
Application of Uninterruptible Power Systems

Comparison of System Configurations



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Abstract

A static Uninterruptible Power System (UPS) is designed to be the prime source of power to a critical load.

A UPS not only provides uninterruptible power to a critical load, but also isolation from the utility line and the associated line voltage variations as well as various forms of voltage transients present on the utility line. The method in which one or more UPS units are utilized will dictate the cost of the system and the degree of load protection provided by the system.

A discussion of the various types of UPS configurations, as well as the various levels of protection provided by the UPS configuration follows.

Introduction

Many of the problems experienced in the areas of data processing, communication, closed loop instrumentation and on-line computers are the result of a power related problem such as temporary outages, momentary interruptions, surges, sags or noise. If you have experienced these problems, your first instinct was probably to contact the utility company. You may have found out that it was not economically feasible for the utility to upgrade their service to you, or the problems were beyond their control. Electric motors, welders, switches or fuse clearing may be causing the problem; either within your own facility or a neighboring facility and the utility company cannot control this. Surges, sags or noise problems can be remedied by varying degrees through the use of various types of line conditioners; however, temporary outages or momentary interruptions may still be a major part of the problem. The solution is an Uninterruptible Power System (UPS).

Single Unit Float Configuration

The single unit Float configuration is the most common configuration requested in UPS applications because it contains the fewest number of major components.

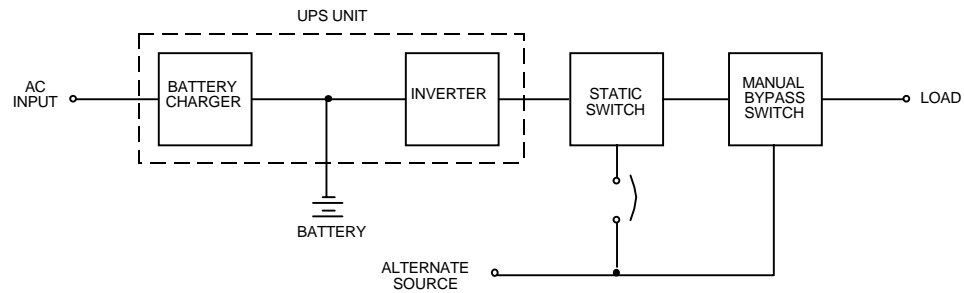


Figure 1 Single Unit Float Configuration

Figure 1 illustrates the most common UPS configuration, a single unit Float configuration. This system utilizes AC power (Typically utility power) and converts it to DC through the battery charger. The regulated DC power is supplied to both a bank of batteries and to the inverter. The inverter "inverts" the DC back into regulated, noise-free AC power and passes it along to the static switch. The static switch, under normal conditions, passes this AC power through to a manual switch and on to the load. If a failure in the inverter should occur, or a fault on the load should occur, which overloads the inverter beyond its maximum capacity, the static switch will automatically transfer to the alternate position and supply the alternate source of power, usually utility power, through the manual bypass switch and on to the load. The manual bypass switch is a mechanical, make-before-break switch that is used to bypass the UPS for maintenance purposes. If AC power to the battery charger is lost, the batteries automatically begin supplying the required DC power to the inverter; there is no switching involved at this point. A brief discussion of the single unit floats configuration static switch, manual switch, rectifier/battery charger section, and inverter section follows.

The Static Switch

The function of a static switch in the UPS is to provide an automatic transfer from the output of the inverter to the alternate source in the event of an overload on the UPS output. An overcurrent transfer circuit is included in the static switch for this purpose.

This circuit provides an overcurrent transfer to the alternate source due to inrushes from the load or faults on the load. Without this feature, the inverter could be driven into current limit prior to clearing a fault. This would most likely cause all the loads to be lost. The static switch, therefore, transfers to the alternate source at 110% to 125% (depending on manufacturer) of rated load, where fault clearing capabilities should exist. Because this circuit cannot differentiate between an inrush and a fault, it is common for the initial energization of a load to cause a transfer and be energized from the alternate source.

The static switch also provides an automatic transfer from the inverter output to the alternate source in the event of an inverter failure. Transfer times of static switches should be evaluated when selecting an UPS. A static switch should have a maximum transfer time of four milliseconds for normal critical loads. Most static switches supplied with a UPS meet this requirement.

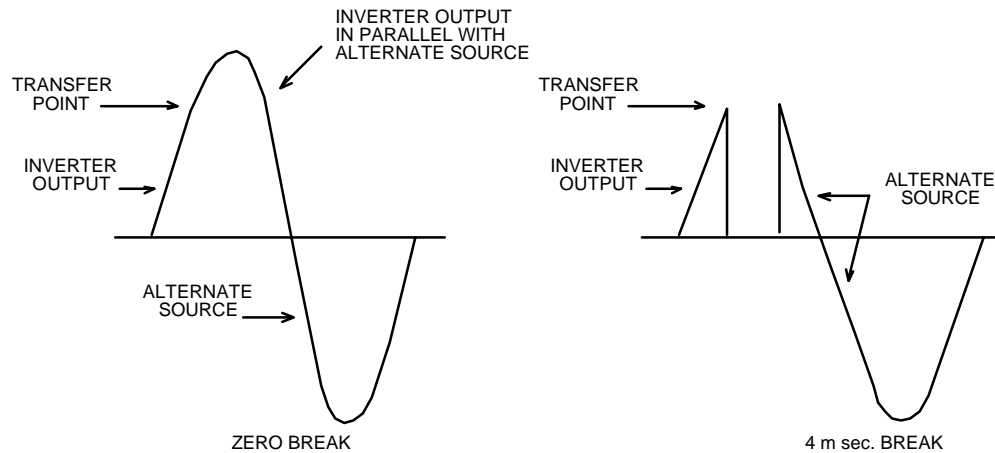


Figure 2 Static Switch Transfer To Alternate Source

A static switch that provides a four-millisecond break when transferring upon inverter failure is sensing the voltage being supplied to the switch from the inverter. Once an inverter failure occurs, the static switch senses the loss of voltage and initiates a transfer. The sense-to-transfer initiation time is approximately four milliseconds. A zero-break static switch is also available but only with a ferroresonant type inverter. The zero-break static switch on the ferroresonant inverter monitors the square wave output of the bridge, prior to the ferroresonant transformer. PH the square wave should deteriorate, indicating an inverter failure; the sense circuit in the switch will initiate a transfer, with the stored energy in the ferroresonant transformer used to accomplish the zero-break. **Figure 2** illustrates the zero-break and the 1/4 cycle break static switch transfer.

The Manual Switch

The manual bypass switch should be a mechanical make-before-break type of switch with overlapping contacts. Its purpose is to bypass the output of the static switch and tie directly to the alternate source for system maintenance. The manual bypass switch should not be used to remove alternate source power from the static switch. Instead, a circuit breaker should be placed in series with the alternate source. This method of isolation is usually preferred to permit testing of the static switch with power applied to both poles while in the bypass mode.

Rectifier/Battery Charger Section

The battery charger provides isolation from the AC line through an isolation transformer, as well as being a regulated source of DC to the battery system and inverter. The output of the charger must be regulated and have current limiting capabilities. The current limit function provides protection for both the batteries and the charger. The battery charger must be sized large enough to supply the inverter and simultaneously recharge a fully discharge battery bank. Output voltage regulation is important since the battery requires a precise charging voltage for maximum life and minimum maintenance.

Inverter Section

The inverter provides three primary functions in the UPS:

- 1) Inversion - the changing of the DC power to AC power composed of a sine wave free from harmful Harmonic distortion; typically 5% THD or less.
- 2) Regulation - the regulation of the AC voltage to a tolerance level acceptable to the load, typically +2% of the nominal voltage.
- 3) Limiting Capability - provides for the current limiting capability as a means of self-protection.

Single Unit Rectifier Configuration

The rectifier configuration differs from the float configuration with a rectifier, usually a regulated rectifier, replacing the rectifier/charger. The rectifier is used only to provide power to the inverter and is not used to charge the battery. A blocking diode or thyristor is used to isolate the rectifier from the battery. A separate battery charger is used to maintain the batteries in a fully charged state. Please refer to **Figure 3**.

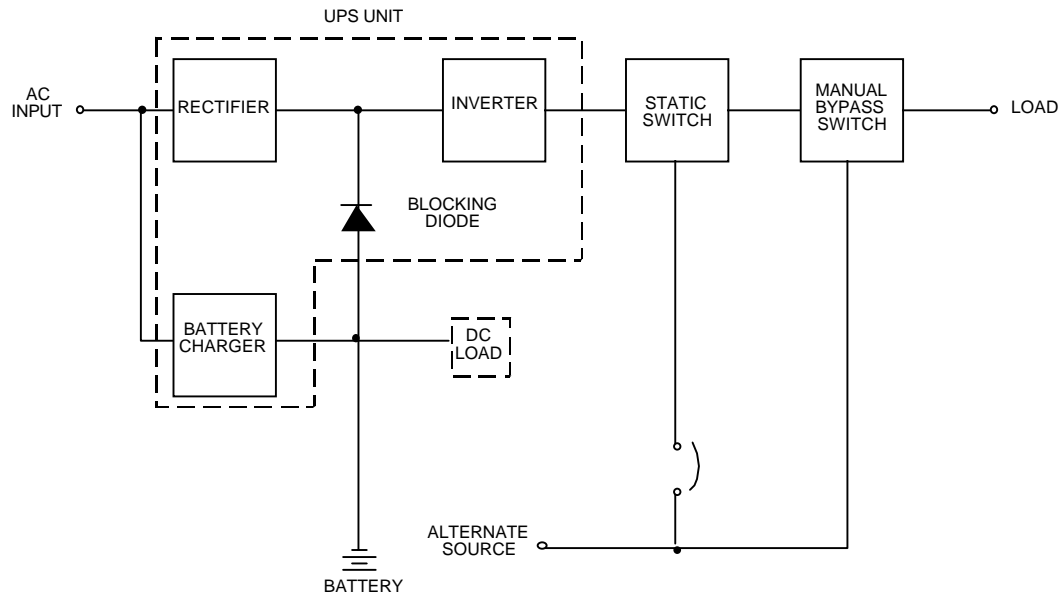


Figure 3 Single Unit Rectifier Configuration

This configuration may be selected when an existing Float configured UPS is being replaced by a larger system where the existing battery charger is salvageable. The existing battery charger will now be used only to recharge the batteries and the rectifier will supply the DC power required by the inverter.

The rectifier configuration may also be selected if a dedicated DC battery bus is not available to supply the inverter. This typically occurs when the UPS may be required to operate from an existing station battery. If an additional DC load must be added, it should

be connected on the battery side of the blocking diode, eliminating the possibility of a DC fault dragging the inverter's DC input voltage down to a level that may cause the inverter to fail.

The float and Rectifier configurations have the disadvantage of possibly placing a critical load on an undesirable alternate source upon an inverter failure. One method of enhancing the first level of bypass protection is to utilize some form of bypass source voltage regulator or noise attenuating transformer or both, whichever is appropriate for the particular application. In this manner, should operation from the bypass source be necessary, the load can be supplied with power suitable for proper operation. There would, however, be no protection from a power outage while operating in this manner.

Redundant Configuration

Figure 4 is referred to as a redundant configuration. This configuration has the capabilities of operating in both a "cold" or "hot" standby mode.

Each inverter is sized to supply the entire load. Inverter "A" will supply the load through static switch "A" and static switch "B" in normal operation. In the "hot" standby mode, with both inverters running, the failure of Inverter "A" will initiate the transfer of static switch "A" to the output of inverter "B". In the "cold" standby mode, inverter "B" off, the failure of inverter "A" will initiate the transfer of static switch "B" to the alternate source-to-load position. Inverter "B" can then be energized and brought into service.

Upon an inrush or overcurrent, static switch "B" will automatically transfer to the alternate source. The over current transfer circuitry of static switch "A" is defeated in this type of configuration.

The redundant configuration UPS is considered by many to offer the best cost versus reliability of all the various types of UPS configurations.

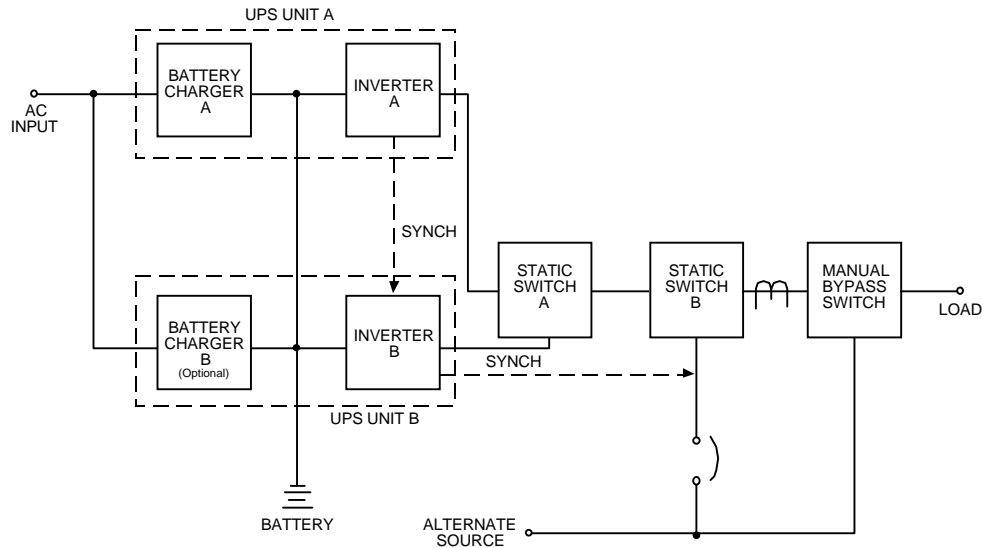


Figure 4 Redundant Configuration

Standby Redundant Configuration

There may be times when it is not feasible to provide a utility fine for the bypass source. In those situations, one may wish to consider the use of the standby redundant configuration shown in **Figure 5**. This system is composed of two UPS units with a static switch between them. Unit "A" is the prime unit, which is normally supplying power to the load. Unit "B" is on, but it is idle. Should Unit "A" fail, the static switch will transfer the load to Unit "B" thus preventing the loss of the load.

Single Inverter - Multiple Switch Systems

There may be circumstances, which require that a number of separate critical loads be sustained from one UPS. It may also be desirable that a fault in one of these critical loads not cause a disturbance to the remaining loads and also not take them off the prime source of power, the inverter. A system such as that shown in **Figure 6** may be considered.

A fault in critical load "B", for example, would cause static switch "B" to sense the resultant overcurrent and transfer that load to the bypass source where fault-clearing capability should exist. All of the other critical loads remain undisturbed. The failure of the inverter would cause all the static switches to transfer to the Bypass source.

Multiple Inverter Systems

A second method to supply multiple critical loads is to provide each load with a separate inverter and static switch. This system will provide the added benefit that should one inverter fail; all other loads will remain on their respective inverters. These could all be supplied from one properly sized battery charger and single battery bank or, if desired multiple parallel chargers.

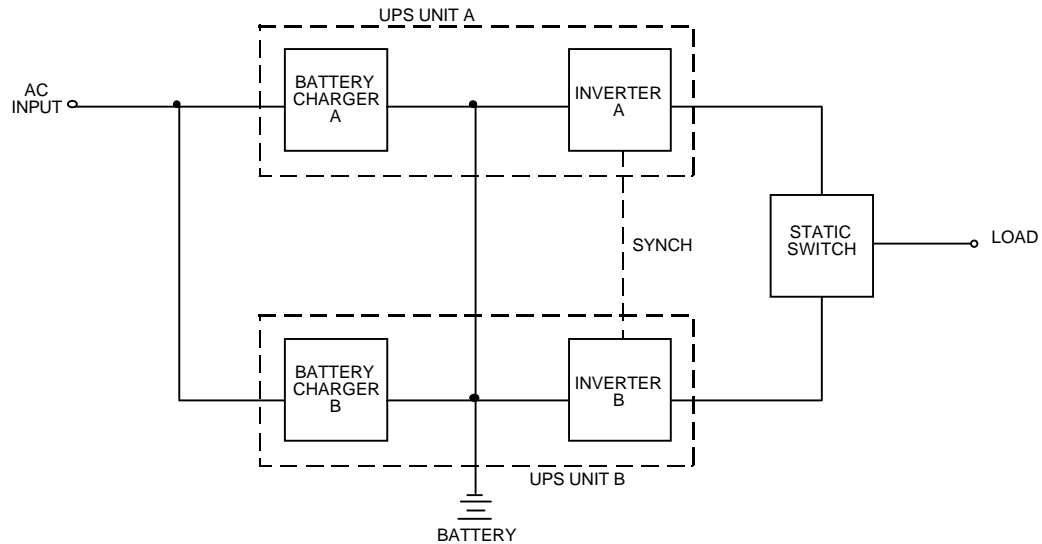


Figure 5 Standby Redundant Configuration

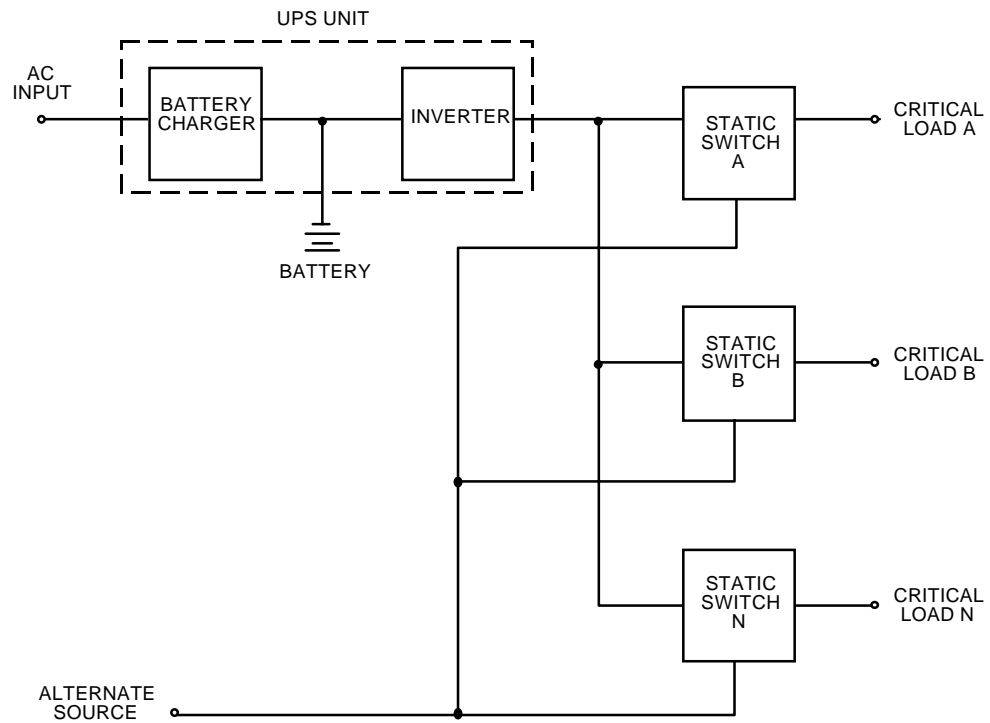


Figure 6 Single Inverter – Multiple Switch Configuration

Conclusion

The UPS configurations that have been discussed will satisfy the needs of approximately 98% of all UPS applications. Various systems can be devised to enhance load protection by using different combinations of parallel battery chargers, rectifier, batteries, inverter and static switches. The cost of each system is a function of the degree of protection required. Cost versus the degree of protection provided should certainly be a prime consideration when selecting any UPS. Where the more common standard configurations are found not to be suitable for the application, it is suggested that the UPS manufacturer be contacted to aid in designing the most economical system for the particular application.