Utility Grid Controlling Using Hysteresis Current Control for Three Phase Current

Manish Umesh Thool[1], Ms. Alka Thakur[2]
M. Tech. Scholar, Department of Electrical Engineering, SSSUTMS University, Sehore, M.P. 466001, India[1]
Associate Professor, Department of Electrical Engineering, SSSUTMS University, Sehore, M.P. 466001, India[2]

Abstract

The full points of interest from hydrogen as a practical fuel can be accomplished exactly when it is delivered from environmentally friendly power sources. Wind and solar energy, as the most bountiful practical energy sources, have encountered the best improvement during several years. The basic goal of proposed research work to display and recreate a Photovoltaic wind half breed electric power framework related to the three phase electrical utility grid. The proposed PV Wind and fuel cell based REPS, considering all radiation, temperature, wind paces and variety of the heap interest during the day. A Matlab simulation has been completed to recreate all the boundaries of proposed REPS like inverter leg and current in each IGBT's for PV and WTG phase voltage. In this displaying and simulation work AC yield current of the inverter that infused to the heap/grid, load current, grid current, power yield from PV and WTG, power conveyed to or from grid lastly power factor of the inverter for PV, WTG and grid are outwardly examined on Matlab Scope dependent on simulation. In the proposed model a hysteresis current control and immediate p-q (real- nonexistent) power hypothesis has used. The exhibition of proposed model which actualized in the Matlab Simulink climate fills in as though ON-line has affirmed dependent on simulation and it is discovered proposed model has better authority over THD when contrasted with past work.

Keywords: REPS, WTG, Matlab, THD, IGBT.

Introduction

Sun is the major source of energy to the entire universe. The recent fall in the cost of solar photo-voltaic (SPV) energy, and ever increasing prices of fossil fuels, has moved the worlds attention towards SPV energy systems. Conventionally two-stage grid interfaced SPV energy systems are used, in which the first stage performs MPPT (maximum power point tracking) and the second stage is used to feed extracted energy into the grid. These two stage systems suffer from drawback of two power converters of full rating. Several configurations of grid interfaced PV farms are proposed in [1]. In grid-connected photo-voltaic systems, three-phase current controlled voltage-source inverters (VSIs) are often employed for power conversion, grid synchronization and control optimization [3], [4]. In addition, synchronization to grid by Phase Locked Loop (PLL). Phase Locked Loop (PLL) will tracks the measured phase voltages Ua, Ub and Uc. under balanced and unbalanced voltage conditions Proper operation is ensured by PLL. fluctuation at the dc-bus capacitor Voltage was used to calculate extra power loss in inverter .using a Proportional–Integral– differential(PID)controller Corresponding phase current amplitude calculated and it was multiplied with PLL output .This output current was added to reference compensation current in each phase. The loss in shunt active power filter is thus taken care of by three phase source and dc bus capacitor voltage becomes a self supporting one. In modified hysteresis controller only 2 switches are controlled at high frequency at any instant of time [5]. This will reduces the switching losses to one third of that of conventional hysteresis controller. Even though using the modified hysteresis controller it is insufficient to maintain current THD within the specified limits. To overcome this drawback, pulses are modified with adaptive control mechanism . Main advantage of the adaptive control is sought out Problem of variable switching frequency. The total harmonic distortion (THD) of the grid current is limited to 5%, as recommended in the IEEE 1547 standards [2].

GRID-CONNECTED INVERTER (GCI)

Fig. 1 shows the typical configuration of GCI, with the DC sources are the representation of renewable energy sources in microgrid such as battery or solar. The grid connected inverter governs active and reactive power delivered to the grid. With this role, the GCI employs phase locked-loop (PLL) feature. PLL generates the angle of the grid voltage and the current reference must refer to the angle of grid voltage. In this paper the zero crossing-method is used to implement the PLL. In order to control the output power, the inverter uses a double-loop controller [6]. The outer loop is the power controller and the inner loop is the current controller. Since the current controller is the inner loop, it has to be ensured that

it response fast enough compared to the outer power loop control. The performance of inner current controller will affect significantly to overall performance of controller.

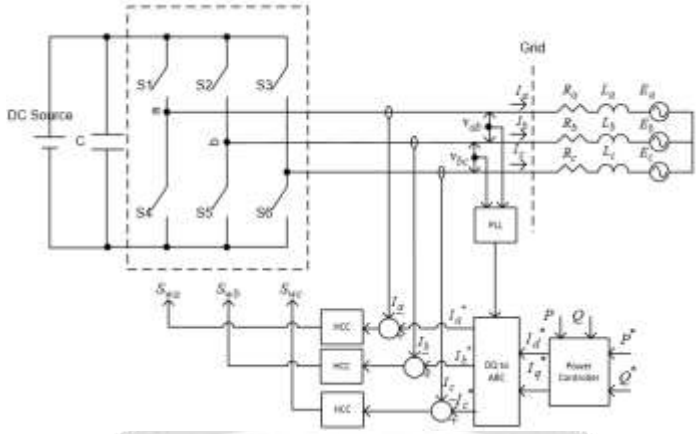

Fig. 1 Power controller of grid-connected inverter

Problem Identification

Protection framework is one of the significant difficulties for microgrid which should respond to both fundamental grid and microgrid shortcomings. The security framework should remove the microgrid from the primary grid as quickly as important to ensure the microgrid loads for the main case and for the second case the insurance framework ought to detach the littlest piece of the microgrid when clears the issue. A division of microgrid, for example a plan of numerous islands or sub-microgrids should be upheld by microsource and load regulators. In these conditions issues identified with selectivity (bogus, pointless stumbling) and affectability (undetected blames or deferred stumbling) of security framework may emerge. Primarily, there are two fundamental issues concerning the security of microgrids, first is identified with various introduced DER units in the microgrid and second is identified with an accessibility of an adequate degree of short out current in the islanded working method of microgrid since this level may considerably drop down after a separation from a hardened principle grid.

Methodology

With the increase in demand for electrical power, the surge in the comprehensiveness of the principle grid, because of consideration of different real sources, Renewable energy sources (RESs) are one of the discretionary source. In any case, Renewable sources represent the issue of stability as for generation. Likewise, Renewable energy sources have their own particular troublesome with regards to the point of support and security of the fundamental grid concerning the system voltage and frequency that will be fixed and a legitimate control [7]. This parameters are joined in one grid that will be called as Micro-grid (MG). The fundamental idea of miniaturized scale grid was concocted in 1998by the Consortium for Electric Reliability Technology Solutions (CERTS).

For giving a sufficient reliability and a decent enhance in the money related and natural perspective parts of the system, the inclusion of MGs comes to the rescue of power systems. Photovoltaic panels (PV), Fuel cells (FCs), Wind turbines (WTGs), Diesel motor (DEGs), and battery for quick back-up keeping in mind the end goal to supply the power so sudden power wavering can be stayed away from and furthermore these are a piece of a Micro Grid, which ought to be kept near the customer side and associated with fundamental grid so as to frame a distributed generations (DGs).

Microgrids are small scale, low voltage consolidated warmth and power supply system expected to supply electrical besides, warmth loads for a little gathering, for instance, a hotel home or a rustic region, or open gathering, for instance, a college or school, a business domain, a mechanical site, a trading home or a common region. Microgrid is essentially a distributed system on the ground that it is the blend of distributed generation frameworks and various weights at dissemination voltage levels. The generators or smaller scale sources used in a microgrid are commonly renewable or non-routine distributed energy assets fused together to create power at transport voltage. From operational point of view, the miniaturized scale sources must be furnished with force electronic interfaces and controls to give the obliged flexibility to ensure operation as a lone amassed framework and to keep up the predefined forced quality and imperativeness yield. This control versatility would allow the microgrid to introduce itself to the essential utility force framework as a single controlled unit that meets neighborhood essentialness necessities for resolute quality and security.

The key contrast between a microgrid and traditional force plant are as take after:

(1) Micro sources are of substantially smaller cutoff with respect to the far reaching generators in routine force plants.

(2) Power produced at transport voltage can be straight forwardly urged to the utility of allocation system.

(3) Micro sources are usually acquainted near with the customers premises so the electrical weights can be profitably provided with acceptable voltage what's more, repeat profile and immaterial line faults.

The particular features of a microgrid make it appropriate for providing energy to remote areas of a country where supply from the national network framework is either difficult to profit due to the topology as a rule irritate as a result of genuine climatic conditions or synthetic aggravations. From lattice point of view, the standard good position of a microgrid is that it is managed as a controlled component within the force framework. It can be filled in as a singular accumulated load. This discovers its basic controllability and consistence with framework standards and directions without hampering the enduring quality and security of the force utility. From customers planned, microgrids are worthwhile for by and large gathering their electrical or warmth essentials. They can supply uninterruptible force, improve neighborhood steadfastness, decrease feeder hardships and give nearby voltage bolster. From ecological point of view, microgrids decrease characteristic defilement and an overall temperature change through usage of low carbon advancement.

Then again, to accomplish a steady and secure operation, different specific, regulatory and budgetary issues must be resolved before microgrids can get the chance to be common. Some issue zones that would require due contemplations are sporadic additionally, environment subordinate nature of period of the distributed energy assets, low essentialness substance of the powers and nonattendance of benchmarks and directions for working with microgrids in synchronism with the force utility. The examination of such issues would require broad consistent and disengaged from net examinations, which can be taken up by the primary building and examination establishment over the globe.

Microgrids produce, convey and deal with the power stream to the area customers. Microgrid speaks to as a small scale power framework because of its abnormal state of flexibility and proficiency in the region of supply and intrigue part [1]-[5]. Technically it can be characterize, microgrid is a system with no less than one request that could be islanded from the principle distribution power system and having no less than one distributed energy assets. Practically, microgrids are to be acquainted with address the crisis of tremendous quantities of distributed energy assets in distribution power system and to ensure secure and perfect operations of perhaps islanded force network.

Microgrid is dealt with as controllable load from the utility point of view. The distributed energy assets are situated inside the microgrid which is contrast from power plant since they have smaller point of confinement and they are direct joined with the microgrid assignment system and this can be revamped to supply nearby load requirements.

The principle focal points of microgrid is enhances the releability with presentation of self recovering at the nearby scattering system, gives higher force quality by keeping up the area loads, diminish in the radiation of carbon by the development of imperativeness sources, money related operation by decreasing the transmission and distribution costs, using less cost renewable energy sources and giving energy proficiency.

The fundamental part of microgrid is capacity to be islanded from the principle cross section by upstream switches at the reason for customary coupling. With the end goal of financial and reliability this islanding is presented. Islanding implies, if any unsettling influences happen from the fundamental power grid, microgrid is traded from the cross section related with the islanded mode and a tried and true and nonstop supply of client troubles is offered by neighborhood period resources. Once the aggravation is expelled in primary power grid, we can resynchronize the islanded microgrid to the principle power grid. Microgrid lessens the aggregate system arranging cost and because of its capacity it expands the system reliability, with the goal that it brings down the likelihood of load shedding. Microgridsoffer a lower improvement time likewise, are seen as reasonable decisions for decreasing the transmission stopping up when generous theories on new time and transmission workplaces are not inevitable.Past force framework orchestrating ponders inspected period additionally, transmission advancement organizing systems in a vertically consolidated force framework. Of course, existing masterminding procedures did not consider the impact of microgrid establishments on the force framework advancement.

For reliability purpose of microgrid incorporate the distributed generations. For a solid energy supply to their clients microgrid administrators take incredible dependable. Due to the essential of the distributed generation, these are must be noted if any system blackouts happens. As of now we examined in the past examinations about the scientific procedure to assess the client's reliability in the distribution power systems that all distributed generation are possessed by one administrator. The impact factor which is altered to acquire the interference cost, wires, photovoltaic cells are incorporated by this proposed strategy.

For low voltage distribution networks can take microgrid as best options. It comprises of number of distributed generators, storage devices, and controllable loads which can work either interconnected or islanded from the primary power grid. The operation of the microgrid amid the interconnected operation that is augment its incentive by streamlining the creation of neighborhood distributed generations and power trades inside the fundamental power grid are pointed by the controller. This low voltage working networks has been connected by some created improvement calculations.

For reliability measure energy storage system in a microgrid are considered. Energy storage system needs ideal size, on the grounds that higher speculation costs are required for bigger energy storage system while microgrid working expenses are diminished. To limit the venture expenses of energy storage system, and expected microgrid working costs, energy storage systems are must be upgraded. Broad applications in the power system operation, for example, enhancing control, alleviating instability and irregularity issues of renewable energy assets, load following, voltage and frequency stability, crest load administration, power quality change, and delay of system overhauls are proposed by energy storage system.

Distributed energy asset contains distributed generators and distributed storage. These two are the wellsprings of energy situated near the neighborhood loads. These two can give different advantages which contain enhanced reliability if the neighborhood loads appropriately work them in the electrical distribution system. Microgrids have one distributed energy assets and partner loads. This can frame purposeful island in the electrical distribution systems. By keeping the upstream switch at the purpose of normal coupling, microgrid can detach the loads and energy sources from the primary grid reconnect to the neighborhood electric power systems. To maintain a strategic distance from the causing issues arranging of microgrid is essential.
Active what's more, reactive power management is fundamental in the microgrid arranging. Active and reactive power management procedures are should have been tended to with regards to different distributed generators microgrid system. Privately estimated signals controls the distributed generators and power management procedures without interchanges. Voltage hang characteristics, voltage control, load reactive power compensation are principle for the power management procedures. Frequency hang characteristics and complimentary frequency reclamation procedure control the active power of each distributed generator unit. A little signals unique model of different distributed generators has been produced by a systematic approach. It shows the active and reactive power management systems.

For enhancing productivity of electrical and warm energy utilization, an opportunity and an attractive framework is given by microgrid. The operation of different energy assets and loads must be composed and advanced to enhance the effectiveness of electrical and warm operation. Photovoltaic and wind turbines are the renewable assets and diesel generators for ordinary microgrids. Batteries are considered as energy storage devices in the average microgrids. By utilizing all these, add up to cost of electrical and warm energy must be limited. Add up to cost incorporates the venture cost, operational cost and support cost of microgrids.

Nowadays power demand is expanding step by step, in the meantime transmission and distribution losses are expanding. Giving quality power and solid power to the remote regions are the fundamental difficulties. For this, inquire about has been begun for the elective arrangements. To defeat these issues, we considered distributed generators or renewable energy assets based microgrids as the conceivable alternative. Distributed energy assets convey the effective and dependable power to the neighborhoods. In a little scale frame work setup, the perfect orchestrating and control of the little scale framework is a vital component to enhancing the potential points of interest of this present reality scaled down scale framework establishment. The makers attempt to develop a perfect diagram and masterminding little scale framework considering diverse passed on imperativeness advancement options, for instance, daylight based photovoltaic, little wind electric generator, biomass gasifier framework, diesel generator and battery amassing for unmistakable applications likewise, with sensible inputs on their physical, working and money related characteristics. The objective is to turned out with various such perfect scaled down scale frameworks with various mixes of renewable essentialness resources with perfect dispatch techniques for differing applications while limiting the costs. It shows the revelations of the executions profiles of various little scale grid courses of action under unmistakable operational circumstances and furthermore chooses make back the underlying speculation partitions for partner the little scale framework with the central networks.

A microgrid can grow the dependability of imperativeness by isolating from the network on account of system faults or reduced force quality. The techniques that have been investigated to control the microgrids are outlined and furthermore those proposed to take care of quality in the midst of the moves starting with one mode then onto the next modes. The microgrid orchestrating structure in Shandong electric power look into organize has been presented and discusses the diverse feasible control procedures used and show for microgrid. By then, in light of showing differing sorts of appropriated periods and essentialness accumulating equipment, the Shandong electric power inquire about establishment microgrid display was emulated with a couple of working modes under shared control system. The hugeness of an imperativeness storing to help reliability in the midst of move between working modes are focused.
The utilization of high faithful quality apportionment framework in the money related operation of microgrid is considered. High reliability distribution system, which offers higher operation faithful quality and less blackouts in microgrids, are associated with hovered systems in transport framework. The microgrid appear in this examination is made out of distributed energy assets including distributed generators, controllable weights, and capacity. The microgrid would utilize the area distributed energy assets and the essential framework for providing its hourly load financially which is obligated power quality and unflinching quality necessities. The high reliability distribution system executed at Illinois foundation of innovation is used as relevant investigation nearby the area distributed energy assets to build the accumulate point resoluteness and diminishment the process cost of the Illinois institute of innovation microgrid. The convenience of flow lines, essential network supply, and microgrid period is seen as using the Markov chain Monte Carlo simulation in the microgrid circumstances. The constancy records in perspective of repeat and term of blackouts are estimated at the microgrid level and the pile point level, and the potential framework enhancements are discussed for upgrading the money related operation Illinois organization of innovation microgrid.

The plausibility to upgrade circulation framework steadfastness is a basic motivation driving the change and sending of microgrids. Past investigations have demonstrated liberal immovable quality points of interest of distributed energy assets. Regardless, the examination and new evaluations methods are required for microgrid instructed by compelled what's increasingly, stochastic distributed generations. An evaluation method for islanded microgrids that practically addresses stochastic resources and explicitly reviews the impact of supply to load relationship on steady quality is introduced. Monte Carlo simulation is used to show part frustration and repair, while certain data is used for the stochastic resources. Stochastic distributed generation yield is appointed to loads in light of a composed demand that records for the dynamic reconfiguration of the microgrid on account of nearby fault. Consider trouble lessening additionally, its impact on trustworthiness is similarly broke down.

At present, thought and decentralized controls are gotten in miniaturized scale framework. Remembering the true objective to send summon information from master controller to slave controller, concentrated control must have a high transmission capacity correspondence channel, which isn't appropriate to execute the distributed and attachment play control. Moreover, when another miniaturized scale source is interconnected to the miniaturized scale cross section, the master should modify all the miniaturized scale source new. Decentralized control is worked using just neighborhood information, yet, in the light of fact that without reference from the overall illustration, the overall perfect execution can't be guaranteed as firmly similarly as with overall controllers. A novel dynamic control for littler scale lattice is proposed. This control procedure still has a specific level of decentralization in any case; in like manner keep a level of centralization through a larger amount control layer that controls bring down level breaking points. The dynamic control is for the most part included three levels: basic control, helper control and tertiary control. Preliminary outcomes are given to exhibit the practicality of the dynamic control system.

Microgrid Structure and Components

A microgrid incorporates distributed energy resource (DER) (photovoltaics, small wind turbines, power modules, inner combustion motors, microturbines, and so forth.), distributed energy storage devices (flywheels, superconductor inductors, batteries, and so on.), and loads. DERs can be isolated into two fundamental gatherings: (i) DER coordinated coupled ordinary rotating machines (e.g., an induction generator driven by a fixed-speed wind turbine), and (ii) DER grid-combined with the inverter (e.g. Photovoltaic, power modules, and so on.). Distributed energy storage devices can be accused of the power abundance and release to cover the power deficiency. Along these lines, they help to upgrade the reliability of microgrid and in addition making it effective and prudent. Besides, energy storage is known as quick reaction devices. In this way, they likewise avert transient instability and partake to control the voltage and the frequency of the microgrid by giving the adjust save running from brief time.

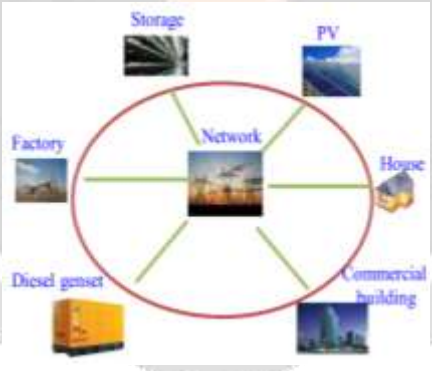

Fig.2 A studied Microgrid structure

The diagram of a microgrid which incorporates numerous systems: PV, a variable-speed wind generator, power device, microturbine and a battery energy storage system is appeared in Figure 3.1. Each distributed energy asset is interfaced with its comparing bus through a power-electronic converter. The microgrid is associated with the upstream network at the Point of regular coupling (PCC). The power is outfitted from a Low-voltage (LV) transmission grid, through a substation transformer. The microgrid works with two modes: the grid-associated mode and the islanded mode. In the grid-associated mode, the PCC is shut and the microgrid is associated with the primary grid. It drives that the microgrid can trade energy with the principle grid. At the point when the upstream network happens the unsettling influence or the microgrid gets the ideal operation express, the switch at PCC can be opened to separate the microgrid. Consequently, the microgrid can keep on operating in the purported islanded mode.

Microgrid Operation

Two operation modes of microgrid can be defined as follows:

Grid-connected Mode: the microgrid (MG) is linked with the upstream system. The MG can get completely or rather the energy by the primary grid (reliant upon the power sharing). After that again, the power profusion can be sent to the essential grid (when the collective generation surpasses consumption).
Island Mode: at the point when the upstream network has a disappointment, or there are some arranged actions (for instance, so as to perform support actions), the MG can easily move to islanded operation. In this manner, the MG work self-governingly, is called island style, in its place to the electric power systems of the physical islands.
Furthermore, the operation of the microgrid may rely upon clashing interests among various partners associated with power supply, for example, system/network administrators, DG proprietors, DER administrators, energy providers, et cetera, and in addition clients or administrative bodies. Ideal operation of microgrid depends on monetary, specialized, or natural viewpoints.
Energy Management of Microgrid

When a microgrid has in excess of two DERs, the energy management system (EMS) is expected to force the power assignment among DER, the cost of energy generation and outflow.

Fig.3 The energy management system

The EMS in a microgrid is appeared in the Figure 3.2. As can be seen from this Figure, the estimate estimations of load demand, the distributed energy assets and the market power cost in each hour on the following day are indicated as inputs. Moreover, the operation goals are considered to enhance the energy management, are given as takes after:

- Economic option
- Technical option
- Environmental option
- Combined objective option.

Some algorithm for the enhancement of microgrid energy management are reported. The ideal energy management of an island microgrid is displayed by utilizing an administer based management. The operation of the system relies upon the created rules; hence, the limitations are constantly fulfilled, yet the improvement isn't worldwide outcomes. Fuzzy logic is utilized to assess the manage to enhance the lead based method. The linear programming (LP) and blend whole number linear programming (MILP) are utilized to locate the ideal energy management. This strategy gives great outcomes; however, the principle restriction is known as the need of a particular numerical solver. The ideal energy management for a grid associated with PV/battery and a vehicular electric power system is tended to by utilizing the quadratic programming (QP). The great outcomes achieved, however, the point of confinement of this strategy is to require the target capacity to be curved. The ideal energy management of a microgrid is fathomed by utilizing Game Theory and multi-target streamlining. The working expense and the discharge level are given as two targets capacities. The Mesh Adaptive Direct Search (MADS) calculation is utilized to advance the microgrid working cost work. A framework real-coded hereditary calculation (MRC-GA) enhancement module is utilized to look through the ideal generation plan. The molecule swarm streamlining (PSO) procedure was proposed. The dynamic programming (DP) and advance dynamic programming (ADP) are utilized to upgrade the energy management. The achieved comes about are demonstrated the effectiveness of these techniques.

Proposed Solution

In this work a simulink model based on hysteresis current control strategy has been implemented for of photovoltaic, wind & fuel cell based hybrid electric power system 3 phase utility grid. Simulink model of proposed system has shown in Figure 4. This method is considered as direct control since the current is controlled in a hysterias loop. The hysteresis current control method is simple, robust, fast- responding, and easy to implement. A simplified block diagram of Hysteresis-based current controller has shown in figure 5.
It also guarantees a peak current limiting capability. The method is based on the switch status, i.e. whether it is on or off when the current error touches its low or high boundary respectively. To reduce the THD in the output current, the

hysteresis band has to be reduced, but this would increase the switching losses. Otherwise, a wider hysteresis band would increase the THD.

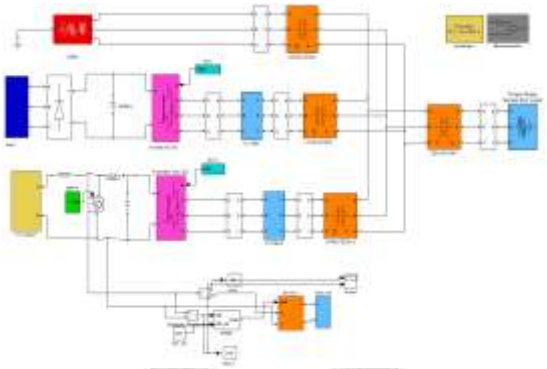

Fig.4 Simulink Model of Proposed System

Therefore, the hysteresis band is chosen to compromise between the low THD and the low losses. The simple hysteresis controller has a variable switching frequency and therefore a relatively high THD. The frequency band width in the current waveform depends on the system parameters, the switching mode, the load and the dc voltage. More advanced types of the controller were developed to limit the bandwidth of the switching frequency.

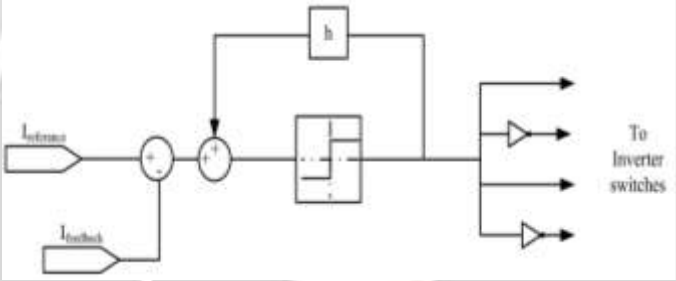

Fig.5 Hysteresis- based current controller

Hysteresis current control technique is utilized to give the accurate gating pulse and arrangement to the IGBT inverter by contrasting the current error signal and the given hysteresis band. As found in figure 4.2 the error signal is fed to the hysteresis band comparator where it is contrasted and hysteresis band, the yield signal of the comparator is then gone through the active power filter to create the ideal compensating current that follow the reference current waveform.

Asynchronous control of inverter switches makes the current of inductor shift between the given hysteresis band, where it is ceaselessly come close with the error signal, consequently inclining action of the current takes place. This method is used because of its robustness, excellent dynamic action which is not possible while using other type of comparators.

There are two points of confinement on the hysteresis band i.e. upper and lower band and current waveform is trapped between those two groups as observed from figure 4.3 At the point when the current tends to exceed upper band the upper switch of the inverter is turned off and lower switch is turned on with the goal that the current again tracks back to the hysteresis band. Similar mechanism is occurring when current tends to cross the lower band. In this manner current exist in the hysteresis band and compensating current pursues the reference current.

Hence,

$$Upper\ limit\ hysteresis\ band = Iref + max(Ie) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.1)$$

$$where,\ Iref = Reference\ Current, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.2)$$ rent,..... (4.2)

and= Iref - min Ie ,.....(4.3)

$$Ie = Error\ Current \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.4)$$

$$As\ a\ result, the\ hysteresis\ bandwidth = 2 * Ie \ldots (4.5)$$

Thus smaller the bandwidth betters the accuracy.

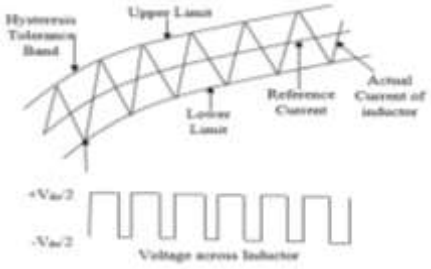

Fig.6 Hysteresis Band

Switching frequency can be easily controlled by looking at the voltage waveform of the inductor. The voltage across inductor relies upon gating succession/gating pulse of IGBT inverter which is again subject to the current error signal of the hysteresis controller. Variable frequency can be obtained by adjusting the width of the hysteresis tolerance band.
Fig. 4.4 shows a simplified block representation of proposed Simulink model where some fundamental elements of the design are represented in simplified manner to expresses proposed model.

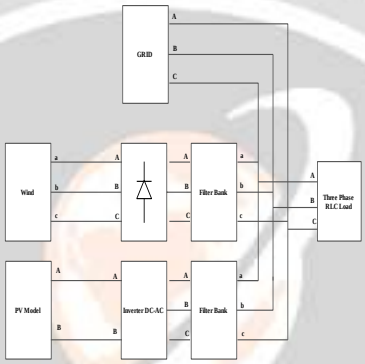

Fig. 7 Simplified Block Representation of Proposed Model

The Simulink model of proposed control circuit using Hysteresis current controller has shown in figure 4.5for three phase RES utility grid.

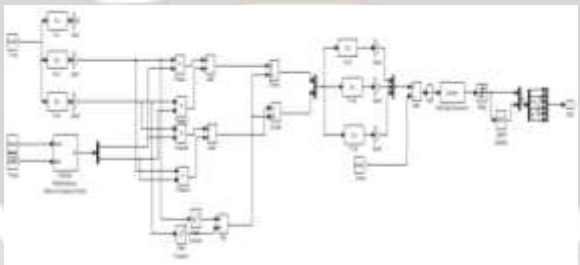

Fig. 8 HCC Control Model of Proposed System

The parameters are considered for the optimal performance of the system is tabulated in table 4.1; in table parameters and their corresponding value for optimal performance are given. The fundamental parameters considered are Grid RMSVoltage, Phase Angle, Frequency, Wind Generator Type, PV Model, Load Phase to Phase Voltage, Active Power etc
.

Table: 1 System Parameters for Optimum Performance

Parameters	***Values***
Grid RMSVoltage (Phase to Phase)	*132 kV*
Phase Angle	*30 Degrees*
Frequency	*50 Hz*
Wind Generator Type	*Synchronous Machine*
PV Model	*Single Diode Model with MPPT*
Load Phase to Phase Voltage	*380 Vrms*
Active Power	*500 kW*

Simulation Results

The verification of proposed model has done based on Simulation. Simulation of proposed model has completed in MATLAB Simulation environment. Various testing parameters waveform are visualized and analyzed on Matlab Scope. The fundamental objective of proposed work is to reduce distortion in current and voltage to achieve better power quality. As the market for small-scale renewable energy systems is rapidly increasing, the need for power electronic converters also increases. The inverter is necessary in the system to produce a sinusoidal wave to supply the ac load or connect to the grid.

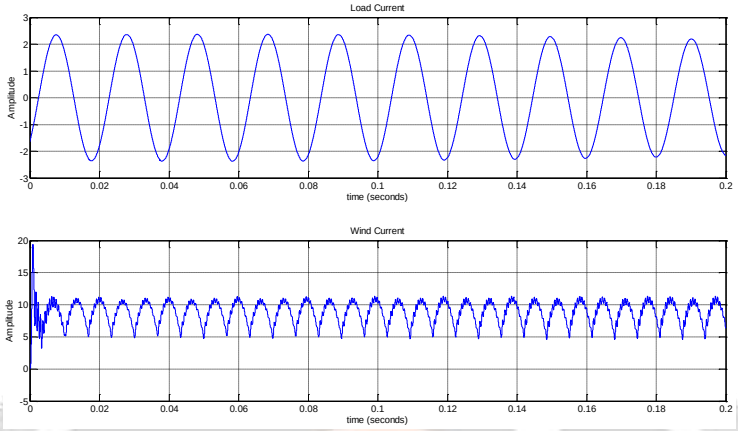

Fig. 9 Load Current and Wind Current

The proposed system in this study can be connected to the utility grid; therefore there are quality standards for such aspects as low THD, elimination of the dc component injected into the grid and active and reactive power control. Figure 5.1 shows the scope of load current and wind current waveform. In Fig 9 top waveform time vs amplitude and corresponding bottom waveform shows the wind current in terms of time vs amplitude.

Figure: 10 shows MATLAB scope waveform of the grid current and load current of proposed model. The top one waveforms represents grid current and bottom corresponding bottom waveform represents load currentof the proposed model.

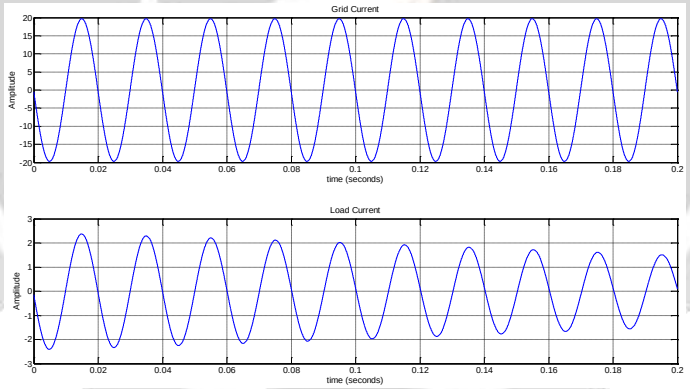

Fig. 10 Grid Current and Load Current Waveforms.

Fig. 11 shows the photo voltaic current waveform of proposed system. Fig shows the characteristics of PV current of proposed simulink model.

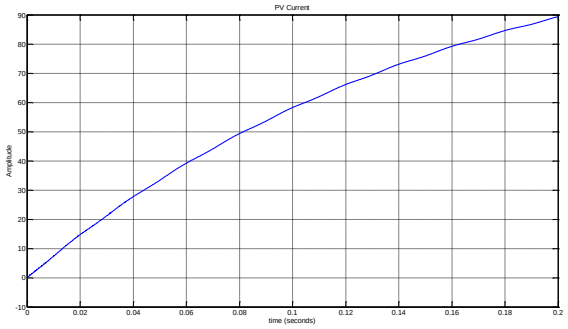

Fig.11 PV Current

Fig. 12 shows the MATLAB Simulinkscope waveform of wind current and grid current on scope wind current and its corresponding grid current waveforms are plotted and examined.

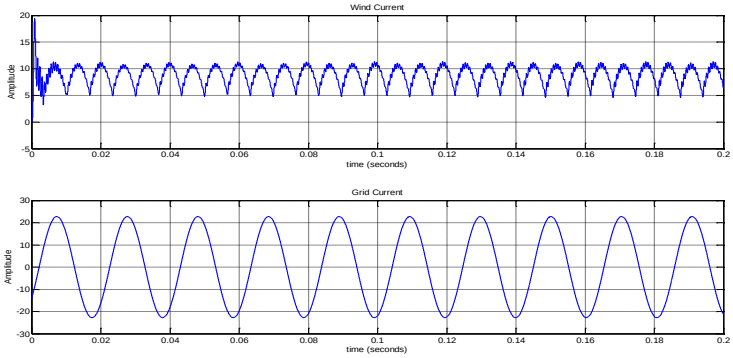

Fig.12 Wind Current and Grid Current Waveforms

THD performance analysis of proposed work is shown in fig. 5.5 at fundamental frequency (50Hz)=9.066. The THD of proposed model has been recorded is about to 1.94% which was 31.9% is previous work.

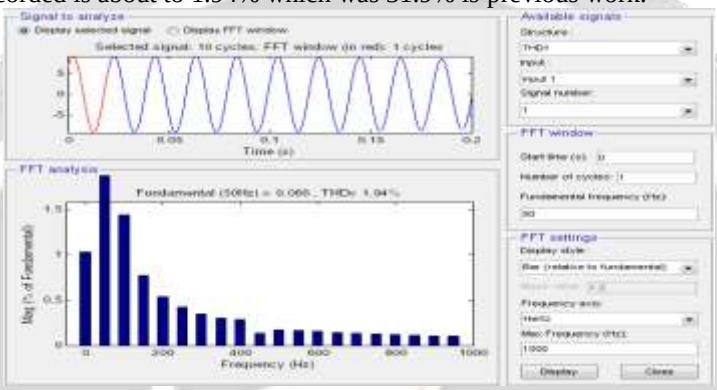

Fig. 13 THD reduced from 31.9 % to 1.94%

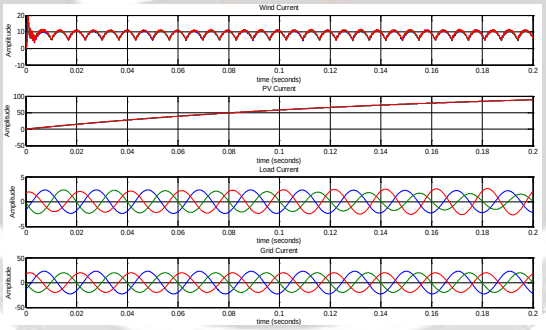

Fig.14 Various Three Phase Waveforms of Proposed System

Figure: 5.6 show various three phase waveforms of proposed system on MATLAB scope. The top most wave form is a wind current waveform top second corresponding to it is a PV current waveform below it load current waveform is plotted and at the bottom grid current waveform is plotted on MATLAB scope. All the waveforms are carried out altogether to analyze the performance of proposed system on various aspects.

The comparative analysis between system without proposed model (Previous base work) and with proposed approach (Proposed model)utilizing current control technique based on Hysteresis investigation is appeared in table underneath table 5.1. Table 5.1 demonstrates the % of individual harmonics distortion w.r.t fundamental present in the system table demonstrates the Total Harmonic Distortion (THD) of the system using filter. As seen from the table Hysteresis Current Control of Photovoltaic, Wind & Fuel Cell Based Hybrid Electric Power System Interconnected with Three Phase Utility Grid having Hysteresis Current Control system strategy gives the better result as compare to the previous base work system.

Table: 2 THD comparison.

Previous Work Base Paper [1]	***Proposed Work***

31.9%	1.94%

Conclusion and Future Work

This work presents implementation and simulation of MATLAB model of a hysteresis current control of photovoltaic, wind & fuel cell based hybrid electric power system interconnected with three phase utility grid. Today, their innovation is winding up economically feasible. Regularly these assets are generally accessible, or maybe even the main accessible energy sources in some remote territories, and are frequently not integrated with a grid. The operation of a wind or solar based system highly depends on weather conditions and thus electricity generation is variable in time, and often the pattern does not actually follow the load demand. In order to fulfill the energy requirements during a period of low available resources, energy needs to be stored. The most popular way to store energy is batteries, but they lose their energy content rapidly and therefore they can be only used over a short time period. Batteries also have a limited life cycle and problems with depth of discharge, often requiring replacement of service. The variable nature of power production from wind is a limiting factor in ensuring a stable and reliable power supply. This study demonstrated the potential of hybrid wind-turbine and hydrogen system to increase the penetration of this type of hybrid system into energy markets. A photovoltaic, wind & fuel cell based hybrid electric power system can be connected to three phase utility grid, injecting power into the grid besides providing power to their local loads. It is therefore important to inject a low THD current from photovoltaic, wind & fuel cell based hybrid electric power system to grid at unity power factor. This can be achieved by using a hysteresis current control, which is simple, easy to design, and easy to implement. As a result, it will reduce the cost and size and increase the reliability of the generators. In future there are following scope in proposed work.

1. In future it is possible to find a better way than current control method to eliminate harmonics in power utility system with maintaining reliability and stability of the system by using PWM based current controller.
2. The implementation a microcontroller is also needed for the proposed system.
3. Experimental set-up is required for the verification of the proposed system with the power conditioning unit control.

References

[1] R. C. Dugan and T. E. McDermott, “Distributed generation,” IEEE Ind. Appl. Mag., vol. 8, no. 2, pp. 19–25, Mar./Apr. 2002.

[2] Z. Yao and L. Xiao, “Control of single-phase grid-connected inverters with nonlinear loads,” IEEE Trans. Ind. Electron., vol. 60, no. 4, pp. 1384–1389, Apr. 2013.

[3] Quoc-Nam Trinh, Student Member, IEEE, and Hong-Hee Lee, Senior Member, IEEE, An Enhanced Grid Current Compensator for GridConnected Distributed Generation Under Nonlinear Loads and Grid Voltage Distortions, IEEE Trans. Ind. Electron., vol. 61, no. 12, Dec 2014

[4] Z. Liu, J. Liu, and Y. Zhao, “A unified control strategy for three-phase inverter in distributed generation,” IEEE Trans. Power Electron., vol. 29, no. 3, pp. 1176–1191, Mar. 2014.

[5] Quoc-Nam Trinh, Student Member, IEEE, and Hong-Hee Lee, Senior Member, IEEE, Advanced Repetitive Controller to Improve the Voltage Characteristics of Distributed Generation with Nonlinear Loads, Journal of Power Electronics, vol. 13, no. 3, May 2013.

[6] Putri, A. I., Rizqiawan, A., Rozzi, F., Zakkia, N., Haroen, Y., & Dahono, P. A. “A hysteresis current controller for grid-connected inverter with reduced losses”, 2016 2nd International Conference of Industrial, Mechanical, Electrical, and Chemical Engineering (ICIMECE). doi:10.1109/icimece.2016.7910446.

[7] U. K. Kalla, B. Singh, S. S. Murthy, C. Jain and K. Kant, "Adaptive Sliding Mode Control of Standalone Single-Phase Microgrid Using Hydro, Wind and Solar PV Array Based Generation," in IEEE Transactions on Smart Grid.