Power Point Presentation on Uninterruptible Power Supplies



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Contents of Presentation

- Types of Electrical Disturbances
- UPS Applications
- Static or Rotary UPS
- Types of Static UPS
- UPS Components
- Redundancy in UPS Systems
- Static Transfer Switch

About Power Quality

- Intelligent technology demands power that is free of interruption and disturbance.
- Industrial and digital firms in USA are losing $45 billion per year due to power interruptions.
- Across all business sectors loss is around $100 to $164 billion due to interruption and around $15 to $24 billion due to other power quality issues.
- The study of power quality, and ways to control it, is a concern for electric utilities, large industrial companies, businesses, and even home users.

About Power Quality

- Ambiguous terms in power quality
- Being able to talk effectively about power, such as knowing the difference between an interruption, and an oscillatory transient, could make a huge difference when making purchase decisions for power correction devices.

Blackout	Brownout	Bump	Power surge
Clean power	Surge	Outage	Blink
Dirty power	Frequency Shift	Glitch	Spike
Power surge	Raw power	Raw utility power	Wink

About Power Quality

- IEEE Standard 1159-1995 defined power quality problems are categorized below:
- Transients
- Interruptions
- Sag/Undervoltage
- Swell/Overvoltage
- Waveform Distortion
- Voltage fluctuations
- Frequency Variations

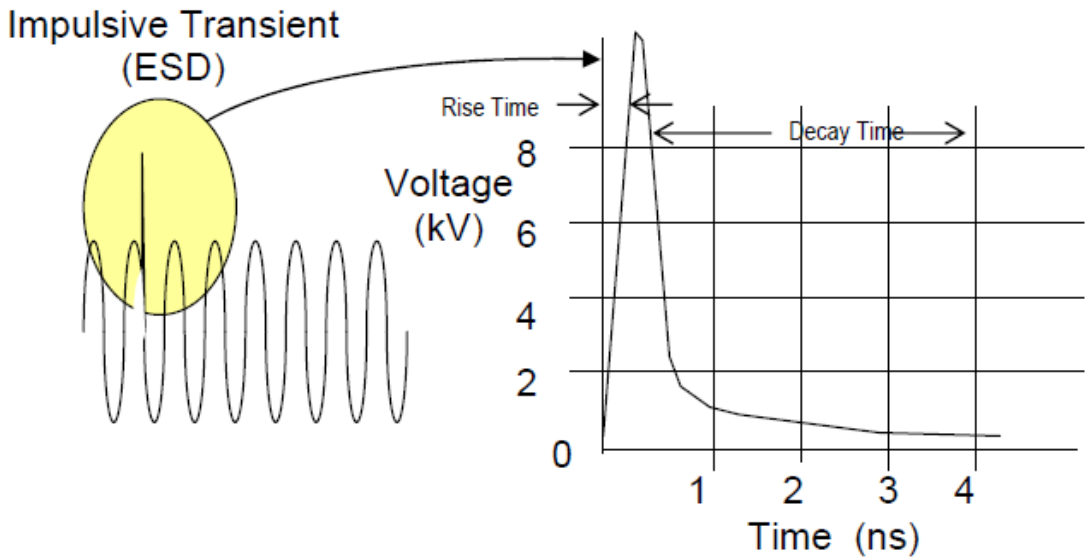
Transients

- Potentially the most damaging type of power disturbance, transients fall into two subcategories:
- Impulsive and Oscillatory
- Impulsive: sudden high peak events that raise the voltage and/or current levels in either a positive or a negative direction.
- These types of events can be categorized further by the speed at which they occur (fast, medium, and slow).
- Impulsive transients can be very fast events (5 nanoseconds [ns] rise time from steady state to the peak of the impulse) of short-term duration (less than 50 ns).

Impulsive Transients

- Many different terms, such as bump, glitch, power surge and spike have been used to describe impulsive transients.
- Causes of impulsive transients include lightning, poor grounding, the switching of inductive loads, utility fault clearing, and Electrostatic Discharge (ESD).
- The results can range from the loss (or corruption) of data, to physical damage of equipment. Of these causes, lightning is probably the most damaging.

Impulsive Transients

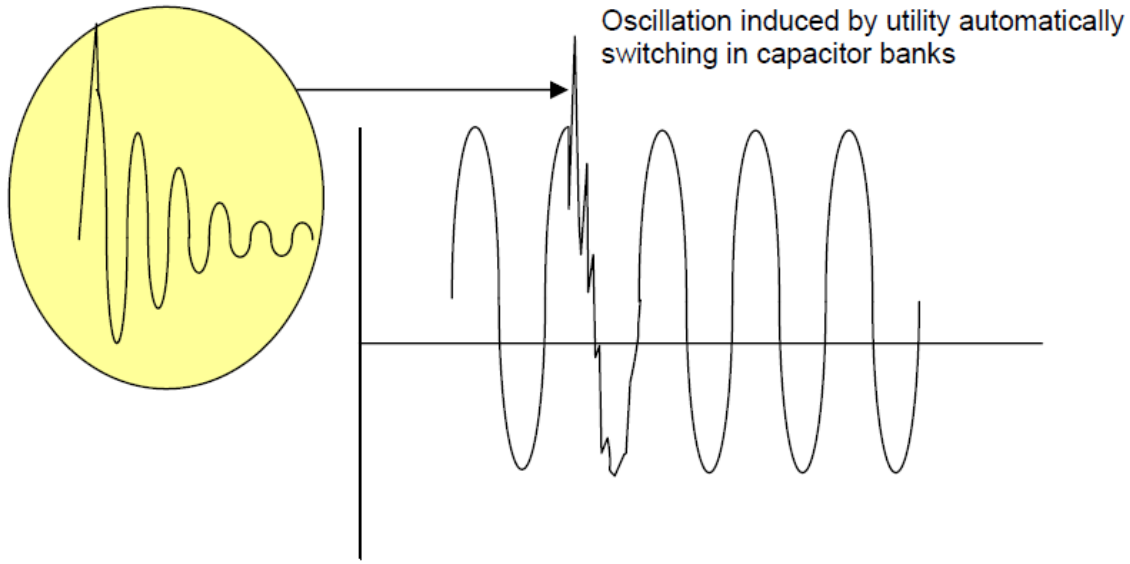


Oscillatory Transients

- An oscillatory transient is a sudden change in the steady-state condition of a signal's voltage, current, or both, at both the positive and negative signal limits, oscillating at the natural system frequency.
- In simple terms, the transient causes the power signal to alternately swell and then shrink, very rapidly.
- Oscillatory transients usually decay to zero within a cycle (a decaying oscillation).
- These transients occur when you turn off an inductive or capacitive load, such as a motor or capacitor bank.

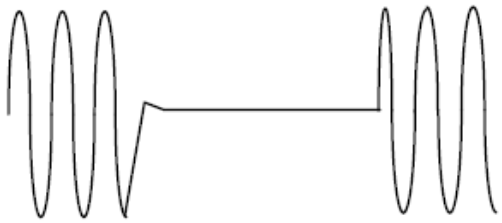
Oscillatory Transients

- When oscillatory transients appear on an energized circuit, usually because of utility switching operations (especially when capacitor banks are automatically switched into the system), they can be quite disruptive to electronic equipment.



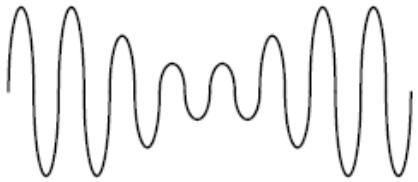
Interruptions

- Defined as the complete loss of supply voltage or load current.
- Depending on its duration, an interruption is categorized as instantaneous, momentary, temporary, or sustained.
- Instantaneous: 0.5 to 30 cycles
- Momentary: 30 cycles to 2 seconds
- Temporary: 2 seconds to 2 minutes
- Sustained: greater than 2 minutes



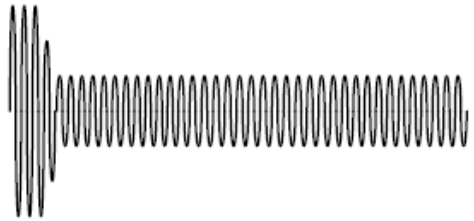
Sag/Undervoltage

- A sag is a reduction of AC voltage at a given frequency for the duration of 0.5 cycles to 1 minute's time.
- Sags are usually caused by system faults, and are also often the result of switching on loads with heavy start up currents.



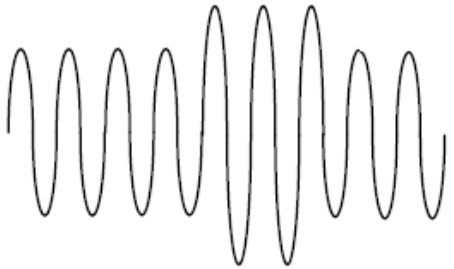
Undervoltage

- Undervoltages are the result of long-term problems that create sags.
- The term “brownout” has been commonly used to describe this problem, and has been superseded by the term undervoltage.
- More importantly, if an undervoltage remains constant, it may be a sign of a serious equipment fault, configuration problem, or that the utility supply needs to be addressed.



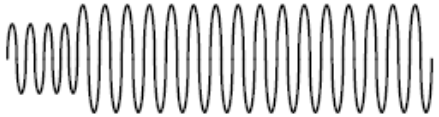
Swell/Overvoltage

- A swell is the reverse form of a sag, having an increase in AC voltage for a duration of 0.5 cycles to 1 minute's time.
- For swells, high-impedance neutral connections, sudden (especially large) load reductions, and a single-phase fault on a three-phase system are common sources.
- The result can be data errors, flickering of lights, degradation of electrical contacts, semiconductor damage in electronics, and insulation degradation.



Overvoltage

- Overvoltages can be the result of long-term problems that create swells.
- Overvoltages are also common in areas where supply transformer tap settings are set incorrectly and loads have been reduced.
- Overvoltage conditions can create high current draw and cause the unnecessary tripping of downstream circuit breakers, as well as overheating and putting stress on equipment.

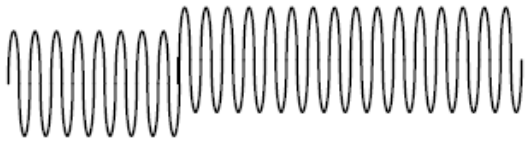


Waveform Distortion

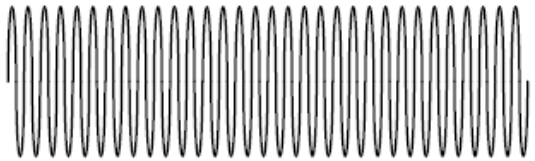
- There are primary 5 types of waveform distortion.

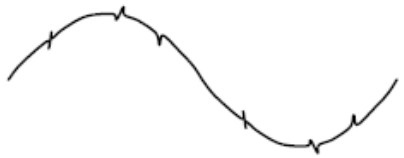
1. DC offset
2. Harmonics
3. Interharmonics
4. Notching
5. Noise

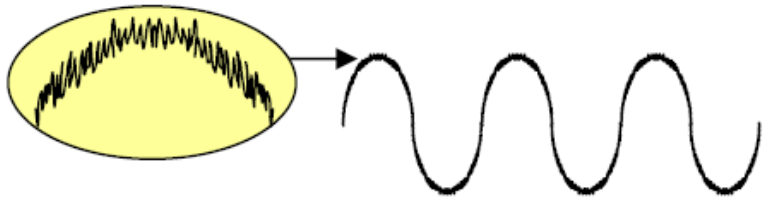
Waveform Distortion





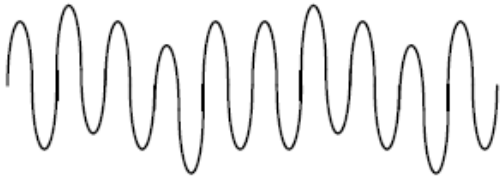






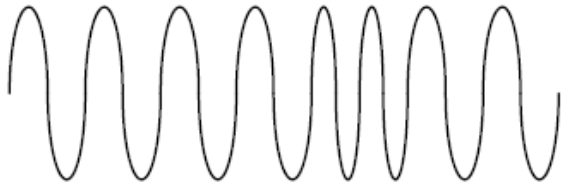
Voltage Distortion

- A voltage fluctuation is a systematic variation of the voltage waveform or a series of random voltage changes, of small dimensions, namely 95 to 105% of nominal at a low frequency, generally below 25 Hz.
- Any load exhibiting significant current variations can cause voltage fluctuations.
- Arc furnaces are the most common cause of voltage fluctuation on the transmission and distribution system.
- One symptom of this problem is flickering of incandescent lamps.



Frequency Variations

- Frequency variation is extremely rare in stable utility power systems, especially systems interconnected via a power grid.
- IT equipment is frequency tolerant, and generally not affected by minor shifts in local generator frequency.
- Frequency variations may cause a motor to run faster or slower to match the frequency of the input power.



UPS Applications

- Modern economic activities are increasingly dependent on digital technologies which are very sensitive to electrical disturbances.
- As a result, many applications require a backed up supply of power to protect against the risk of disturbances in utility power:

1. Industrial processes and their control/monitoring systems - risks of production losses
2. Airports and hospitals - risks for the safety of people
3. Information and communication technologies related to the internet
4. Nuclear power plants
5. Oil Refineries
6. Defense Systems and many more

UPS Definition and Requirements

- UPS is not generally used for “normal loads” and is mainly used for “critical loads”
- UPS is a backup with very less “Take over time”
- Around 20 to 30 ms time is taken by electromechanical switches.
- Diesel generator set have quite high takeover time ➔ Not a solution
- Ideal take over time should be 0 seconds.

UPS Definition and Requirements

- Electronic systems which have a very small thermal time constant require a backup with minimal take over time.
- System with very large time constant can use DG set instead of UPS.
- “Ride through” capability is amount of time taken by RC, RL and LC circuits to settle down and slowly dissipate all its energy and turn off.
- If UPS able to turn on until this time elapsed, then interruption is not felt.
- Motor-Generator set is a type of UPS.

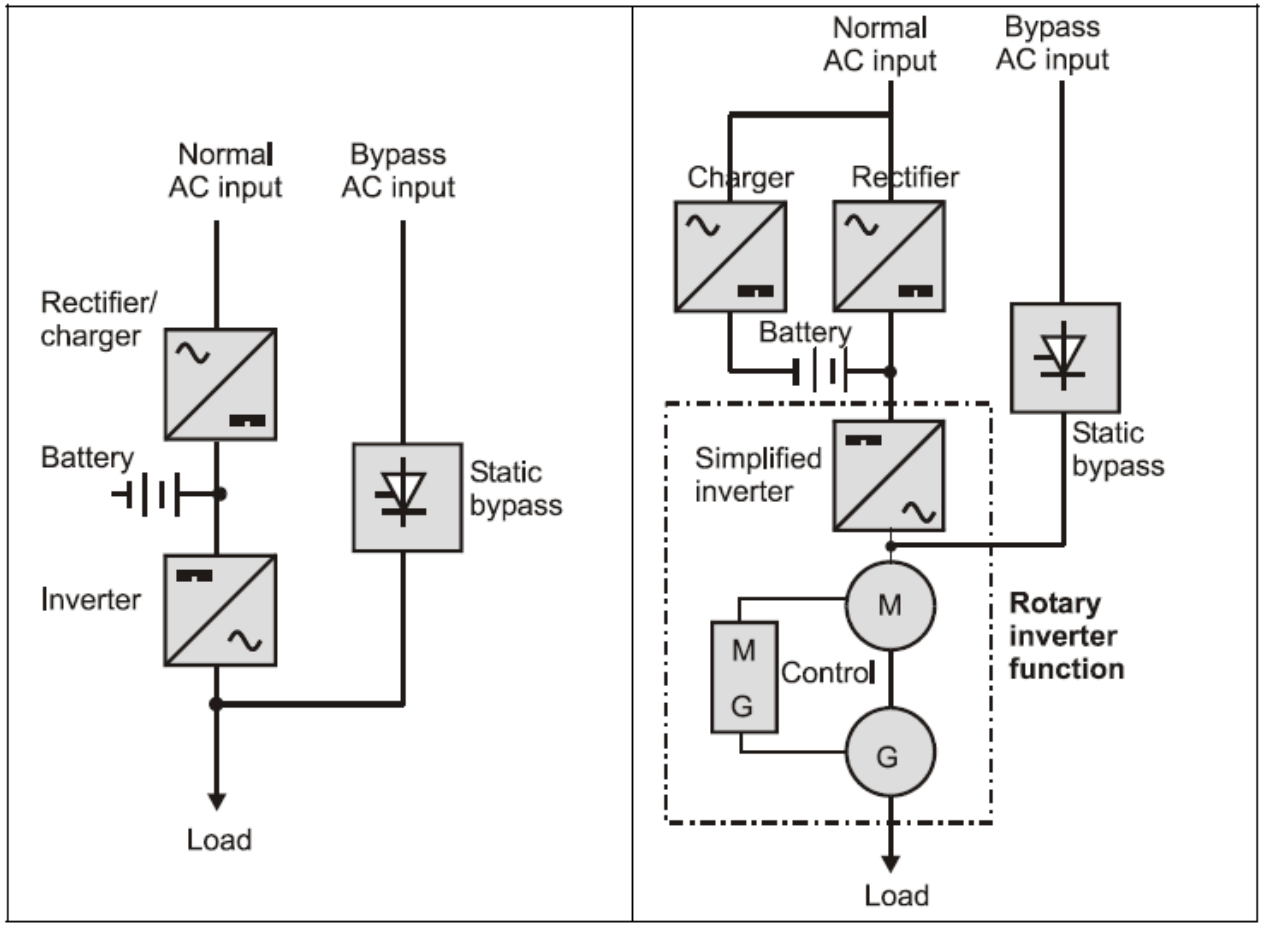
Types of UPS (Static and Rotary)

1. Rotary(Electromechanical)
   - Moving parts
   - Motor Generator Sets
2. Static
   - No moving parts
   - Continuity of supply is maintained by static switches like MOSFET, SCR, IGBT etc.
   - Battery backup size is one of the biggest problem for static UPS, which are generally used for critical loads.

Types of Loads

1. Outage Tolerated ➔ No UPS required
2. Outage Tolerated for some time ➔ Rotary UPS preferred
3. No Outage Tolerated ➔ Static UPS

Static and Rotary UPS



Arguments in Favour of Rotary UPS

- High generator short-circuit current on the order of 10 In (ten times the rated current) that makes setting of protection devices easier.
- 150% overload capacity (of the rated current) over a longer period (two minutes instead of one)
- Downstream installation galvanically isolated from upstream AC source due to the motor/generator set
- Internal impedance providing high tolerance to the non-linear loads frequently encountered with the switch-mode power supplies used by computer systems.

Arguments in Favour of Static UPS compared to Rotary UPS

- Operation in current-limiting mode
- These features, which are more than sufficient in practice, prevent the disadvantages of rotary systems:
  - overheating of cables
  - the effects of an excessive short-circuit current and the corresponding voltage drop on sensitive devices, during the time taken by protective devices to clear the fault.
  - 150% overload capacity (of the rated current) for one minute. The two-minute overload capacity is of no practical use because most overloads are very short (less than one second, e.g. in-rush currents of motors, transformers and power electronics).

Arguments in Favour of Static UPS compared to Rotary UPS

- These features, which are more than sufficient in practice, prevent the disadvantages of rotary systems:
  - Galvanic isolation, when required, by means of an isolating transformer.
  - Double-conversion operation which completely isolates the load from utility power and regenerates the output voltage with precise regulation of the voltage amplitude and the frequency.
  - Very low internal impedance for higher performance with non-linear loads due to the use of power-transistor technologies.

Arguments in Favour of Static UPS

- Static solutions provide many other advantages as well, due to power-transistor technology combined with a PWM chopping technique.
- Simplified overall design, with a reduction in the number of parts and connections, and in the number of possible causes of failure.
- High, constant efficiency whatever the percent load, which is a major advantage for redundant UPS units with low percent loads. A static UPS unit with a 50% load maintains high efficiency (94%), whereas the efficiency of a rotary UPS drops to the 88-90% range (typical value), which directly impacts on operating costs.

Arguments in Favour of Static UPS

- Possible integration in redundant architectures with separate functions that facilitate maintenance by isolating parts of the installation. Rotary systems integrate the UPS, the backup power and the generator as a single component, thus making it impossible to separate the functions.
- No single points of failure. Rotary systems incorporating flywheels depend on the capacity of the motor to start quickly (typically in less than 12 seconds). This means the motor must be in perfect condition and rigorously maintained. If it does not start, there is no time to shut down the critical loads in an orderly manner.

Arguments in Favour of Static UPS

- Reduced dimensions and weight
- No wear on rotating parts, hence easier and faster maintenance
- For example, rotary systems require checks on the alignment of the rotating parts and the replacement of the bearings after 2 to 6 years is a major operation (lifting equipment, heating and cooling of the bearings during the replacement).

UPS Standards

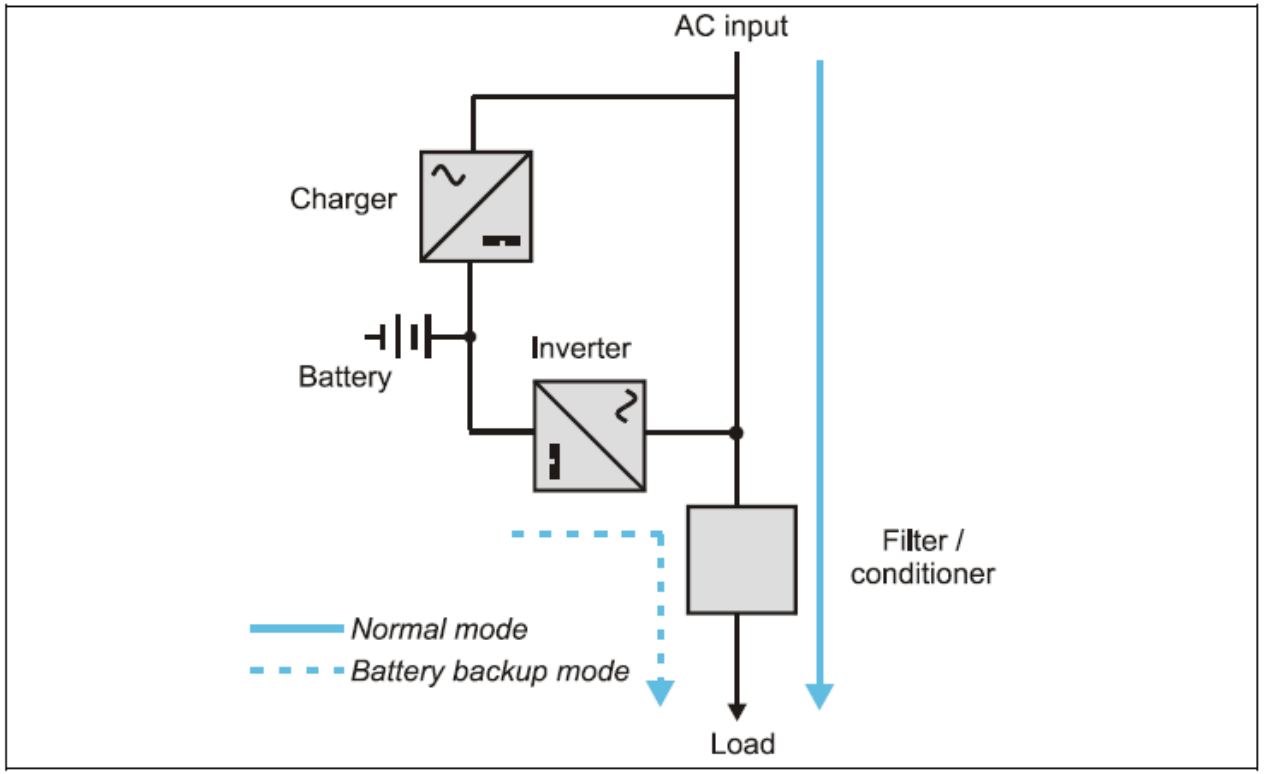
- Due to the vast increase in the number of sensitive loads, the term "UPS" now includes devices ranging from a few hundred VA for desktop computers up to several MVA for data centres and telecommunications sites.
- IEC (International Electrotechnical Commission) established standards governing the types of UPSs and the techniques used to measure their performance levels.
- Standard **IEC 62040-3** and its European equivalent **EN 62040-3** define three standard types (topologies) of UPS and their performance levels.

Passive Standby	Line Interactive	Double Conversion

UPS (Passive Standby Mode)

- *The UPS is installed **in parallel to the utility and backs it up**. The battery is charged by a charger that is separate from the inverter.*
- This configuration is in fact a compromise between an acceptable level of protection against disturbances and cost.
- This type of UPS can be used only for **low power ratings (< 2 kVA)** and cannot be used as a frequency converter.

UPS (Passive Standby Mode)



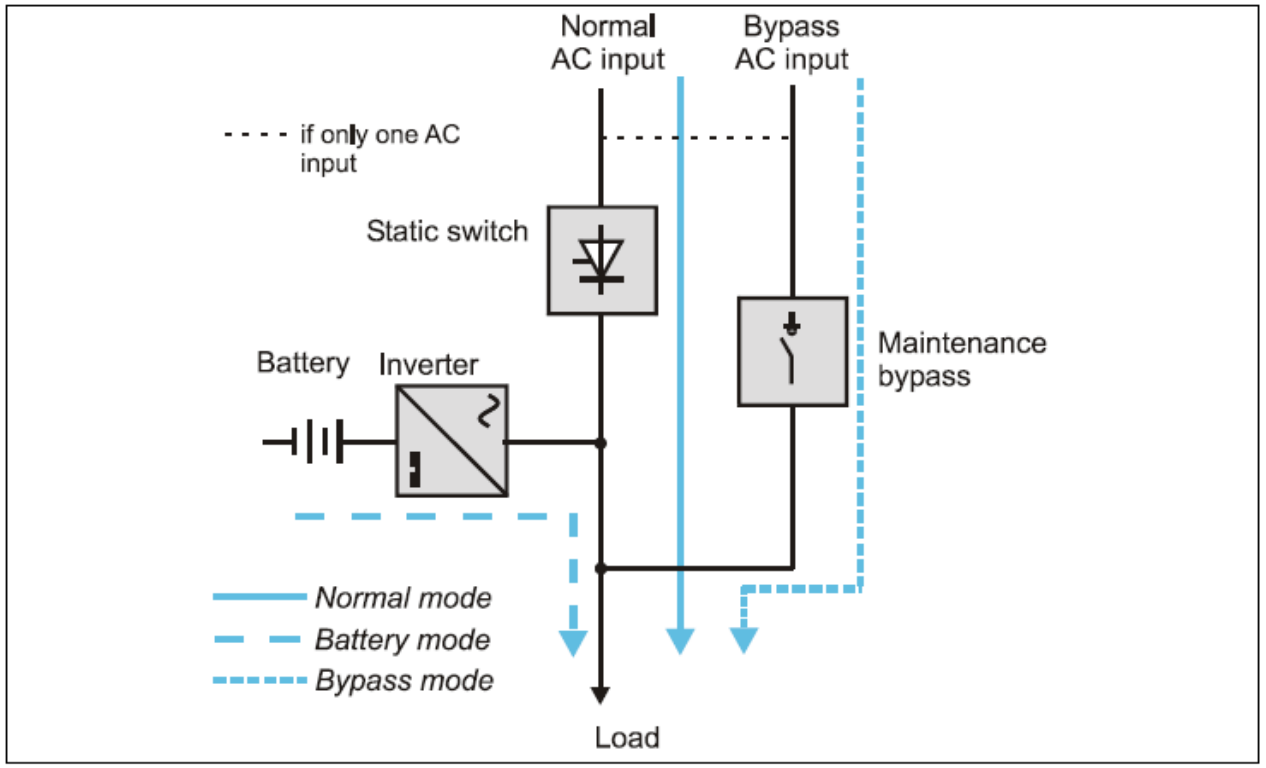
UPS (Passive Standby Mode)

- Advantages
  - Simple diagram, reduced cost
- Disadvantages
  - No real isolation of the load with respect to the upstream distribution system.
  - Transfer time. It operates without a real static switch, so a certain time is required to transfer the load to the inverter.
  - No regulation of the output frequency, which is simply that of the utility power.

UPS (Line Interactive Mode)

- The inverter is connected **in parallel** with the AC input **in a standby configuration**, and also charges the battery. *It thus interacts (reversible operation) with the AC-input source.*
- This configuration is not well suited to regulation of sensitive loads in the medium to high-power range because **frequency regulation is not possible**. For this reason, it is rarely used other than for low power ratings.

UPS (Line Interactive Mode)



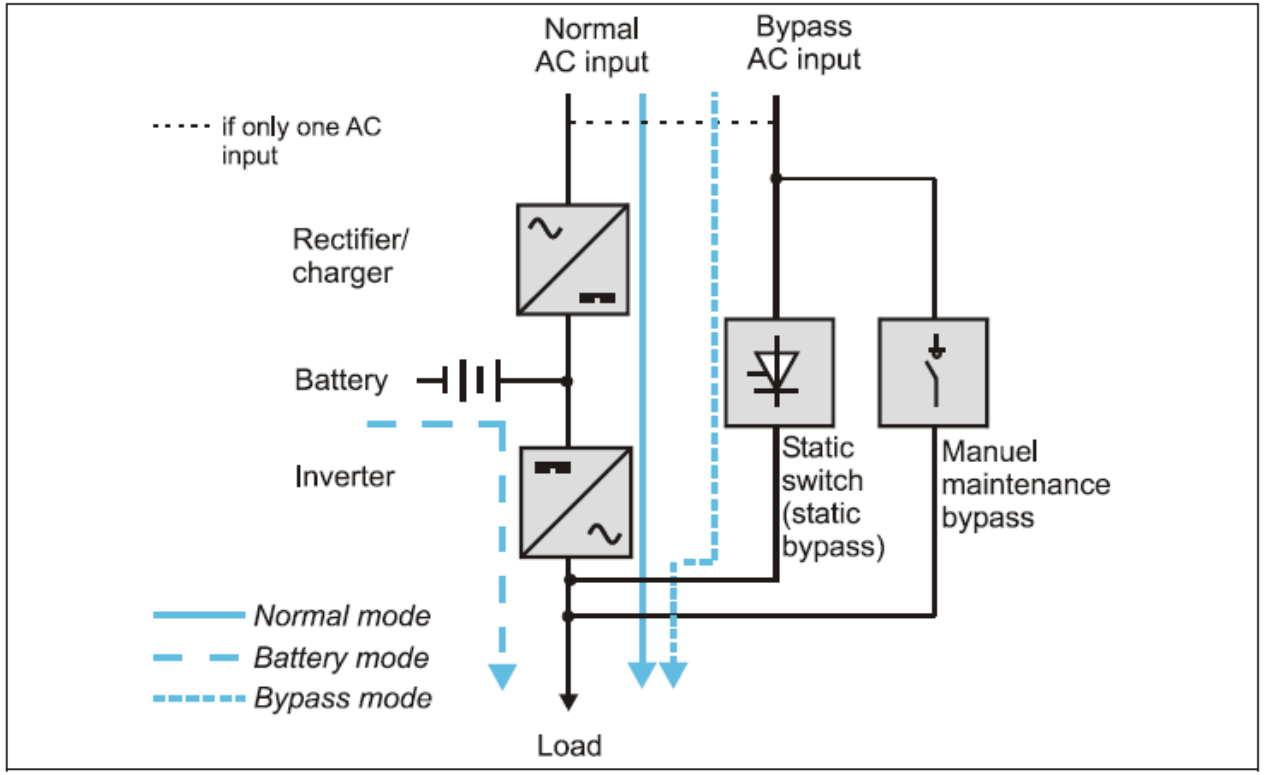
UPS (Line Interactive Mode)

- Advantages
  - The cost can be less than that for a double-conversion UPS with an equivalent power rating because the inverter does not operate continuously.
- Disadvantages
  - No real isolation of the load with respect to the upstream distribution system.
  - No regulation of the output frequency, which is simply that of the utility power.
  - Mediocre conditioning of the output voltage because the inverter is not installed in series with the AC input.
  - Efficiency depends on types of loads.
  - A single point of failure exists due to the absence of a static bypass, i.e. if a malfunction occurs, the UPS shuts down.

UPS (Double Conversion Mode)

- *The inverter is connected **in series** between the AC input and the application. The power supplied to the load continuously flows through the inverter.*
- ***Double-conversion UPSs are used almost exclusively for higher ratings.***
- ***For low power ratings (< 2 kVA), the three standardised technologies coexist.***

UPS (Double Conversion Mode)



UPS (Double Conversion Mode)

- Advantages
  - Complete regeneration of the output power, whether it comes from the utility or the battery.
  - Total isolation of the load from the distribution system and its disturbances.
  - Very wide input-voltage range, yet precise regulation of the output voltage.
  - Much higher performance levels under steady-state and transient conditions.
  - Instantaneous shift to battery backup mode if utility power fails.
  - No-break transfer to a bypass line (bypass mode).
  - Manual bypass (generally standard) to facilitate maintenance.
- Disadvantages
  - Higher price, but compensated by the many advantages.

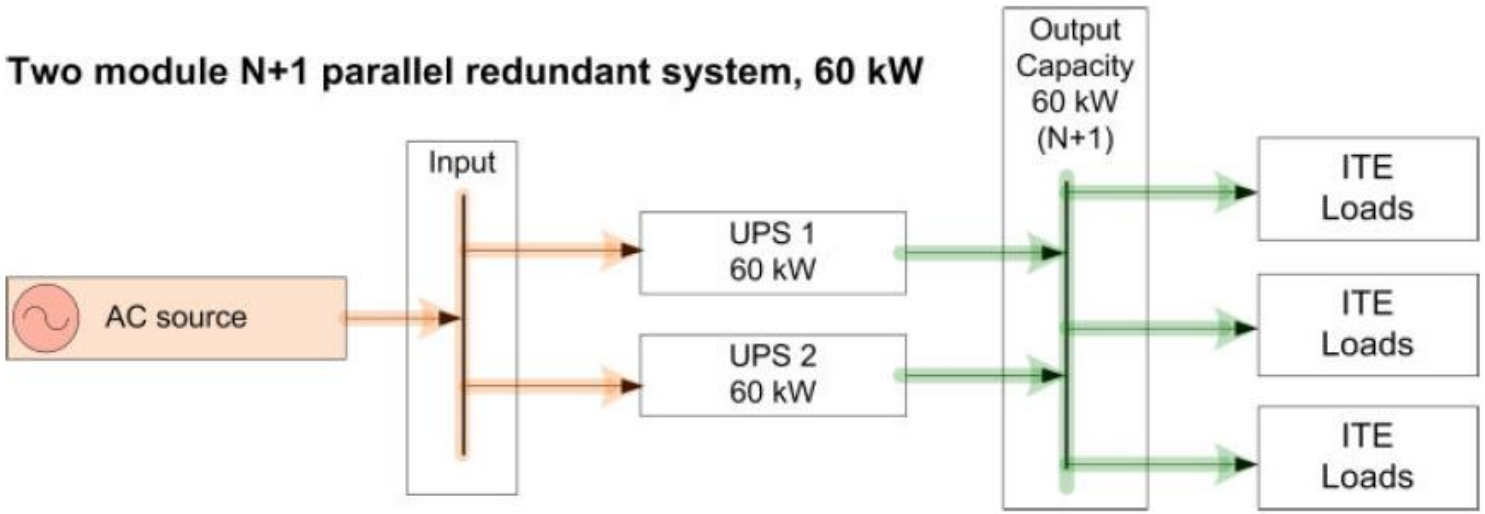
Components of UPS

- Rectifier/Charger
- Inverter
- Battery
- Static Bypass
- Manual Bypass

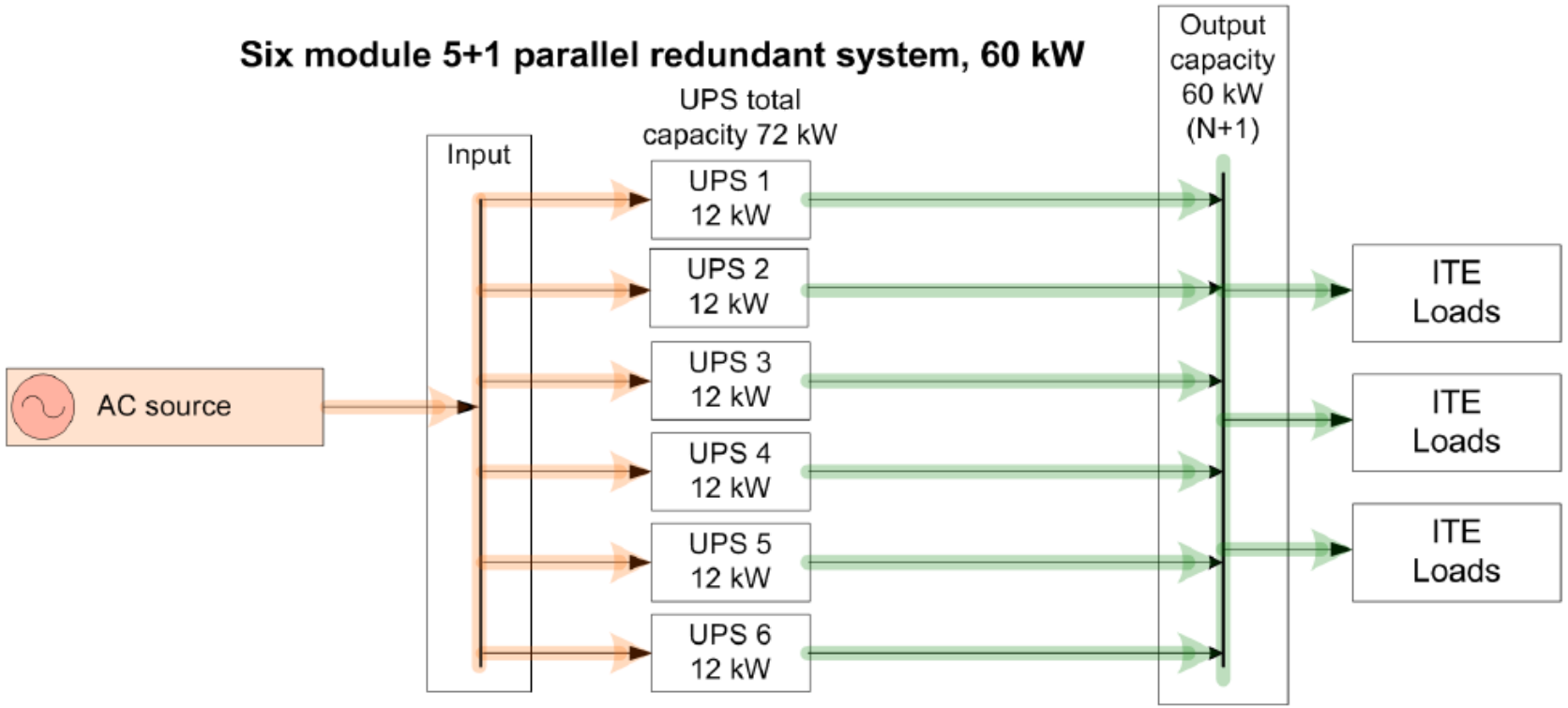
Types Redundancy in UPS

- Dual(Isolated)
  - One UPS is in use and keep one in standby.
  - As one UPS always remains isolated, there are chances that it won’t be actually working when it is required.
  - Keep changing this UPS even if it is in normal condition.
- Parallel
  - Two UPS operate in parallel and both work together.
  - In case one UPS fails, other should be capable to supply full load.
  - If any one transformer of UPS fails then it needs to be isolated.
  - Preferred choice comparatively
  - N+1, N+2 etc.
  - Efficiency may be lower as both UPS work at around 50 % of load, but reliability and availability increases.

Redundancy in UPS



Redundancy in UPS



Redundancy in UPS

- The 60 kW UPSs can only be repaired by a trained professional. Even if that person arrives within four hours, total downtime for the impacted unit would likely be six to eight hours. Moreover, if the service provider doesn’t have easy access to replacement parts, downtime could easily extend past 24 hours. Throughout that period, IT equipment would be at heightened risk due to lack of UPS redundancy.
- The 12 kW UPSs, by contrast, come with hot-swappable electronics and battery modules that end users can replace on their own in minutes, assuming they keep spare parts on hand.

Redundancy in UPS

- Battery-related considerations offer further evidence. The lifespan of a typical UPS battery is four years. Thus, the 60 kW UPS configuration is likely to lose redundancy due to a battery-related issue for at least six hours every four years. The 12 kW UPS configuration, on the other hand, would probably lose redundancy for approximately one hour every four years.
- What is true of batteries is true as well of electronic and mechanical components like fans and capacitors, all of which are typically considered wear-out or consumable items in a UPS. Products designed with hotswappable parts will always experience less downtime. Thus, even though the six-UPS architecture may have a lower part failure MTBF than the two-UPS architecture, its lower MTTR ultimately results in far better availability.

Redundancy in UPS

- $Availability = \frac{MTBF}{MTBF+MTTR}$
- $MTBF = \frac{Total\ System\ Operation\ Time}{Total\ number\ of\ failure}$
- $MTTR = \frac{Total\ Maintenance\ Time}{Total\ number\ of\ Repairs}$

References

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2. www.batteryuniversity.com
3. www.mpoweruk.com