Line Interactive Ups System: An Advantage over Conventional Ups System

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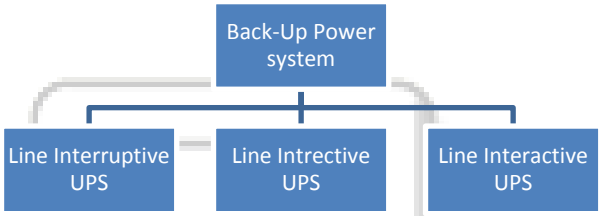
Abstract—At the stage of growing power demand; it is required to have a system that can provide reliable and good quality power. Power System suffers from many disturbances out of which some may cause power cut-off due to which reliability of the system may affected and other may not cause power cut-off but affect operation of those loads which are sensitive to power quality. Line interactive UPS can take care of both situation. In this paper overview of UPS and detail discussion of Line Interactive UPS is covered.

I. Introduction

Evolution in the Back-up System can be briefly described as shown in the below diagram:



In the past, customers who required large amount of power were mainly dependent on the power generating plants. In the power generating plants at the time of maintenance schedule and in fault condition battery supply was used for backup power. This battery supply system uses double conversion phenomenon (DC to AC and AC to DC) [5].

After battery and converter phenomenon, battery supply system was evolved to the Uninterruptable Power Supply System. After that, there was continuous evolution in the UPS supply system such as line interruptive UPS, line intractive UPS system. But due to voltage inequality and disturbance present in the power system, general and sensitive both loads get disturbed and loads were not totally dependent on these UPS [7]. These all drawbacks can be eliminated by a new concept called LINE INTERACTIVE UPS system.

In Line Interactive UPS system many phenomenon are popular such as line interactive UPS containing tap changing transformer, Line Interactive UPS containing power electronic device, etc. [2] [8]. This is a new and better approach towards power reliability and continuity. It also provides a great power quality enhancement [1]. This paper is focusing on the better quality of power.

II. Objective Of Line-Interactive UPS System

- To provide reliability of the power means focusing on the power quality and continuity [1].
- To provide power at fault condition and at time of maintenance schedule of power generation equipment.
- To provide mitigation of the power transfer time between online operation to battery operation and battery operation to on-line operation which directly affects the sensitive loads [4] [9] [13].
- To provide a filter operation in the mode of line interactive UPS to mitigate harmonics caused other line disturbances [3] [6].

III. History Of The Backup Power System

In the early days, loads were dependent on the DG sets which is formally known as diesel generator sets in the condition of power cut-off to provide back-up power. These was the older phenomenon and it was also disadvantageous to the loads because of the larger transfer time. During that time sensitive and critical loads gets disturbed and faulty [7]. To avoid this, generating industry moved to the battery supply system along with the double conversion phenomenon in which at the normal operating condition battery gets charged from the main supply and then at the time of power cut-off the storage power is used to supply power to the load [5]. This is known as double conversion in which AC power gets converted to DC power to store power in the battery and then stored power from the battery converted from the DC to AC when required. So it was known as the double Conversion phenomenon [5]. This is efficient for lower time period operation but for large transfer time it is not useful for critical loads [7].

To overcome that problem line interruptive UPS is used which works as the interruptive device; means with change in line parameters such as voltage, current, power it interrupts the line and continue to supply power from the battery storage. This is a good parameter as functioning as filter [3] but due to disadvantage of large power loss due to uneven line parameters, it is also not so successful.

Then it moved up to latest phenomenon line interactive UPS system, which interacts with line parameter and give support to back up power.

IV. Conventional Ups System

Conventional bidirectional double conversion UPS system uses battery storage UPS system in which back-up power is provided by the double conversion methodology.

A typical backup power supply will continuously provide power with some filtering devices from the utility. When utility power fails, the device will start its internal inverter, and then mechanically transfer from utility power to inverter output. This transfer can take as long as 25 ms, which may be too long for some loads. An Offline UPS will transfer to battery backup during brownouts or surges as

well. Typical offline runtimes in backup mode are from a few minutes to 20 minutes and extended runtime battery packs are rarely available.

Here, in fig 1 shows two operating modes of conventional UPS system namely normal mode of operation and stored energy mode of operation; and in fig 2 block diagram of conventional UPS system is given with dual conversion phenomenon.

Conventional UPS system has its own advantages and disadvantages as follows:

Advantages:

- Low cost
- Small size

Simple design

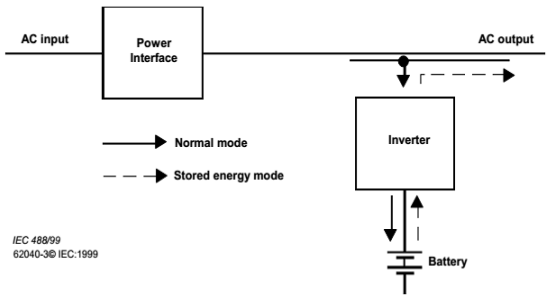


Fig. 1: Mode of operation of conventional UPS system

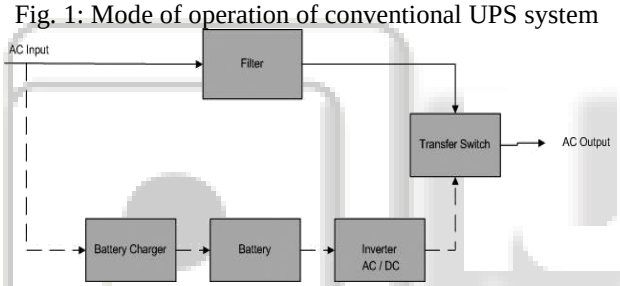


Fig. 2: Block diagram of operation of conventional UPS

Although having these much advantage conventional UPS is not reliable and should not to be used to following disadvantages:

- No power conditioning.
- Slow transfer time.
- Simple battery charger may shorten battery life and increase recharge time.
- Limited additional functionality may not meet enterprise needs.
- Short back-up time.
- No filter application.
- No compensation of voltage/current/power is possible.

V. Line Interactive UPS System

A line-interactive UPS conditions and regulates the AC power from the utility, generally using only one main power converter. Fig. 3 shows the standard description of Line Interactive UPS system topology from IEC standard 62040-3. This figure also shows the modes of operation of the Line interactive UPS system. Detailed topology Line interactive UPS system is given in fig. 4 and fig 5 block diagram representation.

When AC input is present, the "power interface" blocks in Fig. 3 filters the AC power, suppresses voltage spikes, and provides sufficient voltage regulation to operate well within the specifications [3]. This is most often accomplished with passive filter components and a tap-changing transformer.

The main power converter (the "inverter" block) redirects some of the input AC power to keep the batteries fully charged while the AC line voltage is present. This typically requires less than 10% of the UPS power rating, so the components stay cool during its operation. For example, the inverter block in a 3000-watt line-interactive UPS operates at only 300 watts ($1/10^{th}$ of its capacity) or less while charging its batteries. Many components sized for full load operation can run just above the outside ambient temperature when AC is present the most common mode of operation.

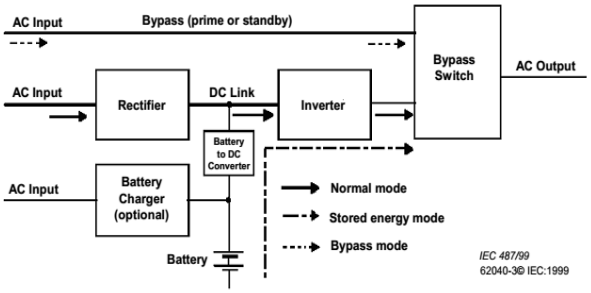


Fig. 3: Mode of operation of Line-interactive

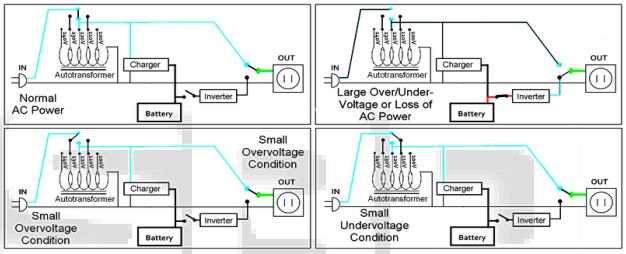


Fig. 4: Topology of Line interactive UPS

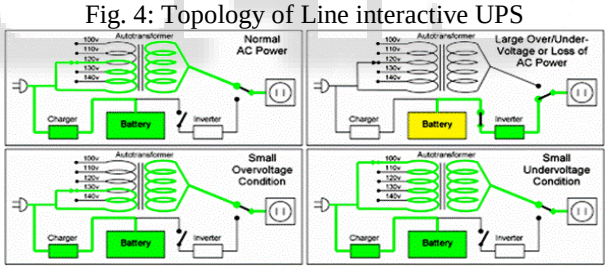


Fig. 5: Topology of Line interactive UPS

When the AC line voltage falls outside the input range of the power interface, the inverter supplies AC output with power from the battery. The input voltage range of the power interface is usually a fixed window, typically -30% to +15% of nominal. For example, a line interactive UPS with 120V nominal output voltage will keep its output between 107 V and 127 V while the input varies from 84 V to 138 V.

Important fact about line-interactive UPS operation is that while it filters and conditions the voltage being supplied to the load [3], it does not alter the wave-shape of the current being drawn by the load. Therefore, if the load has an SMPS with power factor correction (PFC), the line-interactive UPS will not distort or interfere with the power factor correction. If the load SMPS does not have power factor correction and draws its current in peaks, the line-interactive UPS will not alter or "correct" this waveform either.

Block diagram representation of Line Interactive UPS is shown in fig 6. Theoretically, the small number of components and the cool operation of the main power converter (the "inverter" block in Figure) both contribute to long life and high reliability [1]. With its low cost and durability, the line-interactive UPS must be employed.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. Even though the line-interactive 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 run-time 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.

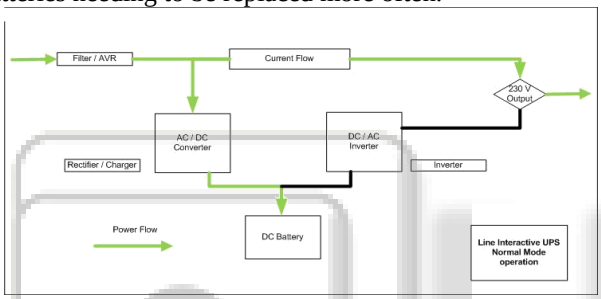


Fig. 6: Block diagram of Line interactive UPS

Line interactive UPS system contains following advantages:

- Lower electricity consumption (less costly to operate) – more efficient because less Power conversion is performed when acceptable AC input is present.
- Theoretically higher reliability - lower component count and lower operating temperatures [1].
- Less components - Other UPS systems as Double-conversion on-line contains more components that run continuously at higher Temperatures and, with all other things being equal, have less service life than similar parts found in line-interactive [5].
- Saving of Power - Double-conversion on-line uses more electricity than line interactive because it is continuously converting and reconverting power from the input to the output when AC input is present [5].
- Less heating - Double-conversion on-line creates more heat that is released into the IT environment. This heat must be effectively removed to reduce life-degrading effects on other systems and even on the UPS' own batteries [5].
- Interacts with line parameters and performs action as UPS – sees the line voltage/current/ power and performs action according to line parameter.
- Act as filter – harmonics and other line disturbance component can be eliminated [3] [6].
- Also act as compensation device – lacking voltage/ current / power can be compensated during on-line performance [11].
- Under voltage condition: Power supply mode – when voltages are lagging behind of lower than actual voltage it Supplies power which is lower than rated.
- Over voltage condition: Charging mode – at the time of over voltage it will provide a charging action to the battery with the help of over voltages
- Less transfer time [4] [9] [13]
- Line interactive UPS can be operated with auxiliaries such as Digital Signal Processer, PWM devices, Converter/inverter, Tap changing transformer, Etc. [8] [10].

Table 1. Comparison of Different UPS

Comparison of the Line Interactive UPS and Double conversion UPS					
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

VI. CONCLUSIONS

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. [4] [9] [13]. It could be compared to conventional systems. From this paper it is observe that Line Interactive UPS is less costly than conventional UPS. To enhance the power quality and to have batter reliability the conventional UPS systems should be replaced by the line interactive UPS.

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