Sweta Kumari, 2022, 10:1
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

Performance of Power Quality Improvement of Hybrid Energy in Grid Connected System

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Abstract- This Paper proposes an Artificial Neural Network (ANN) controller based MPPT controller and Dynamic Voltage Restorer (DVR) utilization to improve the performance of a stand-alone hybrid renewable energy system. The renewable energy system consists of three renewable energy sources, namely, solar PV cells, battery system and fuel cells. These three sources are tied to a common DC link by three boost converters, one for each source. The common DC link is connected to the AC side via a DC/AC inverter. The optimal size of the three proposed renewable sources is calculated using the MATLAB Software. The DVR control is attained through regulating the load voltage at different anomalous working conditions. These conditions are three-phase fault, voltage sag/swell, and unbalanced loading to control DVR by regulating the D-Q axes voltage signals. The input/output data used for training ANNs are obtained by two optimized PI controllers, introduced for regulating the load voltage through DVR pulses at different abnormal operating conditions, and accordingly convert the static optimized PI controller into adaptive one based ANN. The system performance with the proposed ANN-DVR controller is enhanced through improving the current, voltage, and power waveforms of each generating source. With compensation of the faulty line voltage, the system retains an uninterrupted operation of the three renewable sources during fault events and the total harmonic distortion is reduced.

Keywords- ANN-DVR, PV Cell, Grid ,MPPT, Battery, Fuel cell.

I. INTRODUCTION

This work presents a new method of detection to protect distributed generator feed systems. The technique has been tested on allotment buses of 25 kV or below.

The current interest in installing dispersed generators in low-voltage buses near customers has created new security engineers' disputes, which differ from traditional radial-based security methods. Therefore, it is necessary to reconsider typical protection configurations, such as closed sleepless monitoring, impedance relay security areas, and the discovery of unexpected islands in circulated generator systems.

The island situation is defined as when part of the unusable energy production system is isolated from an effective supply system. It is generally measured undesirable because it can cause potential to injure to existing equipment, cause charge to public utilities, and reduce reliability and power quality. Current island detection methods usually passively and actively monitor over voltage / under voltage and overvoltage / under frequency ratios.

However, each technique has ideal sensitive working conditions and insensitive working conditions, and its degree of deterioration in power quality is different, which is called the non-detection zone (NDZ). The method of recognizing islands proposed in this paper adopts a supposedly precise impedance measurement concept or enlarges it to asymmetrical component impedance sphere using natural and human-made imbalances. In specific applications where this island detection method has improved over the existing island detection method, the general solution has studied where protection engineers can conclude when this technique can efficiently use the majority. First of all, this article first briefly introduces the North American electricity system and the motivation to use distributed production. Then other chapters introduce the background and details of this technology in detail.

Renewable energy systems (RESs) are one of the most suitable and environmentally friendly solutions to provide electricity within urban and rural areas. On-grid and off-grid electrification based on the generation of power through the installation of renewable energy power systems in urban and rural households have been proven to be capable of delivering high quality and reliable electricity for heating, lighting, and demands alike.

Using RESs have many advantages over conventional sources including the following [2]: Wind-solar hybrid systems can provide a steady community-level electricity service, such as residential electrification, also offering the possibility to rural areas to be upgraded through grid connection in the future. Furthermore, in case of installation and use in rural areas, due to their high levels of efficiency, reliability and long term performance, these systems can also be used as an effective backup solution to the public grid in case of natural disasters, emergencies, sudden blackouts or weak grids.

The main disadvantage of wind turbines and PV-systems is that naturally variable wind speed and variable solar irradiation cause voltage and power fluctuation problems at the load side.

These problems can be solved by using appropriate power converters and proper controllers both for the PV and the wind turbine system. Another significant point is to store the energy generated by wind turbines and PV-systems for future use when no wind and/or no irradiation is available but the user demand exists. For this, an energy storage bank can be incorporated in such a way that the battery stores energy whenever there is excess supply and discharges when there is more demand than supply.

The power system is a complex consisting of power generation, delivery or transmission systems. It uses forms of power (such as coal and diesel) or exchanges it into power. The power arrangement comprises equipment related to classification, such as synchronous producer, motors, transformers, switches, conductors, etc.

Power plants, transformers, transmission lines, substations, allocation lines, and distribution transformers are the electricity system's six main apparatus. The power generated by the power plant is increased or stepped down through the transformer. Transmission lines transmit power to various transformer stations. The current is transferred to the distribution transformer through a substation, which reduces the current to a suitable value that suits the user.

II. PV MODULE

With no pollutant or greenhouse gas (GHG) emission, PV cells convert sunlight directly to electricity. They are basically made up of a PN junction. Figure 3.1 shows the photocurrent generation principle of PV cells. Basically, when sunlight hits the cell, the photons are absorbed by the semiconductor atoms, freeing electrons from the negative layer. This free electron finds its path through an external circuit toward the positive layer resulting in an electric current from the positive layer to the negative one.

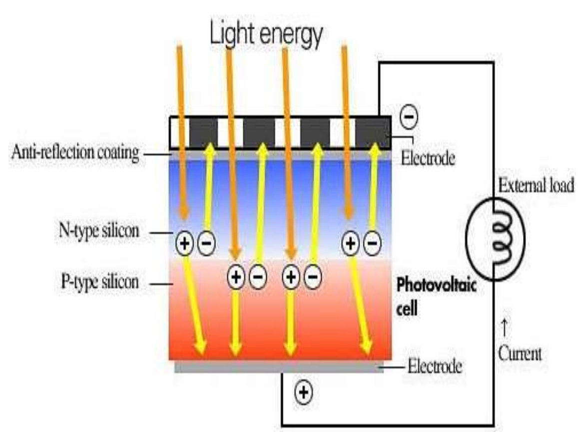

Fig 1. A photovoltaic cell generates electricity when irradiated by sunlight.

Typically, a PV cell generates a voltage around 0.4 V to 0.8 V depending on the semiconductor and the built-up technology [30]. This voltage is low enough as it cannot be of use. Therefore, to get benefit from this technology, tens of PV cells are connected in series to form a PV module. These modules can be interconnected in series and/or parallel to form a PV panel as shown in Figure 3.2.

In case these modules are connected in series, their voltages are added with the same current. On the other hand, when they are connected in parallel, their currents are added while the voltage is the same.

III. RELATED WORK

Manoj Hans et al. (2020) Renewable energy is the future of power generation in the coming years. The network-related upgrade system has caused power outages in the plate during the process of inserting electricity into the plate from multiple locations. This reduces the quality of power provided to the customer. Strengthening stability is the only option the system can rely on.

At the point of contact of renewable energy the static compensator (STATCOM) must be used. It responds quickly and tries to improve the quality of the power by preventing power outages. Recent technological advances show the use of STATCOM hybrid models and mechanical capacitors. The author has developed the simulation of the STATCOM hybrid in the Simulink world. This paper examines and presents the effectiveness of coordination manipulation.

Subarni Pradhan et al. (2019) introduced a speed-based control controller (OASC) and a control-based control system (MAF) based on grid-related hybrid photovoltaic power systems. The solution to these two major problems is to maximize power generation and alleviate the problem of power quality. OASC is an adaptive control that is strong in skepticism (organized and unstructured). The highest power generation goal is achieved through cascade control. Cascade control includes internal hysteresis control based on OASC and external speed control. The OASC proposal includes a mediator interface with spinal control.

In addition, it incorporates a perceptual assessment in accordance with the law of continuous estimation, and then generates a sense of hybrid control. The external speed control loop provides the current stator indicator to the internal cable to monitor the maximum power supply. To improve the reliability of the system, other renewable energy sources (solar photovoltaic energy) are included in the DC link. The relationship between the hybrid system and the grid is based on an inverter that incorporates MAF-based control.

Here, by using the vector method to remove the essential sequence elements from a non-progressive wave to achieve a period of basic non-harmonic reference of the wire electricity, the influence of unbalanced and unbalanced loads can be overcome. The controls provided are customized and compared to conventional technology. Execution controls and performance tests are performed on a hybrid system set up in the laboratory.

Zeng Xiang et.al (2019) this paper offers a new hybrid quality miner (HPQC) for quality compensation and power supply. According to traditional methods, the combined quality control system (UPQC) is often used in the current related energy and power quality (PQ) compensation.

By integrating renewable energy, UPQC is able to operate in island mode. However, UPQC suffers from high DC link costs, which increases system costs and losses. To reduce the cost of DC links, the UPQC has been upgraded to compensate for the quality of the power supply and the power injection. However, when the application is not effective, the modified UPQC cannot work on the island mode.

So, a suggestion for a new HPQC topology, which can work in the event of a technological failure in the traditional way. In this article, we will first give an overview of the proposed HPQC topology process. Then, the HPQC basic control idea is given. Finally, to validate the HPQC proposal, compared to UPQC and modified UPQC, PSCAD chemical analysis is given for HPQC.

TripurariNath Gupta et al. (2019) introduced an autonomous energy-based filtering algorithm (AANF) using sustainable energy-based generators to improve the integration of solar photovoltaic (PV) energy quality production systems (WEGS) for public cable. The AANF controller is designed to transmit the basic components of the current radio. The advanced technology provides high sensitivity and resistance to electrical interference.

The main purpose of the system is to provide dynamic power to the load, and the single network connected to the PCC (common connection point) also mitigates power quality issues such as switching- equality now and the compensation of the force of motion. To achieve maximum power, the MPPT (Maximum Power Point Tracking) algorithm is used based on P&O (disruption and analysis).

The word feed forward about the contribution of solar energy and energy was introduced to improve the dynamic response to changes in sunlight and wind speed. The sense of control offered is simple, and the response of the system is fast. In a laboratory-developed prototype, the efficiency of the system was tested by heavy conditions, variable light rays, and wind speeds. The performance of the proposed system is in line with the objectives of the proposed plan and the IEEE-519 standard.

Zheng Zeming et al. (2019) Because electronics transformers (PETs) can effectively control the quality of power, while allowing AC and DC devices to communicate well with the grid, the voltage rating of the PET system under interference important is in improving the performance of the system The stability and design of the security devices in the system are of great importance.

Based on the typical topology of the three levels of PET and its control strategy, the characteristics of the electricity in the port under two major disturbances. The results show that the 1900V state voltage output in the regulator field may be a major indicator of the nature of the PET / DC hybrid system. Finally, the Prony method is used to overestimate the severity of PET / AC-based hybrid system failures. The results of the research can provide references to the design of PET safety equipment and the analysis of PET systems.

IV. PROPOSED SYSTEM

The proposed method provides a fast response and effective sag compensation capabilities. In addition, in order to detect voltage sag, a Space Vector Modulation (SVM) is employed to estimate three-phase voltages. By using SVM, the voltage sag can be detected faster than other conventional methods. Therefore DVR can compensate voltage sag quickly and accurately. The obtained results that are simulated in Matlab/Simulink indicate that the proposed method can mitigate the balanced and unbalanced voltage sag types efficiently in the distribution networks.

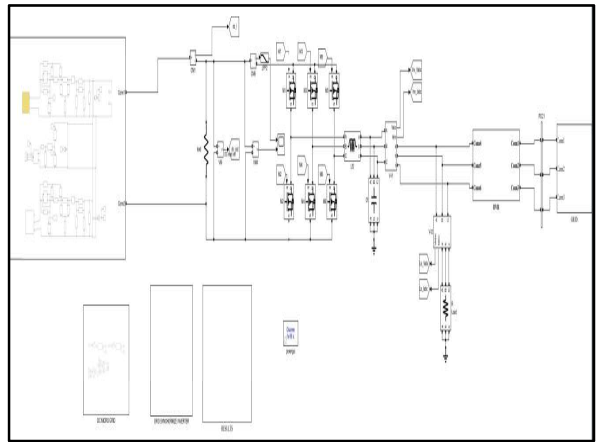

Fig 2. Proposed simulink model.

This converter consists of a coupled inductor with low leakage inductance in comparison with the conventional converters. In this coupled inductor, the secondary winding is connected in series to a capacitor. The coupled inductor is used to develop the converter operating range, and increase the efficiency and reliability. In order to generate different output voltage levels, it is possible to change turns ratio, inductance value, coupling coefficient and time interval of turning on of the switch.

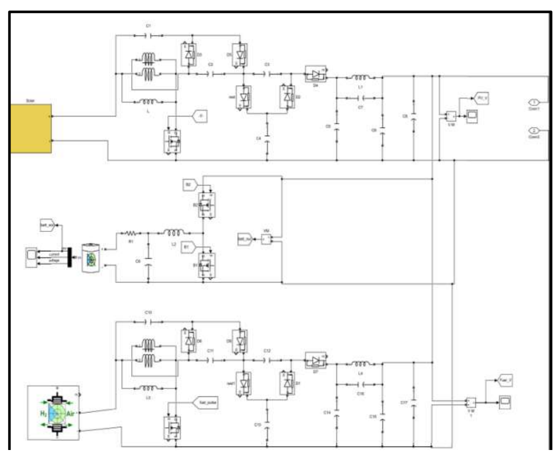

Fig 3. Solar, battery and fuel.

The secondary winding of the coupled inductor is series with a capacitor. In order to decrease the output voltage ripple, a large is connected in parallel with the load. In the proposed boost converter, the power switch of S and diode D are used as a circuit switching elements and rectification.

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The proposed system consists of a hybrid PV/Battery /FC/grid, the system consists of PV system tied to the first DC-DC boost converter.

Table 1. Solar Parameters.

Short-circuit current, Isc: (A)	7.34A
Open-circuit voltage, Voc:	0.6 V
Irradiance used for measurements, Ir0:	1000 W/m^2

The solar Microgrid system is designed to operate in two modes: network interaction and island mode. In the interactive state of the network, the battery system and the photovoltaic system operate in parallel. Solar cell systems are usually used as grid-connected solar cell systems. During peak hours during the day, the battery system is not as active, but when the photovoltaic system does not use most of the inverter power (that is, at night), it can actively participate in the rapid response of frequency adjustment,

1. Modelling of Solar Cell and Array:
The practical model of single solar cell is shown in figure4.

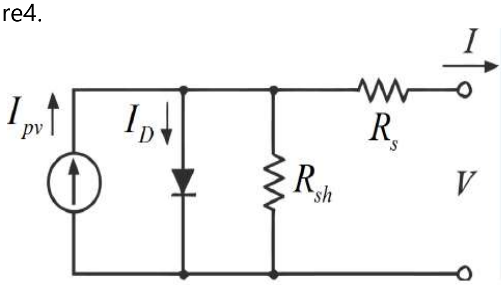

Fig 4. Equivalent Circuit of Solar Cell.

This block models a solar cell as a parallel combination of a current source, two exponential diodes and a parallel resistor, Rp, that are connected in series with a resistance Rs. The output current I is given by:

$$I = Iph - Is1*(e^{((V+I*Rs)/(N1*Vt))}-1) - Is2*(e^{((V+I*Rs)/(N2*Vt))}-1) - (V+I*Rs)/Rp$$

where Is1 and Is2 are the diode saturation currents, Vt is the thermal voltage, N1 and N2 are the quality factors (diode emission coefficients) and Iph is the solar-generated current. Models of reduced complexity can be specified in the mask. The quality factor varies for amorphous cells, and typically has a value in the range of The PS input Ir is the irradiance (light intensity) in W/m^2 falling on the cell. The solar-generated current Iph is given by Ir*(Iph0/Ir0) where Iph0 is the measured solar-generated current for irradiance Ir0.

2. Simulation Model of Solar Cell:

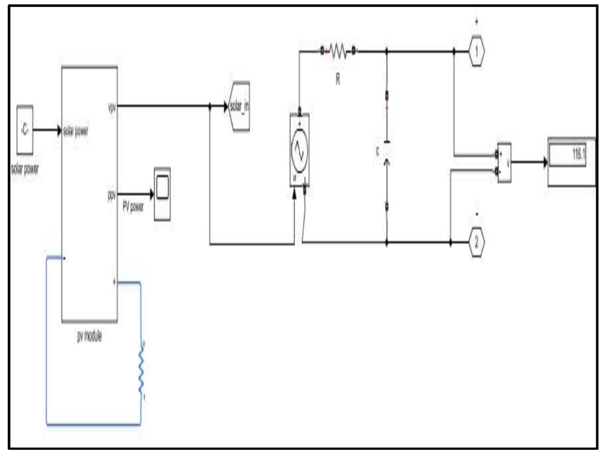

Fig 5. Solar equivalent circuit.

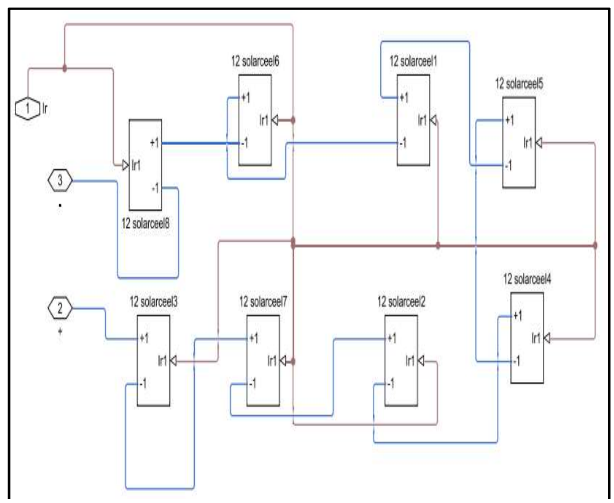

Fig 6. Solar cell subsystem.

Operationally the solar cell array is there to fulfill a defined electrical function. This can usually be reduced to a specified operating voltage and an expected peak daily or annual current output. Where the solar cell is used as a trigger to switch the product on in the dark.

The electrical characteristic at low light level is also important. The voltage is proportional to the number of series-connected cells, while the current is related to the cell area. In monolithically interconnected thin-film arrays, these factors can bear a direct relationship to the dimensions of the solar cell array.

3. Battery:

Implements a generic battery model for most popular battery types. Temperature and aging (due to cycling) effects can be specified for Lithium-Ion battery type.

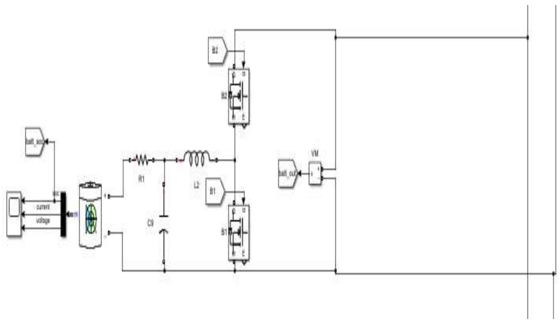

Fig 7. Battery model.

Table 2. Battery parameters.

Parameters	Rating
Nominal voltage (v)	108
Rated capacity (Ah)	26
Initial state of charge (%)	20
Battery response time (S)	30
Maximum capacity (Ah	26
Cut-off Voltage (V)	81
Fully charged voltage (V)	110.3807
Nominal discharge current (A)	22.3478
Internal resistance (Ohms)	0.013333
Capacity (Ah) at nominal voltage	22.8835

4. Fuel Cell:

Implements a generic hydrogen fuel cell model which allows the simulation for the following types of cells:

- Proton Exchange Membrane Fuel Cell (PEMFC)
- Solid Oxide Fuel Cell (SOFC)
- Alkaline Fuel Cell (AFC)

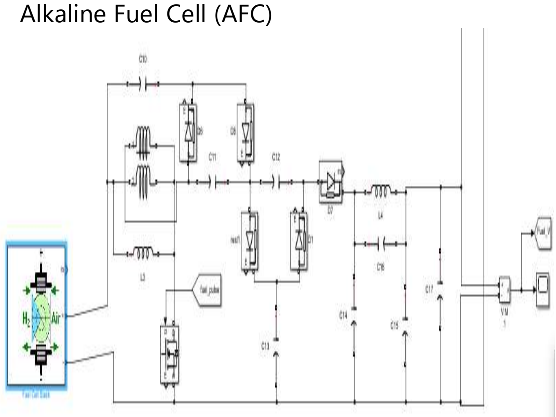

Fig 8. Fuel cell subsystem.

Table 3. Battery parameters.

Parameters	Ratings
Voltage at 0A and 1A [V_0(V), V_1(V)]	[65,63]
Nominal operating point [Inom(A), Vnom(V)]	[133.3,45]
Maximum operating point [Iend(A), Vend(V)]	[225,37]
Number of cells	65
Nominal stack efficiency (%)	55
Operating temperature (Celsius)	65
Nominal Air flow rate (lpm)	300
Nominal supply pressure [Fuel (bar), Air (bar)]	[1.5,1]
Nominal composition (%) [H2 O2 H2O(Air)]	[99.95,21,1]

5. ANN Controller

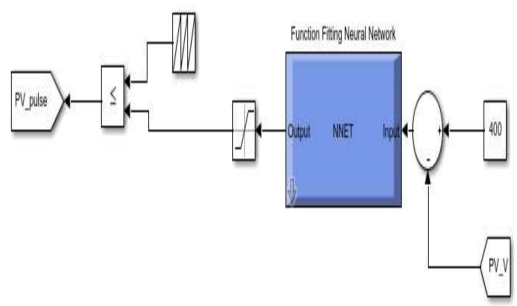

Fig 9. ANN Controller.

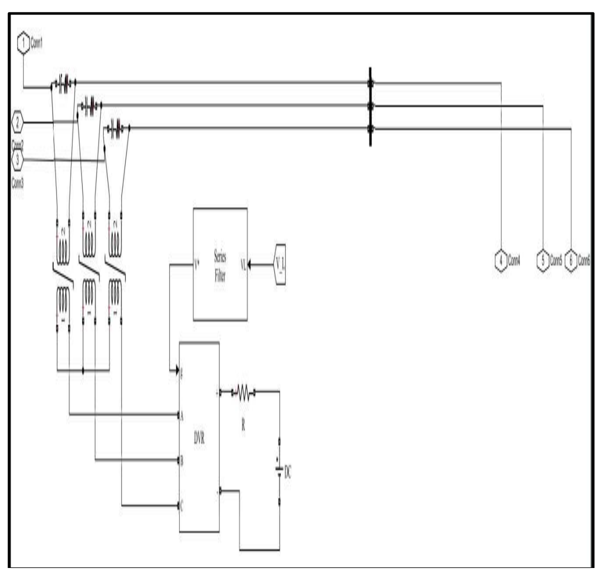

Fig 10. DVR Subsystem.

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6. DVR:

(Dynamic Voltage Restorer) is a series of printers integrated with a large power supply system. The schematic figure of the DVR is shown in Figure 9 which includes a VSC (19-20) with a DC power supply.

The main principle of a DVR is to compensate for power drop / expansion of the flow cable to the converter. DVR is a connected custom power supply Connect in series to inject the required voltage into the truck to maintain the voltage level. Composition The voltage is injected by three single-phase transformers. The voltage is synchronized with the load voltage. Implements a three windings saturable transformer. Click the Apply or the OK button after a change to the Units popup to confirm the conversion of parameters.

Table 4. DVR parameters.

Parameters	Rating
Nominal power and frequency [Pn(VA) fn(Hz)]:	[4000 50]
Winding 1 parameters [V1(Vrms) R1(pu) L1(pu)]	[380 0.02 0.02]
Winding 2 parameters [V2(Vrms) R2(pu) L2(pu)]	[380 0.02 0.02]
Saturation characteristic [i1 phi1; i2 phi2; ...] (pu)	[0 0 ;1.016 9.043]*1e-3
Core loss resistance and initial flux [Rm phi0] or [Rm] (pu)	[117 0]

This block implements a three-phase zero-impedance voltage source. The common node (neutral) of the three sources is accessible via input 1 (N) of the block. Time variation for the amplitude, phase and frequency of the fundamental can be pre-programmed. In addition, two harmonics can be superimposed on the fundamental.

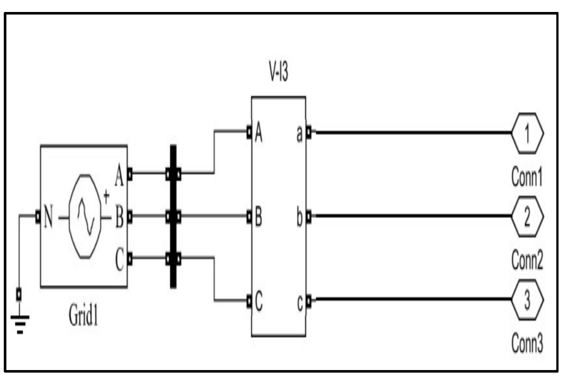

Fig 11. Grid subsystem.

Phasor simulation", frequency variation and harmonic injection are not allowed. Specify Order =1 and Seq=1,2 or 0 to inject additional fundamental components A and B in any sequence.

The supply voltage taken from the DC to DC converter is applied across the battery as well as across the residential AC load or to the power grid via PWM inverter. ... The inverter is utilized to change over direct present (DC) to alternating current (AC).

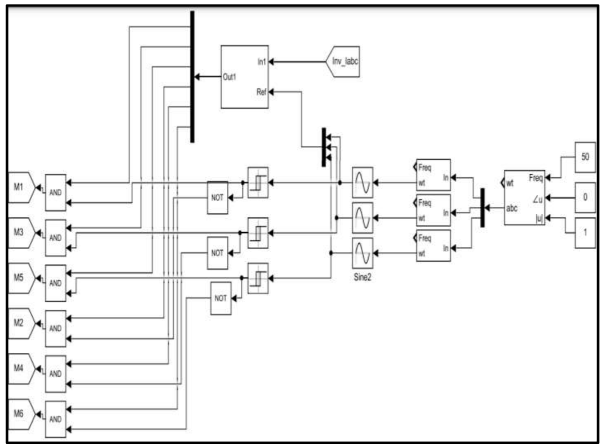

Fig 12. Grid inverter synchronization subsystem

This Phase Locked Loop (PLL) system can be used to synchronize on a variable frequency sinusoidal signal. When the Automatic Gain Control is enabled, the input (phase error) of the PLL regulator is scaled according to the input signal magnitude.

For optimal performance, set regulator gains [Kp Ki Kd] = [180 3200 1] and check the Enable Automatic Gain Control parameter.

- Input: Normalized input signal (pu)
- Output 1: Measured frequency (Hz) = w/(2pi)
- Output 2: Ramp w.t varying between 0 and 2*pi, synchronized on the zero-crossing (rising) of the fundamental of input signal.

Table 5. PLL parameters.

Parameters	Rating
Minimum frequency (Hz): Minimum frequency (Hz):	Minimum frequency (Hz):
Initial inputs [Phase (degrees), Frequency (Hz)]:	[0, 50]
Regulator gains [Kp, Ki, Kd]:	[180, 3200, 1]
Time constant for derivative action (s):	1e-4
Filter cut-off frequency for frequency measurement (Hz):	25

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V. SIMULATION RESULT

The simulation of the proposed model has been performed on MATLAB software.

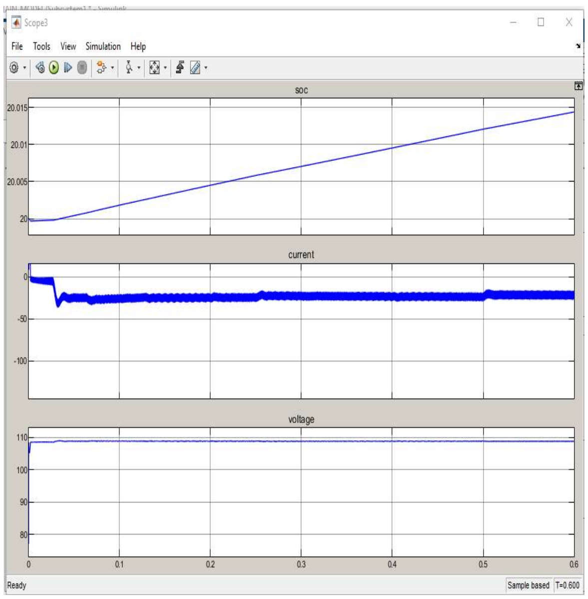

Fig 13. Battery voltage and current.

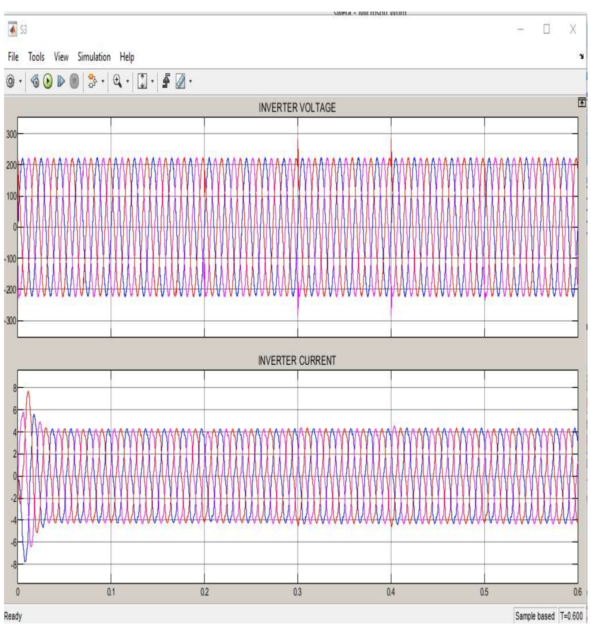

Fig 14. Inverter current and voltage.

Fig 14 showing the inverter current and voltage where y axis showing the current and voltage of the inverter and x axis shows simulation time.

Fig 15 showing the load real power and reactive power Active power is the active power consumed by the load. The reactive force is useless power. Active power is a product of voltage, current and cosine of the angle between them. The reactive effect is the product of the sine of voltage and current and the angle between them.

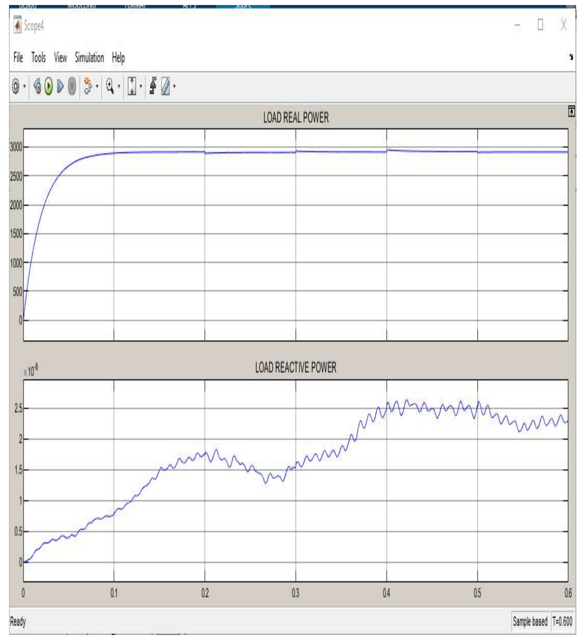

Fig 15. Load real power and reactive power.

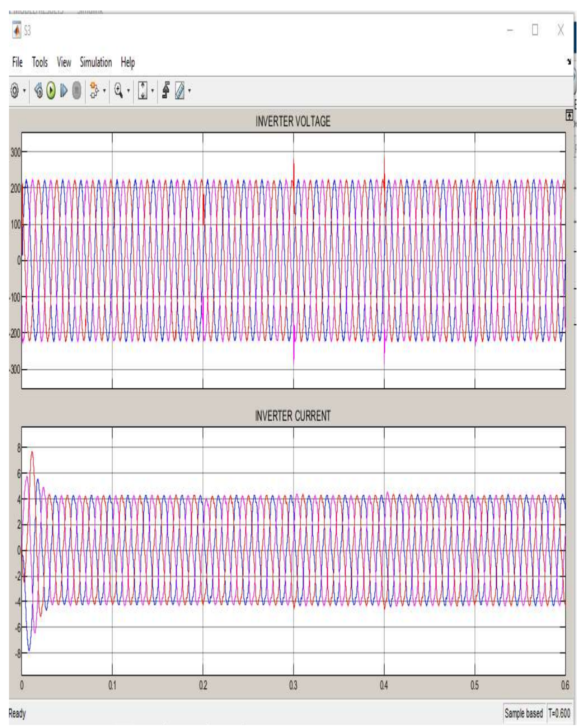

Fig 16. Inverter current and voltage.

Fig 16 showing the inverter current and voltage where y axis showing the current and voltage of the inverter and x axis shows simulation time.

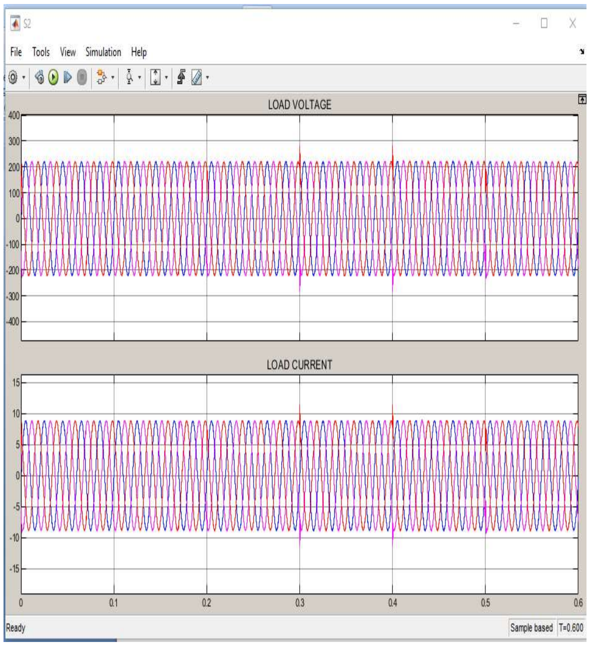

Fig 17. Load voltage and load current.

After the compensation, the load voltage is as shown in fig 17 the total simulation time is 0.6 s and circuit breaker operated at 0.55 sec, circuit breaker operated the grid is turned off so the voltage is dropped showing in the load voltage.

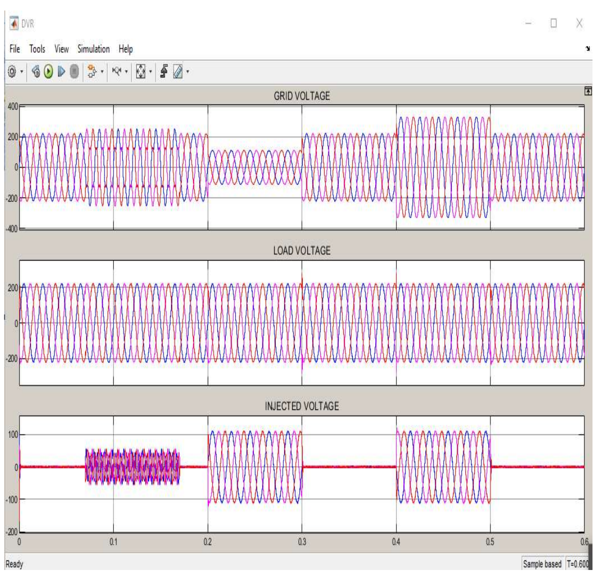

Fig 18. Grid disturbance as swell, sag, harmonics, and load voltage and injected voltage.

Control strategies of synchronous reference frame based DVR were modeled in MATLAB Simulink and its performance is observed under various grid conditions. The voltage swell, sag, harmonics is simulated during the time of 0 to 0.5 sec as DVR will inject required voltage during this period, After the compensation, the load voltage showing.

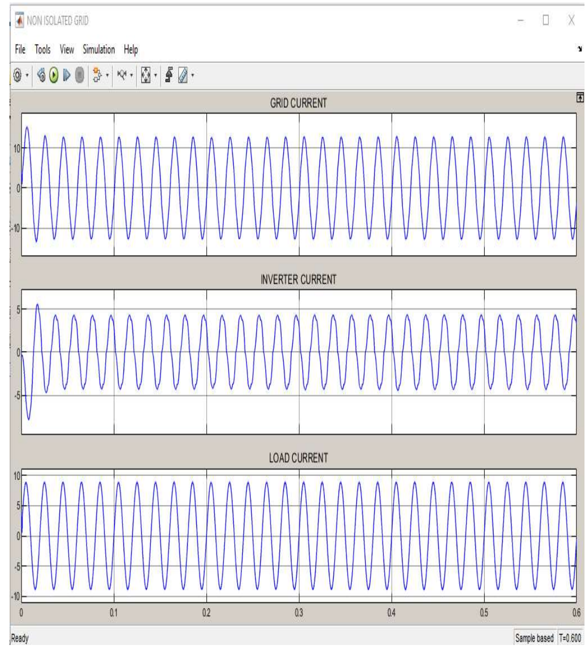

Fig 19. Inverter current, grid current, load current.

Fig 19 showing the inverter current, grid current, load current ,the x axis showing simulation time, When the mains frequency changes from 50 Hz to 49 Hz and from 50 Hz to 51 Hz, as shown in Figure 4.16 .the PLL quickly detects the mains frequency change and accurately compensates for the mains frequency change in a short time. Less than 10 milliseconds, no effect on mains power.

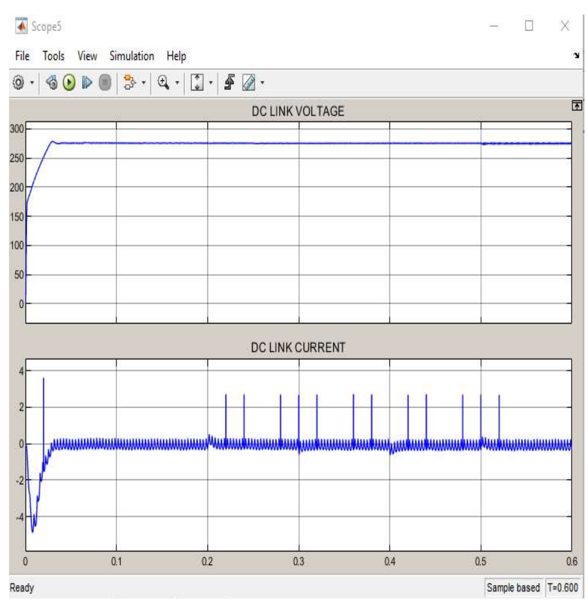

Fig 20. DC link output.

Fig 20 Showing the DC link current and voltage where y axis showing the voltage and current and x axis showing simulation.

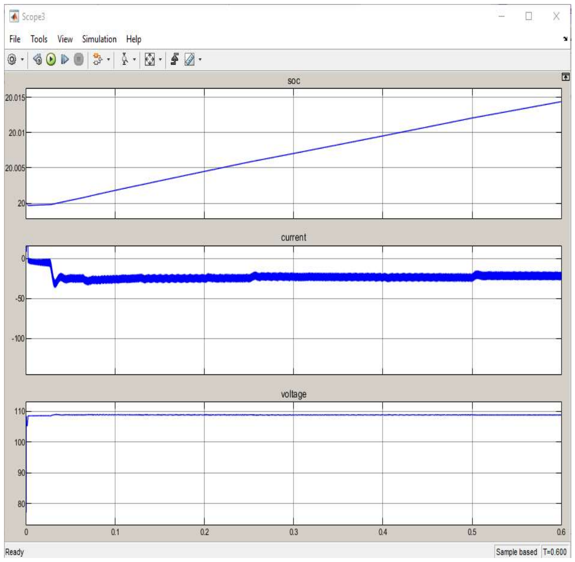

Fig 21. Battery current and voltage.

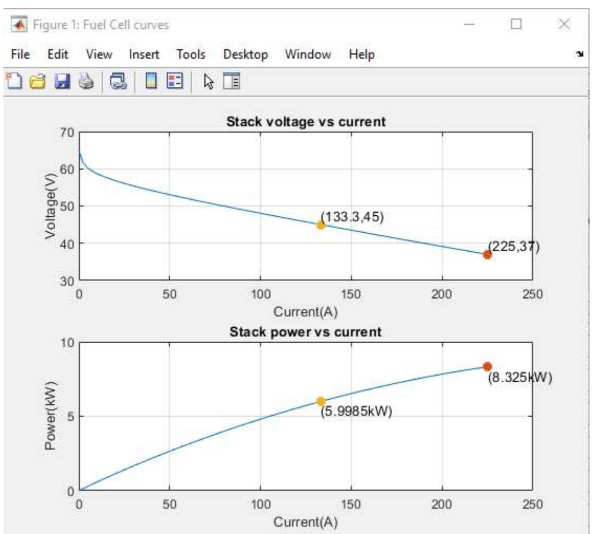

Fig 22. Fuel cell voltage and current.

VI. CONCLUSION

A new boost dc-dc converter is proposed. This converter is same as the conventional boost converter however the coupled inductor is used instead of the inductor in the conventional converter. I

n the proposed converter, the secondary winding of the coupled inductor is connected in series to a capacitor. High numbers of changeable parameters to reduce inductor current ripple is one of the main advantages of the proposed converter that leads to select optimum value to control current ripple and avoid of increasing losses. In other word, it is possible to choose a suitable value for coupling coefficient to get zero ripples in input current of converter. In this thesis, including control, the island detection mode for island mode of operation is proposed and the mode of network limitation mode is verified by the MATLAB Simulink software.

Here, the two modes of operation are mainly controlled by detection technology. It also supports switching from constant present control mode to constant voltage control mode. The output of the imitation diagram clearly shows the island situation and its detection.

The advantage of planned DVR organization is that it can save energy in compensation mode by compensating only for the phases and voltage drop. In standby mode, the IGBT of the inverter is used to bypass the secondary side circuit of serial transformer, so no other bypass switch is required. The results are confirmed in the Matlab / Simulink simulation model. This simulates balanced voltage drop and unbalanced voltage drop to test the presentation of the planned DVR. The replication results show that projected DVR can ensure compensation of power drop and thereby continue load power at nominal voltage.

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