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# A New Electrical System Design of Data Centre

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***Abstract:*** *Currently the data center construction has entered a new stage of rapid development and forming a new trend of construction. Centralized data and computing power to bring huge benefits; a new requirement of data center construction also rises. The power system must be maintaining high stability, in order to ensure the date center is running continuity. Uninterruptible power system (UPS) and emergency backup generators are both the solutions that using widely for maintain the power system stable. Consider the rising needs of IT operation system will consume more non-renewable energy, This report will analysis the structure of a power system, try to identify the contributions of UPS and emergency backup generators about maintaining the power system stability, and how the energies being use while operate the system, identify some workable new technologies to reduce wastage of energies and ensure the sustainability.*
***Keywords:*** *Uninterruptible power system (UPS), data center, power system*

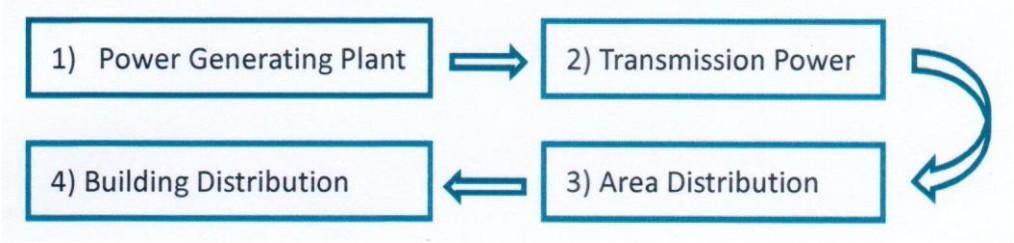
## I. Introduction

The Today, many organizations are preparing to build a new data center or to transform the original data center. Automation and service continuity is a critical factors, company such as bank is mostly dependent on the computer, connecting to the data center, linking with the data base to run their business.

Data Center is known as the Server Farm Room, which is the place of computer systems and associated components, such as telecommunications, banking or insurance computer storage systems. It includes redundancy and backup power supplies, redundant data communications connections, Indoor environmental control such as air-conditioning to control temperature and humidity, and a variety of safety equipment such as fire extinguishers, security systems, and CCTV systems. Some relatively large data center power consumption may equals to an entire factory industry electricity power usage. [1]

The entire power supply system can be divided into four stages, and different potential factors which may led to decline in the power quality will also be analysis as following:

### 1.1 Power supply system




**1. Power generating plant:**
Power Plant may impact by fuel shortage, human error, natural disasters, increase consumption in certain area or reduction requirements.

**2. Transmission Line:**
Transmission line may impact by natural disasters, loading level, equipment service period, and regional weather condition, etc.

**3. Area and Building distribution:**

Area and building distribution maybe impact by the factors such as regional weather condition, equipment service period is too long, maintenance and repair their frequency and quality, whether professional maintenance technology, construction quality, material quality, etc.
Power supply failure such as electricity shock, voltage drop or power outages will occurs when the above situation appear.

IT operations are important factors for company's operation around the world. One of the main concerns is business continuity; companies rely on the information data center systems to maintain the business

continuity, the unavailable of a system may interrupt or stopped the company operation completely. Therefore, it is important to ensure the reliability of infrastructure for IT operations, in order to minimize the chance of disruption. Reduce computer system instability is necessary, but how to do it? Provide a stable power system is a reliable method. Design data center power needs to consider about the cost of downtime, data center risk tolerance, high reliability, resilience strong (MTTR Mean time to repair), load type (single power or dual power). There are many aspects of the design method: Such as parallel redundancy, series redundant, Dual Bus System, etc.

## II. Literature Review

There are many literatures or journals have studied about the Uninterruptible power supply. However, it is often find that the studies are usually taking about the contribution or benefits of the UPS system, or something related to this topic. Some had investigated and identified certain problem about the existing system, and found the way to improve. However, the rooted problem about how to retain the sustainability seems has not yet be solve.

Uninterruptible power supplies and emergency backup generators have been used in many installations, especially in those contains important data information, which cannot afford power failure or being interrupt during operation. The research of [2] indicated that it is often difficult to upgrade the UPS system as the load grows over time. The parallel operation of modularized small-power UPS, which carrying a lot of benefits, including lower cost and easy to increase the system capacity have changed the situation.

The other study of [3] stated that energy storage technologies provide valuable benefits to improve the power stability and enhance the reliability of supply. The study proofed the benefits of energy storage, and the nonpolluting uninterruptible power supplies had enhanced the power quality. However, contributions of nonpolluting uninterruptible power supplies does not include save energy.

The more recent research of [4] has Identified the energy saving problem and the new technology "Elastic Tree" was developed to optimizer the energy use amount the system, it continuously monitors data center traffic conditions, chooses the set of network elements that must stay active and powers down as many unneeded links and switches as possible. It helps to reduce the wastage of energy. But still, it has to consume certain amount of energy; even it is consider less than it used to be.

## III. Power Distribution

### 3.1 Power Distribution Traditional Typical Method:

Electrical power by one set uninterruptible power system (UPS) to back up the critical load. This is the most common and typical examples (N system), one of input switch and one of reserve switch. When normal power failure such as electricity shock or voltage drop, UPS will respond instantly to ensure the maintenance of the normal operation of critical load. Show in figure 3.1

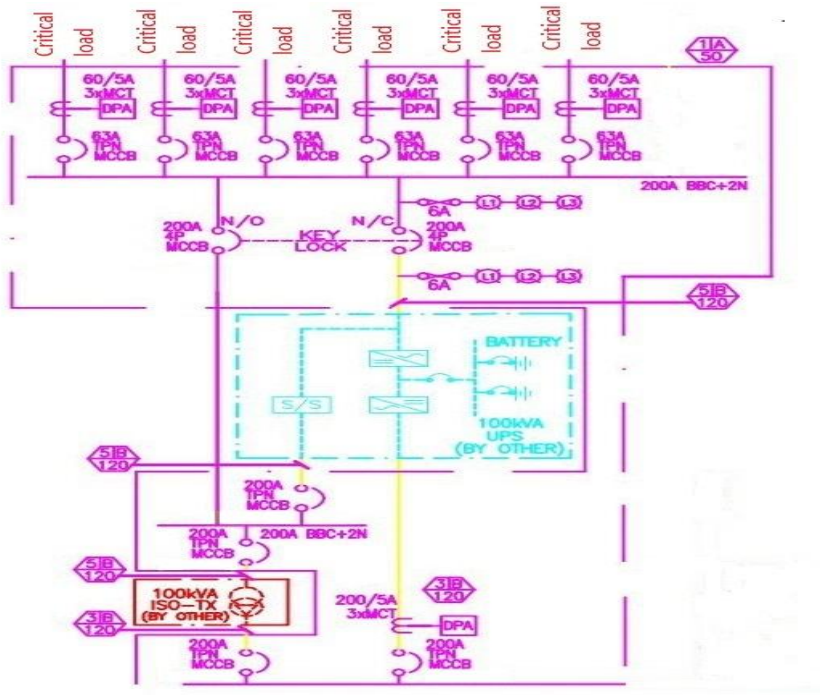



**Figure 3.1**

The mains power is normal, the output terminal using a mains electricity, through the internal inverter (+ stable voltage transformer) is designed together with the inductor, as the same time the UPS's battery is charging also can keep the output voltage stability .

When utility power is unstable, UPS may limit the magnitude of the instability in the + 5% to +10%, but still follow the mains voltage fluctuations, there will be little between the power supply voltage switch Output of the time difference (generally available within 4ms - 10ms), but also in other types of switching regulators within the time difference to battery power to fill that empty period.

When the power fluctuation beyond UPS design range (e.g. + 15% or more), or a power outage, UPS will on battery power is converted into an electronic device that can be used for the output of the alternating current, this UPS output wave mostly class is sine wave switch to almost no time difference (usually available in less than 1ms ~ 5ms) between the UPS power.

**3.2 The advanced Class:**

Also known as a parallel redundant. N + 1 an uninterruptible power supply (UPS) system is always available to provide an electricity of protection. N + 1, which show the number of modules required to plus one more. Show in figure 3.2

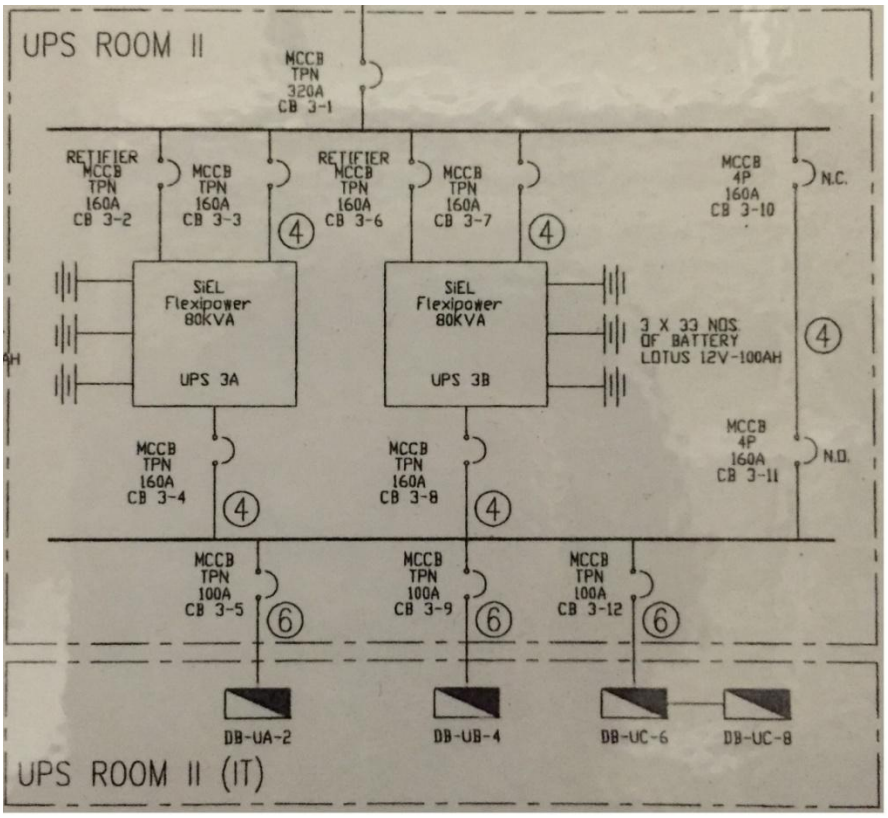



**Figure 3.2**

If a corporate data center and uses a single large UPS module fails, the system will be interrupt. N + several small UPS modules and battery are combined together in one control. In normal operation, if one module fails or needs to be taken maintenance for the operation period, already configured with an additional module for the UPS system will still supply to adequate electricity power supply.

**3.3 Power Distribution Multiplicity Protection methods:**

Although the system includes an N + 1 redundant equipment, however, a redundant system may be will failure, because the system will work on a common circuit instead of two completely separate power supply.

In order to ensure the data center can normal operation for a long time, so use 2 (N + 1) design. 2 (N+1) redundancy is provides two complete (N+1) modules, units, paths, or systems. Show in figure 3.3 If only rely on one single UPS to provide continually power supply, there are still a chance to have power disruption. The reason is because it has no back up, all the important equipment, including computer, lighting, air-condition or even documents, should have to store a back-up copy, that way could reduce the loss when power disruption occur. And back up is different from reserve, reserve is some recover or correction action when things goes

wrong, and back up is to handle it before it happen, store a spare data backup would significantly reduce the loss when error occur. Although UPS is capable to provide continually power supply, but it is only support certain preset area and maintain only a certain period of power supply. Redundancy is one way to enhance the power supply stability, but it cost is considerable. There are many different equipment networking power supply method, each method would aid differently while using in actual site, and each of them has different advantage, if it equip ATS, STS or DSTS, it will has even more benefit.

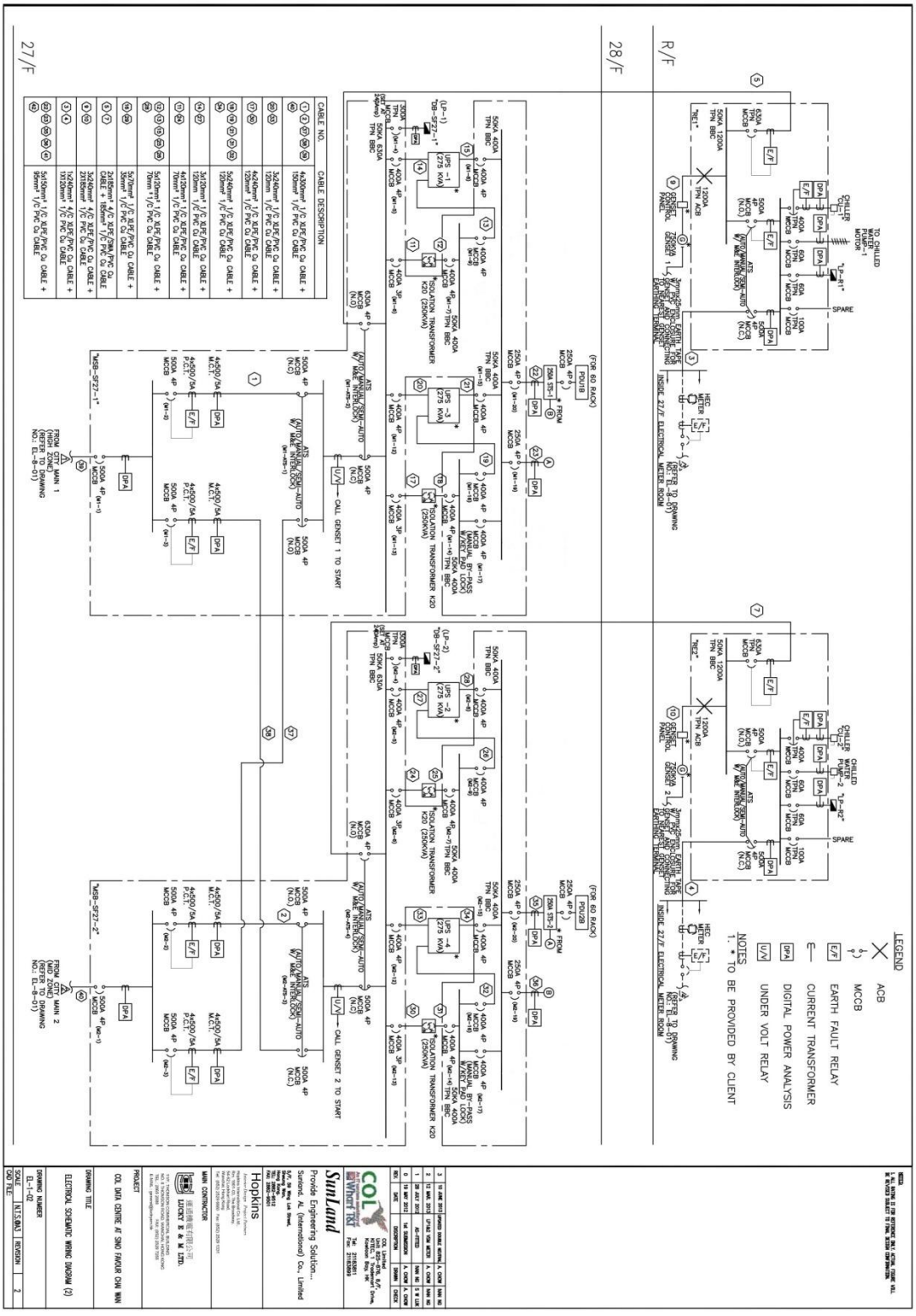



**Figure 3.3**

## IV. Uninterruptible Power System Description (UPS)

UPS has been designed to provide high level of versatility and reliability by using the latest On Line double conversion technology, which the load is constantly supplied by the alternating current (AC) from inverter. The below figure 4.1 explained the concept.

Under a normal situation, the UPS [5] would first converts the alternating current from the mains supply into direct current (DC) and then back to alternating current again to ensure the voltage and frequency output is perfectly sinusoidal, stable and filtered. The frequency and voltage are constantly monitored using microprocessor digital control, this control ensures the input power supply is working independently, with input and output filters that increase the extent to which the load is protected from mains supply borne transients, current surges and noise.

In this operating mode, UPS will switch to battery operation if a line power failure occurs. If an overload or short circuit occurs on the UPS output, or if there is a fault in the inverter, the UPS then will switch to ByPass operation.

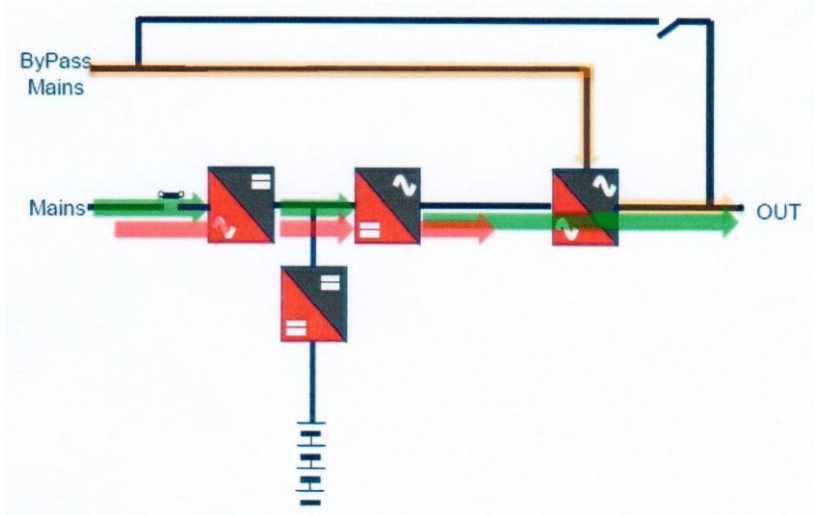



**Figure 4.1**

The uninterruptible power supply can be set to operate in four operating modes: ON-LINE, STANDBY ON, SMART ACTIVE and STAND-BY OFF.

**Mode: ON-LINE**

Most of the UPS operation with On-line mode, which is considered most stable mode. The power switches automatically under different operation to ensure the supply stability.

Normal Operation: The rectifier draws energy from the mains to power up the inverter and keeps the batteries charged; the inverter powers the load with voltage and frequency stabilized and in sync with the by-pass mains when necessary.

Emergency operation: when the mains power supply goes out of the pre-set limit, the rectifier switches off and the battery will power up the inverter for the pre-set back-up time without any disturbance to the load. That way, the mains power supply will restore and the rectifier start to operate gradually, powering the batteries again and charging the inverter.

By-pass operation: When an inverter overload beyond the envisaged limits or shutdown manually, the load will automatically transferred onto the by-pass mains by means of the static switch without any disturbance to the load.

While most of the UPS system operating On-line mode, there are some more advance model would have more operating modes.

**Mode: STAND-BY ON**

The load of Stand-by on mode is normally powered from the by-pass mains and the rectifier keeps the batteries charged.

When the mains goes outside the pre-set range, the load will transfer automatically onto the inverter until the mains returns to a normal level.

This mode is suitable for powering loads that are relatively less sensitive to mains interference, which would increase the system efficiency up to 98%.

**Mode: SMART ACTIVE**

When the UPS is configured in Smart Active mode, it will automatically determine whether to operate in On-Line or Stand-By Off mode through monitoring the by-pass mains. If this remains suitable for a defined period, the system sets itself to Stand-By On mode; otherwise it remains in On-Line mode.

**Mode: STAND-BY OFF**

Under Stand-By Off mode, when the mains power supply is working, the rectifier will keep the batteries charged and the inverter is switched off. When the mains power supply fails, the rectifier switches off and the inverter is activated in approx. 200 ms, using the battery energy. This is usually applied for the power supply of emergency lighting.

**4.1 AC/DC Converter**

The AC/DC Converter converts the alternate voltage into direct voltage to power up the inverter at nominal load and to charge the batteries. Some new design UPS with more advance technology to reduce the harmonics of current rejected into the mains by up to 3% and increase the power factor up to the unit from 10 to 100% of the load.

**4.2 Easy Source**

UPS is designed in order to reduce the impact when the mains source or the upstream Generator Set failed to supply power. In detail the features are as follow:

- Input Harmonics: The lower input harmonics content, the cheaper installation costs and the size of a generator set upstream could also be reduced.
- Power Walk-In: when the input voltage is applied to the rectifier, as per example after the mains power failure, it will reaches the nominal power progressively in the time from 0 to 30 seconds, which is pre-settable.
- Power Walk-in delay timer: The delay of the rectifier' s start-up can reduce the impact to any generator located upstream. The delay start-up can be pre-set up to 120 seconds.
- Inhibition of the battery charge current: while the UPS is operating with a generator set, battery recharging can be excluded so that the available power can be used to feed the load.
- Inhibition of bypass synchronism: In case of the generator set with a very unstable output frequency, the Inverter synchronization with bypass can be inhibited. In such case the inverter generates an output voltage in the free running mode by using the internal oscillator. Therefore, the transfer of the load on the bypass is not allowed.

**4.3 DC/DC Converter**

The DC/DC converter takes the output direct current from PFC converter to allow the battery recharge. Such a system closes inside it a STEP-UP/STEP-DOWN converter that takes care of the charging and discharging of the battery, reducing drastically the current ripple in the battery. The DC/DC converter is also characterized by the following fundamental function:

**Battery Care System**

The "Battery Care System" is a series of functions that control, manage and preserve the battery, in order to ensure it works as long as possible.

**a) Battery Recharging:** The UPS is suitable for hermetic lead batteries (VRLA), AGM, open vase and Ni-Cd. Depending on the battery type, two recharge methods are available:

- Cyclical recharging (factory set): the state of the battery charge is kept constantly under control and when the charge level drops below the established level, a recharge cycle starts up automatically following the IU characteristic (EN 50272-2).
- Two level recharging (configurable): this recharge is carried out with two levels of current at two voltage levels following the IU1 U2 characteristic (EN 50272-2). At the first phase the charging takes place at the rapid charge voltage (U1), and then the second phase at the floating charge level (U2). This type of recharge can be configured on-site and is mainly used with open vase or Ni-Cd batteries.

**b) Battery test:** in normal operating conditions the battery is checked automatically at regular intervals or on manual command. The test takes place without appreciably discharging the battery, in complete safety for the load and without compromising the battery service life. If the test has a negative outcome, a report signal will appear on the UPS panel and remotely.

**c) Protection against slow discharge:** in the event of discharges of long duration and low load, the end of discharge voltage is raised to approx. 1.8 V/el as prescribed by the battery manufacturers so at to avoid damaging the batteries.

**d) Current Ripple:** Thanks to the STEP-UP/STEP-DOWN converter, that provides to recharge and discharge the battery, the current ripple in the battery is extremely reduced. This feature eliminates one of the main causes of reduced battery reliability.

**4.4 DC/AC Converter**

The DC/AC converter converts direct voltage in to stabilized, alternate sinusoidal current to supply the load. With the UPS in ON-LINE mode, the load is always powered from the inverter.
This comprises a three phase inverter with IGBT (Isolated Gate Bipolar Transistor), a transistor that allows high switching frequencies (>20kHz) and consequently low consumption and low noise.
The inverter output is connected to the transformer, thus ensuring galvanic isolation between output and battery.

**Current regulation**

Output current is regulated by using the independent phase control, a characteristic that allows a better static and dynamic response. In detail:
a) Static condition: the output voltage from the inverter remains within ±1% for all the input tension variations within the permissible limits;
b) Dynamic condition: for load variations from 0 to 100%, the output voltage remains within ±5% below the values defined by class 1 of standard EN 62040-3.

**Frequency regulation**

The inverter output frequency is generated autonomously by an internal oscillator in synch with that of the by-pass mains; the frequency stability towards the load therefore depends on the operating conditions:

**a) Frequency stability**

1. With mains available: the internal oscillator follows the variations in frequency of the by-pass mains, according to the set value, which is normally ±2% (can be calibrated form ±1% al ±6%).
2. With mains not available: the inverter generates the output current frequency autonomously with a stability of ±0,05%.

**b) Speed of frequency variation**

The maximum output frequency variation of the inverter to reach onto that of the backup by-pass mains is 2Hz/s for the single UPS and 1Hz/s for the parallel version.

**Output voltage distortion**

The regulation of the inverter guarantees the output voltage distortion with linear loads within 1% (maximum 2% with battery nearly discharged). With non-linear loads, as defined by standard EN 62040-3, the output voltage distortion does not exceed 3%.

**Overload**

The inverter is sized to supply a power overload (kVA) of 110% for 1 hour, 125% for 10 minutes and 150% for 1 minute, on the three phases. On two phases, the limit is 200% for 7 s. If the time or power limits are exceeded, the load is transferred onto the by-pass mains.

**Short circuit capacity**

In the event of a short circuit on the load and with power supply from the battery, the inverter can supply a current limited to 180% for 1 s in the event of a short circuit on the three phases, and 300% for 1 s in the presence of a short circuit between phase and neutral.

**Symmetry of output voltage**

In all conditions, the symmetry output voltage is guaranteed within ±1%, for balanced loads and ±2% for 100% unbalanced loads (e.g. one phase at nominal load, the other two without load).

**Phase displacement**

The inverter three phase output voltages are guaranteed with a phase shift angle of 120° ±1° for 100% balanced and unbalanced loads.

**4.5 Static switch**

The Static Switch is an electronic device that transfers the load onto the by-pass mains without any break in power in the following circumstances:

a) manual shutdown of the inverter;
b) exceeding of the inverter overload limits;
c) exceeding of the internal over temperature limits;
d) inverter fault;
e) DC voltage outside the admitted range.

If at the time of switching the inverter voltage is not in sync with that of the by-pass mains, the transfer takes place with a delay of approx. 20 ms to avoid possible damage to the load. However this value can be set from 10 to 100 ms to cover all the requirements of the various types of load.

**By-pass mains voltage:**

Transfer onto the by-pass mains only takes place if the voltage and frequency are considered "suitable" to power the load. The limits of acceptability are defined by the user in relation to the connected load:

1. Voltage window: ± 10% (can be calibrated from ± 5% to ± 25%);
2. Frequency window: ±1Hz (can be calibrated ±1Hz to ±6Hz).

**Overload**

In order to guarantee the maximum of service continuity, the static switch does not have protection for overload. This allows the compatibility with any type of system, commissioning to protection devices, externally installed, the selectivity ensuring.

The UPS Static switch is sized to support the following overloads:

110% for 60 minutes, 125% for 10 minutes, 150% for 1 minute and 700% for 1 second.

**Zero impact sources:**

UPS solves installation problems in systems where the power supply has limited power available where the UPS is supported by a generator or where there are compatibility problems with loads that generate harmonic currents. UPS has a zero impact on its power source, whether this is the mains power supply or a generator:

- Input current distortion < 3%
- Input power factor 0.99
- Power walk-in function that ensures progressive rectifier start up
- Start-up delay function, to restart the rectifiers when mains power is restored if there are several UPS in the system.

In addition, UPS plays a filtering and power factor correction role in the power network upstream, as it eliminates harmonic components and reactive power generated by the power utilities.

**Tradition UPS and A New UPS Technology Integrity Compare:**

| Tradition UPS Technology | A New UPS Technology |
|---|---|
| -Efficiency <92% - or the need to increase cooling.<br>-Bulky equipment.<br>-Heavy equipment: 120 kVA: 700-1200 kg.<br>-Large area, to be equipped with battery cabinet.<br>-Fixed number of batteries.<br>-When the battery charge, voltage ripple serious.<br>-Input power constant low (0.6-0.8).<br>-Input current distortion> 30% - the need to increase the input filter.<br>-Slow switch controlled rectifier may not be compatible with other devices cause.<br>-Required back-up generators to increase.<br>-Output resistance is high (usually »8%) - the difference between dynamic response and the need to install circuit modified to cope with the unbalanced load.<br><br>-Non-linear load, output distortion higher nature.<br><br>-Switching element at full load current, increasing the work pressure. | -Efficiency> 95% - little or no increase in cooling demand.<br>-Small equipment size.<br>-Equipment Lightweight: 120 kVA = 350 kg.<br>-Small area<br>-A variable number of batteries.<br>-Independent battery charger to ensure correct charging battery, less voltage ripple.<br>-Constant input power is high (0.98).<br>-Input current distortion <7% - without the installation of the input filter.<br><br>-Fast switching diode rectifier input will not lead to non-compatibility issues.<br><br>-Without increasing the standby generator.<br><br>-Output resistance is low (<1%) - Excellent dynamic response and performance, even if the load is unbalanced no influence.<br><br>-Under no load conditions, the output low distortion.<br><br>-Due to reduced switch stress, increase reliability. |

## V. Recommendation

**E&M System Installations**

Since the critical load is very important, and they consume a larger proportion of electricity (Show in figure 7.1) and power company's that the power quality instability, in the above analysis shows that Uninterruptible power system (UPS) is essential part of the entire electricity system.

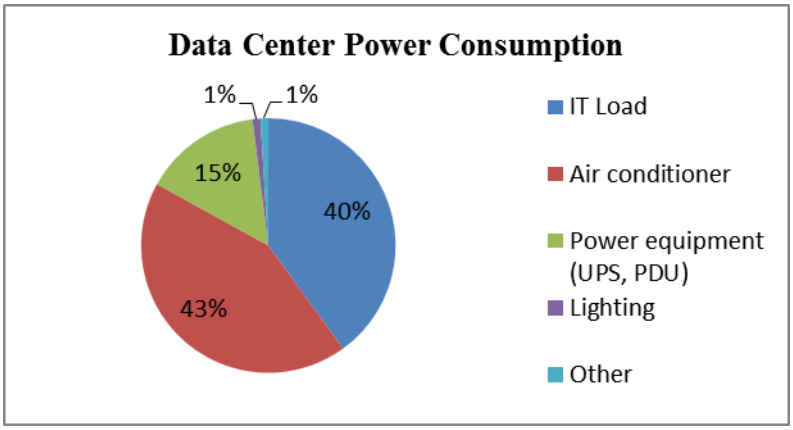



**Figure 5.1**

Uninterruptible power system (UPS) will use batteries discharge when Power supply failure, so there have a time limit. We need to power generator if a prolonged power outage.

Switch control: one or several load circuit from power conversion to another electrical power. We also called Automatic Transfer Switches (ATS); it is two power inputs and can complete the two power exchange, only providing one side input power to outgoing.

The propose of this report will try to reduce the chance of disruption of power system, ensure the power supply stability and to maintain the business continuity.

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