Transformer less Intelligent UPS System for Smart Grid to Meet the Reliable Energy by Designing H-Bridge Converter

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Abstract: ***In the present scenario all sector needs continuous power supply to meet our day to today's demand. To achieve these parameters like voltage, current and frequency of the power system should be at rated values, because of remote generation, transmission and distribution we are failing to receive the reliable power. In view of this we are proposing transformerless intelligent uninterruptible power supplies (UPS) for smart grid to meet the reliable energy which operates in multi-functional modular, intelligent UPS system for smart grid consists of four identical H-bridge converters. This concept will include the SPWM techniques to achieve the commanding of intelligent UPS system, also not only can realize all the basic functions of the traditional on-line UPS system, but also can gives pictorial path for the cyclic use of the electrical power between the power grid and storage battery. In the proposed system also we can easily interface the renewable energy sources in order to achieve the sustainable energy. Moreover, due to the modular design, it can easily operate in any power converters mode for any applications. The configuration and working principle of the proposed IUPS system are analyzed, and controlling is achieved by designing and modeling of intelligent UPS system and results are verified with the help of MAT LAB/Simulink.***

Keywords: Intelligent UPS, Smart Grid, Renewable Energy Sources, Converter/Inverter, Distribution Generation and SPWM.

1. Introduction

The modern area trend technology completely depends on the continuous power supply and the economic growth of the nation is completely depending upon the availability of the power supply. Many of the problems are due to the failure of equipment due to poor quality of power supply, are the result of a problematic supply of power. The power problems are described in different way according to the condition. In most countries, commercial power is made available via central power grid, by connecting different generating stations to the consumer [3]. The grid should be fulfilling the requirement of the different consumers of different application[1] .In order to achieve the continuous power supply existing UPS power supply no longer safe and not satisfies the demand days are becoming more and more smarter also the demand of electricity also increasing so to over coming this smart grid took place but how longer alone it will be fulfill the demands so in view of this here we are proposing an intelligent UPS system for smart grid which will be works as backup to the system and also fulfill the demands[9]. Intelligent UPS is designed such way; it will operate in the different multifunctional modes according the necessary conditions [2]-[5]. This system is entirely separate from other UPS system it doesn't have any transformer and which will make a system simpler and more effective and less cost. In the mean time we can easily interface the renewable energy sources and as well as interface easily distributed generation. The proposed system will not only drawn the power supply from the main source but also it will fed back to the grid or utility when ample amount of sources are available at the battery storage. Transformer-based units integrate passive magnetic with fewer active power conversion components resulting in a simpler manner. In choosing between transformer-based and transformer-free uninterruptable power supply system and designer should be understood that where the transformer are best utilized and whether they should be internal and/or external to the UPS in view of physical and electrical distribution requirements and tradeoffs. In mean tine easily interface reneable energy sources [4].

2. Proposed Intelligent UPS for Smart Grid

This section reviews the techniques and tradeoffs utilized in the different rectifier unit, storage unit, inverter unit and the bypass functions of these two UPS designs for various UPS system performance functions. Site Planning and Adaptability Many users find that transformer-free UPS equipment provides greater flexibility in accommodating uncertain future requirements [6]. Transformer-free designs are usually smaller in size than an equally power-rated transformer-based design, providing opportunities to locate the UPS physically closer to the point of power usage or on a more lightly rated (pounds/sq. ft.) raised floor. Applying a transformer-free UPS to a critical power distribution system does not mean that all transformers in the power path can be eliminated, but does allow the system designer to place transformers only where they are needed. The below fig.1 shows the pictorial representation of Intelligent UPS for Smart Grid.

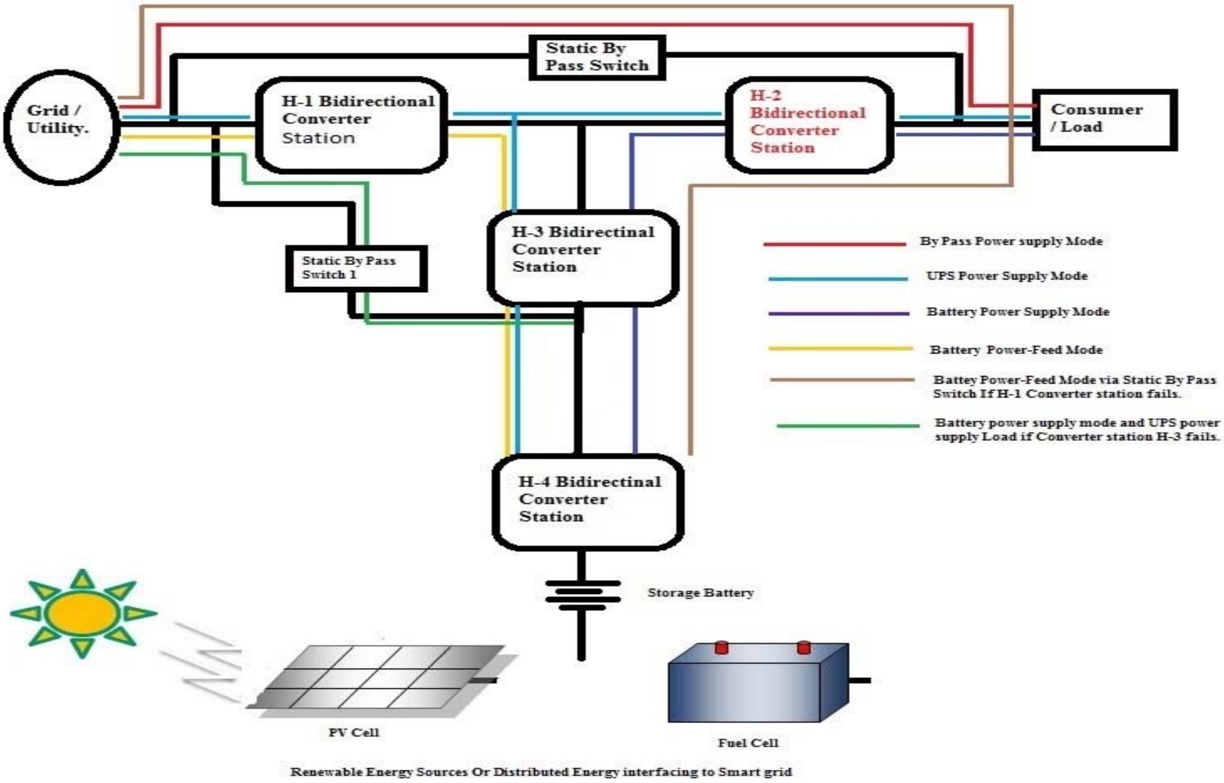

Figure 1: Intelligent UPS for Smart Grid

Once it is determined where transformers may be needed in the system, transformer-free UPSs may permit more optimal placement in the power distribution path. However, it must be remembered that transformer-based UPSs have some of these functions internally integrated as part of the system design, a potential reliability benefit. Reliability and Availability Transformer-based UPSs have an inherently higher reliability due to a much lower parts count, robust redundant.

They also benefit from technology innovations and an installed base of thousands of machine-years of experience and refinement. The newer design of the transformer-free UPS achieves its high-availability performance through advanced power conversion technologies, redundancy, modularity, active fault management and lessons learned from transformer-based designs.

All major UPS manufacturers produce both topologies for mission critical applications to accommodate UPS system designer preferences. Transformer-based UPS units utilize a combination of passive and active fault diagnosis systems, transformerless systems is designed [7]. The control strategies and expanded power conversion processes within the SPWM rectifier, DC/DC converter and inverter of the transformer-free UPS power supply.

3. IUPS Description

The main theme of the IUPS is to provide the clean and continuous source and acceptable power to the load irrespective of the source. It consists of 4- identical H-Bridge bidirectional converter/inverter station [10]-[11]; they are named as station H1, H2, H3and H4 converter station. The controlling action is achieved by with the help of SPWM technique in order to get the pure sine wave [8]. This technique is characterised by constant amplitude pulses with different duty cycle for each period and the width of the pulses are modulated to get inverter output voltage control and also it will reduces the harmonic value.

In SPWM technique a sinusoidal modulating signal is compared with a switching frequency triangular waveform to generate the switching signal for the inverter devices, by changing the control signal magnitude the width of the gate drive for the devices can be varied and hence output voltage magnitude is also varied also by changing the frequency of the modulating wave the fundamental frequency at the inverter output changes.

In general terms, robustness is an expression of a qualitative level of abuse that an online UPS system can handle beyond its 0-to-100 percent ratings while still meeting its availability requirements [7]. Both transformer-free and transformer-based UPS can provide excellent and similar dynamic overload capabilities for phase-to neutral or three-phase dynamic load events.

These units provide automatic handling of temporary overloads and faults on the downstream distribution network and can provide on-the-fly paralleling with the AC bypass in support of overload and load fault management. Transformer-based UPSs add the benefit of some degree of passive fault handling through internal transformers and filters. Most transformer-based designs use circuit breakers at key disconnect points (Input, Output, Bypass and Battery). These circuit breakers provide over-current protection and allow for greater fault clearing capabilities.

Some transformer-free designs may use a contactor and fuse combination which can present problems during certain overload or fault conditions. Specifically, an inverter IGBT can fail short which may cause the contactor to weld and introduce a DC current onto the bus along with this most of the contactors will be unable to open during DC fault conditions or high, AC fault current situations which could be easily handled by a properly sized circuit breaker. Also, in a transformer-based UPS, the DC fault current cannot pass through an isolation transformer. As a result, the input feeder or the critical bus cannot experience any DC fault conditions, or cascading DC faults.

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5. Engine-Generator Interface

The input filter on the transformer-based design is large enough in kVAR to cause the input power factor to become leading (capacitive) when the UPS is lightly loaded (less than 40 percent). This can cause engine generator (Genset) control issues if not taken into account during the engine-generator/UPS integration design. The added kVAR of the filter also requires that the engine-generator be oversized when compared to the UPS power rating.

For this reason, most UPS manufacturers offer an option to automatically eliminate the leading power factor under light loads. The transformer-free design, with its near unity power factor and very low input current distortion over the full output load range, circumvents these characteristics and allows a more closely matched engine-generator to be used. The engine generator may still need to be oversized to some degree to handle the full critical load plus battery recharging. As a side note regarding system design, be sure to confirm that the DG system and any power distribution components, can handle the critical load power factor and AC current distortion separately from the UPS. From time to time, the UPS will be on bypass, with the critical load powered directly from the utility input source, engine generator or other alternate AC source.

UPS Output Considerations The output transformer in the transformer-based UPS design provides flexibility in output voltage, phasing and grounding. The delta-wye transformer can be configured as a 3-wire delta (three phases plus ground) or 4-wire wye (three phases plus neutral plus ground), 600, 480, 400 or 208 Volt system output. The wye provides for adherence to the National Electric Code separately derived neutral definition. It also permits the neutral to be grounded and a local distribution reference established. Grounding points for separate rectifier AC input and bypass AC input sources will not need to be closely coupled, as would be required for transformer-free designs. Transformer-free UPS design is typically executed as a three-wire in-and-out-only system with the output voltage the same as the input voltage (Figures 6 and 7). Neutral establishment (i.e., 4-wire wye output) for distribution occurs farther downstream in an isolation transformer, whether stand-alone or within a Power Distribution Unit (PDU). If an output neutral is required in a transformer-free UPS, a fourth leg is added to the inverter (Figure 8). The created neutral does not have magnetic isolation and will be referenced.

6. Analysis and Design of IUPS System

The smart grid plays a very important role now days to meet the demands of the consumer. In order to make this smart grid more smart and smarter the single use of online UPS system no longer satisfies so to overcome this and make smart grid success the transformer-less Intelligent UPS suggesting by this paper which will be operating very smartly according to the necessary conditions. The below fig.2 shows the transformer less IUPS for smart grid.

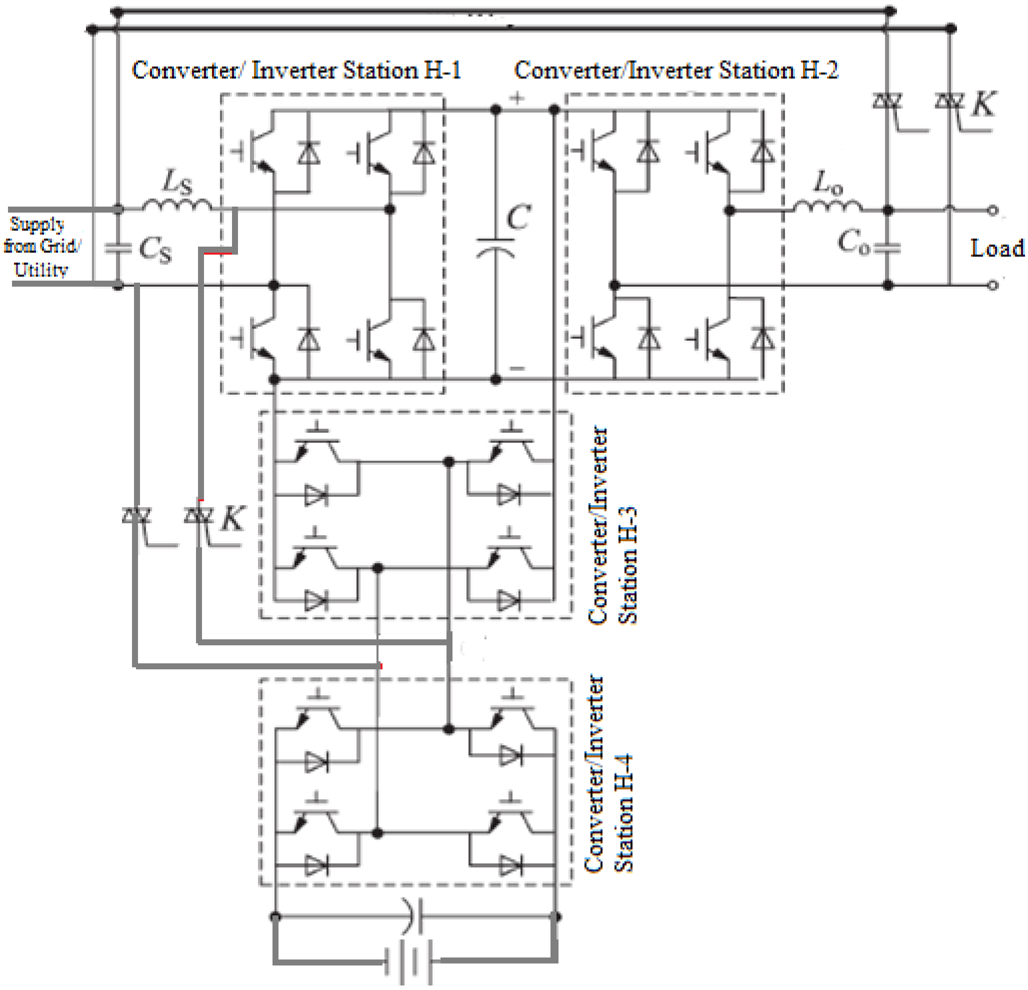

Figure 2: Structure of Intelligent UPS for Smart Grid

6.1 Operating Modes of IUPS

As name it indicates that intelligent UPS it will be operating in the different multifunctional modes according to the necessary condition it will totally operating in the following modes as follows

IUPS Mode-1: Static by Pass Power supply Mode:
When the UPS is under in malfunction condition the grid supply will be directly fed to the load via the static by pass switch which leads continues power supply, under this condition the converter/inverter station H-1, H-2, H-3 & H-4 will not come into action.

IUPS Mode-I1: UPS- Power supply Mode:
In the UPS power supply mode, the static by pass switch will not come into action and all converter/inverter station will starts working and in this mode station H-1 will be working as a converter which will converts the ac-dc and mean time it will be connected to load via H-2 inverter station. The energy stored in the battery through converting ac-dc-ac-dc under this case converter stations H-3 & H-4 will come into picture and supply the energy in the battery bank

IUPS Mode-III: Battery - Power supply Mode:
During the failure of the grid supply this battery power supply will come into action and it will fulfill the demand of the consumer. Under this case the H-3 and H-4 and H-2 will come into action it will convert dc-ac-dc-ac then it will be connected and fulfill the demand under the power grid source failure case.

IUPS Mode-1V: Battery – Feed power supply Mode:
During in this case the demand of the load less and the energy stored in the battery is ample due to the interfacing of the renewable energy generation can be feed it back to the grid by converting into dc-ac-dc-ac the to grid under this case utility grid will be act as a load the battery under this converter station H-4, H-3 and H-1 will be come into picture. So by this we can support the smart grid to become success in the future [12].

IUPS Mode-1V: Battery – Feed power supply via static bypass switch if H-1 Failure Mode:
Under this mode if the converter station H-1 fails and it's not possible to send the sources to load but we have battery power supply mode, we can feed the load without interrupting, in the meantime if grid requires a sources to full fill the other load that time, we can easily feed the grid by battery source any way here we are interfacing the renewable energy source we can also easily support grid to make more smarter.

IUPS Mode-V: Battery supply mode and UPS power supply mode if Converter station H-3 fails mode:
Under this mode it will be perform 3 additional functional according to the necessary conditions firstly it will feed the load via H-4, H-1 & H-2 converter station, secondly UPS power supply mode it will feed the load via H-1 & H-2 and as well as charge the battery via H-3 and thirdly it will also works in static by pass mode via H-4 station totally it will check the condition's according it will turns on the particular mode of operation and will be continuously feed load if necessary or it will feed the grid when it requires. So this we can make smarter intelligent UPS system.

7. Simulink Model of IUPS for Smart Grid

The Intelligent UPS is designed by using Matlab Simulink toll and constructed according to the proposed work the below fig.3 shows the basic model of IUPS which consists of two parts firstly is

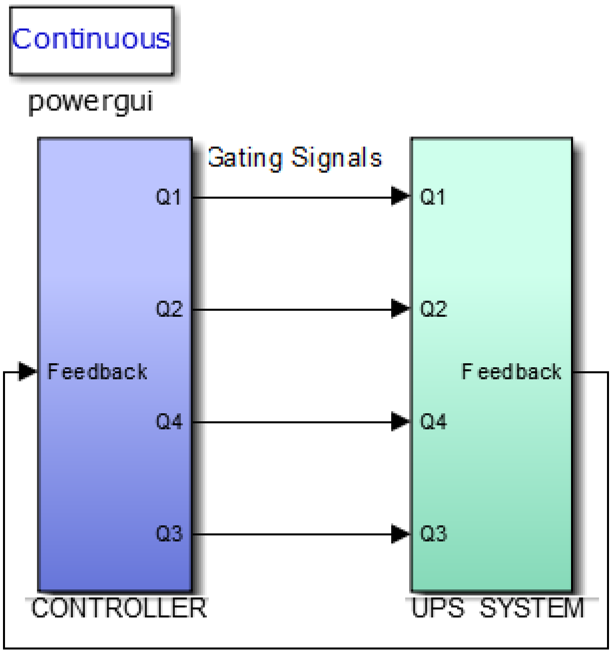

Figure 3: Intelligent UPS for Smart Grid

Controller part and the second one is UPS system. The IUPS will operating in the different modes that can be controlled by using SPWM technique to generate the pulses for converter station according to in which made necessary by giving a feedback signals to the controller and which will be generates the pulses by comparing with the reference signals and gives the pulses to bridge which is shown in the fig.4.a & b below

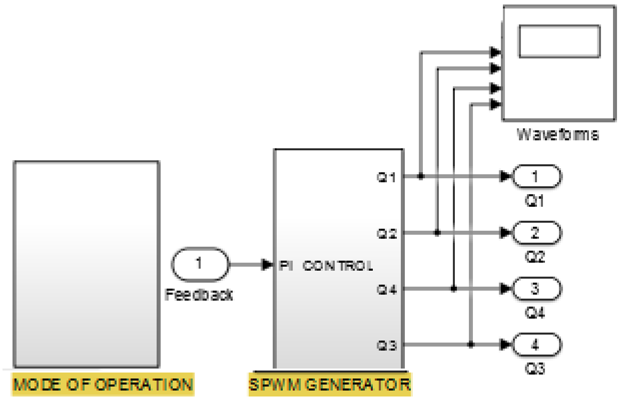

Figure 4: a. SPWM feeding to converter station

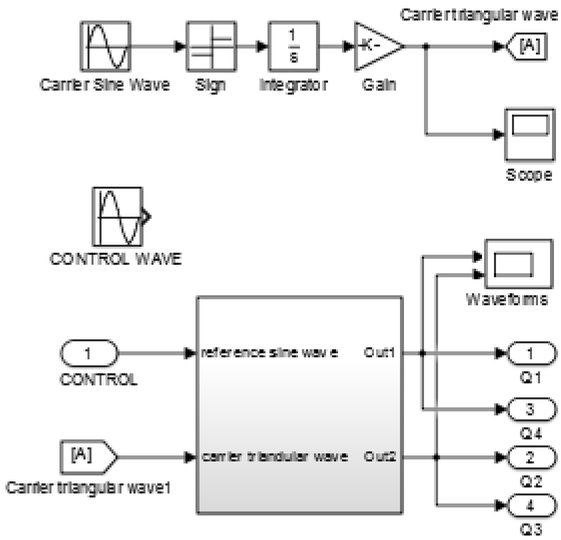

Figure 4 (b): Generation of pulses with comparing of reference sine wave and triangular wave

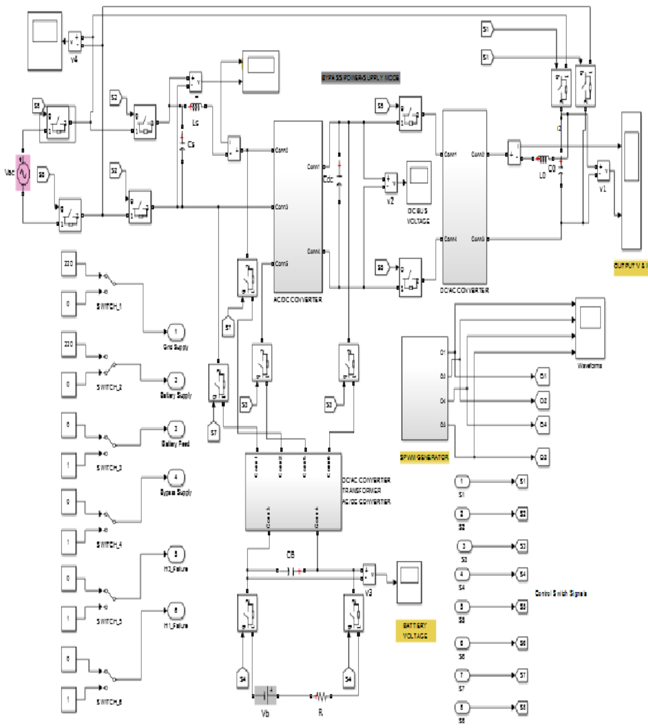

Figure 5: Simulink Model of Intelligent UPS for Smart Grid

The above fig.5. Shows the final modeling of Intelligent UPS system for smart grid. By constructing this we can easily make the system smarter and smarter, also we can easily achieve the online UPS for both the load and as well grid connecting if grid requires additional sources in order to meet the demand of the other load which connected to grid.

8. Simulation Results of IUPS System.

The modeling of the IUPS has been done and the different modes of operation simulation results are expressed below.

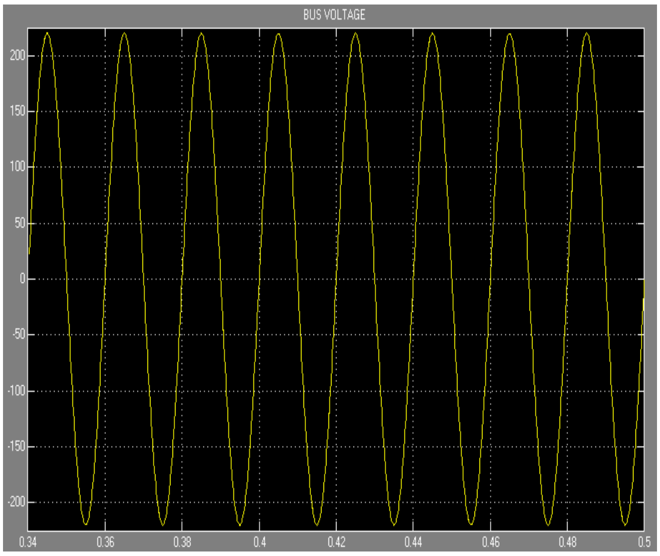

Figure 6: Input source voltgae from grid

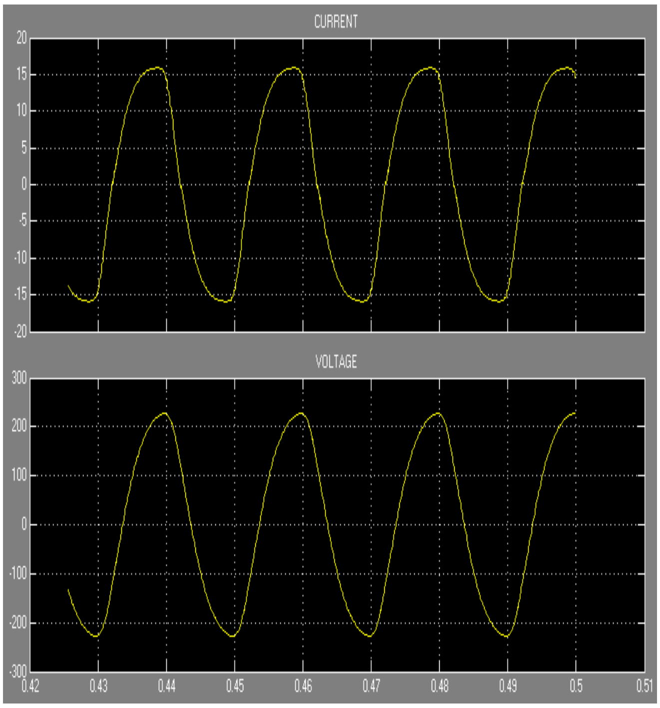

Figure 7: Static by pass power supply mode

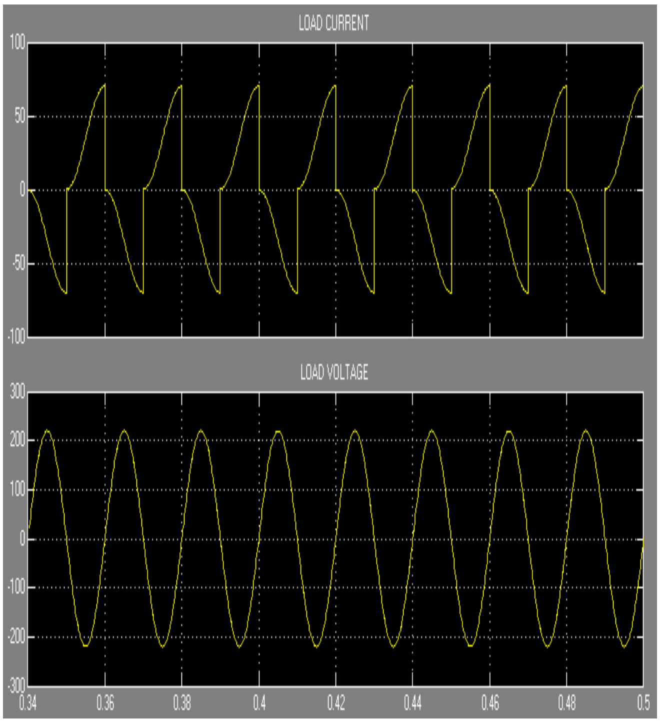

Figure 8: Load current and voltage During UPS mode

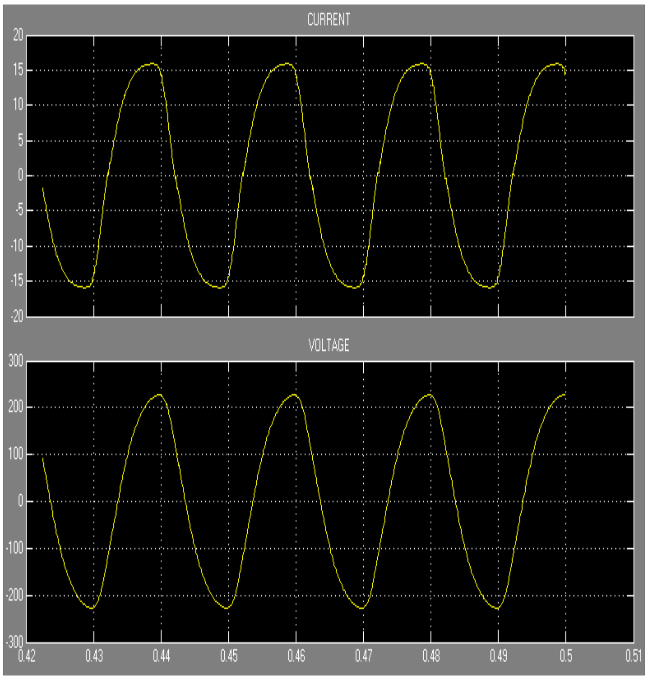

Figure 9: Load current and voltage during battery power supply mode

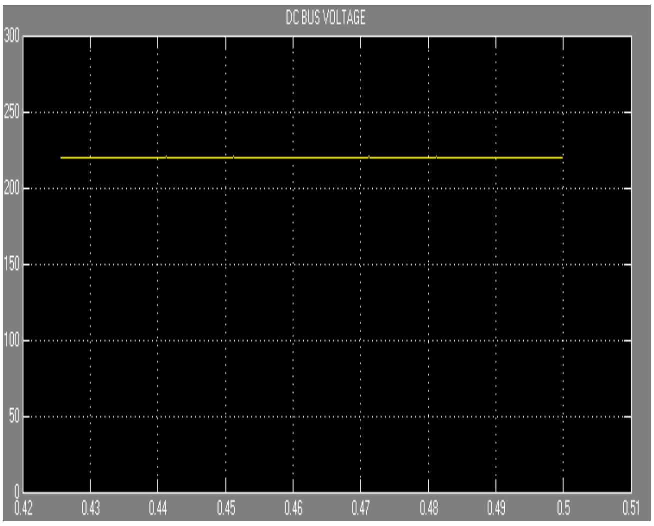

Figure 10: DC Link BUS Voltage

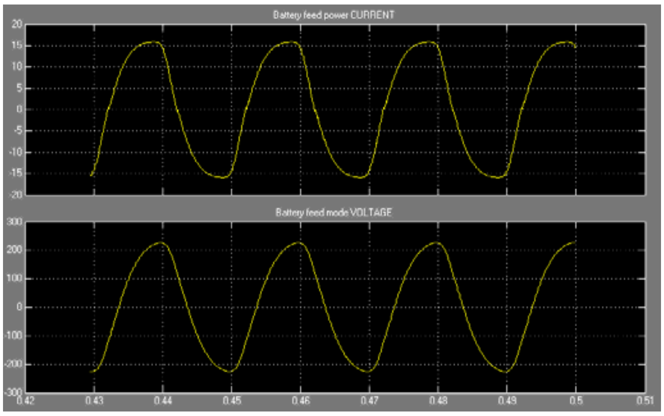

Figure 11:.Battery feed power supply mode

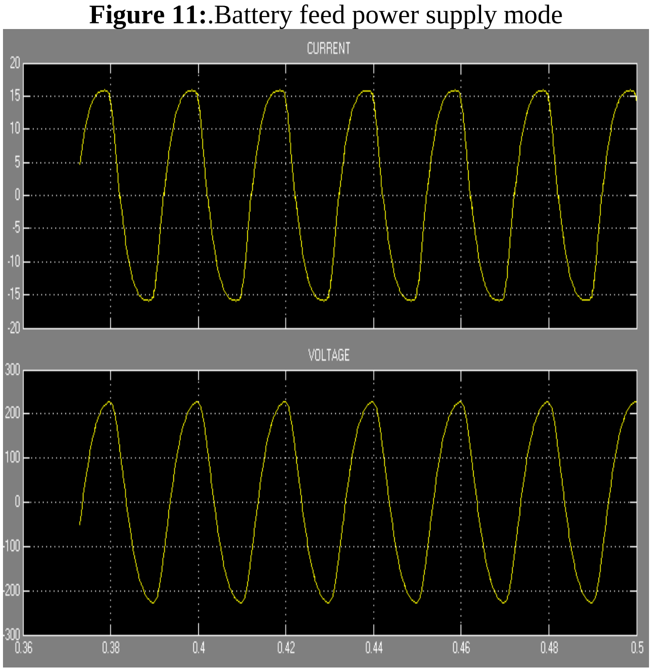

Figure 12: Battery power feed & Battery supply mode mode if H-3 failure

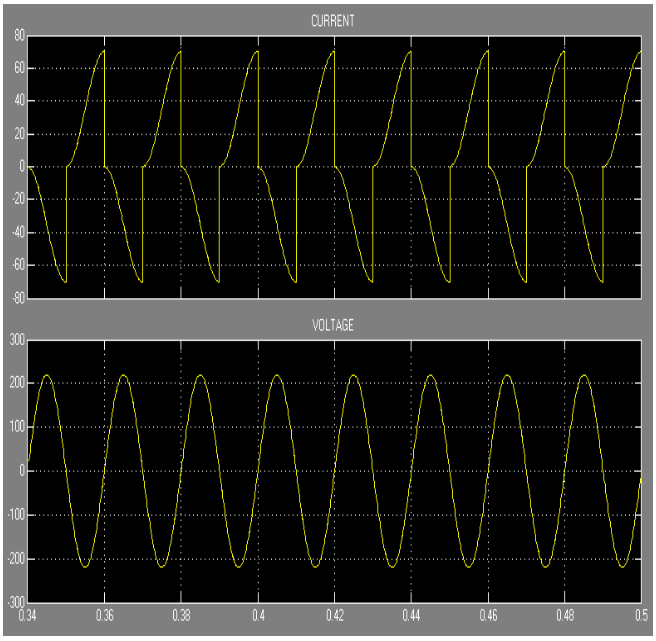

Figure 13: UPS & battery feed power supply mode if H-1 failure

9. Conclusion

In order to meet the present modern trend electricity demand and as well as to give additional support to the smart grid, the proposed intelligent uninterruptable power supply will plays a very important role, in view of this we are proposed the IUPS and analysed, the whole system by designed the system with the help of Matlab Simulink toll and we are verified for the different modes of operation. The unidirectional electricity providing UPS system can't satisfy the need of the demand of it anymore, "Green," energy saving, modular, and IUPS system become the main development trend. The proposed IUPS system not only can analyse all the basic functions of the conventional UPS system, but also can fill the gap between the electrical power and the power grid and storage battery and make it become a "Green" user to the power grid. By this we can easily achieve the continuous power supply without interrupting and also it can be easily switched into different mode depending of the need of application also can apply for type drive system and other so many applications and ultimately it leads to the growth of the country economy and the whole system will looks holistic manner.

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