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Line Interactive Based Designed UPS for Micro Grids



Viral P. Parmar
M.E (Power Electronics) Student,
Electrical Engineering Department,
Parul Institute of Technology,
Vadodara,Gujarat,India.

Keyur R.Kinariwala
M.E (Power System) Student,
Electrical Engineering Department,
Parul Institute of Technology,
Vadodara,Gujarat,India.

Mithilesh Verma
Assistant professor,
(M.Tech Power Eletronics & Drives),
Electrical Engineering Department,
Parul Institute of Technology,
Vadodara,Gujarat,India

Abstract:

Line interactive Uninterruptable Power offer (UPS) systems area unit smart candidates for providing energy storage inside a microgrid to assist improve its responsibleness, economy and potency. In grid-connected mode, power are often foreign from the grid by the UPS to charge its battery. Power may also be exported once needed, e.g., once the tariffs area unit advantageous. In complete mode, the UPS provides native distributed masses in parallel with different sources. during this paper, a line interactive UPS and its system area unit conferred and mentioned.

Power flow is controlled victimisation the frequency and voltage drooping technique to make sure seamless transfer between grid-connected and complete parallel modes of operation. The drooping coefficients area unit chosen to limit the energy foreign by the USP once re-connecting to the grid and to administer smart transient response. Experimental results of a microgrid consisting of 2 60kW line interactive UPS systems area unit provided to validate the planning.

Index Terms:

Line interactive UPS, microgird, distributed generation.

1. INTRODUCTION:

To INCREASE responsibility, energy storage systems among a microgrid ar essential. Energy is hold on whereas in grid-connected mode, once the microgrid's Distributed Generation (DG) systems manufacture excess power, to be used later to produce important masses throughout power outages.

In complete mode, they will be accustomed boost the facility provided by the microgrid if the weight unit systems cannot meet the expected level of power. to fulfill these demands, the energy storage system must be able to add grid-connected and complete modes. within the latter mode of operation, the system must operate in parallel with different weight unit systems to fulfill the variable power demand of the load. a lot of significantly, it must switch seamlessly between the 2 modes.Line interactive UPS systems ar sensible candidates for providing energy storage among microgrids as they will be connected in parallel with each the most grid and native load. The classical topology of line interactive UPS systems [1],[2] is easier, cheaper, a lot of economical and a lot of reliable than the on-line double conversion UPS. This topology, however, doesn't give voltage regulation to the load. Voltage regulation ispossible as in series-parallel or delta conversion line-

interactive UPS [3]-[6] at the expense of lower potency and further size and value because of the employment of additional electrical converter and hulking electrical device. However, this topology remains a lot of economical than classical on-line double conversion UPS as a result of the complementary electrical converter has solely to produce 100 percent to twenty of the UPS nominal power [7]. There ar variety of publications on the management of line interactive UPS systems [8]-[15]. Tirumala et al. [8] planned a bearing algorithmic rule for grid interactive PWM inverters to get a seamless transfer from grid-connected mode to complete mode and contrariwise. once it's connected to the grid, the electrical converter operates in current-controlled mode control the present injected into the purpose of common coupling (PCC). In complete mode, however, the electrical converter operates in voltage-controlled mode control the output voltage across the load.

Similar approaches were conjointly reportable in [9] and [10]. the most disadvantage of those systems is that the load voltage when the grid fails and before beginning the transmutation amount (from current-controlled to voltage controlled mode) depends on the present demand and therefore the load. This may lead to terribly|a really|a awfully} high or very low voltage across the load throughout the transmutation amount. A notch filler that's accustomed mitigate these voltage transients was planned in [11]. Kim et al. [12] planned a controller for actually seamless transfer from grid-connected mode to complete mode.

The manage mentler has associate degree inner voltage control loop that regulates the output voltage. throughout grid-connection, the facility associate degreegle (the angle between the electrical converter voltage and therefore the voltage at the PCC) of the output voltage is about by an outer management loop counting on the specified injected grid current. once the grid fails, the facility angle is saturated to a most predefined worth. within the system reportable in [13], the facility angle between the UPS voltage and therefore the grid voltage is measured by a part detector and adjusted to manage the facility. the road interactive UPS system planned in [14] has the voltage controller and therefore the current controller operating in parallel so as to attain seamless transfer between the 2 modes. though the controllers reportable higher than change seamless transfer of one unit from grid-connected and complete mode, the most disadvantage is that the UPS units aren't capable of operational autonomously in parallel with different weight unit units and so they cannot kind a microgrid.

Chandorkar et al. [15] planned a line interactive UPS system supported P-ω and Q-V droop management wherever the electrical converter frequency and voltage amplitude ar drooped linearly with the electrical converter output active and reactive power, severally. UPS units will operate in parallel and cargo sharing is achieved while not the requirement for communication signals between theinverters. In [16], a line interactive UPS system that's capable of operational in a very microgrid was planned. The controller of the UPS electrical converter relies on 2 management loops: associate degree inner voltage feedback loop that regulates the output voltage associate degreed an outer active and reactive power sharing loop that is enforced by drooping management.

each systems in [15], [16] give actually seamless transfer between grid-connected mode and stand-alone parallel mode and contrariwise. However, the integration of the battery and its DC/DC convertor into the system wasn't studied. Also, the steadiness of the DC-link voltage wasn't mentioned. This becomes a vital issue, taken into the account the necessity to transfer seamlessly from battery charging mode in grid-connected mode to battery discharging in complete paralleling mode. This paper presents and discusses a line interactive UPS system to be used among a microgrid as illustrated in Fig. 1. The system will transfer much seamlessly between grid connected and complete modes sharing the load among a microgrid in parallel with different weight unit units. The management of the complete system together with the battery and its bidirectional DC/DC convertor is taken into account. the most novel contributions of the paper are:

1) Analysis, style and experimental implementation of a replacement management strategy of a line interactive UPS system among a microgrid that permits seamless transfer between grid connected and complete parallel modes of operation,

2) The planning of a DC-link controller loop that sets the active power demand throughout battery charging mode which permits for a sleek transition between battery charging and discharging modes.

The general overall structure of a microgrid (Fig. 1) consists of weight unit units, UPS units, native hundreds, higher-up controller, and a static transfer switch (STS). The STS is employed at the PCC to isolate the microgrid from the grid just in case of grid faults and reconnect seamlessly to the grid once the faults area unit cleared. Local hundreds area unit connected on the microgrid facet of the switch therefore that they're perpetually furnished wattage regardless of the standing of the switch. The controller of every weight unit system uses native measurements of voltage and current to regulate the output voltage and power flow. there's still but a requirement for low speed communication between the STS and therefore the weight unit units to update them concerning the standing of the switch, i.e., whether or not it's opened or closed. what is more, the higher-up controller measures the ability at the PCC, receives info concerning the state of charge (SOC) of the batteries from the UPS controllers and sends active and reactive power

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commands and to the opposite weight unit units supported tariffs, native load necessities, and potency of the units. When the grid is connected, the UPS will export power to the grid or it will import power to charge their batteries. For example, the superior controller could charge the battery during the grid off-season tariff and discharge it throughout peak tariff periods. once a grid fault happens, the anti-islanding controllers embedded within the controllers of the metric weight unit units push the voltage amplitude and/or frequency at the PCC toward their upper or lower limits. Once the amplitude or frequency higher or lower limits ar reached, the controller of the STS decides that the grid isn't healthy and opens the switch. It conjointly sends a signal to the metric weight unit units to update them regarding the standing of the switch.

The metric weight unit units keep on activity power in parallel according to their ratings, sharing the ability demanded by the distributed native masses. when the grid fault is cleared, the STS reconnects the microgrid: it monitors the voltage signals on both sides and closes once these signals ar in section to make sure transient free operation. The microgrid thought of during this paper consists of 2 60kW line interactive UPS systems every battery-powered by a 30Ah (550-700 V) lithium-ion battery. The circuit diagram of every UPS system is shown in Fig. 2. The UPS system consists of a battery, a duplex DC/DC convertor [17], and a bidirectional three-phase DC/AC convertor with AN output LCL filter.

The DC/AC convertor parameters ar given in Table I. When the ability flows from the grid to the battery, the DC/DC converter operates in buck mode and therefore the boost IGBT is control open. once the ability flows within the other way, the buck IGBT is control open and therefore the DC/DC convertor operates in boost mode regulation the DC-link voltage to an acceptable level so as to inject power into the grid. Fig. three shows the controller of the bidirectional DC/AC convertor.

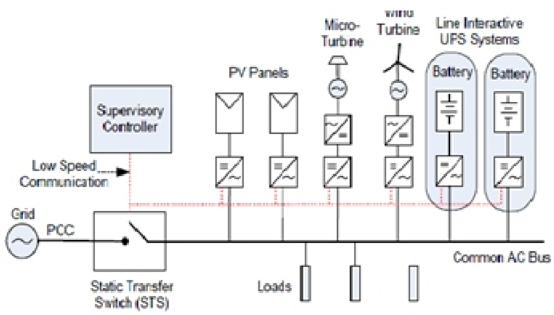

Fig. 1. Microgrid structure

AN outer power flow controller sets the voltage demand for AN inner voltage core controller loop. The core voltage controller (not shown) regulates the capacitor voltage . The reaction time for the inner core controller is way quicker than the outer power flow loop and hence it'll be assumed (from the purpose of read of the ability flow controller) as a perfect voltage supply with settable magnitude and frequency. Fig. four shows the controller of the bidirectional DC/DC convertor. throughout battery charging mode, the Buck IGBT is pulse breadth modulated and, betting on the battery voltage, the controller operates either in current mode or voltage mode regulation the battery current or voltage, respectively. once the battery discharges, the boost IGBT is modulated to control the DC-link voltage.

Throughout battery charging, the DC-link voltage is controlled by the three-phase DC/AC convertor, that during this case operates as an energetic rectifier. once discharging, however, the DC-link voltage is controlled by the DC/DC convertor, operative in boost mode as mentioned earlier. To decouple these 2 controllers, which control a standard DC-link voltage, the voltage demand for the active rectifier is set to be higher (800 V) than the voltage demand of the boost (750 V). to know how the controllers react throughout a fast transition between operating modes, the subsequent situation is taken into account. Suppose that the UPS is in charging mode, the DC-link during this case can be regulated by the DC/AC convertor operative as an energetic rectifier and therefore the DC/DC convertor are going to be charging the battery in buck mode.

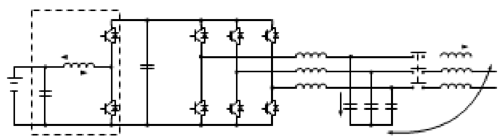

Fig. 2. Circuit diagram of the UPS system

At the moment when the grid fails and before the fault is detected by the STS, the power flow through the three-phase converter changes direction immediately and automatically as a consequence of losing stiffness at the PCC. Thus the power starts to flow from the DC-link capacitor to the AC load causing the DC-link voltage to drop from the demand. Once, the DC-link drops below , the DC/DC controller recognizes the event and changes its mode from buck to boost immediately and start regulating the DC-link voltage.

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In this scheme, the smooth transition from grid connected charging mode to stand-alone mode is possible without relying on external communication. When the grid fault is cleared, the STS closes and sends an update signal to the UPS units. If the power demand received from the supervisory controller during grid-connected mode is positive, i.e. , the power flow controller sets the drooping controller demand to such that as shown in Fig. 3. However, if the power demand from the supervisory controller is negative, i.e. , the DC-link voltage controller, within the power flow controller, starts to raise the DC-link voltage to . The output of the DC-link voltage controller will be a negative active power demand to the power flow controller.

The DC/DC converter will stop operating in boost mode because the DC-link voltage (regulated to) is higher than its demand . It will then start to operate in buck mode either in current mode or in voltage mode depending on the battery voltage . If it operates in current mode, the battery current demand is set to/where is the battery charging power demand and equals to (| |), (the absolute value is used because the in this case is negative).

The rate of change of the ramp function needs to be slow enough so it does not disturb the DC-link voltage controller. For instance, if the is changed suddenly, the DC/DC converter will draw a large amount of power from the DC-link capacitor which may result in a drastic drop in the DC-link voltage before the DC-link voltage controller reacts to this drop. To avoid any unnecessary transient, any changes required to and values in the power flow controller also happen gradually via ramp functions.

III. POWER FLOW CONTROLLER :

A. Small Signal Analysis :

The proposed drooping control is given by

$$\omega = \omega_o^* - \left(k_\omega + k_{\omega\_I}/s\right)\left(P - P^*\right)$$
$$V = V_o^* - \left(k_a + k_{a\_I}/s\right)\left(Q - Q^*\right)$$

where , , , and are the nominal frequency reference, nominal voltage reference, proportional frequency drooping coefficient, and proportional voltage drooping coefficient, respectively.

The integral frequency and voltage drooping coefficients , are set to zero during island mode but they are activated during grid connected mode to make sure that the power output follows the demand precisely especially when the grid voltage and frequency deviate from their nominal values. The values and are set to the demanded power in grid connected mode. In stand-alone mode, however, they are set to nominal active and reactive power and to improve frequency and voltage regulation. Because this is a bidirectional UPS system and are set to zero.

The inverter can be modelled by a two-terminal Thevenin equivalent circuit as shown in Fig. 5(a). G(s) and Zo(s) represent the closed loop and output impedance transfer functions, respectively [18]. Fig. 5(b) shows an equivalent circuit diagram of the grid-connected UPS unit. Zo(s) has been replaced by sLo because the output impedance is predominantly inductive around the fundamental frequency [18]-[20]. The inductance Lo can be determined by the slope of Zo(s) around the fundamental frequency and it was measured to be 996µH.

2. PROPOSED SYSTEM:

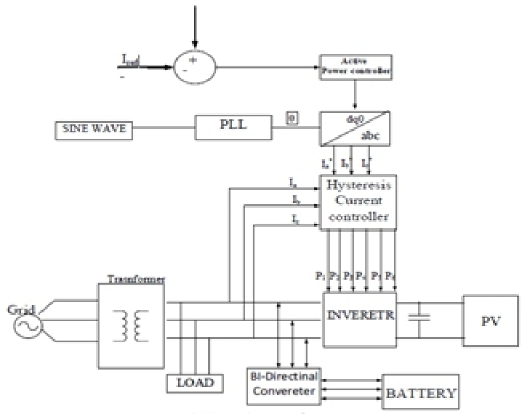

Fig. 3. Circuit diagram of the Proposed system

Things to consider for line-interactive UPS: In developing countries or other infrastructure challenged areas where the AC line voltage is unstable, fluctuates wildly, or is highly distorted, a line-interactive UPS may go to battery once or twice a day or even more frequently. This is because the line-interactive design has a somewhat limited ability to keep large voltage swings and heavy distortion from reaching the load unless it disconnects from the AC supply and transfers to battery power.

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Even though the lineinteractive UPS will provide an output voltage within the IEC limits for as long as battery power is available, frequent use of the battery will reduce its capacity, leaving less runtime available for an extended outage. Also, even if the batteries are not discharged to exhaustion, frequent use can result in the batteries needing to be replaced more often.

3.MICRO GRIDS:

The Micro grid concept assumes a cluster of loads and micro sources operating as a single controllable system that provides both power and heat to its local area. This concept provides new paradigm for defining the operation of distributed generation. The micro sources of special interest for Micro grids are small (<100 kW) units with power electronic interfaces. These sources are placed at customers sites. They are low cost, low voltage and have a high reliability with few emissions. Power electronics provide the control and flexibility required by the Micro grid concept. A properly designed power electronics and controllers insure that the Micro grid can meet the needs of its customers as well as the utilities. Defined characteristics of Micro grids as;

- Not centrally planned (by the utility)

- Not centrally despatched.

- Normally smaller than 50-100 MW.

- Usually connected to the distribution system.

Implementing an Micro grid can be as simple as installing a small electricity generator to provide backup power at an electricity consumer's site, or it can be a more complex system that is highly integrated with the electricity grid that consists of electricity generation, energy storage, and power management systems. Micro grids devices provide opportunities for greater local control of electricity delivery and consumption. They also enable a more efficient use of waste heat in combined heat and power (CHP) applications, which boosts efficiency and lowers emissions. This systems provide electricity, hot water, heat for industrial processes, space heating and cooling, refrigeration, and humidity control to improve indoor air quality and comfort.

TABLE-1 Comparison of line interactive and conventional UPS system

Topology	Reliability	Total cost of ownership	Input	Output	Size/Weight
Line-Interactive UPS	+ Fewer Parts Lower operating temperature	+ Lower Initial Cost (Fewer Parts) Lower Operating Cost(Less Electricity)	- No PFC Extreme Voltage Distortion can Require Frequent Battery Usage	+/- Output Frequency varies within a Configuration Range	- Typically larger/heavier
Double conversion On-Line	- Many Parts Higher Operating Temperature	- Higher Initial Cost(more parts) Higher Operating Cost (electricity and cooling)	+ Has PFC Accepts extreme Voltage Distortion without going to battery	+ Output fixed to a Configurable Frequency	+ Typically smaller/Lighter, At higher power level

4.SIMULATION AND RESULT:

For simulation test;

- We are required a system with generation of specific power, transmission lines, effective mid buses sub system, load condition, and conventional UPS system etc.

- That has been already prepared and further progress is going on towards built up of line interactive UPS.

Summery;

- After these much progress we are required to connect load and test these model of conventional & line interactive UPS on power cut-off condition.

- Also critical loads can be attached and to be tasted.

- Test data & transfer time should be calculated and then concluded for the better results.

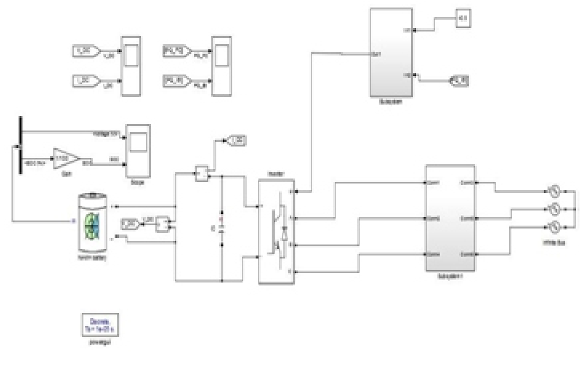

Fig.4.1 Basic Simulation Model for Purposed Project Work

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In this simulation as we can see ac grid, conventional UPS system has already developed with battery storage, in which grid synchronization and interconnection blockcontains sub systems. Further we will move up to the line interactive UPS system.

5.2 Sub system for Grid synchronization block:

In the line interactive UPS simulation model we are containing the sub system which is shown below, sub system for the grid synchronization block is as follows:

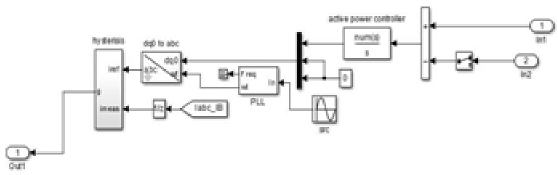

Fig.5.2 Sub system for Grid synchronization block

5.3 Sub System for Interconnection block:

we are containing an interconnection block, which also contains a sub systemwhich can be shown below:

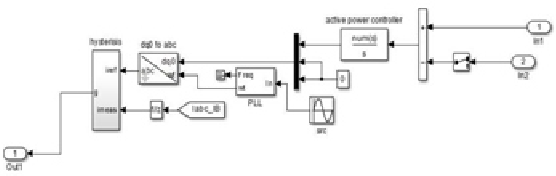

Fig.4.3 Sub System for Interconnection block

5.4 Waveforms of Simulation REF. TIME = 1 sec, REF. VOLTAGE = -0.5V

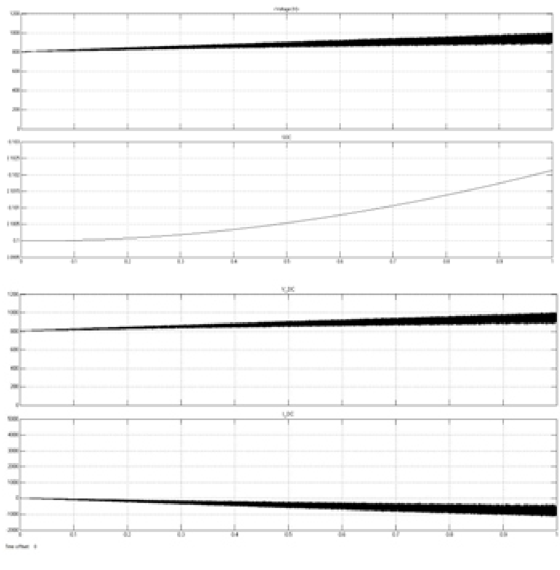

Fig 5.4 Simulation results For Battery charging REF. TIME = 1 sec, REF. VOLTAGE = -0.5V

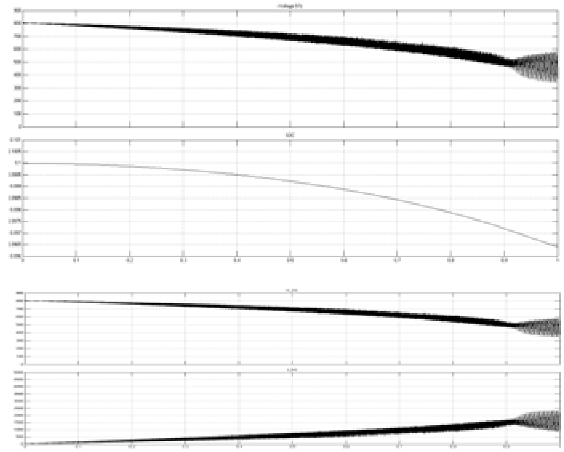

Fig 5.5 Simulation results For Battery discharging

CONCLUSION:

Entire work can be concluded as follows Line interactive UPS is more beneficial compared to conventional UPS system. In each parameter it is advantageous compared to others which ever its transfer time / Power reliability etc. It could be compared to conventional systems. We can observe from the above work that it is less costly than conventional UPS. We can say that conventional UPS systems should be replaced by the line interactive UPS for enhanced power quality.

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Author's Details:

1.Viral P. Parmar

Viral P. Parmar was born in Gujarat,India.He receive the B.E degree in Electrical Engineering from C.K. Pithawala College, surat from Gujarat Technological University.Presently he is pursuing M.E POWER ELECTRONICS in Parul Institute of Technology,Vadodara,Gujara t,India. His research interest include Advance power electronics,Advance electrical machine,Renewable energy sources.

2. Keyur R.Kinariwala

Keyur R.Kinariwala was born in Gujarat,India. He receive the B.E degree in Electrical Engineering from Sarvajanik college of Engineering & Technology,Surat from Gujarat Technological Univesity.Presently he is pursuing M.E POWER SYSTEM in Parul Institute Of Tech nology,Vadodara,Gujarat,India.His research interest include Advance power system,Facts devices,Renevable energy sources.

3. Mithilesh Verma

Graduated in B.E ELETRICAL from Hemchandracharya North Gujarat University in 2007.She receive M.Tech(Power Electronics&Drives) from NIT Kurukshetra in 2012.She served as Assistant Professor in Parul Institute Of Technology,Vadodara,Gujarat,India. Her research interest include Advance electrical drives and Artificial Intelligence.She has publish research paper in various National and International conference.