BROCHURE

Continuous Power in Data Centers

Selectivity in UPS networks

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Introduction

After everyone saw the effect of the COVID-19 pandemic and the importance of digitalization became crystal clear, modern society and businesses have relied on data centers like never before. This dependence in addition to the requirement for zero-downtime in data center operations, necessitate that each tiny detail of data center design becomes of the ultimate importance and has to be carefully managed.

Since the reliability of electrical distribution infrastructure in data centers is one of the key design factors to ensure this high availability due to the sensitive nature of its IT loads that need clean and continuous power supplied through a UPS, the selectivity coordination of different protective devices (upstream and downstream of the UPS) during faults plays a vital role in increasing the availability of the electrical network.

Double Conversion UPS Topology

There are three main configurations of UPS systems available in the market depending on application requirements.

- Standby UPS
- Line-interactive UPS
- Double conversion UPS

Protection philosophy needs to be designed depending on the chosen type of UPS configuration. We will focus on the low voltage double conversion UPS as it is the most commonly used configuration in data centers globally.

Double conversion UPS (as the name itself indicates, conversion is twice – AC to DC and DC to AC), which guarantees total isolation through the DC bus between the output of the UPS system connected to the loads and the input that may include power quality problems.

In this configuration, the UPS might have a possibility of accepting three different sources of power:

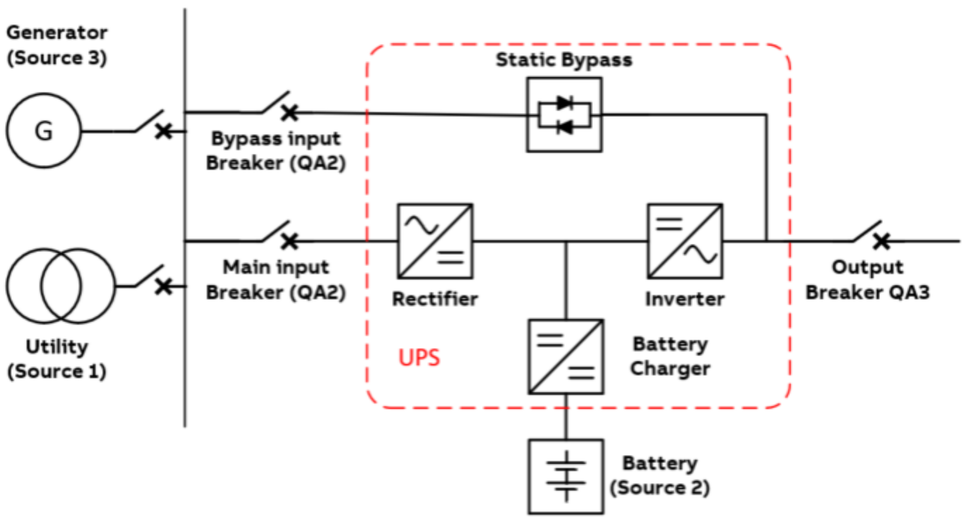
1. The First Source is from the utility which acts as a main power source and supplies power to the battery charging source in addition to power to the load through the rectifier/ inverter combination.
2. The Second source is the battery itself which provides power instantaneously during any transient event at the input side and provides bridging time till the generator starts (usually in the range of minutes).
3. The Third source is a generator which provides backup during outages (usually in the range of hours).

Static bypass switch supply power to the load normally during eco-mode, and also during abnormal conditions such as short circuit or temporary overload situations.

When temporary overloading is required due to the nature of loads, the power supply is guaranteed to the load from the network through a static bypass switch which will exclude the UPS during this phase.

Knowing the different sources of power and UPS's operating modes is imperative to dimension and implement the right protection scheme along with selecting the right protection devices.

Figure 1: Simplified diagram of Double Conversion UPS.



UPS Modes of Operation

The UPS's main function is to provide clean and continuous power to the downstream loads. If the UPS cannot provide clean energy or an adequate voltage level, as per IEC 62040-3, the UPS will transfer the load to the static bypass switch.
A UPS represents an additional power source in the electrical network that has its own behavior/characteristics, which needs to be taken into consideration during system and protection design.

In a normal operation, the UPS supplies the load from either:

1. The utility (or Generator) through the rectifier in path 1 in Figure 2.
2. The utility (or Generator) through the static bypass switch to minimize losses (Eco-mode), as shown in path 2 in Figure 2
3. Through the battery in the case of a utility outage till the generator comes online, as shown in path 3 in Figure 2

The UPS inverter capability on current delivery for downstream short circuits is limited to 2-3 times of its rated current value, while the static bypass switch is often dimensioned to carry at least 10 times of the UPS rated current for a period of 20-100 milliseconds.

During downstream load faults, the load circuit breaker is required to clear the fault as fast as possible to restore the voltage on the output bus and stay within the ITIC requirements of other connected IT loads.

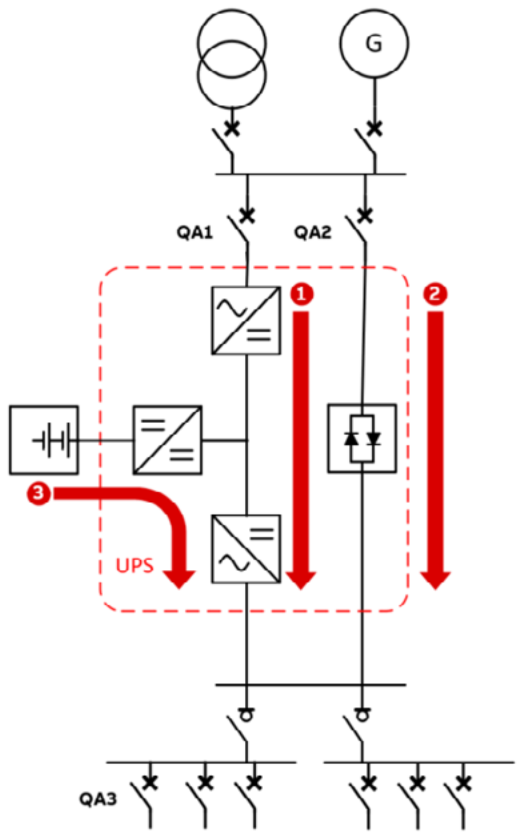


Figure 2 : Current paths during normal operation of Double Conversion UPS.

Sizing considerations

The circuit breaker selection needs to take into consideration factors based on the location of the breaker in the circuit.

Below are a few factors to support the UPS network design and component selection.

The UPS input breaker (QA1) shall consider:

- The UPS rated power and overload characteristics.
- The Battery charging current.
- Must withstand the prospective short circuit from the most powerful of sources (utility transformer).
- Must trip the prospective short circuit delivered by the least powerful of sources (typically the generator).

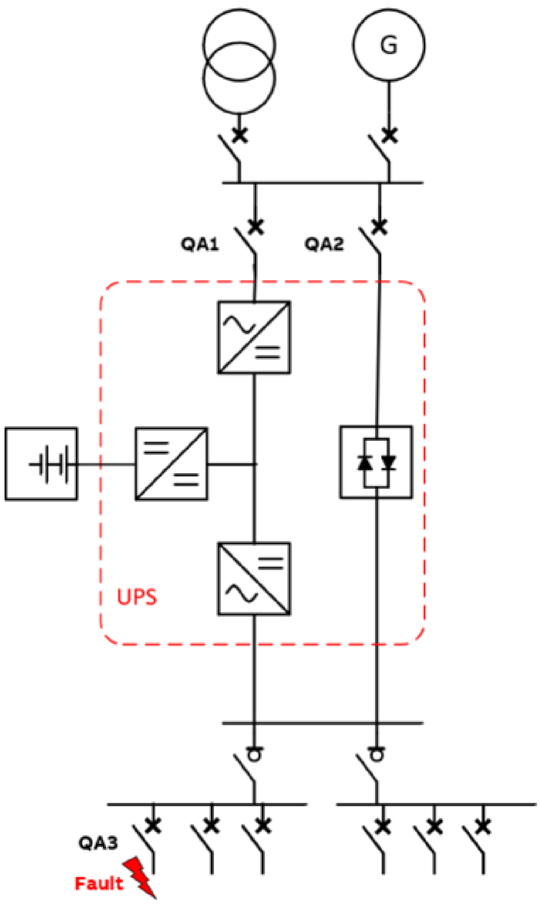
The static bypass switch input breaker (QA2) shall consider:

- The same rules for short circuit withstand for QA1 in relation to different power sources apply as well to QA2
- Shall withstand the simultaneous energizing of all loads.
- Shall limit the let-throw energy below the thyristor I^2t value.

Downstream Load breakers (QA3)

- The breakers shall be sized for the load needs and to trip and clear short circuits as fast as possible.
- The breakers should be selective with the upstream circuit breakers (will be discussed in the next section).

Figure 3: Example of a downstream fault



Sizing considerations

Selectivity is defined in IEC 60947-2 “Low voltage Equipment – part 2: Circuit breakers”, and we can accordingly explain it as the selectivity during a fault between two protection devices (i.e., circuit breakers) connected in a series, where the protection device closer to the fault would trip without tripping the upstream protection devices.

This is mainly achieved to isolate the fault and maintain the supply for other circuits that are not directly connected to the fault, and if selectivity is not achieved between circuit breakers, the purpose of installing an expensive UPS system is defeated.

There are two types of selectivity: “Total selectivity”, where the selectivity is achieved for all the short circuit current values up to the maximum capacity of the downstream breaker, and “Partial selectivity”, which is achieved only up to a certain level before the upstream breaker trips .

Now, let’s take an example assuming a downstream fault. As shown in Figure 3, the UPS will be transferred to a static transfer switch to supply the fault current as explained earlier. It is definitely required that you trip the QA3 circuit breaker and isolate the faulty section before tripping QA2 and dropping the entire load supplied by the UPS. It is also important to isolate the fault as quickly as possible to restore the output voltage for the load bus supplied by UPS.

ABB provides selectivity tables through the SOC tool to define the selectivity between its different products, as shown in the Figure 4 extract. Here, for example, if the load downstream was protected by a MCB S803 B 63, the upstream breaker could be Tmax XT2 100 A, which provides partial selectivity up to 4.5 kA only, or 160A, which provides total selectivity.

Figure 4 : Extract of the selectivity tables for S800B MCBs downstream and Tmax XT2 upstream.

400 Vac

Technology	PR	Series	Ch.	Icu	In	63	100	160	63	80	100	125	160
					Technology	MCCB							
					PR	Tmax XT							
					Series	XT2							
					Version	N,S,H,L,V							
					Relay	EL			TM				
					Iu	160							
					Icu	36,50,70,120,150							
MCB	S800	S800B	B,C,D,K	16	32	4.5	10	T	4.5	7.5	10	10	T
					40		7.5	T			7.5	7.5	T
					50		4.5	T			4.5	4.5	T
					63		4.5	T			4.5	4.5	T
					80			T					T
					100			T					T
					125			T					T

ABB UPS Building Blocks

ABB has created standard building blocks for data centers to speed up the design phase, taking into consideration the related breaker sizing considerations and selectivity based on the UPS, and bypass characterstics for different UPS power ratings, including maximum input current, overload capability, short circuit, and selectivity.

Below are table examples for such building blocks for two of ABB's commonly used UPS systems in Data Center environments to protect IT loads.

Conceptpower DPA 250 S4

UPS Size		**Upstream breaker (Bypass)**		**Upstream breaker (Rectifier)**		**Downstream breaker**	
Module	UPS rated power	CB Type & Selectivity		CB Type & Selectivity		CB Type & Selectivity	
1	50 kW	XT3 TMD 200A or XT2 ELT 100 A	Total	XT1 TMD 160A	Total	S203 B25 A	Up to 0.6 kA
2	100 kW	XT3 TM 200A or XT4 ELT 250 A	Total	XT3 TM 200A	Total	S203 B25 A	Up to 1.75 kA
3	150 kW	XT5 320 A	Total	XT5 320 A	Total	S203 B63 A	Up to 2.5 kA
4	200 kW	XT5 400 A	Total	XT5 400 A	Total	S203 B63 A	Up to 4.2 kA
5	250 kW	XT5 630 A	Total	XT5 630 A	Total	S203 B63 A	Up to 6.8 kA
6	300 kW	XT5 630 A	Total	XT5 630 A	Total	S203 B63 A	Total

PowerWave 33 S3

	Upstream Breaker		**Downstream breaker**		
UPS rated power [kW]	CB Type & Selectivity		CB Type	Selectivity with upstream bypass	Altrenative downstream breaker
60	XT1 TMD 160 A or XT2 ELT 100 A	Total	S203M B 40A	Up to 8.5 kA	Total with S803 B 16A / S203 B 16A
80	XT2 ELT 160 A	Total	S803 B 63A	Up to 28.5 kA	Total with S803 B 32A / S203 B 40A
100	XT3 TMD 200 A or XT4 ELT 250 A	Total	S803 B 50A or S203M B 50A	Total	
120	XT5 TMA / ELT 400 A	Total	S803 B 630A or S203M B 63 A	Total	

Figure 5: PowerWave 33 S3 - Double conversion UPS

Figure 6: DPA 250 S4 - Modular three phase UPS

DC Breaker Selection

Are you searching for a way to protect the UPS's battery cabinet? This tool will also guide you through the selection of a DC breaker, which is fundamental to protect the battery cabinet in case of a fault in between the cabinet and the inverter inside the UPS.

The Energy storage connected to a UPS consists of battery strings in parallel. Each string has its own disconnection/protection method, such as switch disconnector, MCB, MCCB or a fuse, depending on its rating. The parallel strings are then connected to the UPS either through a switch disconnector (if the protection was already provided by a fuse or circuit breaker on a string level), or a DC circuit breaker to provide DC protection in the paralleling switchgear at the point of UPS connection. The DC breakers should be at least enter in either DC-21 or DC-22 categories and should provide bi-directional power flow capability.

To quickly isolate the DC side of the UPS in case of an electrical fault and avoid affecting the reliability and integrity of the Data Center electrical infrastructure, ABB has a wide range of solution blocks for the UPS's DC section, based on the below notes for sizing.

Notes for sizing

- DC side isolated from ground
- Maximum breaking capacity to be selected according to the prospective short circuit current for different installation
- Circuit breaker size has been selected considering maximum voltage and maximum discharge current
- Probability of fault occurring between the batteries and DC circuit breaker is not considered, and the circuit breaker shall be installed as close as possible to the batteries.
- Ambient temperature up to +40°C
- Maximum discharge current refers to 1.7V/cell as battery cut off voltage
- Always refer to UPS technical data sheets for details on number of blocks vs autonomy and temperature

Conceptpower DPA 250 S4

UPS rated power [kW]	UPS number of poles	12V Battery blocks per string	Battery float Max. [Vdc]	Battery min. voltage [Vdc]	Maximum discharge current [A]	Circuit Breaker
50	2 or 3	40 - 50	675	396	130	T4 250 TMA 200
100	2 or 3	40 - 50	675	396	261	T5 400 TMA 320
150	2 or 3	40 - 50	675	396	391	T5 400 TMA 400
200	2 or 3	40 - 50	675	396	521	T6 630 TMA 630
250	2 or 3	40 - 50	675	396	652	T6 800 TMA 800
300	2 or 3	40 - 50	675	396	782	T6 800 TMA 800

PowerWave 33 S3

UPS rated power [kW]	UPS number of poles	12V Battery blocks per string	Battery float Max. [Vdc]	Battery min. voltage [Vdc]	Maximum discharge current [A]	Circuit Breaker
60	2	42 - 48	648	415.8	149	T4 250 TMA 160
80	2	42 - 48	648	415.8	199	T4 250 TMA 200
100	2	42 - 48	648	415.8	248	T4 250 TMA 250
120	2	42 - 48	648	415.8	298	T5 400 TMA 320

For enquiries related to project specific details, please contact ABB.
Tables are based on calculations and these building blocks are not tested by ABB.

For more information, visit the websites
UPS systems
Circuit breakers

Site Planning Tool

Technical Guide

Site Planning tool

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