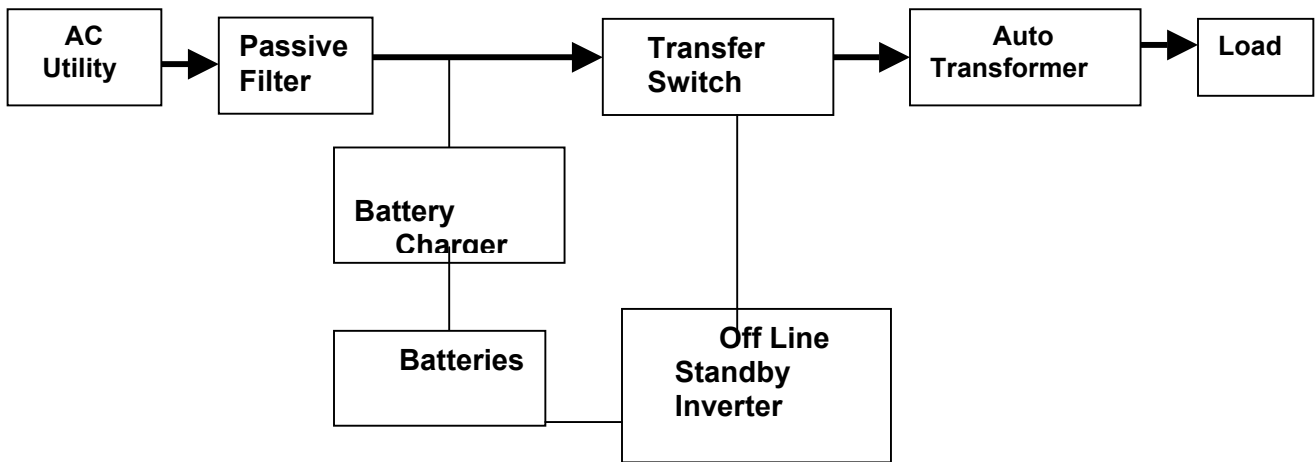


This document describes three types of Off Line Standby UPS Topologies:

- **Basic Offline Standby UPS**
- **Standby with Boost UPS**
- **Ferro Standby Type UPS**

Basic Off-line Standby UPS



An Off Line Standby Power Supply (SPS) is an AC back-up power source where the inverter only supplies the load when a brownout or blackout occurs. During normal operation the load is powered directly from the AC Utility, the inverter is not operating and the SPS is off-line from the load in standby mode. When a blackout or brownout occurs, the SPS senses the blackout or brownout condition, turns on the inverter and transfers the load to the inverter and battery through a transfer switch after a delay. The delay results in a gap in power to the load and is referred to as transfer time.

The Basic SPS has the following characteristics:

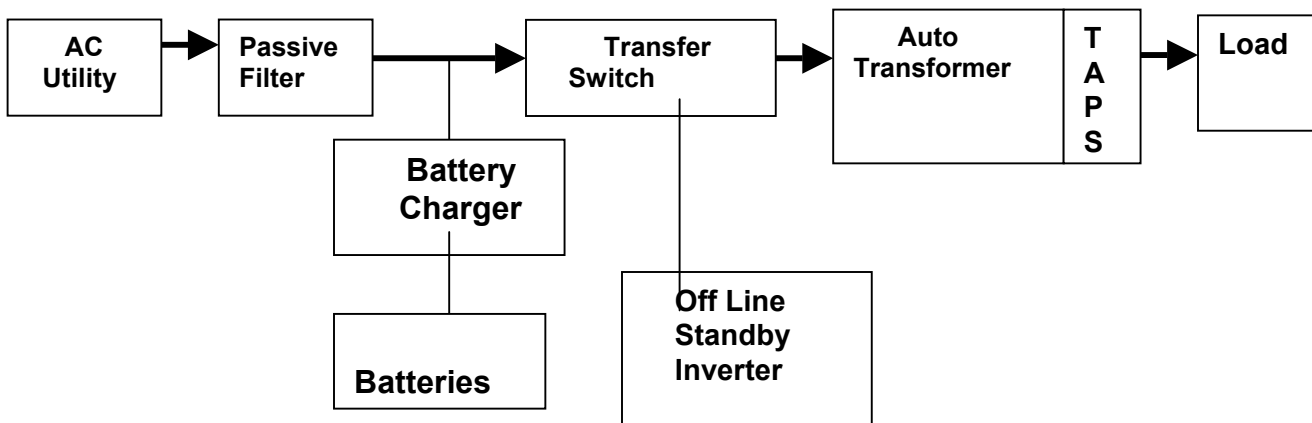
- The primary power source is supplied directly from the AC utility through a simple passive filter/surge suppresser, similar to a surge strip. (It does not regenerate the output and provide continuous conditioning of the power to isolate the wide range of power problems on the AC utility line from the computer load.)
- The actual transfer time will usually be several times slower than the ideal time of approximately 4 milliseconds indicated in the product specs if the input voltage is low or if the batteries are not fully charged at the time a blackout occurs. Also the computer power

supply ride-through is greatly reduced when the input voltage is low because its own input capacitor is not charged up.

- When a blackout or brownout occurs, the inverter must start-up and takeover the load, which causes sudden stress on the inverter and transmits switching transients to the load as well as a time delay. The inverter is most vulnerable to fail and drop the load at the critical time when it is needed to take over the load.
- The output voltage is not regulated and will follow the input voltage variations, usually from 102 volts to 136 volts or higher which is a range of 34 volts (28%). At the lower limit, the SPS transfers to inverter and battery which uses up battery energy during brownouts. Some SPS units also transfer to inverter and battery at the upper limit.
- Typically the output waveform for this type of UPS is square wave or step waveform instead of a sinewave.

In addition to the Basic Standby Power Supply, other variations of Off-Line Standby UPS products include Standby With Boost (incorrectly called “line interactive”) and Standby-Ferro types.

Standby With Boost Type UPS **(Incorrectly called “Line Interactive”)**



This type of Off-Line Standby Power Supply is essentially the same topology as the Basic Off Line Standby UPS described above except for the addition of one or two taps on its output autotransformer. It also includes an additional relay switch to switch between different transformer taps causing the output voltage to switch abruptly between one level to another level, either increasing the output by 12% or reducing the output voltage by 12%. Its purpose is to boost the output during brownout conditions, allowing the standby UPS to remain on the AC utility at somewhat lower or higher input voltages rather than switch permanently to battery and inverter output.

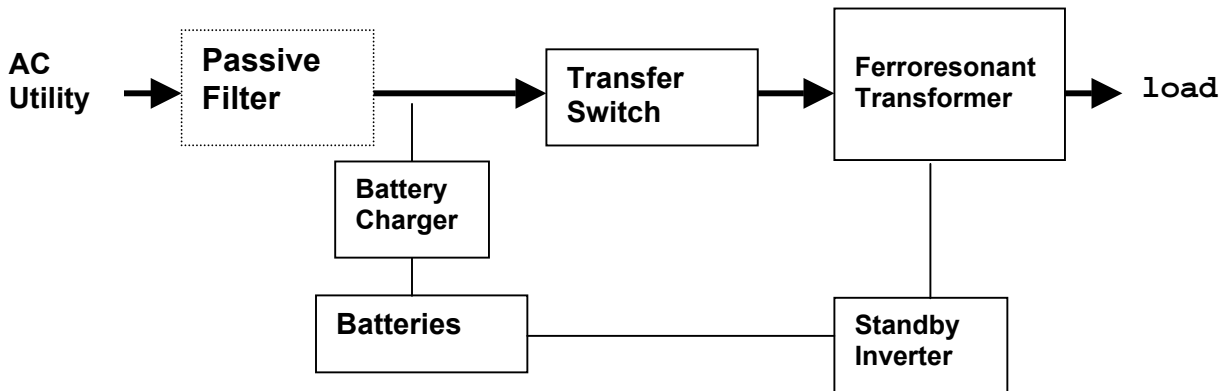
As with the Basic Standby Power Supply, the Standby With Boost UPS has a transfer switch with its associated a transfer time and gap in power when it turns on its off line inverter and switches to battery when AC power is lost. It has been incorrectly labeled as a line-interactive type UPS even though it does not fit the definition of a true line-interactive UPS. The true line-interactive topology is described in the attached document.

The operating characteristics of the Standby with Boost type UPS has the same operating characteristics as the Basic Standby UPS except for the following:

- Instead of switching permanently to inverter and battery when the input (and output) drops to 102 - 104 volts as with a Basic SPS, the Standby With Boost increases the output by 12% or 15 volts by switching in the higher voltage tap on the auto transformer to change from a direct pass-through of the input voltage to the output to an output voltage that is boosted by 12%. This bump in output allows the computer to continue operating during certain brownout conditions, but it obviously does not provide good voltage regulation. However, it causes a step-change in the output voltage from 103 volts to 118 volts, which in turn causes additional current and voltage oscillations and transients resulting in added stress to the computer. After the time gap required to switch transformer taps, the sudden step-increase in output voltage results in an inrush of current to the computer. The output voltage is unregulated and follows utility input changes between 103 volts and 136 volts. This can allow an output swing of about 33 volts or 28% of nominal voltage.
- When a voltage sag occurs, some of the Stand-by UPS's with Boost will initially transfer to inverter and battery power as if a blackout had occurred. If the sag turns into a brownout, the boost function is activated by transferring input taps on the output auto-transformer. It may also cycle back and forth between AC and battery for short duration sags. According to Bell Lab's power study, sags and brownouts represent up to 87% of all power problems. As a result, the Stand-by With Boost UPS will hit the inverter with frequent stressful cold starts.
- As with other Off Line Standby UPS's, this topology is not compatible with generators and other causes of distorted waveforms and input fluctuations. A distorted waveform from a generator input to the UPS causes this type of UPS to turn on the inverter and switch to battery and then cycles back and forth between AC and battery. This so-called "line interactive" UPS goes to battery because the distortion is interpreted by the UPS as an impending blackout. Then the UPS recognizes that an AC input is still present and switches back to AC, turning off the inverter and going off of battery. This cycle is repeated causing stressful fluctuations to the load and eventually using all of the battery capacity.

Only a true double conversion ON-LINE UPS is compatible with generators.

Standby-Ferro-UPS with Ferro-Resonant Transformer



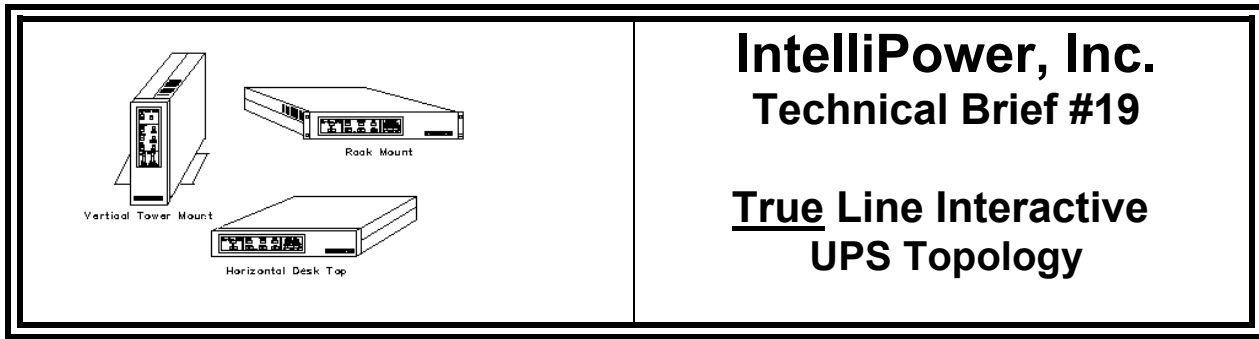
This type of Standby Power Supply uses a Ferro-resonant output transformer instead of an autotransformer with added voltage taps as used in the Standby with Boost type. The primary power source is from the AC utility through a transfer switch and through the transformer to the output. When a blackout occurs, the transfer switch transfers the load to the inverter and battery. The Ferro-transformer provides limited linear voltage regulation instead of the step-change inherent with tap change transformer used in the Standby With Boost type units.

Manufacturers sometimes represent the Standby-Ferro type as an On Line UPS claiming no break in power when blackout occur and sometimes it is represented as a Line-Interactive type. However, it is actually a variation of a Standby Power Supply because it has a transfer switch, and the inverter does not operate while in the standby mode. It also has a transfer characteristic during a power failure, which may cause a brownout to the load

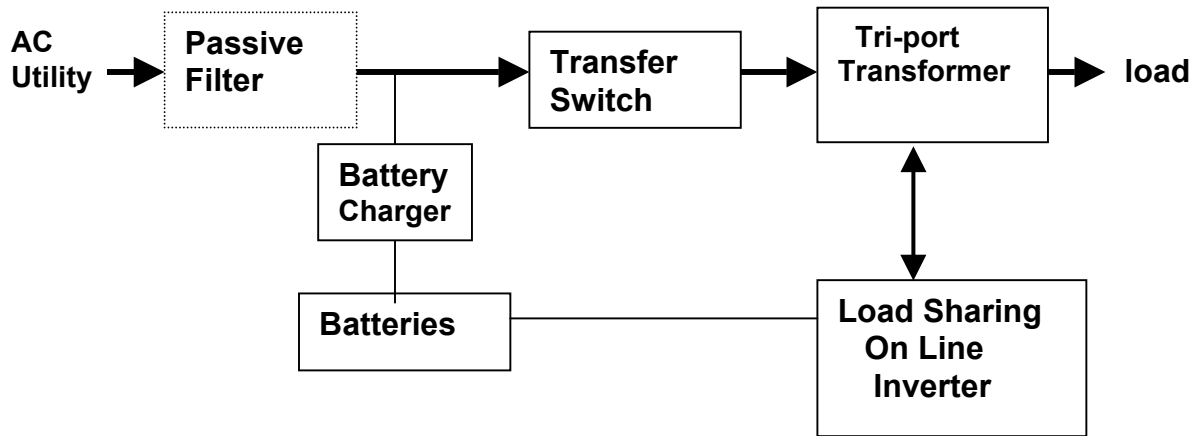
The Standby-Ferro type system has the following characteristics:

- The transformer inductance and the capacitors make up a resonant "tank" circuit, which oscillates at a resonant frequency of 60Hz. If the tank circuit is excited by a line transient, it can oscillate at a multiple of the resonant frequency causing problems for the load.
- Manufacturers of Ferro type UPS's often falsely claim no break or zero transfer time upon power failure by simulating a blackout with a misleading pull-the-plug demonstration. Since this causes an **open circuit** on the input line, the energy stored on the Ferro transformer can sometimes hold-up the output voltage until the standby inverter is able to startup. Most importantly this demonstration does not properly simulate an actual power outage. During a real power failure, the input AC utility power fails as a **short (not an open) circuit**. Under an actual power failure condition, the short circuit causes energy stored in the Ferro transformer to flow back into the Utility before the transfer switch can open to disconnect the input AC utility line from the Ferro transformer. Tests have shown that the output voltage then decreases for several cycles which can result in a transfer time of approximately 35 ms. As the standby inverter is transferred to the output, high peak currents with flow to the load causing added strains to the computer power supply.

- The Ferro type Standby design is inherently not stable with certain loads such as power factor corrected computer power supplies. This is because it is a high output impedance source unlike an AC utility source.
- If a Standby-Ferro UPS is used as an input source to a ferroresonant type power supply, uncontrolled voltage oscillations can occur.
- The efficiency of standby-Ferro is very low when lightly loaded because it constantly circulates almost 100% of full rated input current at all output load levels, including no load. Standby-Ferro units must be lightly loaded in actual applications to 50-75% maximum to avoid current limiting and voltage regulation problems created by high peak currents. A ferroresonant device has a current limiting factor of 125% to 150% of the rated RMS capability. Switch mode power supplies draw peak current of 2.5 to 3.0 times the RMS rating of the power supply.
- The standby-Ferro type system does not work well with engine generators because frequency variations cause the output voltage of the Standby-Ferro to go out of regulation.
- Large output voltage transient spikes can be created when a ferroresonant transformer load changes significantly, when momentary large start-up currents are required, or during flicker power outages.
- Ferro type back up power supplies are much larger and heavier than other types.



True LINE-INTERACTIVE UPS
(Also called a Load Sharing UPS)



The definition of a true Line-Interactive UPS is one where the inverter is running 100% of the time interacting continuously with the changing state of the input AC utility line. It is always sharing the load with the line and providing continuous linear regulation of the output voltage. The Line-Interactive type UPS is also called a Load-Sharing UPS or a Hot Standby. During normal operation, the inverter might provide a small fraction of the current needs of the load. Most of the current would be drawn from the AC utility line. When a sag occurs, the inverter would be called upon to supply added make up power to support the load in combination with the line.

A True Line-Interactive type UPS has the following characteristics:

- The Inverter is running 100% of the time and sharing the load with the AC utility.
- The Inverter continuously interacts with the AC line to compensate for input voltage variations and provides limited linear output voltage regulation.
- There is some limited ongoing power conditioning with the true Line-Interactive approach to protect the computer from the wide range of power problems on the AC line.
- The true Line-Interactive System is considered a "no-break" system since there should be no measurable delay for the inverter to transition from handling part of the load to handling 100% of the load when a power failure occurs.

- Several manufacturers have used the true Line-Interactive topology for UPS's in the 5 KVA to 15KVA range. We have not seen any smaller UPS products that have True Line Interactive topology. Recently some manufacturers have incorrectly added the Line-Interactive label on their Standby With Boost products to avoid the negative connotations or limitations of the Standby label. This is done for marketing reasons and the original product literature for these this type of UPS did not attempt to make any claims that this type of UPS was a Line Interactive type.
- The Standby With Boost or so-called "line interactive" type products do not provide the functions of a true Line-Interactive UPS. The inverter on these systems is not sharing the output load and regulating the voltage on a continuous basis. These units have a transfer switch and an advertised transfer time of approximately 4 ms. When a sag occurs, some of the Standby With Boost UPS products activate the inverter and transfer the load to the inverter and the battery. If the sag turns into a brownout, the transformer tap change is activated. Thus, the Standby With Boost type UPS is very different from a True Line Interactive UPS and the two should not be confused.