



IEEE Seminar Houston

October 20-21, 2015

Presented by: Gert Andersen, CTO Gutor UPS Product Line

Life Is On | **Schneider**
Electric

UPS and Battery Systems

IEEE Seminar Houston, October 20th – 21st, 2015

Tuesday, October 20th 2015

6:00 – 8:50 PM

Agenda

- Introduction
- Basic functions of UPS
- Industrial UPS markets
- Find the best UPS solution
- UPS configurations
- UPS solutions in detail - AC and DC
- Q&A and wrap-up

Wednesday, October 21st 2015

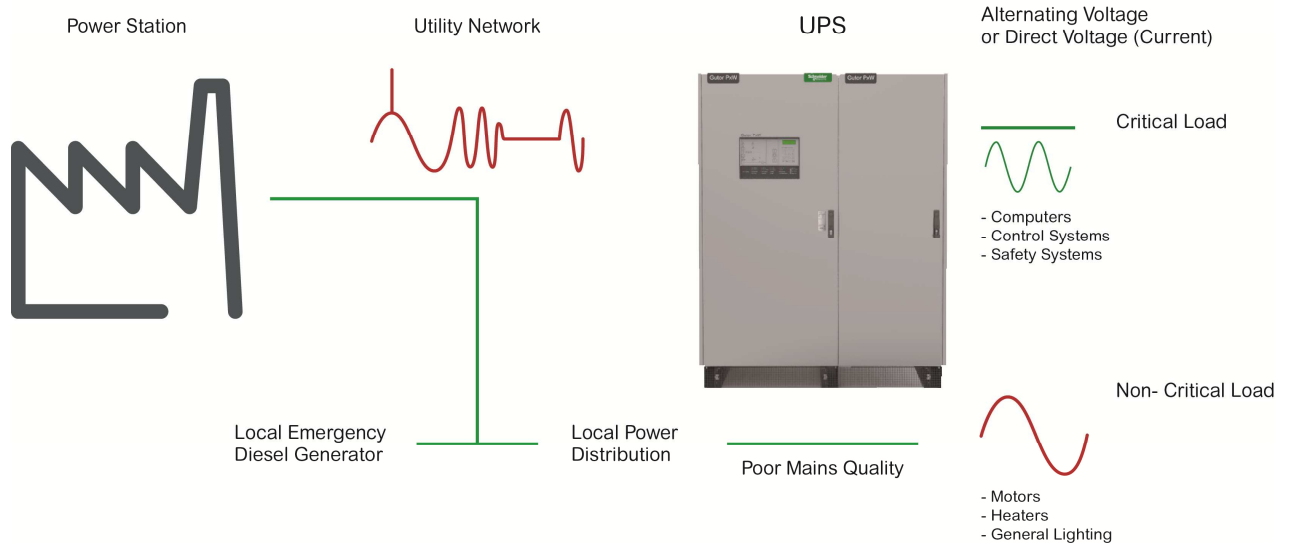
6:00 – 8:50 PM

Agenda

- Follow-up day 1
- UPS technology
- Operating and monitoring of UPS
- UPS for nuclear applications
- Batteries
- Standards
- Maintenance
- Q&A and wrap-up

Introduction

UPS in the Mid-Point between Utility and Critical Load

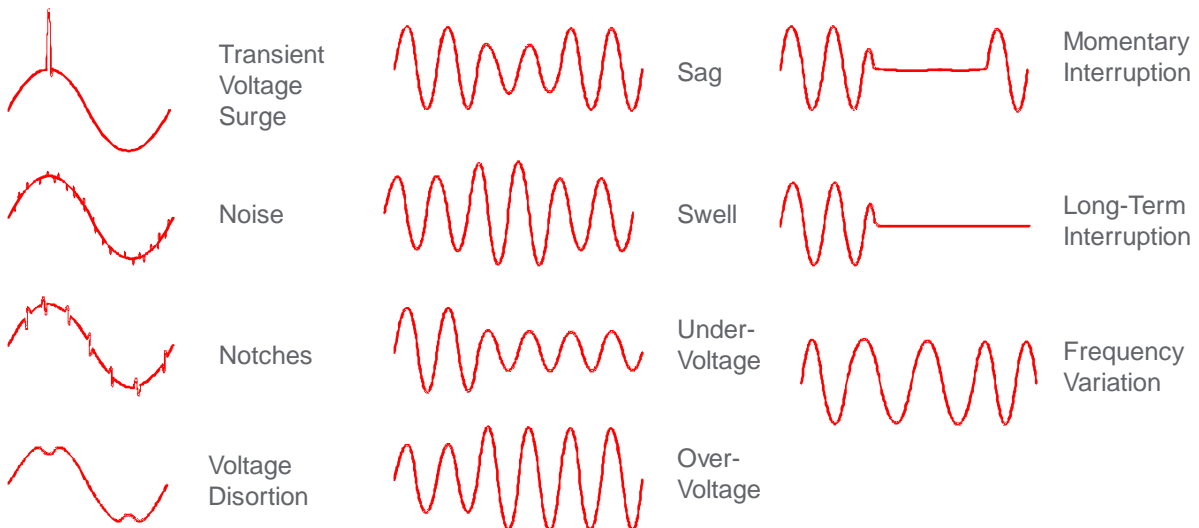


Introduction

Typical Mains Disturbances

3% of failures are related to direct power failures.

The rest is mainly due to fluctuations.

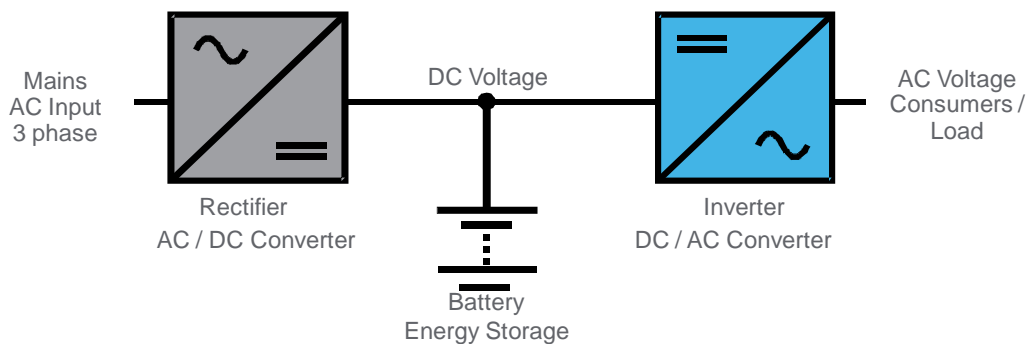


Basic functions of UPS

- Why do we need a UPS (Uninterruptible Power Systems) ?
- Basic function of UPS
 - Secure electrical power for critical loads as long as power/energy is available from at least one of the UPS sources:
 - Rectifier mains – 1st Priority
 - Battery – 2nd Priority
 - Bypass mains – 3rd Priority and “high current” back-up
 - Protect critical load against upstream disturbances
 - All kind of transients and blackouts
 - Technologies
 - UPS
 - Rectifier/Battery charger
 - Inverter

Basic functions of UPS

AC UPS System



- 3 Phase Input
- Voltage 3x200... 3x690V
- Frequency 50 or 60 Hz
- 6-pulse thyristor controlled rectifier
- Opt.: 12 pulse thyristor controlled rectifier
- Opt.: oversized for higher charge
- Float or boost charge
- Opt.: PFC

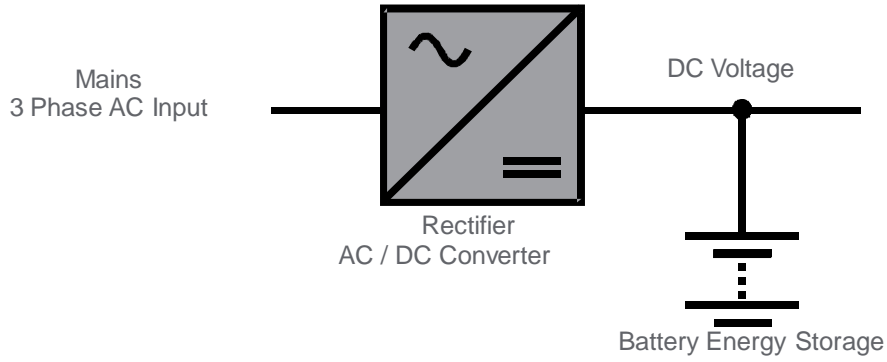
- 4 Standard DC
- Voltages: 110, 125, 220 or 400 VDC
- Lead Acid Type
- Nickel Cadmium Type

- 1- or 3-Phase Output IGBT-PWM controlled inverter
- Short-circuit proof inverter
- Opt.: oversized for inverter module to interrupt bigger fuses

Online double Conversion System

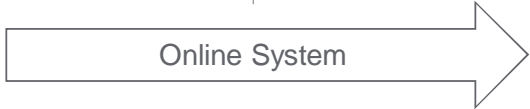
Basic functions of UPS

DC UPS System



- 3 Phase Input
- Voltage 3x200...3x690V
- Frequency 50 or 60 Hz
- 6-pulse thyristor controlled rectifier
- Opt.: 12 pulse thyristor controlled rectifier
- Opt.: oversized for higher charge
- Float or boost charge
- Opt.: PFC - Modular

- 5 Standard DC Voltages:
24, 48, 110 125 or 220 VDC
- Lead Acid Type
- Nickel Cadmium Type

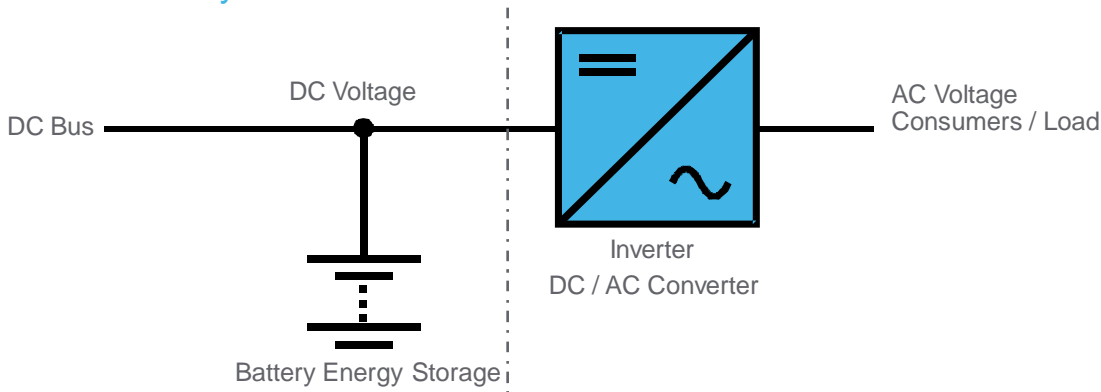


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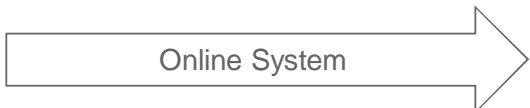
Basic functions of UPS

Inverter System



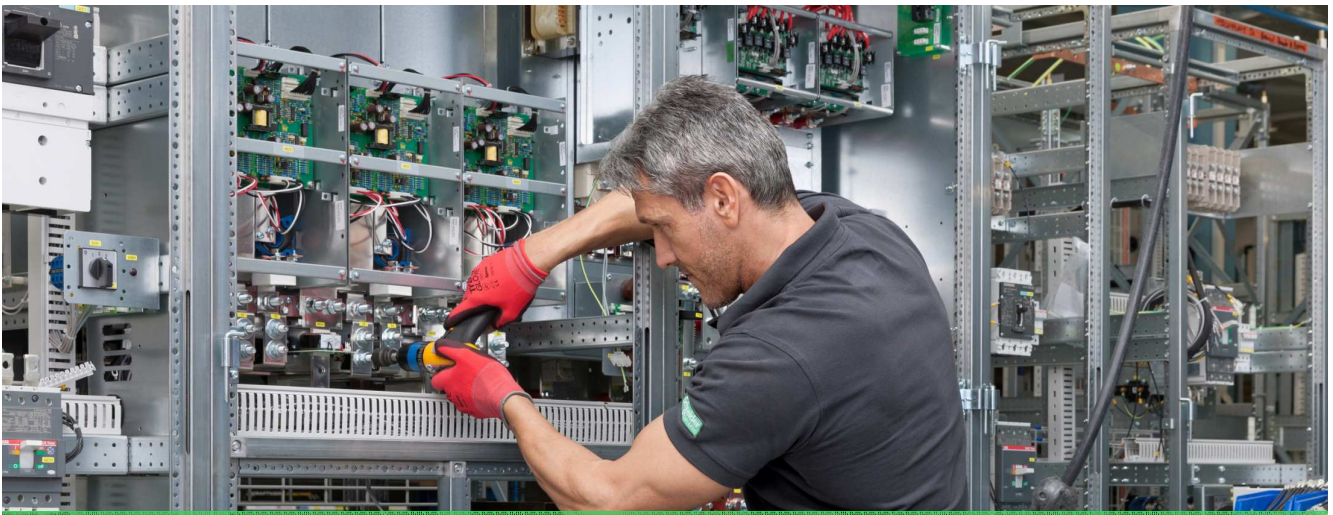
- 4 Standard DC Voltages:
110, 125, 220 or 400 VDC

- 1- or 3- Phase Output IGBT-PWM controlled inverter
- Short-circuit proof inverter
- Opt.: oversized for inverter module to interrupt bigger fuses



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Industrial UPS markets

Typically Industrial markets | Industrial (ETO) vs. Commercial UPS | Single vs. Three Phase Inverters



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Industrial UPS Markets

Typically industrial markets



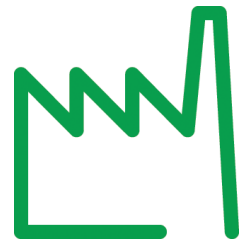
Oil & Gas,
Petrochemicals



Nuclear Industry



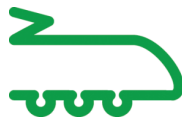
Power Generations



Other industrial
applications



Mining



Transport



Desalination



Chemical

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Industrial UPS Markets

Industrial (ETO) vs. Commercial UPS

| | Engineering | Documentation | Service |
|---------------------------------------|--|--|---|
| Industrial ETO (Process and Power) | <ul style="list-style-type: none"> Customized solutions Flexible specifications FAT / Type Testing Many options Upgradeable Harsh environment | <ul style="list-style-type: none"> Customized layout Approval procedure Project related | <ul style="list-style-type: none"> Comprehensive 20 years life Spare parts Upgrade packages |
| Commercial (IT) | <ul style="list-style-type: none"> Standard solutions Fixed specifications Limited testing Limited options No engineering Office environment No options | <ul style="list-style-type: none"> Standard Limited | <ul style="list-style-type: none"> Limited 10 years life Limited spare parts |

Industrial UPS Markets

Industrial (ETO) vs. Commercial UPS

| | |
|---------------------------------------|---|
| Industrial ETO (Process and Power) | <p>Electrical Design</p> <ul style="list-style-type: none"> • Full Inverter output performance over wide load power factor range • Galvanic isolation between Input, DC branch and output • Different DC levels (battery voltage) available • Individually scalable modules (rectifier, inverter, bypass) • Mechanical Design • Segregated disconnect- and incomer panel • Front access for major components |
| Commercial (IT) | <p>Electrical Design</p> <ul style="list-style-type: none"> • Full Inverter output performance limited to certain load power factor • No- or only limited galvanic isolation • DC level typically 400 VDC or 2 x 400 VDC • Given module sizes • Mechanical Design • Integrated disconnect- and incomer section • Limited front access to major components |

Industrial UPS Markets

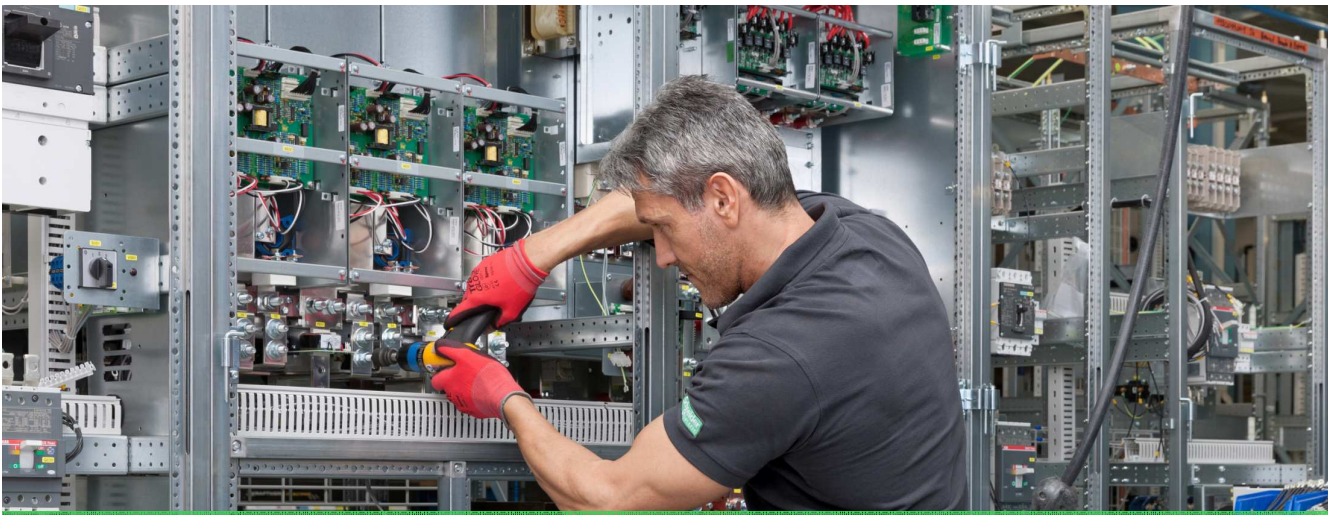
Single vs. Three Phase Inverters

| | Single Phase | Three Phase |
|----------------------|---|---|
| Typical Applications | Single phase loads | Three-and single phase loads |
| Advantages | <ul style="list-style-type: none"> • Higher short circuit current • Commercial, for ratings up to 30kVA • Same cross section, Phase and Neutral Conductors • Better availability through less components • No consideration concerning balancing the load on three phases required | <ul style="list-style-type: none"> • Total power shared by 3 phases • Commercial, rating above 40 kVA |

Industrial UPS Markets

Single vs. Three Phase Inverters

| | Single Phase | Three Phase |
|-----------------------------------|----------------------------|---|
| Disadvantages | Big conductor sizes | <ul style="list-style-type: none"> • Balancing of single phase loads on all three phases • Increased neutral current in connection with single phase SMPS loads none PFC type |
| Short circuit capabilities | Example: 30kVA / 230VAC | Example: 30kVA / 3x400/230VAC |
| Nominal current | 130 AAC | 3x44 AAC |
| Single Ph-N short circuit current | 260 AAC | 152 AAC |
| Three Ph short-circuit current | | 3x88 AAC |



Find the best UPS solution

Decision-making



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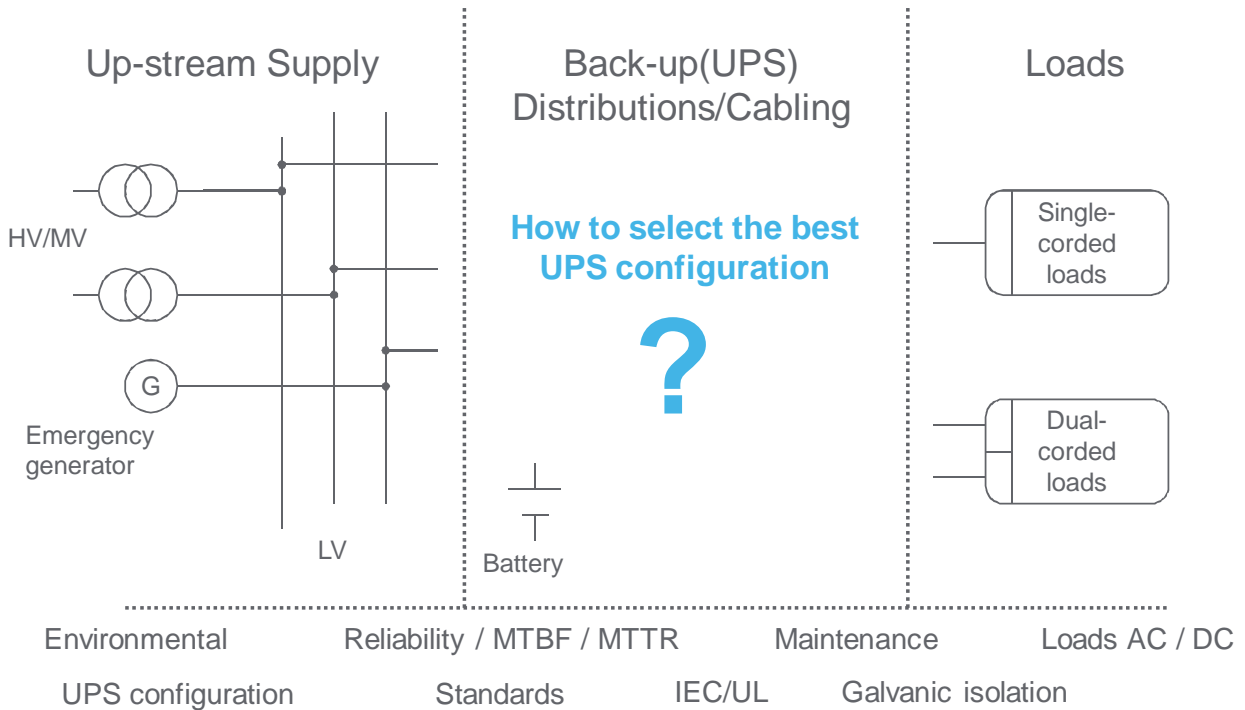
Find the best UPS solution

Decision-making

Find the best UPS Solution depending on

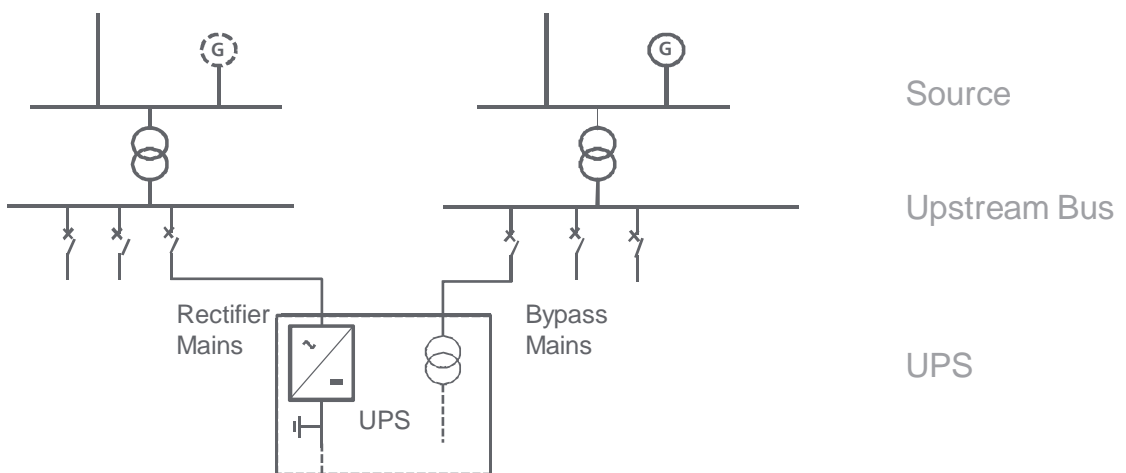
- Upstream supply
- Type of loads
- Environmental
- Maintenance
- Availability – in % or real hours?
 - MTBF (Mean Time Between Failure)
 - MTTR (Mean Time To Repair)
- Basic UPS
- UPS configurations

Find the best UPS solution



Find the best UPS solution

Upstream supply



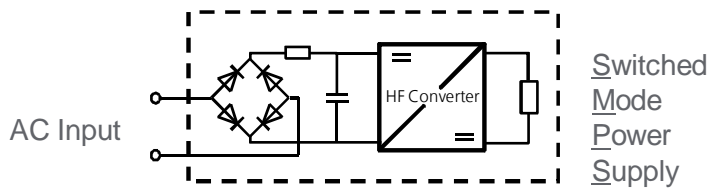
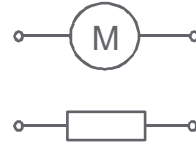
Two upstream independent supplies, together with UPS with separate inputs for Rectifier and Bypass, results in overall higher reliability. Emergency generator will reduce required battery back-up time for UPS.

Find the best UPS solution

Type of loads

Single input loads (single-corded loads)

- Motors
- Valves
- Relays
- Heaters
- Switch Mode Power Supplies
- Other process equipment as for e.g. DCS, PLC,
- SCADA



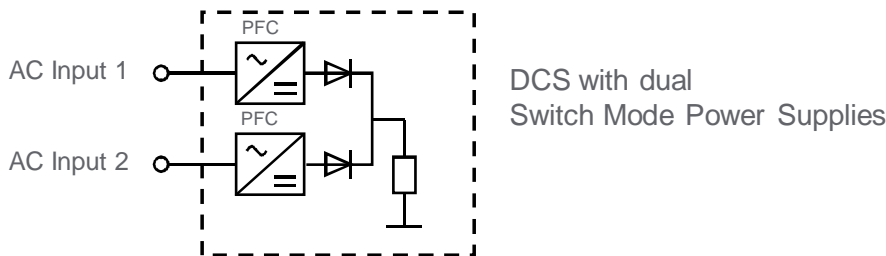
Single or Parallel Redundant UPS preferred for loads with single inputs.

Find the best UPS solution

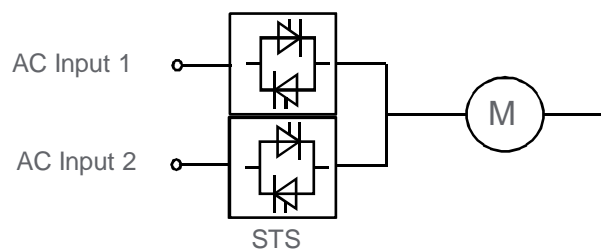
Type of loads

Dual input loads (dual-corded loads)

- DCS with dual Switch Mode Power Supplies
- Other process equipment with front end Static Transfer Switch (STS)



Dual UPS independent or synchronised preferred for loads with dual inputs. 100% redundancy including down stream distribution and cabling.



Find the best UPS solution

Environmental

Major environmental issues, which have an impact on reliability of UPS and Battery during storage, commissioning and operation

- Temperature
- Humidity
- Dust
- “Corrosive” e.g. “salty” air, H₂S

Environmental

Temperature

Temperature

- UPS part
 - Standard rating for industrial UPS up to 40°C/104°F
 - Option for temperature up to 55°C/131°F typically available for industrial UPS
- Battery
 - Average temperature 20 - 25°C/68 - 77°F
 - Lead Acid will be preferred type
 - Average temperature >25°C/77°F
 - NiCd to be considered



Environmental

Humidity

Humidity

- UPS part
 - Critical during installation and commissioning
 - Cubicle heating required during this period
 - During operation humidity up to ~95% acceptable
 - By risk of condensation above UPS IPX2 (Rain roof) required

- Battery
 - Critical during installation and commissioning
 - Depending on battery type vents needs to be protected
 - Terminal posts to be protected
 - Faster self discharge when not connected to Rectifier
 - Shorter time interval between refreshing charges needed



Environmental

Dust

Dust

- UPS part
 - Critical during installation and commissioning
 - Recommended to use air-filters in air-inlet of the UPS

- Battery
 - Critical in combination with humidity



Environmental Corrosives

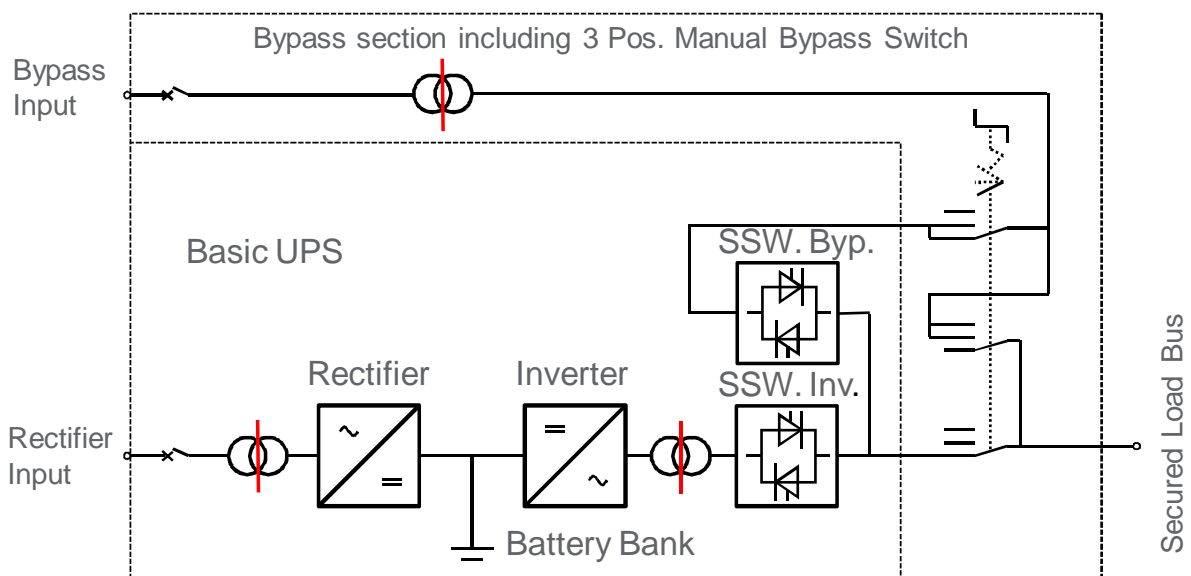
“Corrosives” e.g. salty air, H₂S

- UPS part
 - Additional protection of metal parts may be required
 - PCB (Printed Circuit Board) may required conformal coating, depending on concentrations of corrosives

- Battery
 - May shorten maintenance interval (cleaning)
 - Check grease on terminal posts and connectors



Basic AC UPS configuration with 100% Galvanic isolation



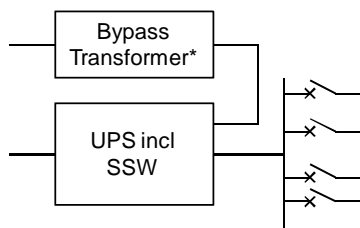
Basic UPS with 100% galvanic isolation (⚡) and Bypass section.
The basic UPS configuration will be used in all Gutor AC-UPS solutions.

AC-UPS Product Line

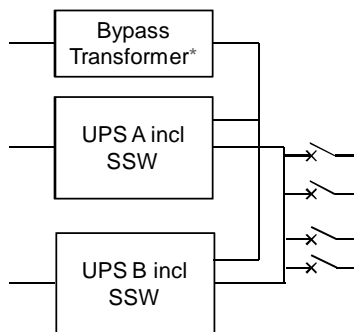
AC-UPS configurations

- Single UPS (also available for DC)
- Parallel Redundant UPS (also available for DC)
- Dual UPS Independent (also available for DC)
- Dual UPS Synchronised

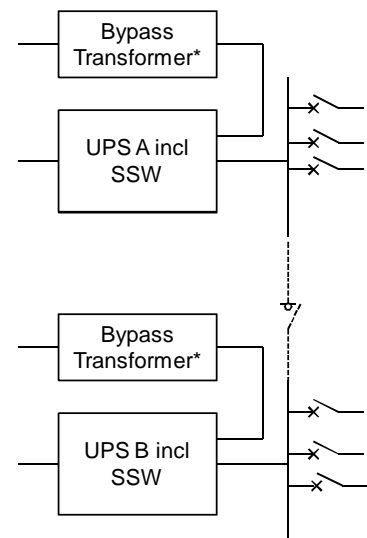
Single UPS * Option



Parallel Redundant UPS * Option



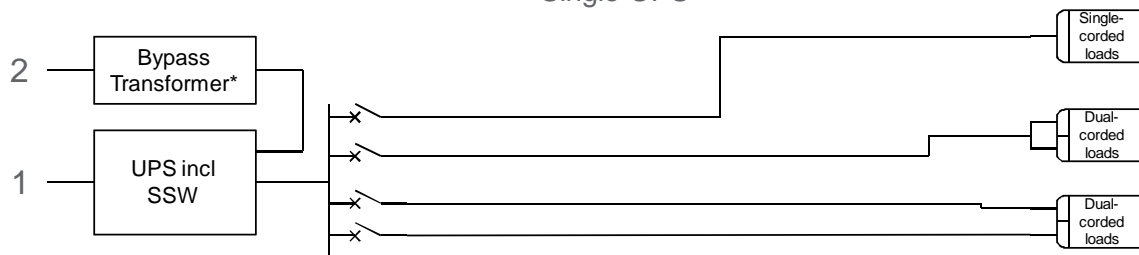
Dual UPS Indp/Synch * Option



AC-UPS Product Line

Single UPS

Single UPS



Configuration

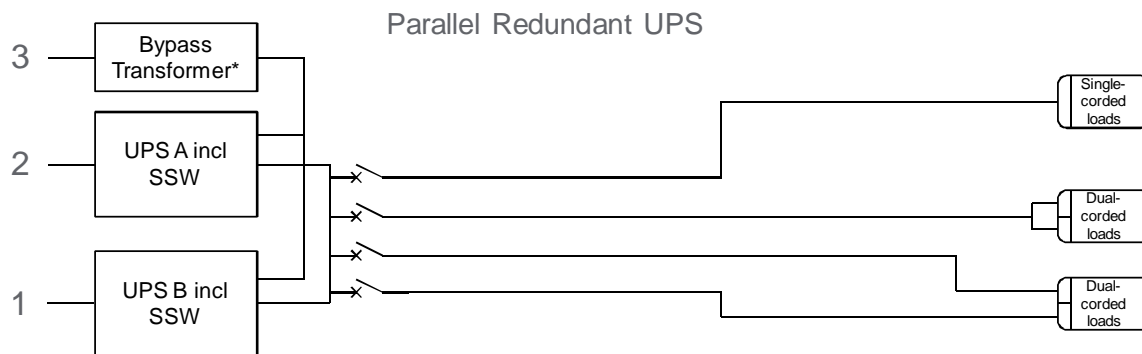
UPS consist of: Rectifier, Battery, Inverter, Static Switch Inverter, Static Switch Bypass, Bypass transformer*

Operation modes

- Normal operation: Load is supplied from Rectifier => DC-link => Inverter => Static Switch Inverter => Load
- Battery operation: Rectifier or mains not available, load is supplied from Battery => Inverter => Static Switch Inverter => Load
- Bypass operation: Due to overload above available overload profile of the Inverter, or Inverter is not available. Load is supplied direct from Bypass => Static Switch Bypass => Load

AC-UPS Product Line

Parallel Redundant UPS



Configuration

- UPS A and B each: Rectifiers, Batteries, Inverter, Static Switch Inverter, Static Switch Bypass sharing one Bypass transformer*
- The Inverters are sharing the actual load by taking each 50% of the actual load
- System overload profiles are equal to two times the overload profile of each Inverter
- System stay in the highest possible operation modes, and in this way save battery capacity until really needed

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AC-UPS Product Line

Parallel Redundant UPS Operation modes: See following pages for details

- Normal operation; both inverters supplying the load
- Normal operation; one inverter supplying the load, second inverter in standby
- Battery operation; both inverters available
- Battery operation; one inverter supplying the load, second inverter in standby
- Bypass operation

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AC-UPS Product Line

Parallel Redundant UPS: Normal Operation - load sharing

| | UPS A | UPS B | Comments |
|-----------------------------|----------------|----------------|--|
| Rectifier mains | Available | Available | In tolerance |
| Rectifier | ON | ON | |
| Battery | Charging/Float | Charging/Float | |
| Inverter | ON | ON | Load sharing; each inverter deliver 50% of the actual load |
| Static Switch EA (Inverter) | ON | ON | |
| Bypass Mains | Available | | In tolerance |
| Static Switch EN (Bypass) | OFF | OFF | Ready to takeover the load |
| Output voltage | Available | | In tolerance |

AC-UPS Product Line

Parallel Redundant UPS: Normal Operation – One system part A or B out of service, example with Mains B out of tolerance

| | UPS A | UPS B | Comments |
|-----------------------------|----------------|---------------|--|
| Rectifier mains | Available | Not available | Mains A in tolerance Mains B out of tolerance |
| Rectifier | ON | OFF | Or not available |
| Battery | Charging/Float | Available | |
| Inverter | ON | Standby | Inverter A supply load 100%. Inverter B ready |
| Static Switch EA (Inverter) | ON | OFF | |
| Bypass Mains | Available | | In tolerance |
| Static Switch EN (Bypass) | OFF | OFF | Ready to takeover the load |
| Output voltage | Available | | In tolerance |

AC-UPS Product Line

Parallel Redundant UPS: Battery Operation - load sharing

| | UPS A | UPS B | Comments |
|-----------------------------|---------------|---------------|--|
| Rectifier mains | Not available | Not available | Mains A and B out of tolerance |
| Rectifier | OFF | OFF | Or not available |
| Battery | Discharging | Discharging | |
| Inverter | ON | ON | Load sharing each 50% of the actual load |
| Static Switch EA (Inverter) | ON | ON | |
| Bypass Mains | Available | | In tolerance |
| Static Switch EN (Bypass) | OFF | OFF | Ready to takeover the load |
| Output voltage | Available | | In tolerance |

AC-UPS Product Line

Parallel Redundant UPS: Battery Operation – One battery discharged

| | UPS A | UPS B | Comments |
|-----------------------------|---------------|---------------|--|
| Rectifier mains | Not available | Not available | Mains A and B out of tolerance |
| Rectifier | OFF | OFF | Or not available |
| Battery | Discharging | Discharged | Battery B has reach end of discharging stage |
| Inverter | ON | OFF | UPS A supply the load |
| Static Switch EA (Inverter) | ON | OFF | |
| Bypass Mains | Available | | In tolerance |
| Static Switch EN (Bypass) | OFF | OFF | Ready to takeover the load |
| Output voltage | Available | | In tolerance |

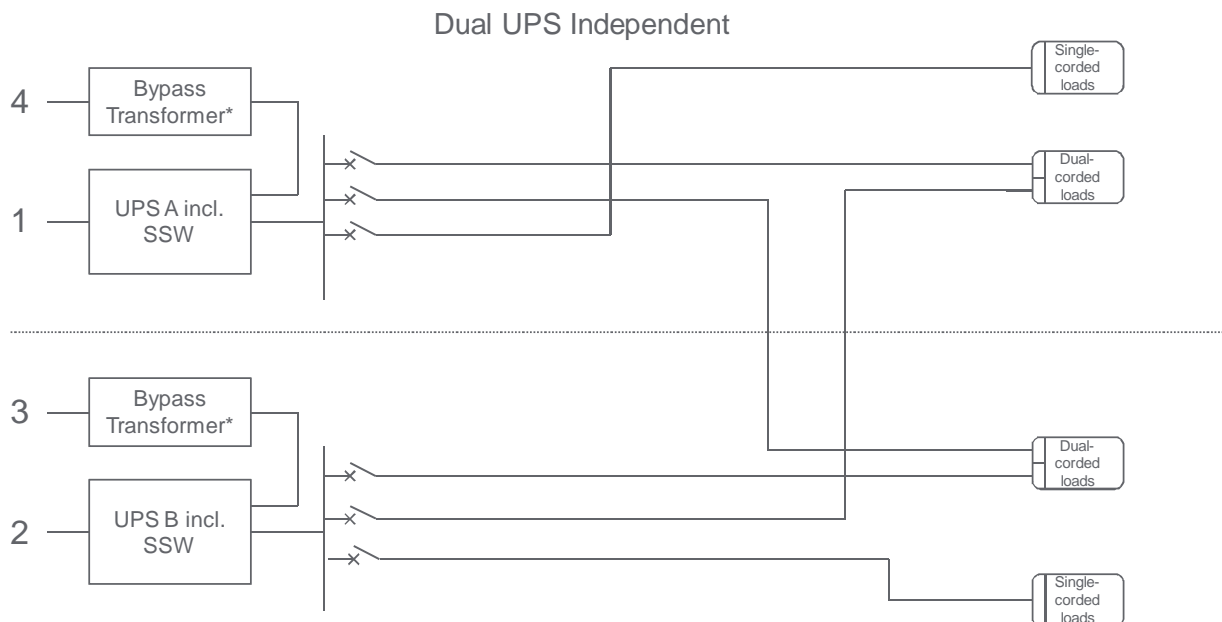
AC-UPS Product Line

Parallel Redundant UPS: Bypass operation

| | UPS A | UPS B | Comments |
|-----------------------------|---------------|---------------|----------------------------|
| Rectifier mains | Not available | Not available | May be available |
| Rectifier | OFF | OFF | May be available |
| Battery | Discharging | Discharged | May be charging or charged |
| Inverter | OFF | OFF | May be in Hot-Standby |
| Static Switch EA (Inverter) | OFF | OFF | |
| Bypass Mains | Available | | In tolerance |
| Static Switch EN (Bypass) | ON | ON | |
| Output voltage | Available | | In tolerance |

AC-UPS Product Line

Dual UPS Independent



AC-UPS Product Line

Dual UPS Independent

Configuration

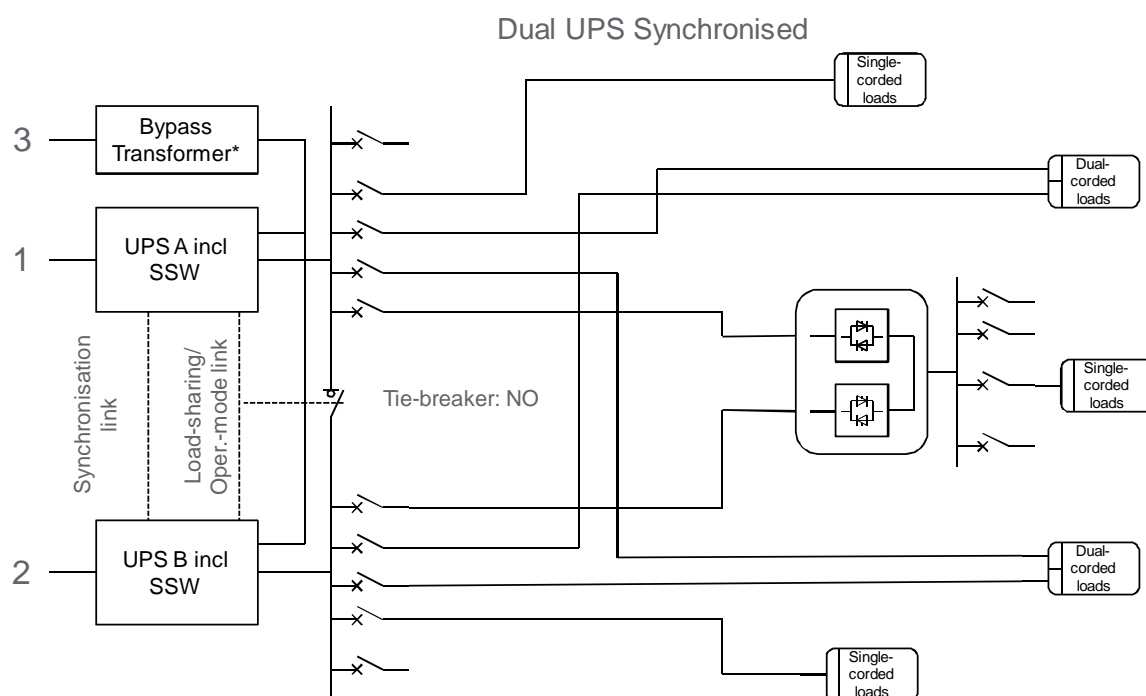
UPS A and B consist of each: Rectifier, Battery, Inverter, Static Switch Inverter, Static Switch Bypass, Bypass transformer

Operation modes

- UPS A and B operates independently as two Single UPS
- Normal operation: Load is supplied from Rectifier => DC-link => Inverter => Static Switch Inverter => Load
- Battery operation: Rectifier or mains not available, load is supplied from Battery => Inverter => Static Switch Inverter => Load
- Bypass operation: Due to overload above overload profile of the Inverter, or Inverter is not available. Load is supplied direct from Bypass => Static Switch Bypass => Load

AC-UPS Product Line

Dual UPS Synchronised



AC-UPS Product Line

Dual UPS Synchronised

Configuration

- UPS A and B consist of each: Rectifiers, Batteries, Inverter, Static Switch Inverter, Static Switch Bypass, sharing one common Bypass transformer
- The inverters are synchronised to bypass as well as to each other
- Even during loss of bypass mains both inverters are synchronised
- Due to the synchronisation of the two inverters, it's possible to feed a third distribution board by a no break STS unit (Static transfer switch), the change over from supply from UPS A to UPS B and vice versa will be without interruption.
- Its even possible to operate the Dual Synchronised UPS with the tie-breaker closed, due to communication between the tie-breaker and the two UPS. In this mode the active load-sharing between Inverter A and B will be active as well as the operation mode control, securing that both Inverter will be in the same mode or if not possible one Inverter will be in standby.
- Operation of the two manual bypass switches, when the tie-breaker is closed, must be strictly according to manual.

AC-UPS Product Line

Dual UPS Synchronised

Operation modes

- Tie-breaker open
 - Each UPS A and B operates independently, as two Single UPS
- Tie-breaker closed
 - UPS A and B follow the same sequence of operations modes as for Parallel Redundant UPS