation taking consideration of all the practical conditions. The system is also provided with a provision of external power support for the battery charging without any additional requirement. Neuro Fuzzy logic algorithm is used to track the power from PV system. A simulation model of system is developed in MATLAB environment and simulation results are presented for various conditions e.g. unviability of wind or solar energies, unbalanced and nonlinear loads, low state of charge of the battery.***

***Keywords: maximum power point tracking, doubly fed induction generator***

## 1. INTRODUCTION

As electric distribution technology steps into the next century, many trends are becoming noticeable that will change the requirements of energy delivery. The microgrid often supplies both electricity and heat to the customers by means of combined heat and power plants (CHP), gas turbines, fuel cells, photovoltaic (PV) systems, wind turbines, etc[2]. The energy storage systems usually include batteries and flywheels. Clearly, distributed generation located close to loads will reduce flows in transmission and distribution circuits with two important effects: loss reduction and ability to potentially substitute for network assets. Microgrids can offer network support during the time of stress by relieving congestions and aiding restoration after faults[2]. The development of microgrids can contribute to the reduction of emissions and the mitigation of climate changes. This is due to the availability and developing technologies for distributed generation units are based on renewable sources and micro sources that are characterized by very low emissions. There are various advantages offered by microgrids to end-consumers, utilities and society, such as: improved energy efficiency, minimized overall energy consumption, reduced greenhouse gases and pollutant emissions, improved service quality and reliability, cost efficient electricity infrastructure replacement. Technical challenges linked with the operation and controls of microgrids are immense[14]. Ensuring stable operation during network disturbances, maintaining stability and power quality in the islanding mode of operation necessitates the improvement of sophisticated control strategies for microgrids inverters in order to provide stable frequency and voltage in the presence of arbitrarily varying loads. A segmentation of microgrid, i.e. a design of multiple islands or sub microgrids must be supported by micro source and load controllers.

In case of disturbances on the main network, microgrids could potentially disconnect and continue to operate separately. This operation improves power quality to the customer.

- To implement hybrid energy system based three phase micro grid.
- To maintain constant voltage to the DC grid using Modified LUO converter with Neuro fuzzy logic based MPPT algorithm.

## EXISTING SYSTEM

This paper proposes a hybrid ac/dc micro grid to reduce the processes of multiple dc–ac–dc or ac–dc–ac conversions in an individual ac or dc grid. The hybrid grid consists of both ac and dc networks connected together by multi-bidirectional converters[15]. AC sources and loads are connected to the ac network whereas dc sources and loads are tied to the dc network. Energy storage systems can be connected to dc or ac links. The proposed hybrid grid can operate in a grid-tied or autonomous mode. The coordination control algorithms are proposed for smooth power transfer between ac and dc links and for stable system operation under various generation and load conditions. Uncertainty and intermittent characteristics of wind speed, solar irradiation level, ambient temperature, and load are also considered in system control and operation[7]. A small hybrid grid has been modeled and simulated using the Simulink in the MATLAB. The simulation results show that the system can maintain stable operation under the proposed coordination control schemes when the grid is switched from one operating condition to another.

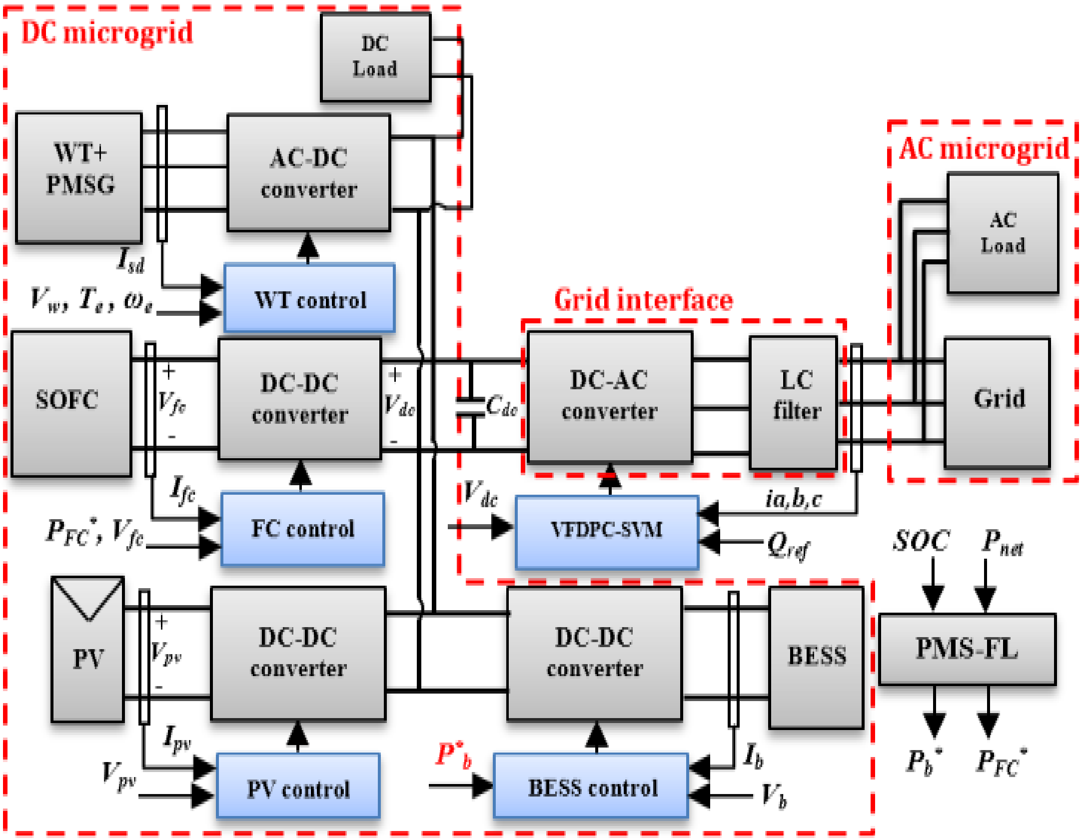

Figure 1 Existing system Block Diagram

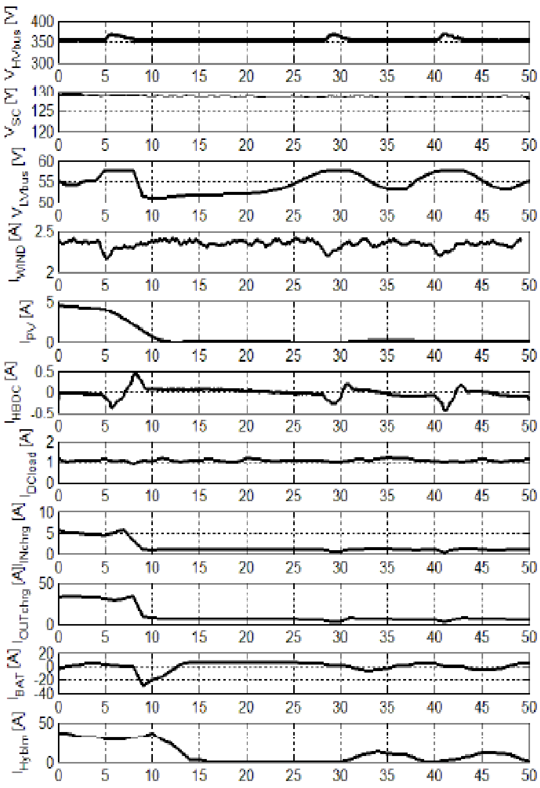
Figure 2 Results of Existing system

## PROPOSED SYSTEM

The concept of microgrid is considered as a collection of loads and micro sources which functions as a single controllable system that provides both power and heat to its local area[7]. This idea offers a new paradigm for the definition of the distributed generation operation. To the utility the microgrid can be thought of as a controlled cell of the power system. For example this cell could be measured as a single dispatch able load, which can reply in seconds to meet the requirements of the transmission system. To the customer the microgrid can be planned to meet their special requirements; such as, enhancement of local reliability, reduction of feeder losses, local voltages support, increased efficiency through use waste heat, voltage sag correction . The main purpose of this concept is to accelerate the recognition of the advantage offered by small scale distributed generators like ability to supply waste heat during the time of need[9]. The microgrid or distribution network subsystem will create less trouble to the utility network than the conventional micro generation if there is proper and intelligent coordination of micro generation and loads.

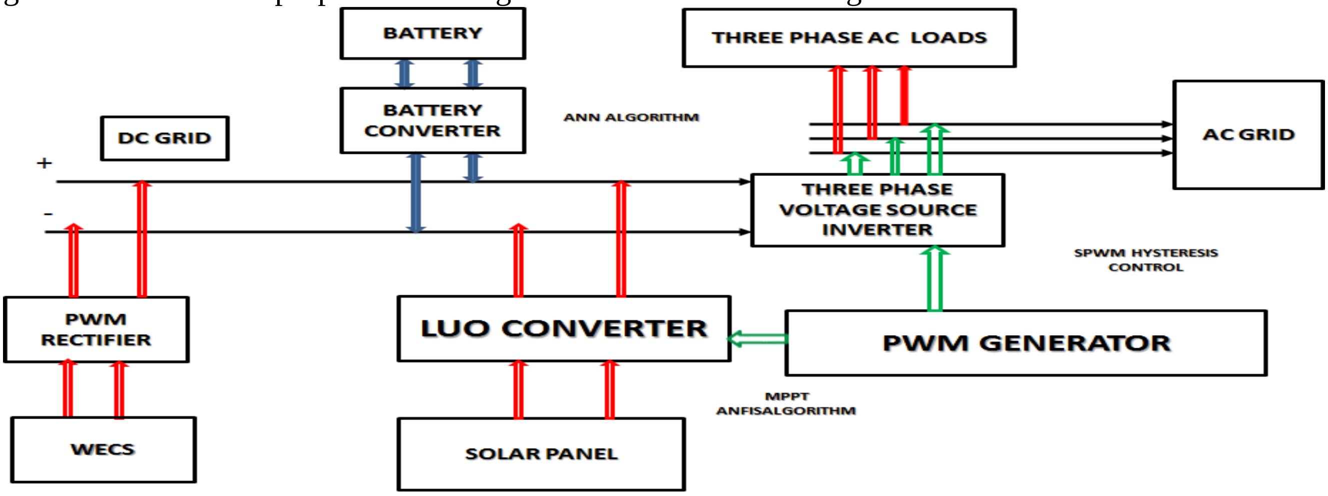


Figure 3 Proposed system Block Diagram

## CIRCUIT DIAGRAM

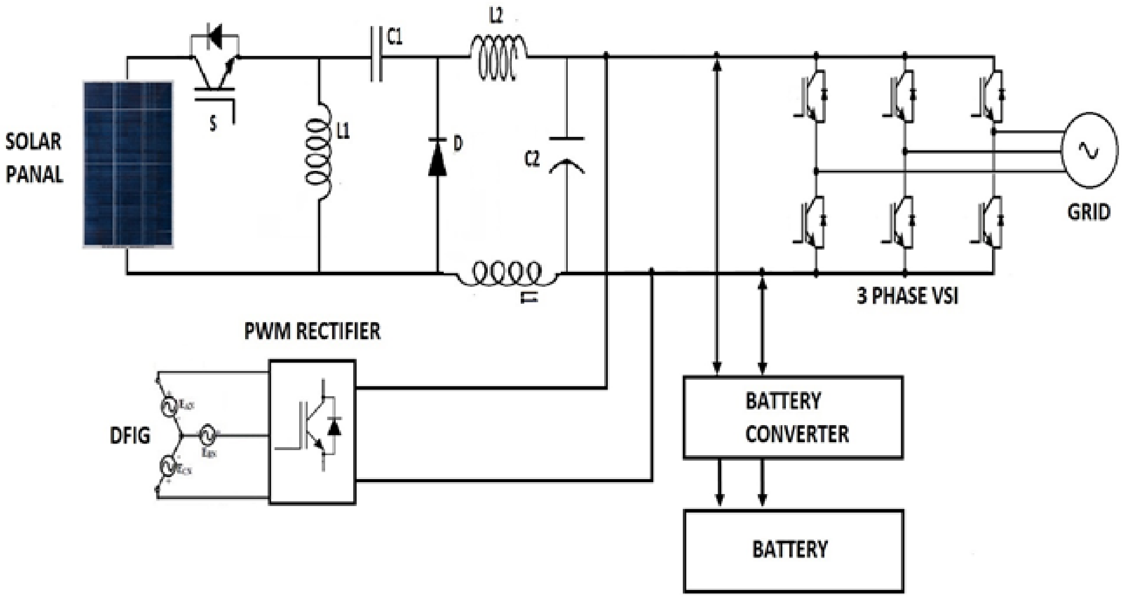


Figure 4 Proposed system circuit diagram

The configuration of the hybrid system is shown,where various AC and DC sources and loads are connected to the corresponding AC and DC networks. The AC and DC links are linked together through two transformers and two four quadrant operating three phase converters. The AC bus of the hybrid grid is tied to the utility grid. It describes the hybrid system configuration which consists of AC and DC grid. The AC and DC grids have their corresponding sources, loads and energy storage elements, and are interconnected by a three phase converter. The AC bus is connected to the utility grid through a transformer and circuit breaker. In the proposed system, PV arrays are connected to the DC bus through boost converter to simulate DC sources. A PMSG wind generation system is connected to AC bus to simulate AC sources. A battery with bidirectional DC/DC converter is connected to DC bus as energy storage. A variable DC and AC load are connected to their DC and AC buses to simulate various loads. PV modules are connected in series and parallel. As solar radiation level and ambient temperature changes the output power of the solar panel alters. A capacitor C is added to the PV terminal in order to suppress high frequency ripples of the PV output voltage. The bidirectional DC/DC converter is designed to maintain the stable DC bus voltage through charging or discharging the battery when the system operates in the autonomous operation mode. The three converters (boost converter, main converter, and bidirectional converter) share a common DC bus[15]. A wind generation system consists of doubly fed induction generator (PMSG) with back to back AC/DC/AC PWM converter connected between the rotor through slip rings and AC bus. The AC and DC buses are coupled through a three phase transformer and a main bidirectional power flow converter to exchange power between DC and AC sides[9]. The transformer helps to step up the AC voltage of the main converter to utility voltage level and to isolate AC and DC grids.

### 3.1 OPERATION OF GRID -GRID TIED MODE

In this mode the main converter is to provide stable DC bus voltage, and required reactive power to exchange power between AC and DC buses. Maximum power can be obtained by controlling the boost converter and wind turbine generators. When output power of DC sources is greater than DC loads the converter acts as inverter and in this situation power flows from DC to AC side[11]. When generation of total power is less than the total load at DC side, the converter injects power from AC to DC side. The converter helps to inject power to the utility grid in case the total power generation is greater than the total load in the hybrid grid[8],. Otherwise hybrid receives power from the utility grid. The role of battery converter is not important in system operation as power is balanced by utility grid.

### 3.2 OPERATION OF GRID -AUTONOMOUS MODE

The battery plays very important role for both power balance and voltage stability. DC bus voltage is maintained stable by battery converter or boost converter. The main converter is controlled to provide stable and high quality AC bus voltage.

### 3.3 INTRODUCTION TO NFLC

Neuro fuzzy logic has rapidly become one of the most successful of today's technology for developing sophisticated control system. With it aid complex requirement so may be implemented in amazingly simple, easily minted and inexpensive controllers. The past few years have witnessed a rapid growth in number and variety of application of Neuro fuzzy logic[12]. The application range from consumer products such as cameras ,camcorder ,washing machines and microwave ovens to industrial process control ,medical instrumentation ,and decision- support system .many decision-making and problem solving tasks are too complex to be understand quantitatively however ,people succeed by using knowledge that is imprecise rather than precise .

Neuro fuzzy logic is all about the relative importance of precision. Neuro fuzzy logic has two different meanings .in a narrow senses, Neuro fuzzy logic is a logical system which is an extension of multi valued logic .but in wider sense Neuro fuzzy logic is synonymous with the theory of Neuro fuzzy sets . Neuro fuzzy set theory is originally introduced by Lotfi Zadeh in the 1960, resembles approximate reasoning in it use of approximate information and uncertainty to generate decisions.

Several studies show, both in simulations and experimental results, that Neuro fuzzy Logic control yields superior results with respect to those obtained by conventional control algorithms thus, in industrial electronics the FLC control has become an attractive solution in controlling the electrical motor drives with large parameter variations like machine tools and robots[15]. However, the FL Controllers design and tuning process is often complex because several quantities, such as membership functions, control rules, input and output gains, etc must be adjusted. The design process of a FLC can be simplified if some of the mentioned quantities are obtained from the parameters of a given Proportional-Integral controller (PIC) for the same application.

## 3.4 NEURO FUZZY LOGIC CONTROLLER

Neuro fuzzy logic expressed operational laws in linguistics terms instead of mathematical equations.

Many systems are too complex to model accurately, even with complex mathematical equations; therefore traditional methods become infeasible in these systems. However Neuro fuzzy logics linguistic terms provide a feasible method for defining the operational characteristics of such system.

Neuro fuzzy logic controller can be considered as a special class of symbolic controller. The configuration of Neuro fuzzy logic controller block diagram is shown.

The Neuro fuzzy logic controller has three main components

- Fuzzification
- Neuro fuzzy inference
- Defuzzification

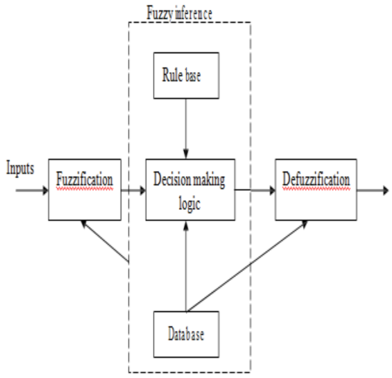


Figure 5 Block Diagram of Neuro fuzzy logic control

## 3.5 FUZZIFICATION

The following functions:

- Multiple measured crisp inputs first must be mapped into Neuro fuzzy membership function this process is called fuzzification.

- Performs a scale mapping that transfers the range of values of input variables into corresponding universes of discourse.
- Performs the function of fuzzification that converts input data into suitable linguistic values which may be viewed as labels of Neuro fuzzy sets.

Neuro fuzzy logic linguistic terms are often expressed in the form of logical implication, such as if- then rules. These rules define a range of values known as Neuro fuzzy membership functions. Neuro fuzzy membership function may be in the form of a triangular, a trapezoidal, a bell or another appropriate form.

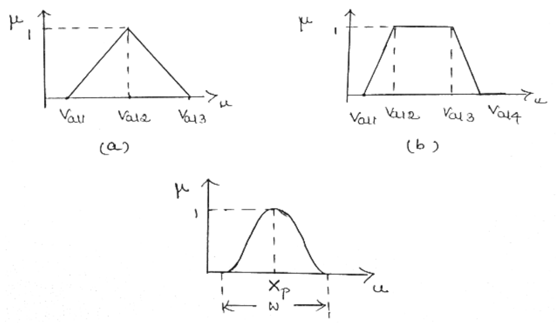


Figure 6 Membership function

The inputs of the Neuro fuzzy controller are expressed in several linguist levels. As shown in Fig. 4.7 these levels can be described as Positive big (PB), Positive medium (PM), Positive small (PS) Negative small (NS), Negative medium (NM), Negative big (NB) or in other levels. Each level is described by Neuro fuzzy set.

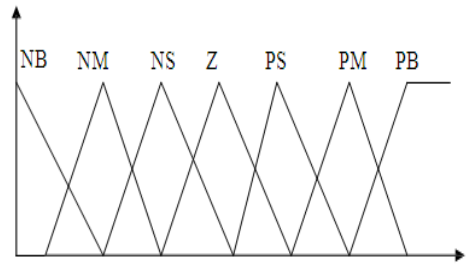


Figure 7 Seven levels of Neuro fuzzy Membership function

### 3.6 NEURO FUZZY INFERENCE

Neuro fuzzy inference is the process of formulating the mapping from a given input to an output using Neuro fuzzy logic[14]. The mapping then provides a basis from which decisions can be made, or patterns discerned. There are two types of Neuro fuzzy inference systems that can be implemented in the Neuro fuzzy Logic Toolbox: Mamdani-type and Sugeno-type[10]. These two types of inference systems vary somewhat in the way outputs are determined.

Neuro fuzzy inference systems have been successfully applied in fields such as automatic control, data classification, decision analysis, expert systems, and computer vision[2]. Because of its multidisciplinary nature, Neuro fuzzy inference systems are associated with a number of names, such as Neuro fuzzy-rule-based systems, Neuro fuzzy expert systems, Neuro fuzzy modeling, Neuro fuzzy associative memory, Neuro fuzzy logic controllers, and simply (and ambiguously) Neuro fuzzy.

The second phase of the Neuro fuzzy logic controller is its Neuro fuzzy inference where the knowledge base and decision making logic reside[6] .The rule base and data base from the knowledge base. The data base contains the description of the input and output variables. The decision making logic evaluates the control rules .the control-rule base can be developed to relate the output action of the controller to the obtained inputs.

### 3.7 DEFUZZIFICATION

The output of the inference mechanism is Neuro fuzzy output variables. The Neuro fuzzy logic controller must convert its internal Neuro fuzzy output variables into crisp values so that the actual system can use these variables. This conversion is called Defuzzification. One may perform this operation in several ways. The commonly used control Defuzzification strategies are

(a).The max criterion method (MAX)

The max criterion produces the point at which the membership function of Neuro fuzzy control action reaches a maximum value.

(b)The height method

The centroid of each membership function for each rule is first evaluated. The final output $U_0$ is then calculated as the average of the individual centroids, weighted by their heights as follows:

$$U_o = \frac{\sum_{i=1}^{n} u_i \mu(u_i)}{\sum_{i=1}^{n} \mu(u_i)}$$

(c) The centroid method or center of area method (COA)

The widely used centroid strategy generates the center of gravity of area bounded by the Membership function are

$$\bar{y} = \frac{\int \mu_Y(y).ydy}{\int \mu_Y(y)dy}$$

## 2. SIMULATION RESULTS

A hybrid microgrid is simulated using MATLAB/SIMULINK environment. The operation is carried out for the grid connected mode. Along with the hybrid microgrid, the performance of the doubly fed induction generator,photovoltaic system is analyzed.The solar irradiation, cell temperature and wind speed are also taken into consideration for the study of hybrid microgrid. The performance analysis is done using simulated results which are found using MATLAB.

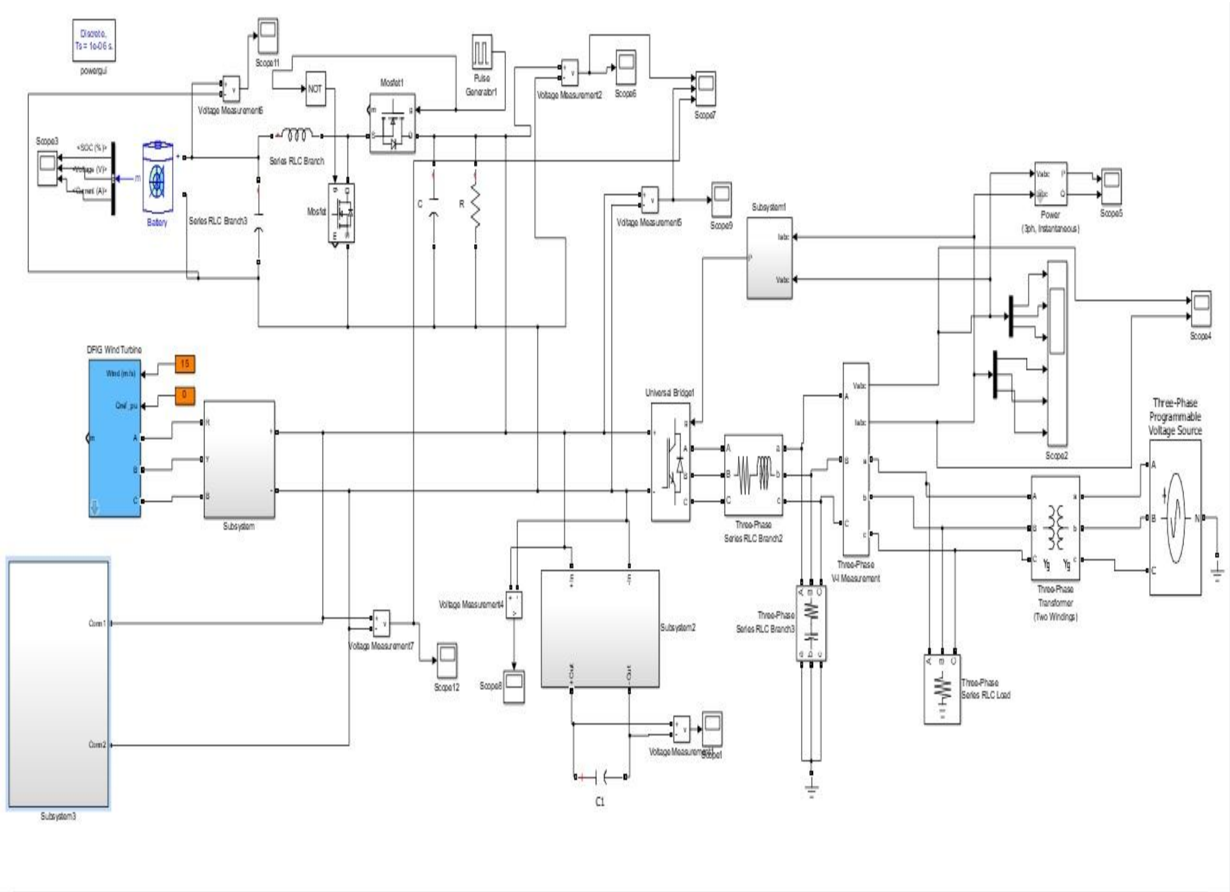


Figure 8 Proposed system simulation diagram

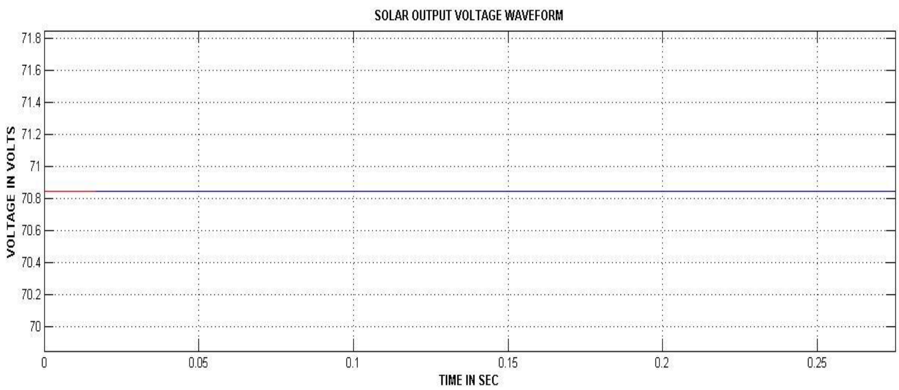


Figure 9 SOLAR PANEL OUTPUT VOLTAGE WAVE FORM

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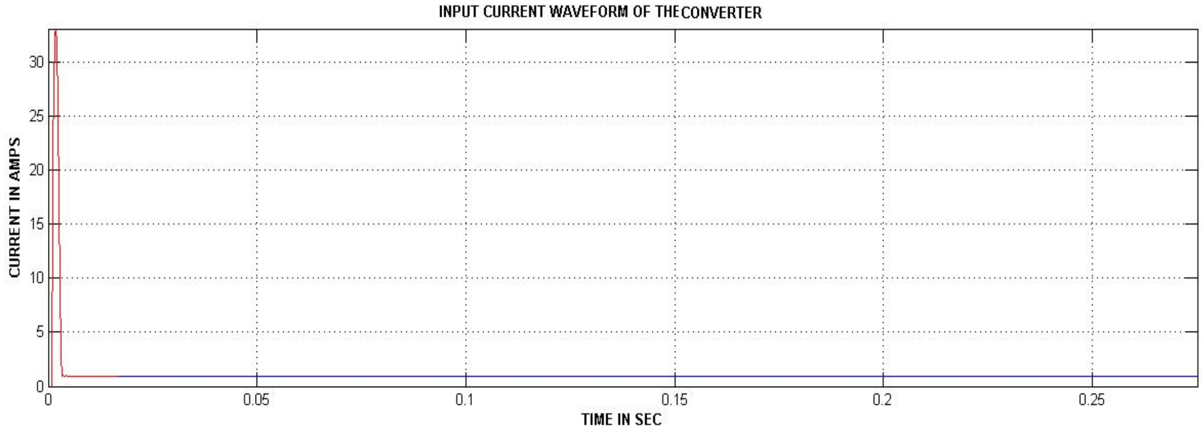


**Figure 10 LUO CONVERTER INPUT CURRENT WAVEFORM**

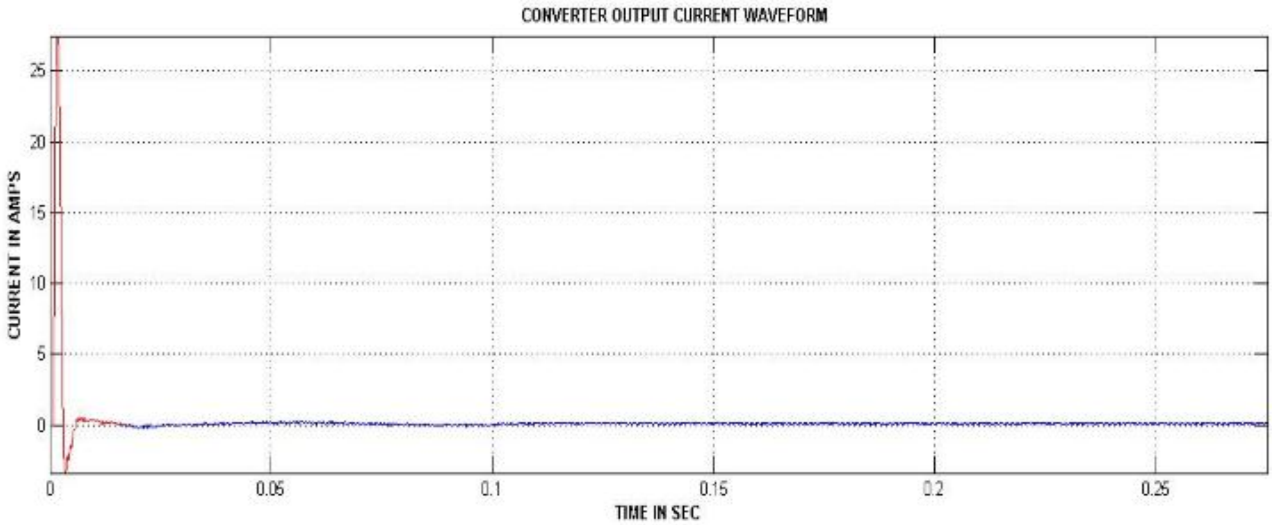


Figure 11 LUO CONVERTER OUTPUT CURRENT WAVEFORM

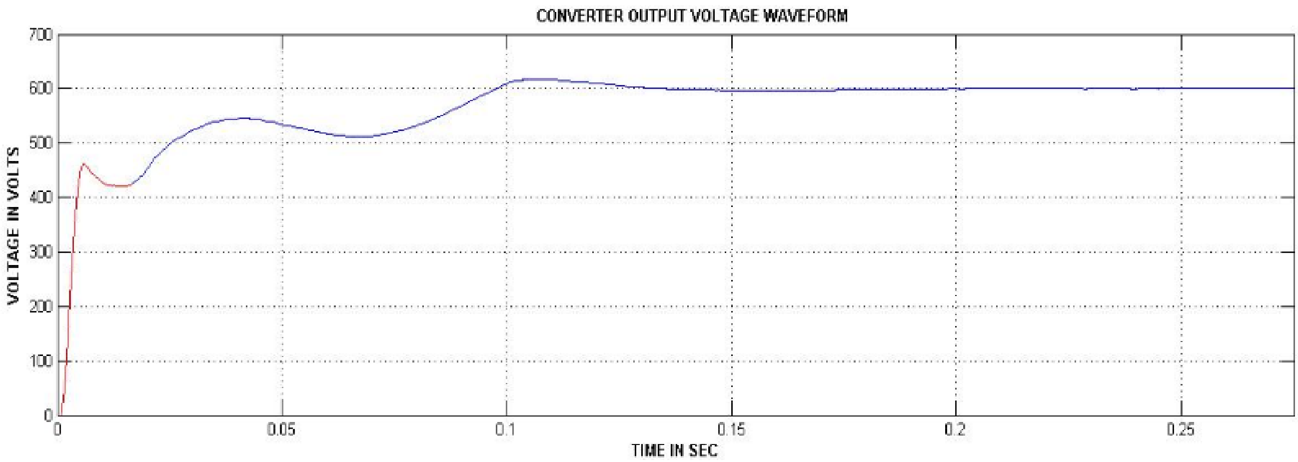


Figure 12 LUO CONVERTER OUTPUT VOLTAGE WAVEFORM

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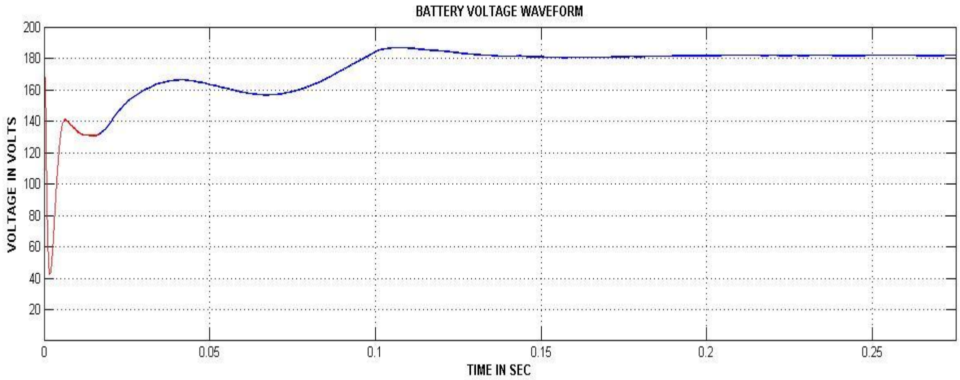


Figure 13 BATTERY VOLTAGE WAVEFORM

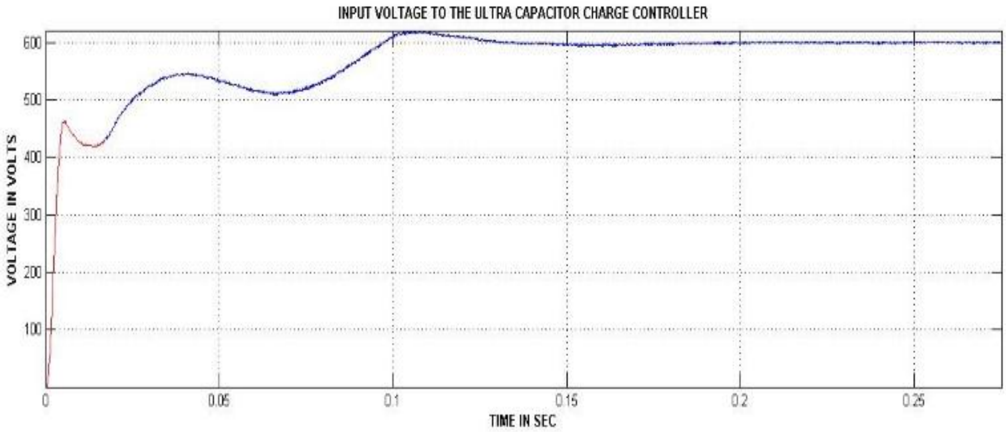


Figure 14 INPUT VOLTAGE TO THE VSI

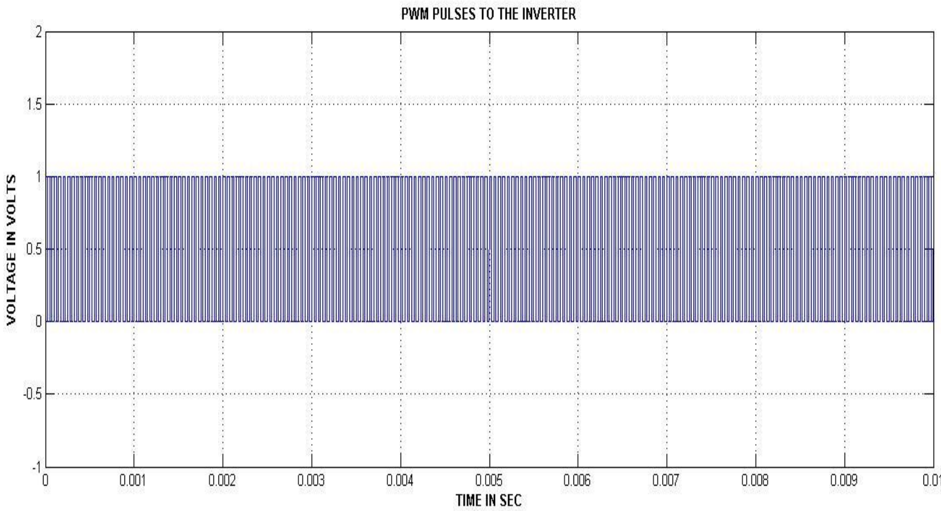


Figure 15 PWM PULSE TO THE VSI

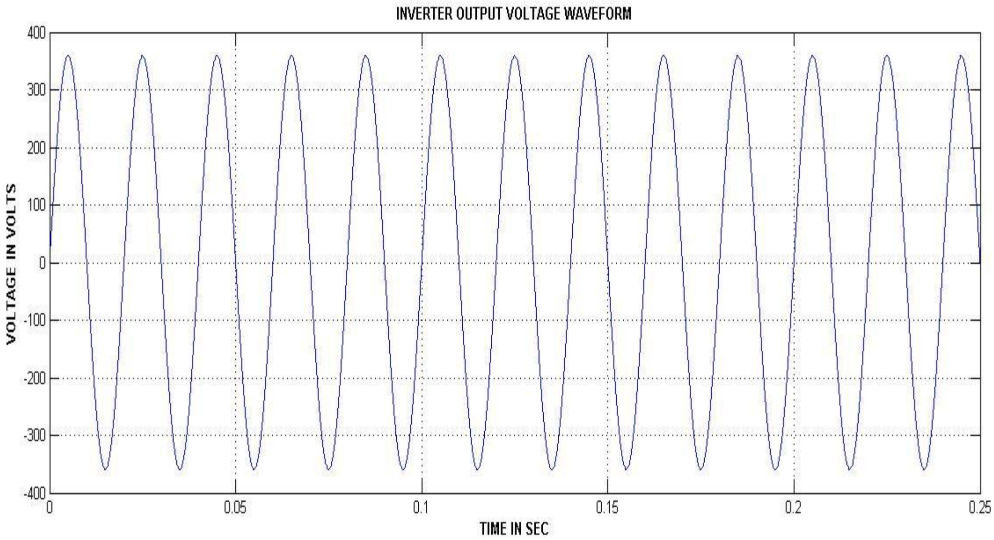


Figure 16 PHASE INVERTER VOLTAGE WAVEFORM

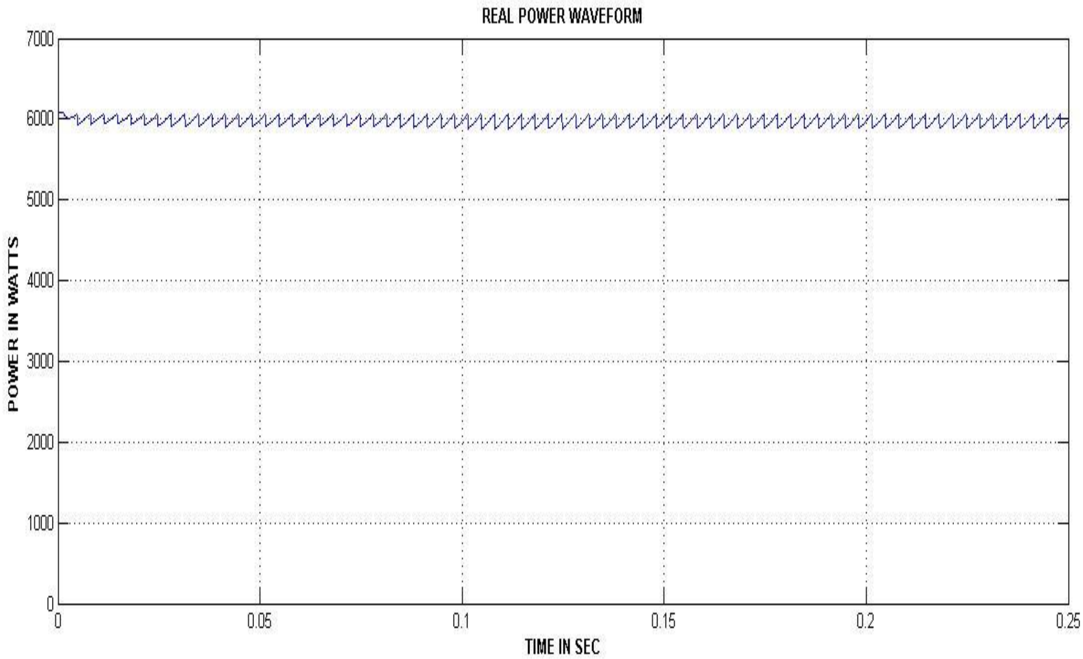


Figure 17 REAL POWER WAVEFORM

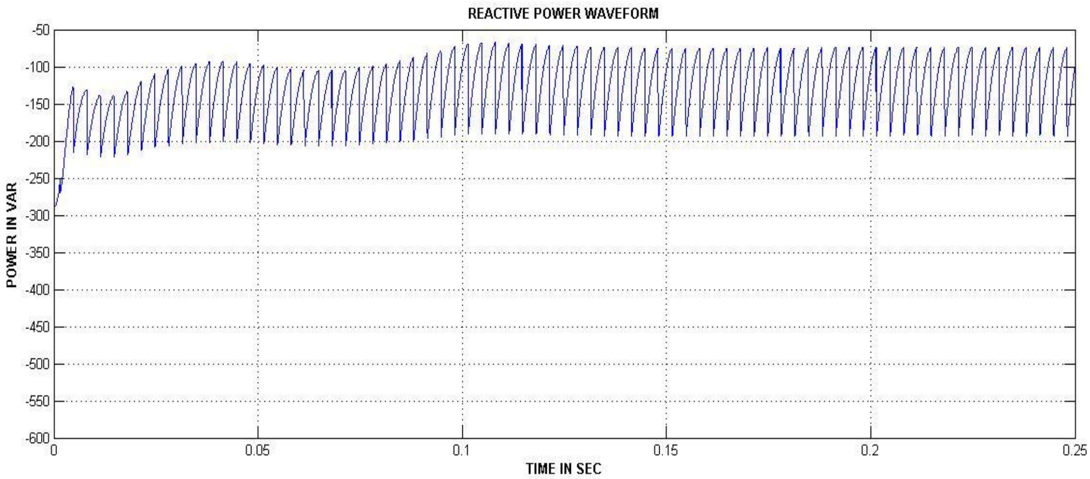


Figure 18 REACTIVE POWER WAVEFORM

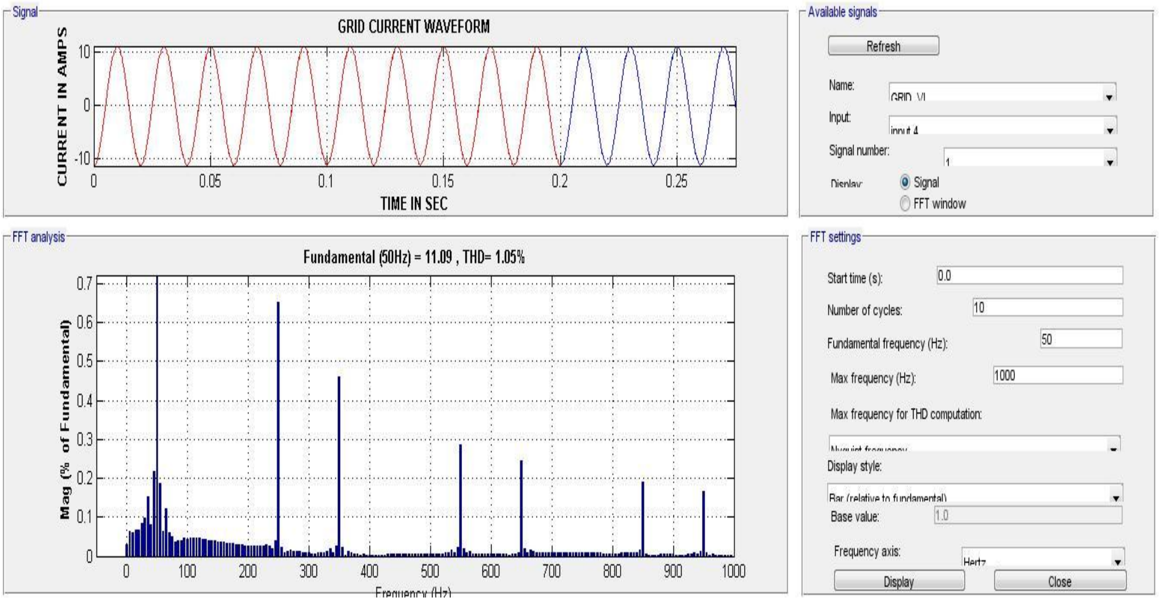


Figure 19 GRID CURRENT THD RESULT

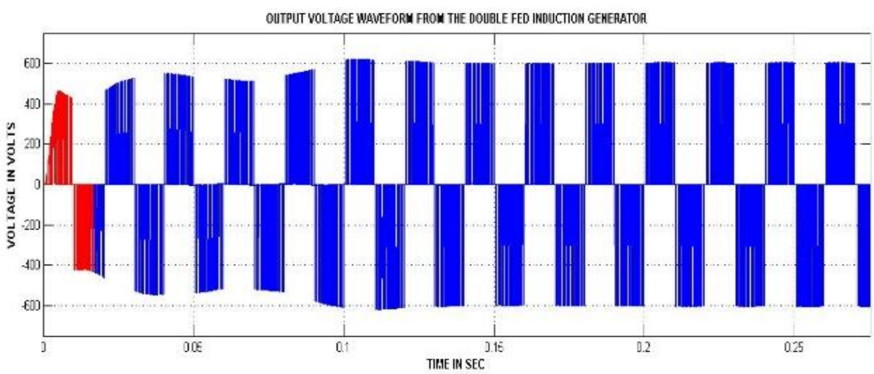


Figure 20 WIND ENERGY OUTPUT VOLTAGE WAVEFORM

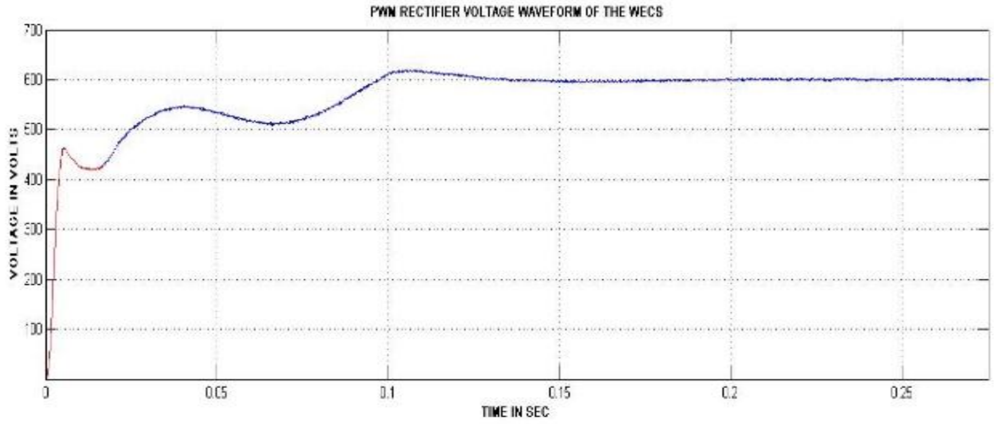


Figure 21 WIND SYSTEM OUTPUT DC VOLTAGE WAVEFORM

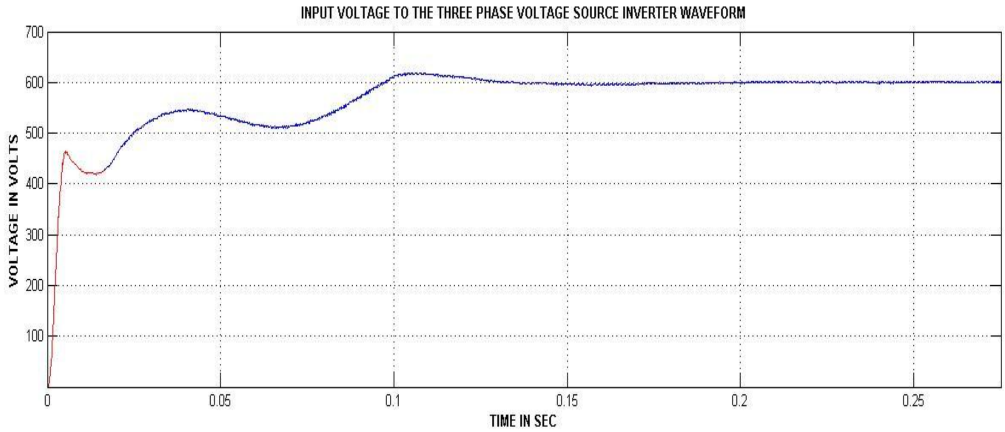


Figure 22 ULTRA CAPACITOR INPUT WAVEFORM

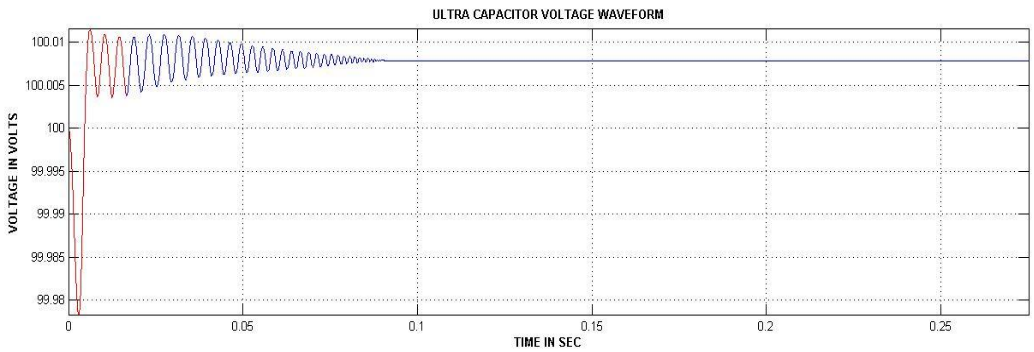


Figure 23 ULTRA CAPACITOR OUTPUT WAVEFORM

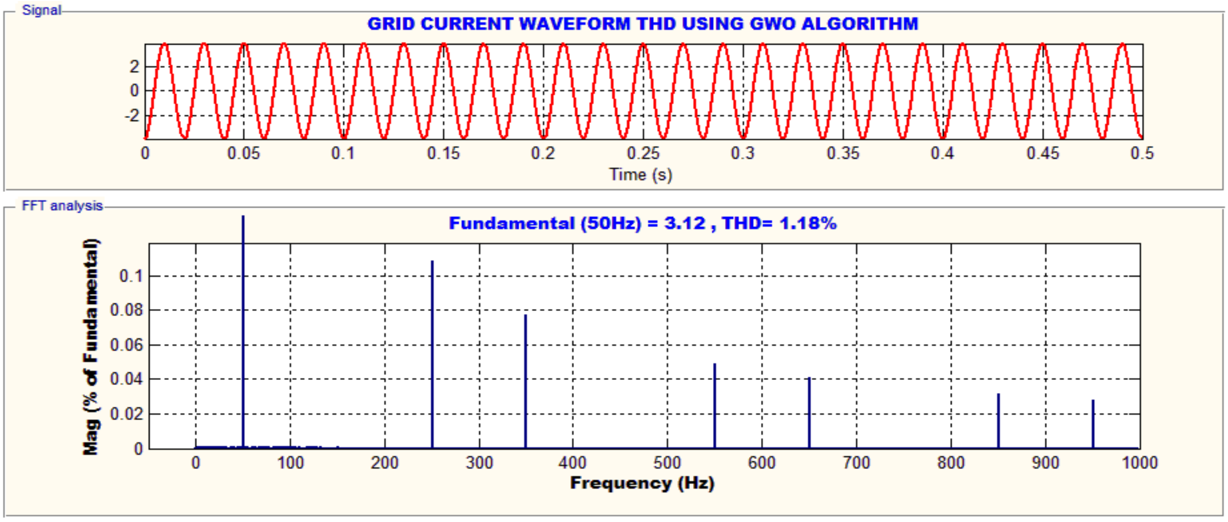


Figure 24 THD RESULTS USING FUZZY LOGIC ALGORITHM

| Si No | Parameters | Existing LUO converter | Modified LUO Converter |
|---|---|---|---|
| 1 | THD | 1.98 | 1.18 |
| 2 | MPPT Efficiency | 92% | 96% |

Figure 25 COMPARISON BETWEEN EXISTING AND PROPOSED WORK

## 3. CONCLUSION

The modelling of hybrid microgrid for power system configuration is done in MATLAB/SIMULINK environment. The present work mainly includes the grid tied mode of operation of hybrid grid. The models are developed for all the converters to maintain stable system under various loads and resource conditions and also the control mechanism are studied. MPPT Neuro fuzzy algorithm is used to harness maximum power from DC sources and to coordinate the power exchange between DC and AC grid. Although the hybrid grid can diminish the processes of DC/AC and AC/DC conversions in an individual AC or DC grid, there are many practical problems for the implementation of the hybrid grid based on the current AC dominated infrastructure. The efficiency of the total system depends on the diminution of conversion losses and the increase for an extra DC link. The hybrid grid can provide a reliable, high quality and more efficient power to consumer. The hybrid grid may be feasible for small isolated industrial plants with both PV systems and wind turbine generator as the major power supply.

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