

WHITE PAPER

System plus system (2N) electrical distribution

Data Center Design IEC

0.5 MW IT load design



Index

002–003	1. Introduction
004–007	2. Data Center Description
005	2.1. IT load distribution
006	2.2. Cooling system loads
007	2.2. Cooling system loads
008–023	3. Data Center Power Distribution
010	3.1. Remote Power Panels (RPPs)
013	3.2. Secondary distribution board
015	3.3. UPS system
015	3.3.1. DPA 500 UPS
017	3.3.2. DPA UPScale S2 ST 120 for supplying the CRAH units
017	3.3.3. Power Scale 30 kA
018	3.4. Main distribution board
020	3.5. Other secondary distribution boards
021	3.6. Transformers
022	3.7. Generators
024–025	4. Data Center Monitoring
026	5. Data Center Selectivity
027	6. Data Center Modularity
028	7. Bibliography

1. Introduction



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Single line diagram of
a power distribution
design and ABB Ability™
Energy and Asset
Manager wiring diagram

This document provides a reference for how advanced solutions can be used to support the design and implementation of a power distribution and monitoring system for a data center.

The main objective is to support data center electrical distribution designers by providing an example of a fully designed low voltage power distribution for a data center along with its main components.

The reference design is realized so that it can be adapted and adjusted according to specific loads, plant layout, MV connection point, etc.

The user of this documentation should perform the necessary actions to adapt this reference design for their own particular project requirements.

ABB can provide support throughout the project, but ABB cannot be considered accountable or responsible for the final design and/or project outcome.

This document is intended for use with the following list of documents¹:

- 1) Single line diagram of the power distribution design
- 2) Ability™ Energy and Asset Manager wiring diagram

The following paragraphs elaborate on the chosen design and explains the main power distribution components and their features.

More specific details about the products and solutions used to realize this reference design can be found in the package's separate documents.

¹ Please download the documents using the QR code provided top left in this page and inputting the required information. For an editable version of these documents, please contact ABB directly.



The reference design for data centers (Reference Design) will be available free of charge. The Reference Design is provided 'As Is' without any express or implied warranty of any kind, including but not limited to any warranties of merchantability, non-infringement, or fitness of a particular purpose.

The intended use is only to facilitate the customer or any consulting third party addressing our standard possible solutions. ABB will not be in any way responsible for any malfunctions or damages that could arise from the use of the Reference Design itself. The Reference Design itself is generic tool and may require customization and if needed tests for the specific application / customization.

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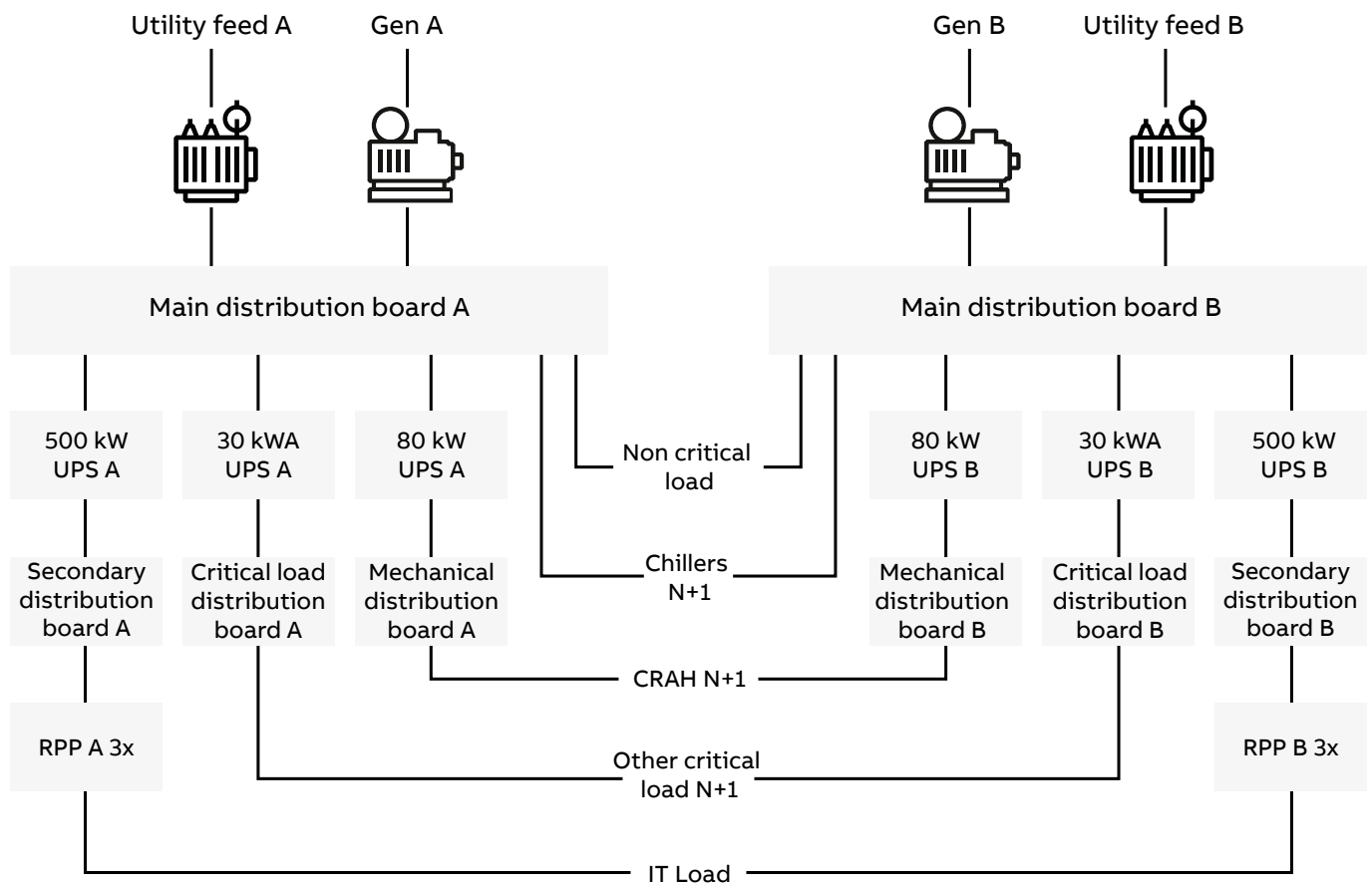
2. Data Center Description

Data center electrical design redundancy

Data center system plus system design comprises 2N redundancy capacity components (generators, UPS) and independent active distribution paths

(distribution boards, RPP) that serve the IT load and mechanical devices for continuous cooling, as shown in the diagram below*.

Figure 1. System plus system 0.5 MW IT load data center power distribution



(*) Detailed single line diagram of power distribution can be downloaded separately

The electrical load consists of IT loads, mechanical loads, critical and non-critical loads as follows:

- IT load: Computer room load, network infrastructure, building automation system control
- Panels, sensors, actuators
- Mechanical loads: chillers, CRAHs, pumps
- Critical loads: fire protection systems, telecommunication systems, security systems
- Non-critical loads: service

Table 1. Data center maximum load breakdown

Load type	Number of loads	Nominal input electrical power [kW]	Double input feed internal to unit	Connected to UPS	Configuration	Type of load	Load connection	Total load N [kW]
Computer room (servers)	63	7	yes	yes		IT load	Single phase	441
Building automation system	2	0.5	yes	yes	N+1	IT load	Three phase	0.5
CRAH	6	15	no	yes	N+1	Mechanical load	Three phase	75
Chillers	3	100	no	no	N+1	Mechanical load	Three phase	200
Fire extinguishing pumps	3	5	yes	yes	N+1	Critical	Three phase	10
Intrusion alarm control	2	0.5	yes	yes	N+1	Critical	Three phase	0.5
Excess control	2	0.5	yes	yes	N+1	Critical	Three phase	0.5
Fire detection	7	0.5	yes	yes	N+1	Critical	Three phase	6.5
Other critical loads	2	1	Yes	Yes	N+1	Critical	Three phase	1
Service	11	2.5	no	no	N+1	Non-critical	Three phase	25
Total load								760

2.1. IT load distribution

Table 2. Maximum IT load breakdown

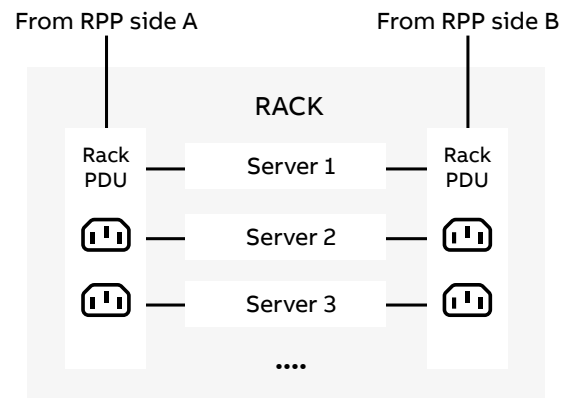
RPDU load	7	kW/RPDU
Number of RPDUs supplied by one RPP	21	units/RPP
RPP load	147	kW/RPP
Number of RPP units (N)	3	Units
Total Number of RPP units (2N)	6	Units
Total Supplied Units (RPDU) (2N)	126	Units

The exact IT load distribution is provided in Table 2. The total load of one cabinet (rack) supplied by the Rack Power Distribution Unit (RPDU) is 7 kW. The RPDU is inside the rack and is considered as a load.

The IT devices inside the racks can be designed with:

- Dual input feed, which allows power supply from both redundant RPDUs at the same time
- One input feed, in which case there is a static transfer switch right before the device that allows instantaneous power distribution

Figure 2. Servers inside rack, with dual input feed



Every load is doubly supplied, the number of RPDUs is doubled. In normal operating conditions each RPDU has a 50% maximum load.

2. Data Center Description

Each RPDU is supplied by dedicated cables and circuit-breakers situated in the power distribution unit (PDU). In this case it is called the Remote Power Panel (RPP).

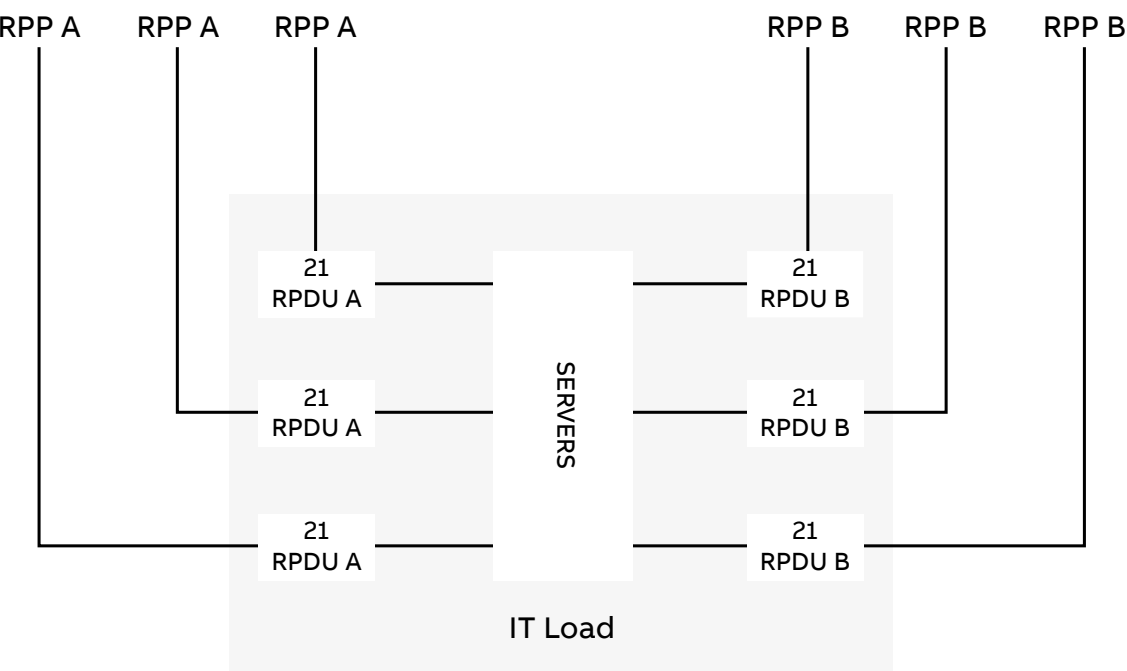
Each RPP supplies 21 RPDUs, making the total maximum load of each RPP 150 kW. As there are 126 RPDUs, 6 RPPs are needed – each works with a maximum of 50% of the nominal power in normal operating conditions.

2.2 Cooling system loads

In this data center example, the cooling system is based on external cooling units called chillers that are connected to CRAH units, positioned in the data center’s white space.

This provides high efficiency cooling. It is assumed that 3 chillers of 100 kW in N+1 configuration and 6 CRAH units of 15 kW in N+1 configuration are needed.

Figure 3. Distribution: RPPs => RPDUs => servers



To satisfy data center design requirements for fault tolerant systems, in the event of any failure the temperature rate of change inside IT spaces must not be more than 5 degrees Celsius during a 15 minute period.

It is assumed that the previously described cooling system satisfies these requirements as well as requirements set by ASHRAE [1].

The data center cooling is completely flexible and can be adapted to any type of cooling system. ABB can provide power distribution equipment to supply and protect any type of data center cooling system.

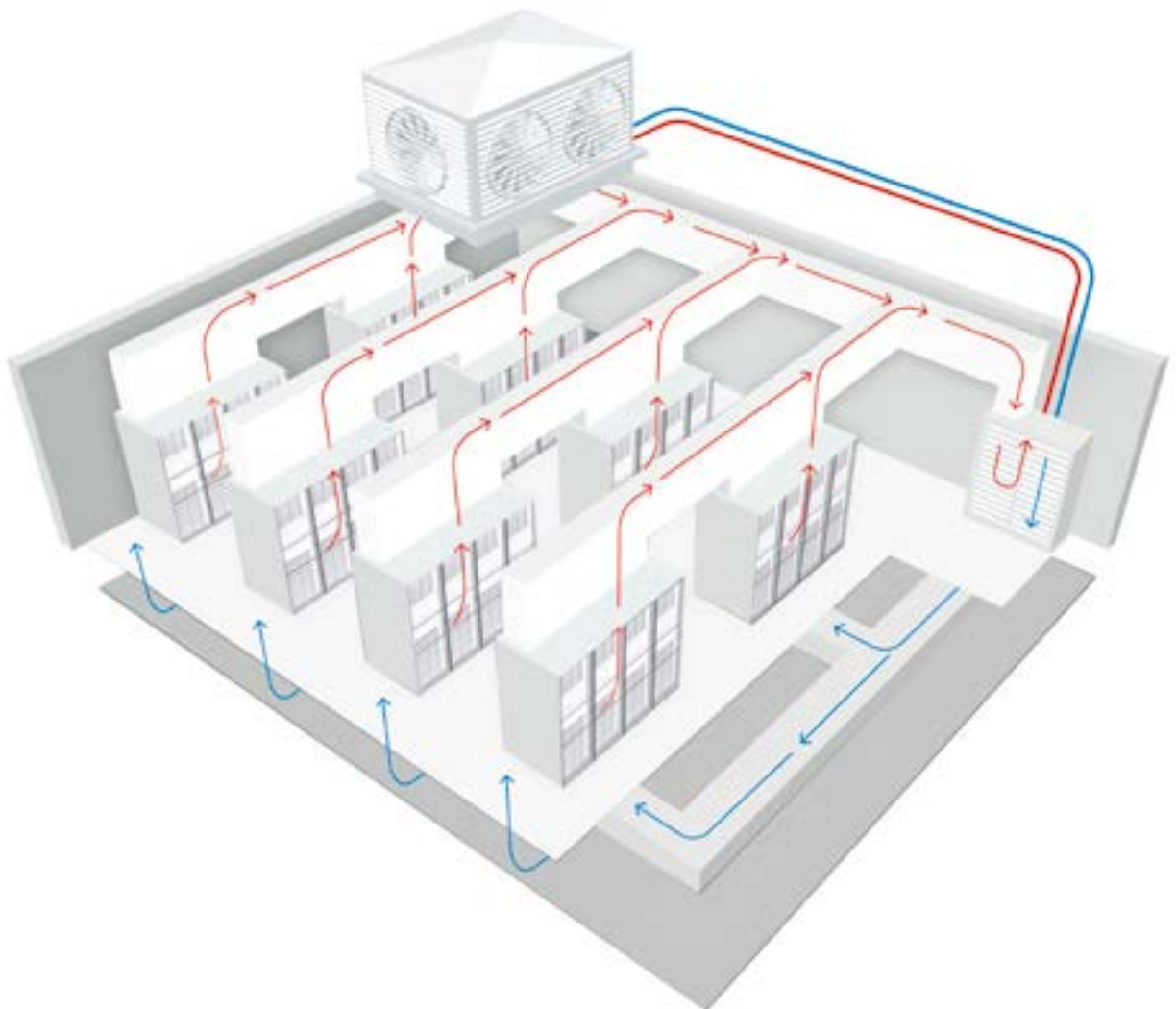
2.3 Critical and non-critical loads

Critical load and non-critical loads represent a very small portion of the total data center load.

Examples of critical loads are emergency lighting, fire protection systems, security surveillance equipment and other critical parts of the data center, which are not IT equipment.

Examples of non-critical load are building lighting, sockets and other data center parts that cannot influence the correct operation of IT load and other critical loads in the event of a fault.

Figure 4. Data center cooling system example



3. Data Center Power Distribution



—
Single line diagram of
a power distribution
design and ABB Ability™
Energy and Asset
Manager wiring diagram

Detailed single line diagram (SLD) which can be download through QR code on the left is for Side A of a power distribution for a 0.5 MW IT load in a modular data center with 2N redundancy. Represented design is developed following requirements and recommendations provided by Uptime Institute for Tier IV data center [1]. ABB provides only guidelines for electrical distribution design and cannot guarantee any Tier certificate for the user following specifications provided in this document.

Full topology of Side A and Side B of the data center and all equipment selections are available in the accompanying package. For a more detailed view, please scan the QR code.

Following Uptime Institute Tier standard topology [1], the main difference between Tier III and Tier IV data centers is that Tier III data centers are “concurrently maintainable”, while Tier IV data centers are “fault tolerant”.

Concurrently maintainable data centers are those where the planned maintenance of any data center part can be performed without disruption to the power distribution to the critical loads. Tier III data centers are not fault tolerant, and unplanned faults or failures can cause data center outages.

A fault tolerant data center is one where there are no single points of failure. Any type of fault or failure on any part of the data center will not affect the continuity of the power distribution to critical equipment and there will be no outage. For more detailed information about the Tier topology classification, please refer to Uptime Institute "Data Center Site Infrastructure Tier Standard, Topology [1]".

The single line diagram topology does not change a lot from Tier III to Tier IV, since there is a need to duplicate power distribution to the critical loads to allow serviceability (Tier III) and fault tolerance (Tier IV).

The main difference in the power distribution is that in the case of Tier III, there is no need for both power distribution paths to be simultaneously supplying the load. There is also no need for the cooling system to be connected to a UPS. Switching from power distribution Side A (active) to power distribution Side B (passive) should be performed when there is a need for maintenance on the main power distribution side (Side A).

In normal operating conditions, each side of a Tier IV data center is loaded with no more than 50% of the maximum load.

A single failure will not cause an outage since Side A or Side B can individually supply the load for an unlimited amount of time.

Another difference between Tier III and Tier IV is the physical separation (compartmentalization) between Side A and Side B. For a Tier IV data center, two redundant sides need to be physically separated, so that a failure in one part cannot influence other parts of the data center. For Tier III data centers, redundant power supply parts need to be realized so that each of the power distribution paths can be maintained without influencing the redundant power supply path.

The topology realized in this work represents both the power distribution for the IT load and the power distribution for the non-IT loads. More in-depth analysis of each part of this topology and the equipment selections follows.

Table 3. Summary of difference between different Tier levels according to Uptime Institute

	Tier I	Tier II	Tier III	Tier IV
Minimum capacity components to support the IT Load	N	N+1	N+1	N After any Failure
Distribution paths-electrical power backbone	1	1	1 Active and 1 Alternate	2 Simultaneously Active
Critical power distribution	1	1	2 Simultaneously Active	2 Simultaneously Active
Concurrently maintainable	No	No	Yes	Yes
Fault tolerance	No	No	No	Yes
Compartmentalization	No	No	No	Yes
Continuous cooling	No	No	No	Yes

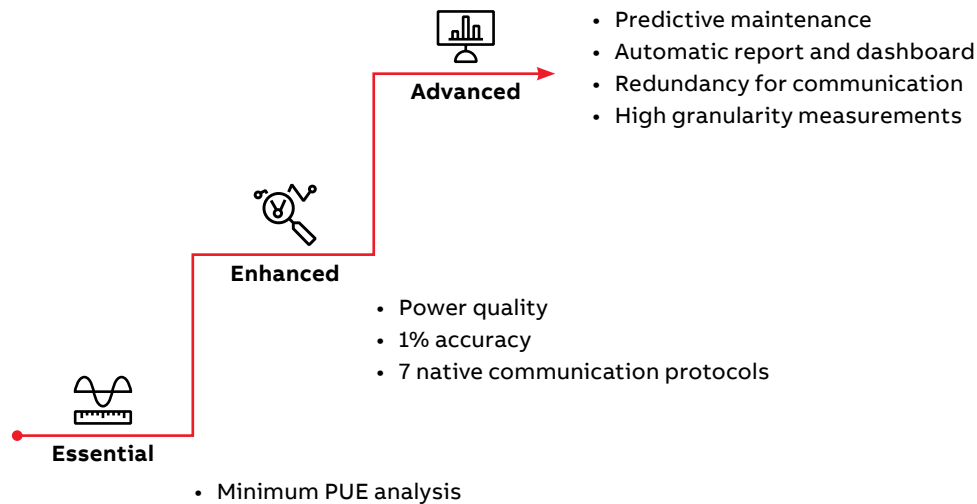
ABB intelligent distribution offering for data center

Data center reference architecture presented here is an example of standardized solution achievable thanks to modularity of ABB components. From that, it is easy to realize scalable solutions, both in terms of extension and of complexity.

To support customers, ABB already pre-defined offering bundles, customers can choose among essential, enhanced, and advanced offering, according to data center type and preferences.

ABB pre-designed packages provide many advantages:

- Reduce project time up to 80%, package is already defined, it can be simply customized if necessary.
- Reduce project risk, digital connectivity is tested by ABB
- Scalability, the modular design of ABB components ensure adaptability to different projects
- Upgradability, all packages can be upgraded at any time, without need to change hardware, adding advanced functionalities available on ABB marketplace. This can be translated in a reduction of maintenance costs for upgrading electrical system over 22000\$ per system life.



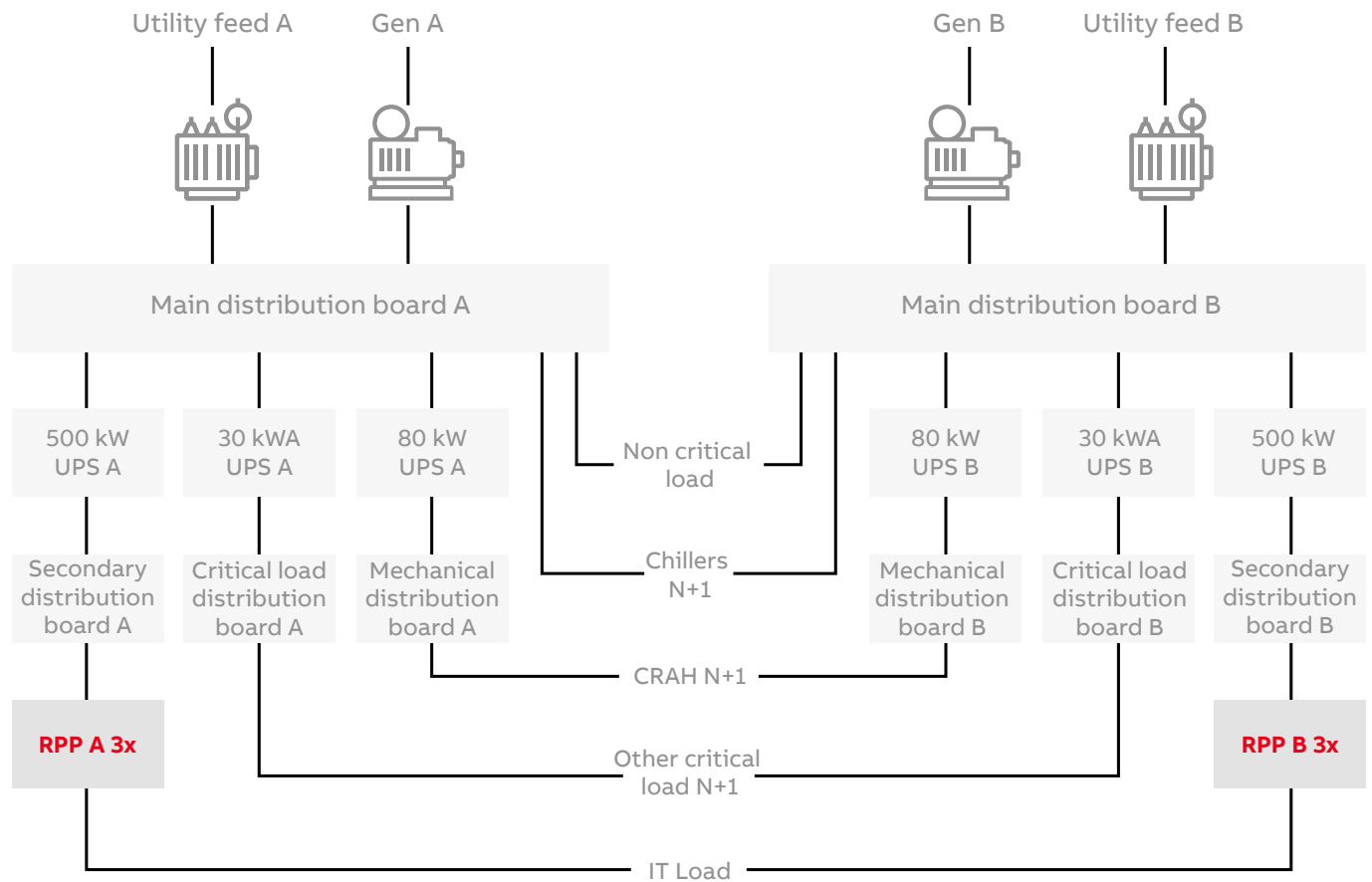
- Essential offering is a basic solution which provides the possibility to monitor the PUE, it might be a perfect solution for small installations.
- Enhanced offer provides a complete view of power consumption, enabling analysis for energy efficiency.
- Advanced offer consists of complete packaging for metering of consumption and predictive maintenance. It is a package suitable for larger data center.

ABB pre-designed packages can be used to modify the standard reference architecture presented here, in order to better fit project specifications.

3. Data Center Power Distribution

3.1 Remote Power Panels (RPPs)

Figure 5. 0.5 MW IT load modular data center configuration - PDUs





Remote Power Panels
(RPP)

The servers are supplied by the rack power distribution units (RPDUs) that are installed inside the server cabinet (rack).

These RPDUs are supplied by a remote power panel (RPP). The RPP supplies the row of the server racks. Inside the RPP cabinet, protection and measurement devices for each outgoing connection to the RPDUs are installed.

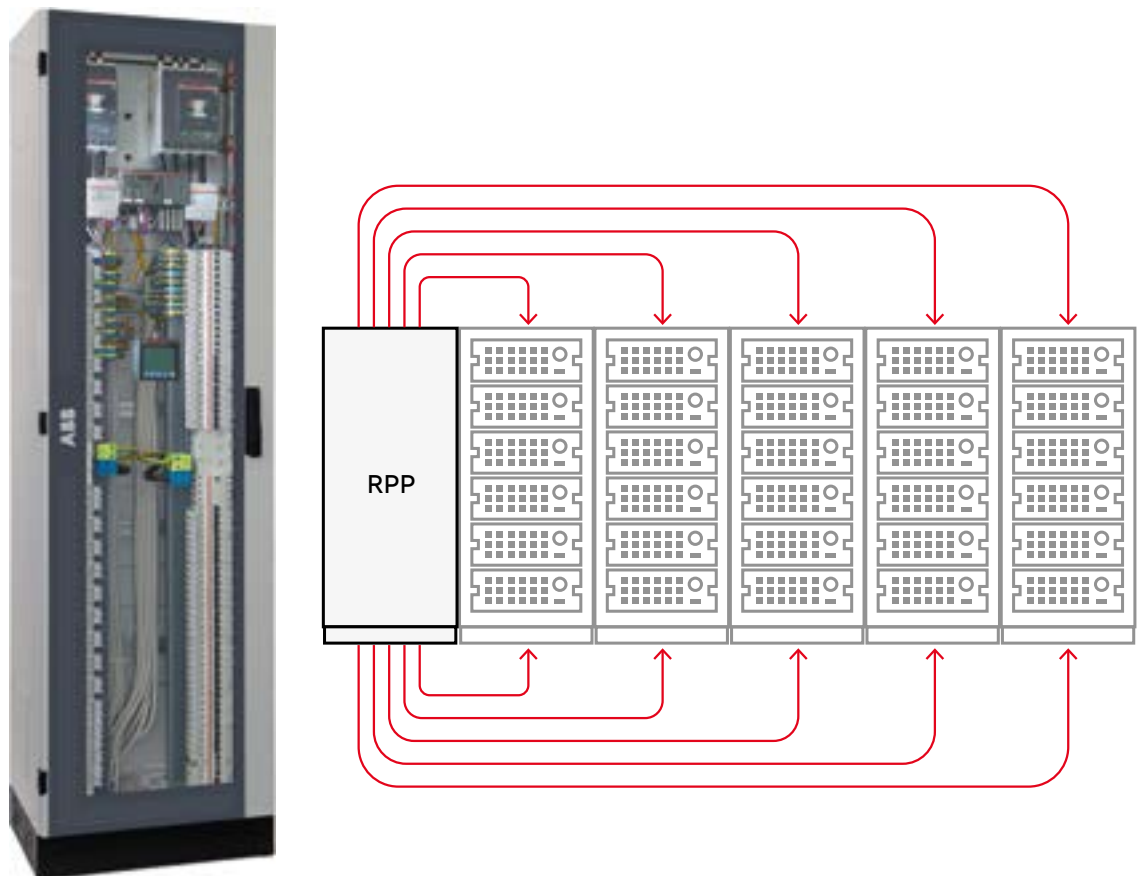
The protection devices inside RPPs are miniature circuit-breakers (MCBs) that are mounted on the unique SMISSLINE TP busbar system.

Using the SMISSLINE TP line protection solution for critical applications ensures the highest possible reliability level.

This solution allows the replacement or addition of MCBs without the need to turn off the power distribution to other circuit-breakers inside the RPP.

This fully touch-proof solution allows maintenance and connection new equipment without risk to the personnel working on live equipment. Compared with conventional DIN rail devices space savings of up to 20% and installation time reductions of 45% are possible.

Figure 6. RPP supplying a row of server cabinets



3. Data Center Power Distribution



System pro M
compact® InSite

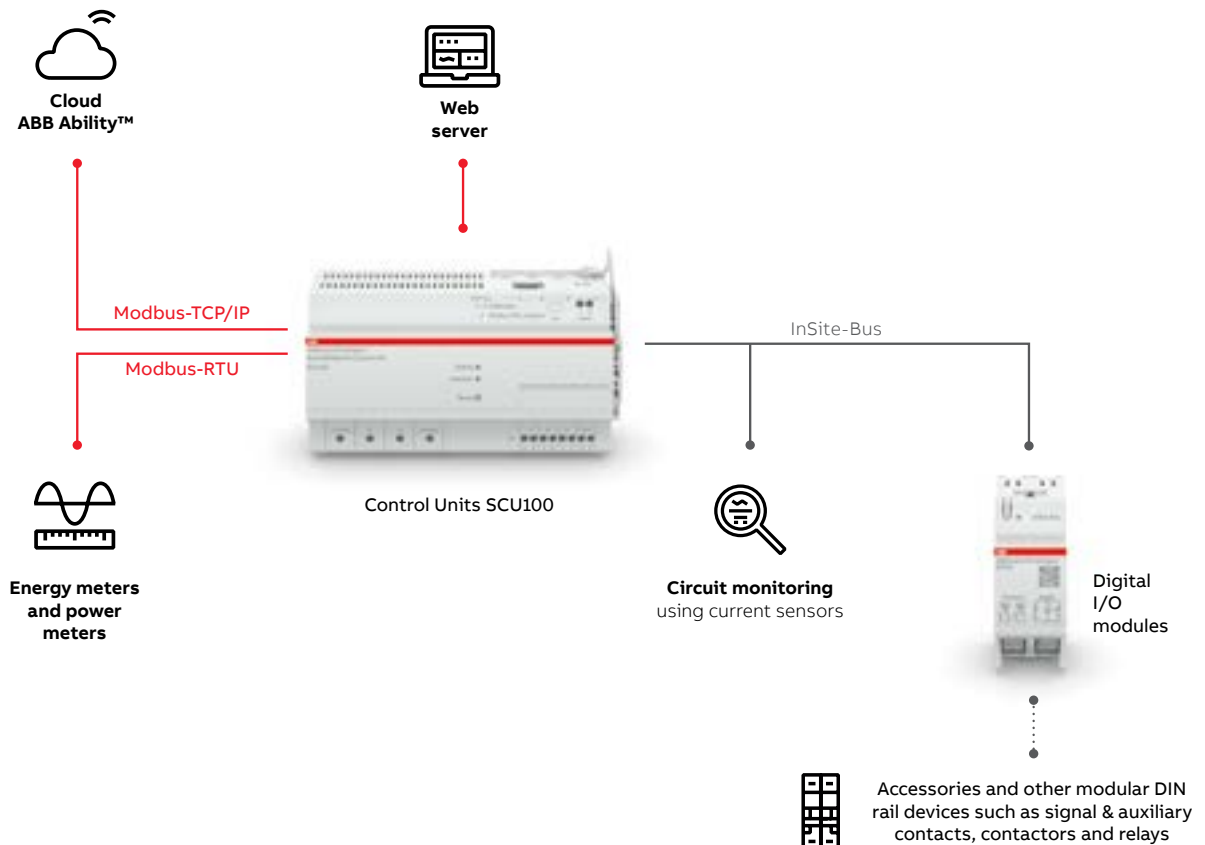
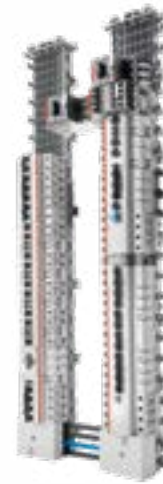
All circuit-breakers are equipped with current sensors, available with either an open or a solid core.

The measurement units connect to the System pro M compact® InSite, a unique device that tracks the power consumption of each server rack as well as the RPP's consumption.

This is an important measure that provides a precise picture of the power usage effectiveness (PUE) level as well as the status of each cabinet.

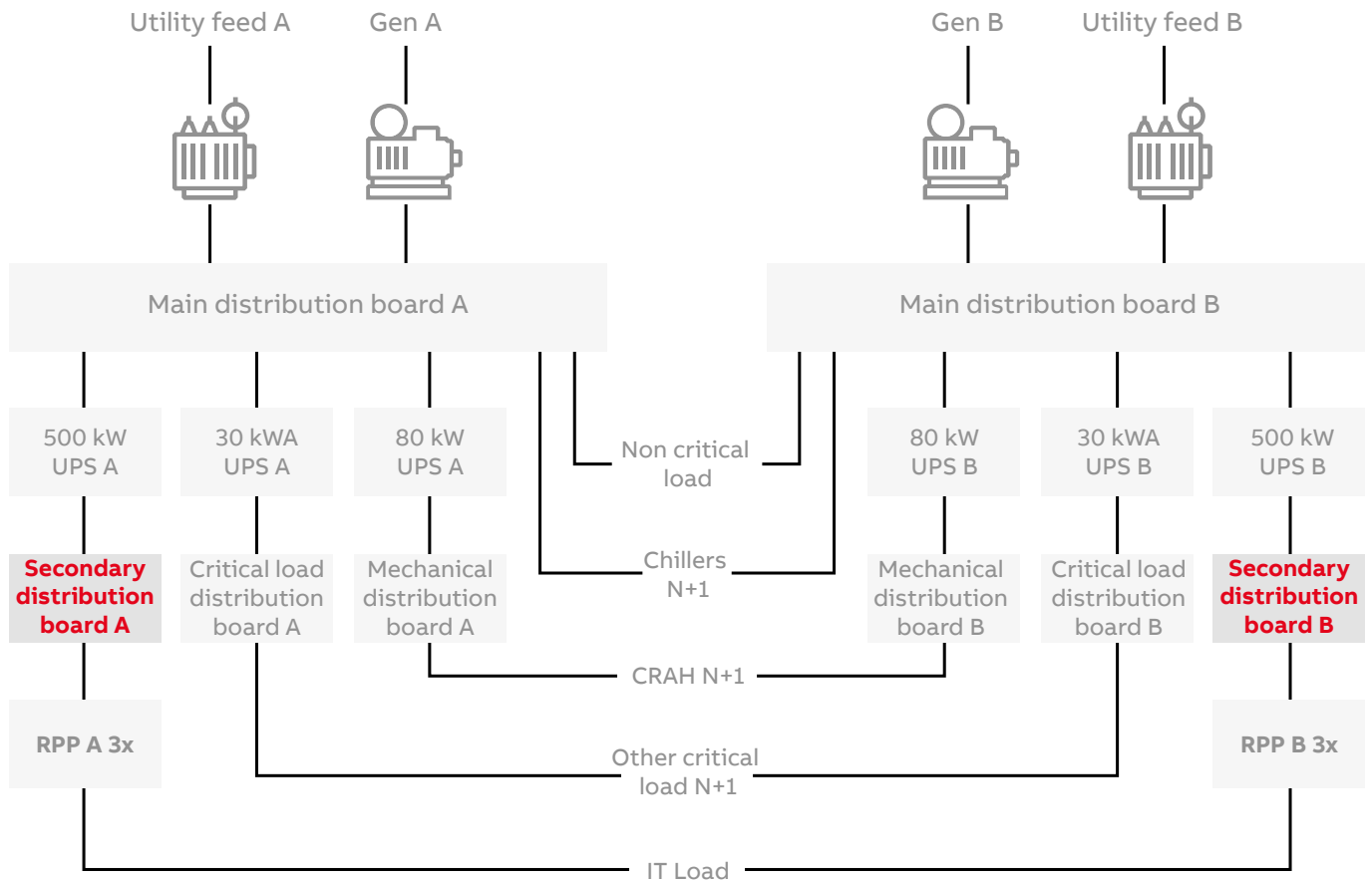
System pro M compact® InSite is equipped with the Modbus TCP communication protocol to ensure easy remote access to the measurements. It is also possible to replace switch disconnectors with the Tmax XT molded case circuit-breaker (MCCB) as the incomer. With exception of its protection functions, the MCCB is able to perform measurements and network analysis and to communicate data to the monitoring and control system.

In this case the monitoring of each RPP is performed by the MCCB placed in a secondary distribution board (See section 3.2). As a result only a switch-disconnector is used as the incomer to the RPP.



3.2 Secondary distribution board

Figure 7. 0.5 MW IT load modular data center configuration – secondary distribution board



Tmax XT

Secondary distribution board serves to connect UPS outputs to the IT loads that require continuous and uninterruptable power distribution. These loads are the RPPs, described above, providing power distribution to the IT loads (Figure 7).

Incoming cables from the UPSs are via the switch-disconnector connected to the busbar system (The switch-disconnector can also be replaced with a circuit-breaker). These cables are

coming from the UPS DPA 500 cabinets (See Section 3.3.1) and one cable from the UPS maintenance bypass.

The outgoing Tmax XT4 MCCBs, together with the cables, provide power distribution to the RPPs. It is possible to add an additional switch-disconnector in order to provide a connection to the other adjacent secondary distribution board for enhanced reliability.



3. Data Center Power Distribution



System Pro E Power

All circuit-breakers chosen are withdrawable in order to ease maintenance, lowering servicing costs and improving reliability.

On this distribution board, it is necessary to track power consumption and power flow – and to have a network analyzer as well as the status of each circuit-breaker.

All these functions are embedded inside the Tmax XT circuit-breakers, so no additional measuring devices are needed for this purpose. It follows that the total number of devices is lower and thus the reliability level is higher.

Adding Class 1 accuracy for power and energy measurements according to IEC61557-12 and measurement up to 50th harmonic ensures the provision of accurate information at the appropriate level.

Circuit-breakers are also equipped with the Ekip Signalling 3T module in order to monitor the temperature inside the switchboard, environmental temperatures and the temperature of the busbar system.

This provides an additional level of reliability, as the user can set the temperature thresholds and any actions in case the value exceeds set limits. The connection to the monitoring system makes remote measurements and monitoring simple.



Predictive Maintenance



Ekip Signalling 3T



Arc Guard TVOC-2

All the protection devices are placed inside a System Pro E Power distribution board, which provides extreme reliability, compact dimensions and high levels of flexibility to fit any desired configuration.

For critical applications such as data centers, an arc flash incident can cause unexpected outages and, in severe cases, can cause hazardous situations. To prevent these situations, the switchboard is equipped with the Arc Guard TVOC-2 system. This system allows fast detection of the arc flash and sends an instantaneous tripping signal to the circuit-breaker.



OT Switches



Significant additional value can be gained from equipment that provides simpler servicing, and which has self-monitoring and predictive maintenance functions to improve the ease of planning and executing maintenance.

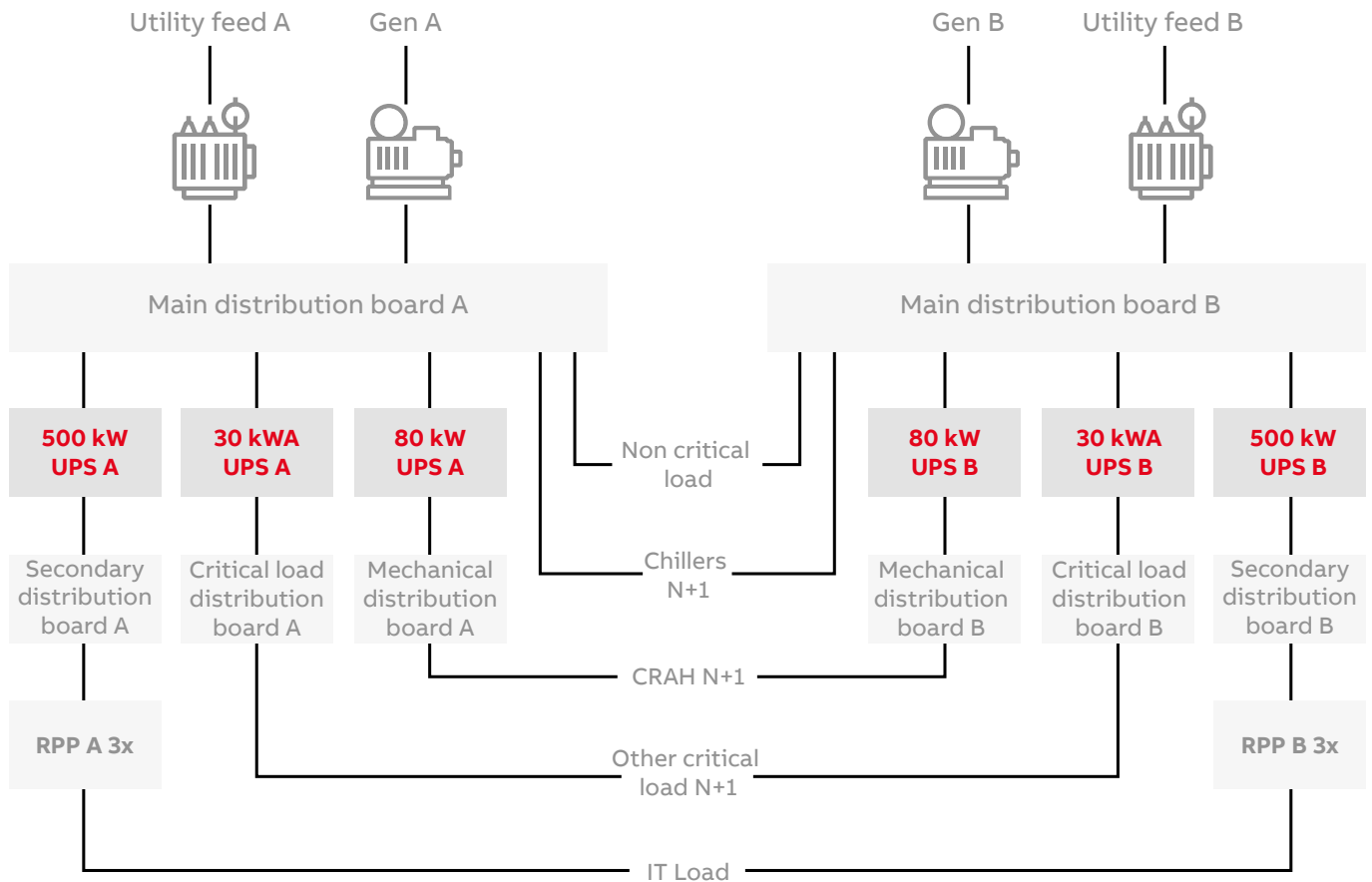


Please note that only one power distribution path was addressed. The same considerations also need to be taken into account for “Secondary Distribution Board B”.

All the considerations for secondary distribution boards are also valid for other distribution boards, including Arc Guard TVOC-2, Ekip Signalling 3T, Predictive Maintenance, and Class 1 accuracy measurements.

3.3 UPS system

Figure 8. 0.5 MW IT load modular data center configuration – UPS system



DPA 500



UPS system

For this data center design, three different types of UPS have been used:

- 1) **Conceptpower DPA 500 UPS** for supplying the IT loads
- 2) **DPA UPScale S2 ST 120** for supplying the CRAH units
- 3) **Power Scale 30 kVA** for supplying other critical loads

3.3.1 DPA 500 UPS

Since the UPSs are the most valuable part of the data center installation and the most frequently maintained pieces of equipment and the most frequent cause of power distribution failure, great attention should be paid to it.

The Conceptpower DPA 500, (Decentralized Parallel Architecture), the most advanced UPS system currently available was chosen for this reason. This modular UPS allows full modularity and maintainability. Each UPS cabinet comprises up to 5 independent UPS modules.



3. Data Center Power Distribution



Continuous power
in datacenters -
Selectivity with UPS

Each module has 100 kW of power, so the power of a single cabinet can range from 100 kW to 500 kW. Locating up to six cabinets in parallel, it is possible to achieve power of 3 MW. Each module has an internal static bypass switch in case of network quality issues or short circuit currents.

It is possible to connect a common battery to all UPSs inside the cabinet or to have the separate batteries for each module.

All the cabinets and modules in the row are interconnected and failure of one or more cabinets/modules does not influence the rest of the cabinets/modules.

This is due to an advanced technology that allows UPS modules to work completely independently from other modules.

Additionally, in the event of the failure of one or more modules, the other active modules can automatically overtake its function if their power

is sufficient.

Since the maximum load of the UPSs is not more than 500 kW, one cabinet is needed for each redundant side. This means that for the 0.5 MW IT load data center, each cabinet should have five modules, in order to supply the maximum of 500 kW of IT load.

Suitable circuit-breakers must be chosen for protection in accordance with the UPS specifications. They are connected to the main distribution board (See Section 3.4).

For continuous power it is required to select protection devices also respecting selectivity rules, if selectivity is not achieved between circuit breakers and protections inside UPS, in case of electrical distribution failure, continuity of supply might be compromised.

ABB provides coordination tables to speed up the design phase, taking into considerations breaker sizing and selectivity rules according to UPS models and bypass characteristics for different UPS power ratings.

In order to guarantee the total selectivity between the UPS and protection devices up- and downstream, the following circuit-breakers are selected:

- 1) MCCB XT7S 1000 Ekip Hi-Touch LSI 1000A connecting to the UPS inverter
- 2) ACB E1.2B 1250 Ekip Hi-Touch LSI 1250A connecting to the static bypass



The additional manual bypass (optional), with a Tmax XT7S 800A circuit-breaker is provided to allow maintenance of the complete UPS cabinet. If this bypass is used, the following operational sequence must be followed: upstream UPS circuit-breakers need to be opened, the upstream bypass circuit-breaker needs to be closed, the OTM800E transfer switch needs to be switched.

This bypass is used only in the event that the whole UPS cabinet needs to be maintained or replaced. This situation is highly uncommon, however, due to the modularity principle of the UPS and this mechanical bypass can therefore be



UPS DPA UPScale ST S2



UPS PowerScale

3.3.2 DPA UPScale S2 ST 120 for supplying CRAH units

To realize fault tolerant design, part of the cooling system needs to be connected to the UPS in order to guarantee continuous air flow inside the room in the event of power supply outage. For this reason, CRAH units and cooling automation systems that guarantee fault tolerance are connected to the UPS in order to ensure the continuous operation of the cooling system.

CRAH units are connected to UPS DPA UpScale S2 ST 120 modular UPS. This UPS follows the same modularity principle described previously for DPA 500 UPS, where maximum cabinet power is 120 kW and the modules installed are 20kW. Since in this example the maximum load of the CRAH units is not more than 80 kW, four UPS modules of 20kW are integrated into a 120kW UPS cabinet. If the cooling system requires a higher power supply, UPS modules can be added.

Following UPS specifications, suitable circuit-breakers are chosen for protection. They are connected to main distribution board (paragraph 3.4). In order to guaranty total selectivity between UPS, UPS upstream and downstream protection device, following circuit-breakers are chosen:

- 1) MCCB XT4N 250 Ekip Hi-Touch LSI 250A connecting to UPS inverter
- 2) MCCB XT4N 250 Ekip Hi-Touch LSI 250A connecting to static bypass



3.3.3 Power Scale 30 kA

To guarantee power supply to other critical loads such as fire protection, security, emergency lights, and telecommunication equipment, additional UPSs need to be installed. ABB's standalone Power Scale UPS complies with the EN 50171 CPSS (Central Power Supply System) standard, meaning it can provide continuous service to the previously described critical loads.

Following UPS specifications, suitable circuit-breakers are chosen for protection. They are connected to the main distribution board (See Section 3.4). In order to guarantee total selectivity between UPS, UPS upstream and downstream protection device, following circuit-breakers are chosen:

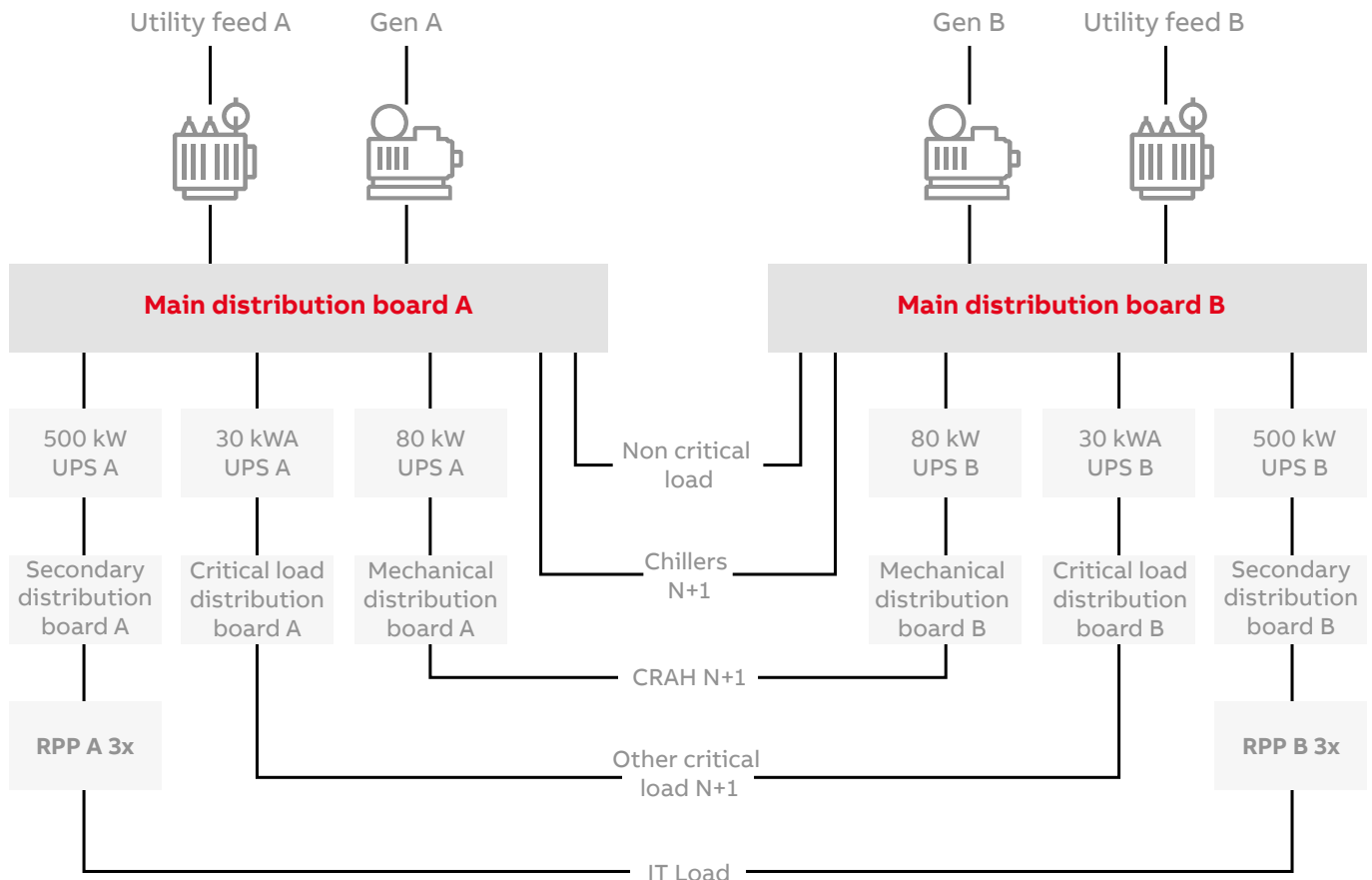
- 1) MCCB XT2N 160 Ekip Hi-Touch LSI 63A connecting to UPS inverter
- 2) MCCB XT4N 250 Ekip Hi-Touch LSI 100A connecting to static bypass



3. Data Center Power Distribution

3.4 Main distribution board

Figure 9. 0.5 MW IT load modular data center configuration – main distribution board



Transfer switching solutions



Emax 2 Embedded ATS

The main distribution board connects a transformer and generator to the data center. Automatic Transfer Switching (ATS) is needed between the generator and transformer circuit-breakers.

In the event of a transformer failure or the need for transformer maintenance, the power distribution is automatically provided by the generators. This function is embedded inside the Emax 2 circuit-breaker, which means there is no need for additional relays or connections.

This solution provides space reductions, reliability improvements, time and cost savings.

More information and a detailed diagram (See Annex B of this document) for realization of this solution can be found in separate documents.

Two main air circuit-breakers (ACBs) are equipped with network analyzers and Class 1 accuracy measurements, as well as communication protocols. In this way they can measure and communicate all parameters with high accuracy levels, including the previously described Ekip Signalling 3T module.

This is the same feature previously described for the Tmax XT molded case circuit-breakers (MCCBs) (See Section 3.2).





TruONE™ ATS

Service note
Predictive
Maintenance

The outgoing circuit-breakers provide power supply to UPSs, cooling systems and non-critical loads.

This document provides just an example of how mechanical power distribution can look. As ABB has a flexible solution for power distribution to the cooling system and other mechanical, non-critical loads, this part of the power distribution can be easily adjusted to serve any type of cooling system, or any type of distribution.

There is a possibility to add an additional switch-disconnector to provide a connection to the adjacent secondary distribution board for the enhanced reliability.

All protection devices are placed inside the System Pro E Power distribution board, which provides extreme reliability, compact dimensions and the flexibility to fit any desired configuration. The switchboard is also equipped with Arc Guard TVOC-2 for arc flash protection, as described in Section 3.2.

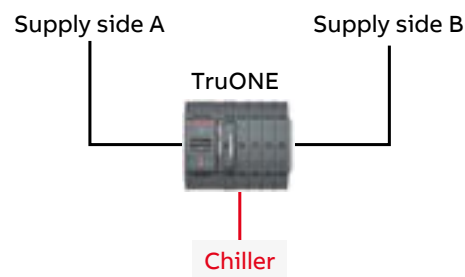
All air circuit-breakers have predictive maintenance functions, as described in Section 3.2 and the accompanying white paper. Thanks to this feature, users can remotely monitor the health condition of each protection device in the plant and receive a clear picture of when the next maintenance event is required.

Three chillers in N+1 configuration are included, each with input electrical power of 100 kW, supplied from two power supply sides. Since chillers usually do not include a transfer switching solution, an additional device needs to be placed next to chiller to provide double supply from two redundant power sources. For this purpose, ABB's TruONE ATS can be used. The TruONE is the world's first true automatic transfer switch,

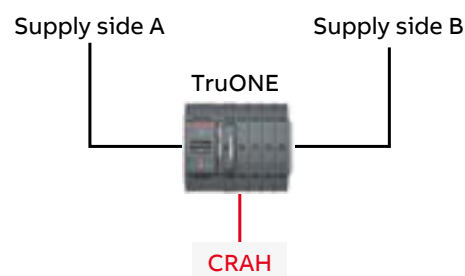
providing a ready-to-go solution for a wide range of applications.

The device is designed for maximum reliability and provides time savings of up to 80% during installation and commissioning. It has the same comprehensive communication and measurement capabilities as the Tmax XT and Emax 2 circuit-breakers.

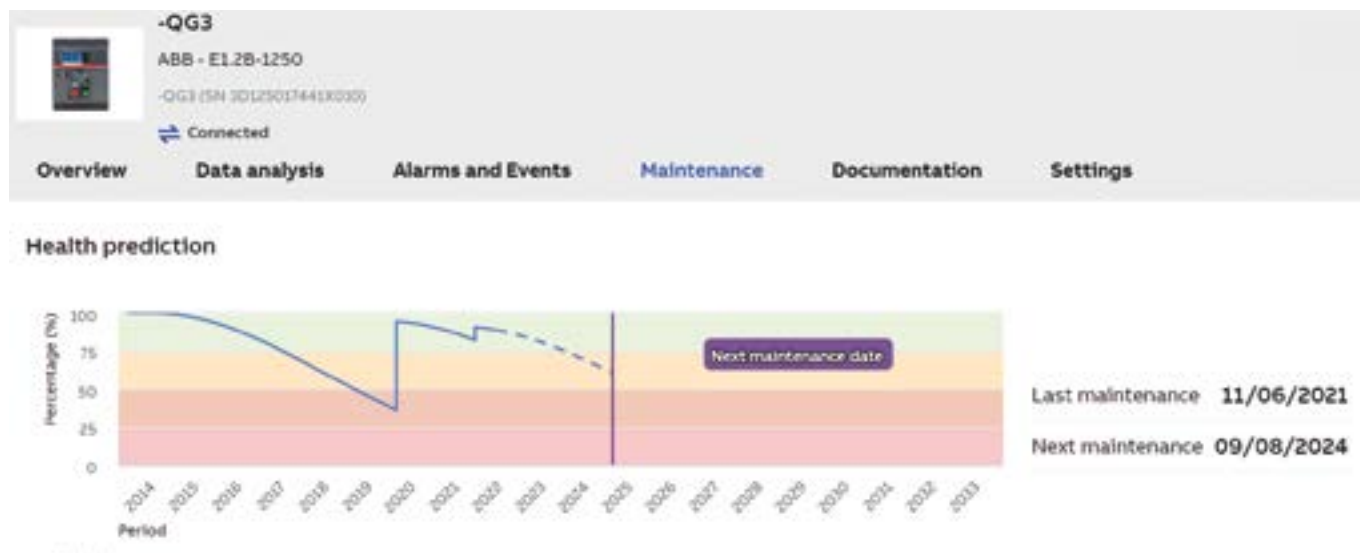
The additional benefit of using TruONE is its ability to withstand high short circuit currents. It can thus be used for applications where short circuit current ratings are higher, a common situation in data center electrical distribution.



In a system plus system design, to guarantee fault tolerance by using N+1 configurations for equipment, all N+1 devices need to be simultaneously supplied from Side A and Side B. For this reason, if the device itself does not have a dual input feed that is fast enough and reliable enough, an ATS needs to be associated with each device, for example CRAH units. In this project, the TruONE ATS is used as it meets all the set requirements.



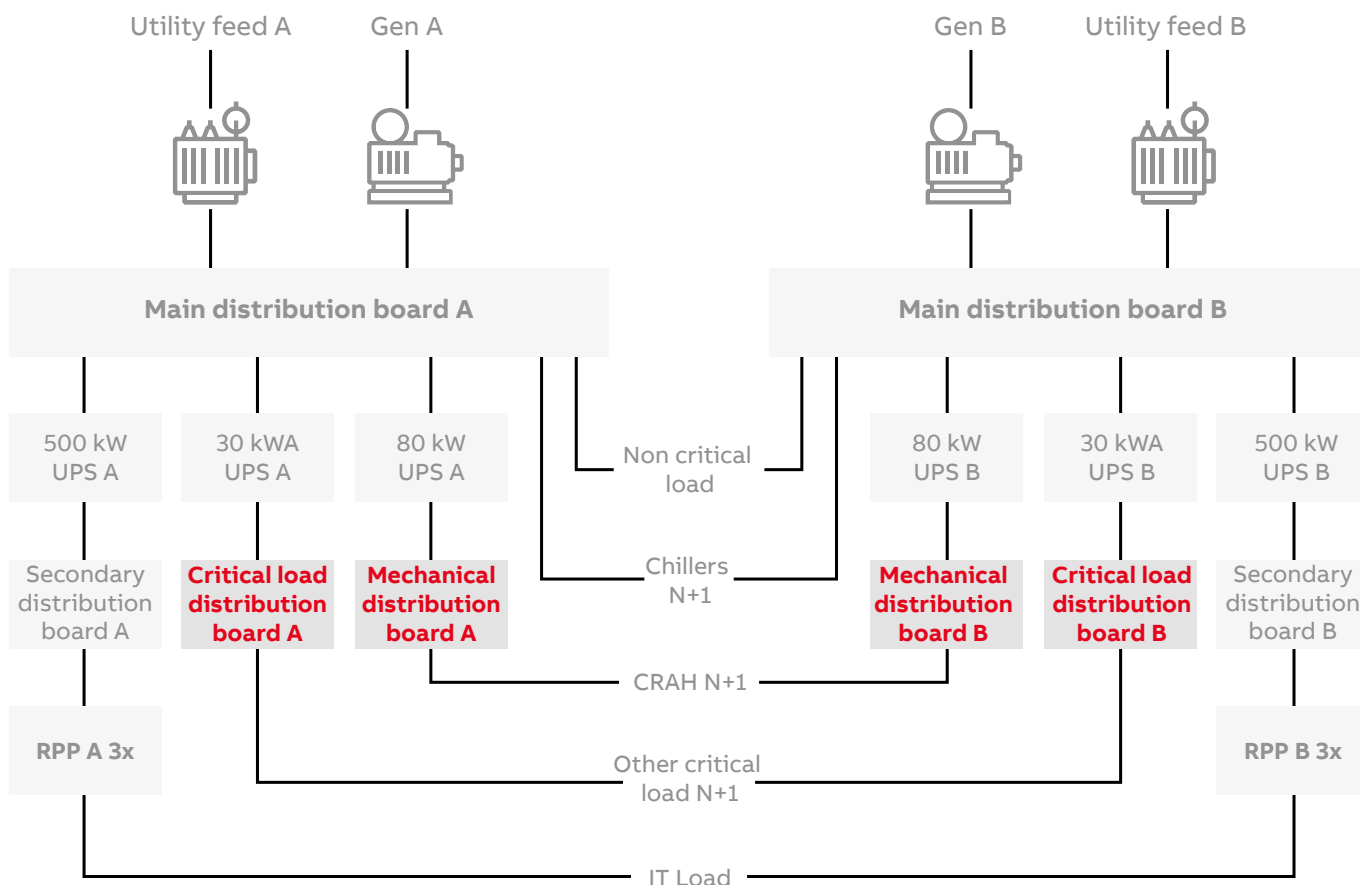
Low-Voltage products predictive maintenance



3. Data Center Power Distribution

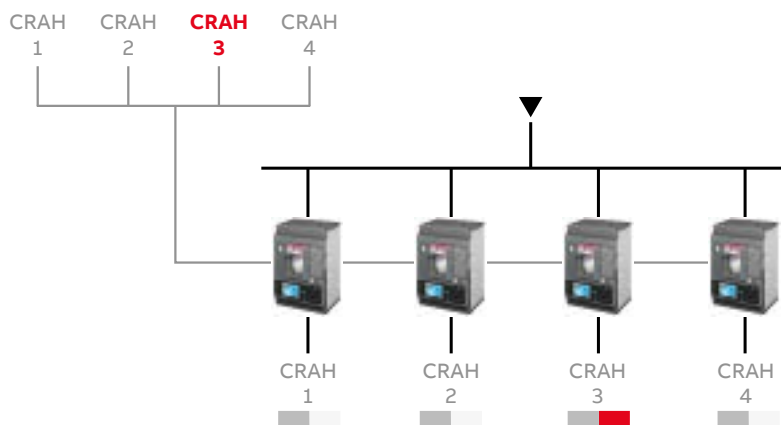
3.5 Other secondary distribution boards

Figure 10. 0.5 MW IT load modular data center configuration – other distribution boards



The secondary distribution boards for other critical loads, CRAH units and service are realized in the same way as the distribution boards described previously.

Figure 11. CRAH units power consumption allocation



The incoming feeder can be a circuit-breaker or switch disconnector. For this project a switch disconnector was chosen.

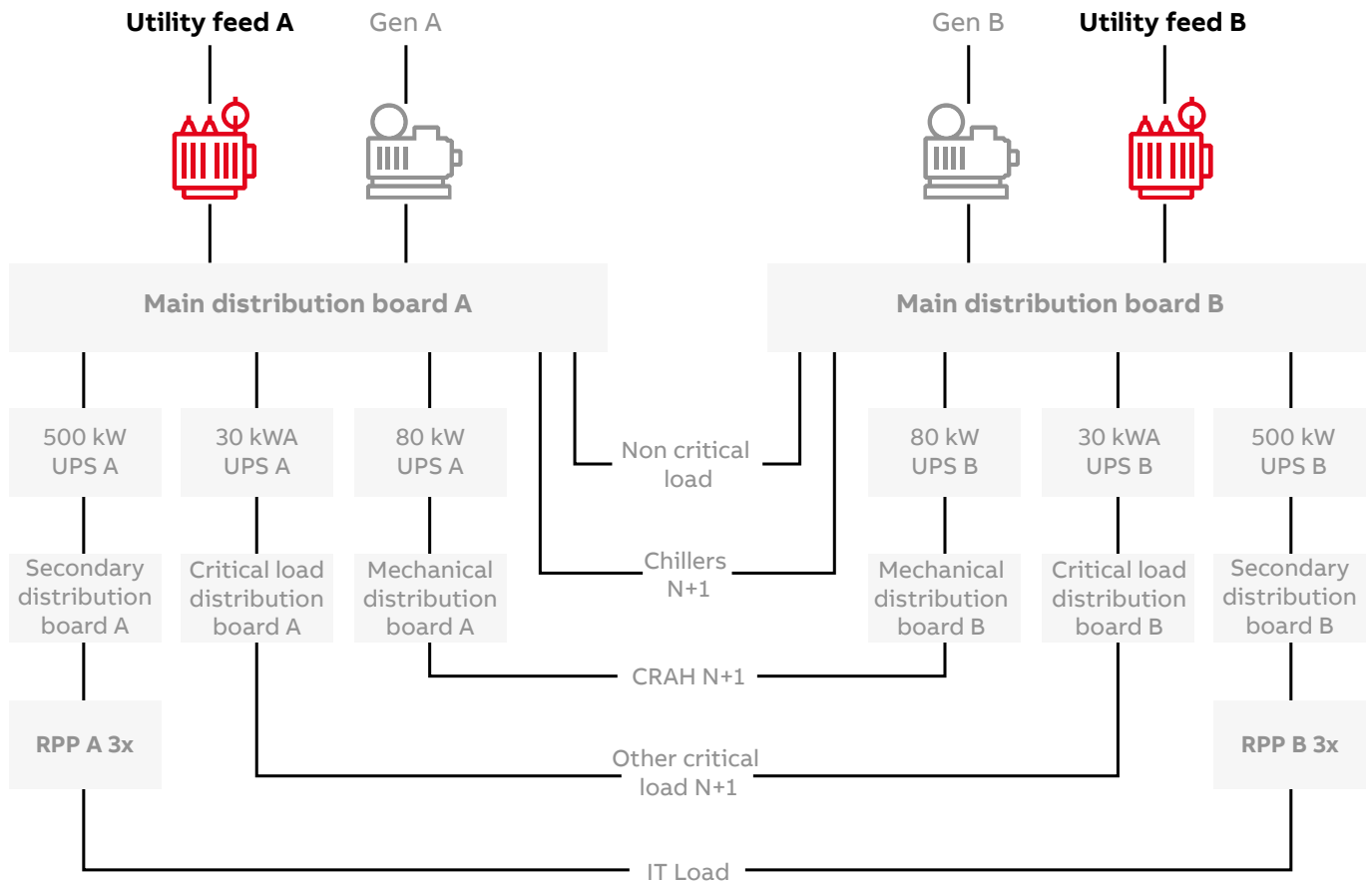
The outgoing circuit-breakers are all able to perform metering in the same way as described previously, in order to precisely monitor energy distribution and allocate energy losses.

For example, by monitoring each CRAH unit's power and energy consumption, it is possible to precisely identify if one of the CRAH units is loaded more than the others and thus if the data center cooling system is not performing efficiently enough (See Figure 11). This provides enough information for the data center to take the actions to improve energy efficiency and reliability..

As in the previously described cases, the distribution switchboards are realized using System Pro E Power.

3.6 Transformers

Figure 12. 0.5 MW IT load modular data center configuration – transformers



Dry-type transformer

There are some general considerations that apply for all transformers. It is highly recommended to use dry-type transformers for data centers. Dry-type transformers require less space and maintenance than other types of transformer.

The main reason however is that, in the event of failure, there is a much lower risk of hazardous situations of the failure influencing the surrounding equipment. In the event of failure, oil-type transformers can cause explosions and fire that can influence other equipment or the whole data center facility.

It is desirable to monitor the transformer's status, especially of its most vulnerable components. Measuring equipment should be positioned to measure the status of important components and to provide alarms in case some values exceed set limits. This can ease maintenance planning, streamline the execution of servicing work and prevent failures, thus significantly increasing the reliability. This can be easily realized with the Ekip Signalling 3T module previously described in Section 3.2.

In this case, a three-phase, dry-type, medium to low voltage (10/0.4 kV) and delta-wye earthed connection, LLLN/ TN-S low voltage distribution transformer is used.

The nominal parameters of the transformer are:

- a) 10/0.4 kV; $S_n=1250$ kVA; $v_{cc}=6\%$

This transformer is connected to the main distribution board through circuit-breaker previously described (one performing the ATS operation). On the high voltage side, the transformer is connected through the medium voltage circuit-breaker to the medium voltage network connection point. In this example, the connection to the 10 kV network is chosen.

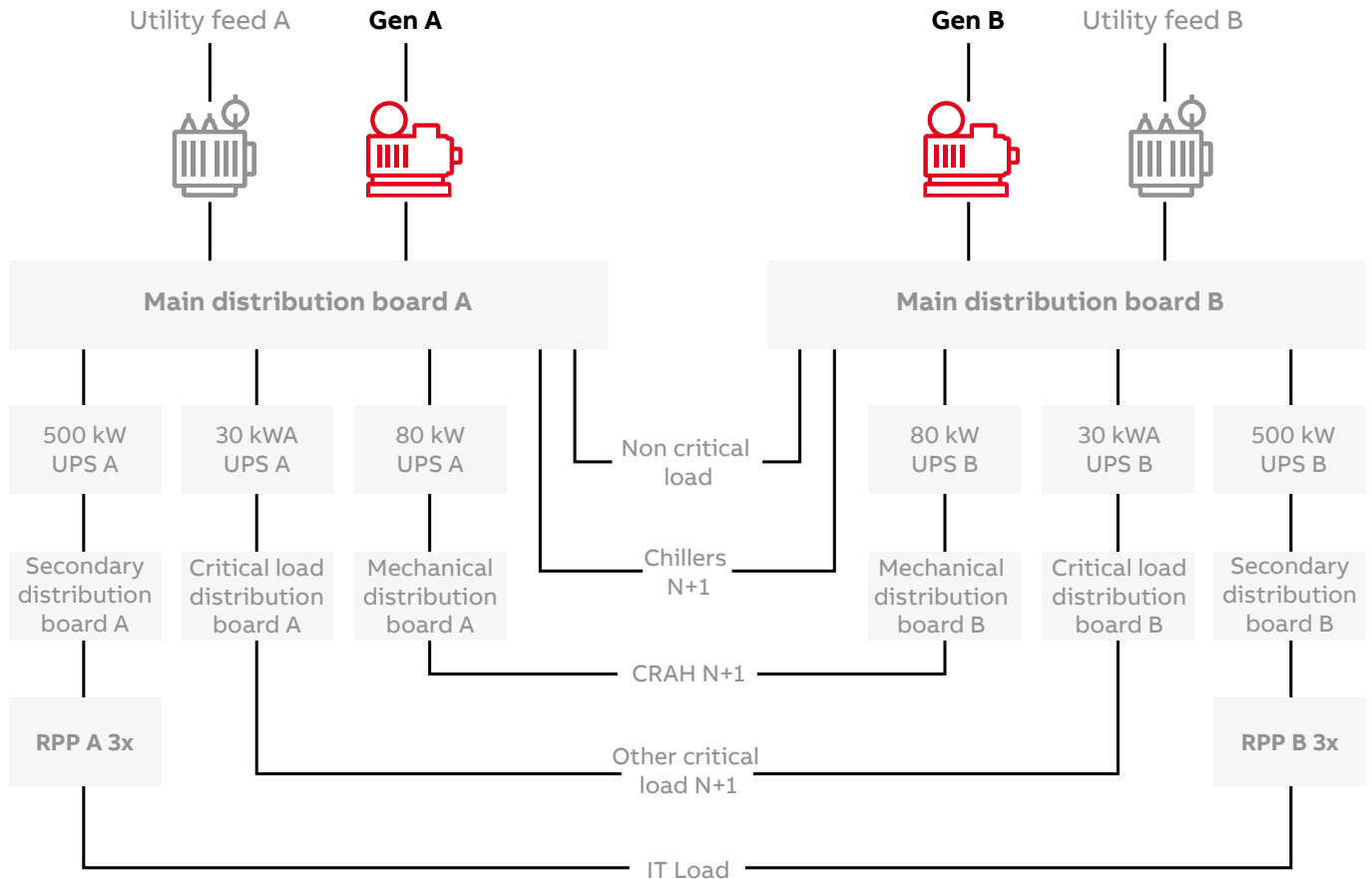
As the most general case, the three-phase short circuit apparent power is chosen to be $S_k=750$ MVA, with the following data for the phase to ground short circuit current: $C_e=5.569 \mu F$, $R=381.1 \Omega$, $L=606.5$ mH.



3. Data Center Power Distribution

3.7 Generators

Figure 13. 0.5 MW IT load modular data center configuration – generators



Ekip G

Every data center needs backup generators able to supply the full data center load. For the higher reliability levels, the generators should be able to supply the load for an unlimited amount of time. If there is a failure on the main power distribution, the generators should automatically turn on, and, via the automatic transfer switch, connect to the load (See Section 3.4).

The short period (maximum 10 minutes) between the main power distribution interruption and generators being turned on is allowed. During the time when the IT load is supplied by the UPS systems, temperatures in the cooled areas during this short period must not increase enough to jeopardize the critical equipment.

The low voltage (400 V), 1250 kVA, 4-pole salient pole generator is used. It is connected to the main distribution board through Emax 2 Ekip G Hi-Touch circuit-breakers.

This circuit-breaker is equipped with generator protection functions so that no additional protections for the generators should be added. This is in addition to all the previously explained functionalities for the circuit-breakers, which also need to be considered for this type of circuit-breakers. Having a unique device that protects the generators and has all the previously explained functionalities brings additional advantages in terms of reliability and serviceability.



Table 4. Protection available on Ekip G circuit-breakers

Function	Description	ANSI	ABB
Synchrocheck	Control of adequate conditions for parallel connection	25	SC
Active overpower protection	Protection against active overpower supply	32OF	OP
Reactive overpower protection	Protection against reactive overpower supply	32OF	OQ
Reverse active power protection	Protection against active power absorption (reverse power)	32R	RP
Directional overcurrent protection	Protection against directional current	67	D
Active underpower protection	Protection against active underpower supply	32LF	UP
Loss of excitation or reverse reactive power protection	Protection against energizing anomalies, checking of reactive power absorption	40/32R	RQ
Overload protection	Current protection against temperature rise	49	L
Instantaneous overcurrent protection	Instantaneous protection against phase overcurrent	50	I
Time-delayed overcurrent protection	Inverse/definite time protection against phase overcurrents	51 50TD	S
Earth fault protection	Inverse/definite and instantaneous time protection against earth overcurrent	51N 50NTD; 51G 50GTD	G; Gext
Differential ground fault protection	Definite time protection against earth overcurrents in the generator windings	87N	Rc
Voltage controlled overcurrent protection	Protection against short circuit between phases with current threshold depending on voltage (controlled/restrained mode)	51V	S(V)
Residual overvoltage protection	Protection detecting loss of insulation in the machine	59N	RV
Undervoltage protection	Protection against voltage decrease	27	UV
Overvoltage protection	Protection against voltage increase	59	OV
Current unbalance protection	Protection against phase current unbalance	46	IU
Voltage unbalance protection	Protection against voltage unbalance and detection of rotation direction of phases	47	VU
Rate of change of frequency protection	Protection against rapid frequency variations	81R	ROCOF
Overfrequency protection	Protection against frequency increase	81H	OF
Underfrequency protection	Protection against frequency reduction	81L	UF

4. Data Center Monitoring System



ABB Ability™
Energy and
Asset Manager

Thanks to the embedded metering of ABB's products there is no need to add additional meters to the installation to make the measurements required. According to Green Grid [2], the body that defines data center Power Usage Effectiveness (PUE), highly detailed Level 3 measurements can be made in this way.

All ABB products have the Modbus TCP/IP communication protocol embedded to enable all device information to be exchanged.

A sample wiring diagram for Side A of the data center which can be downloaded through QR code for wiring diagram on the left, shows the communications to be implemented to allow connection to the local monitoring system and/or the transmission of information to the cloud based Ability™ Energy and Asset Manager platform. The same communication should also be realized for Side B of the data center in order to have comprehensive monitoring and redundancy.

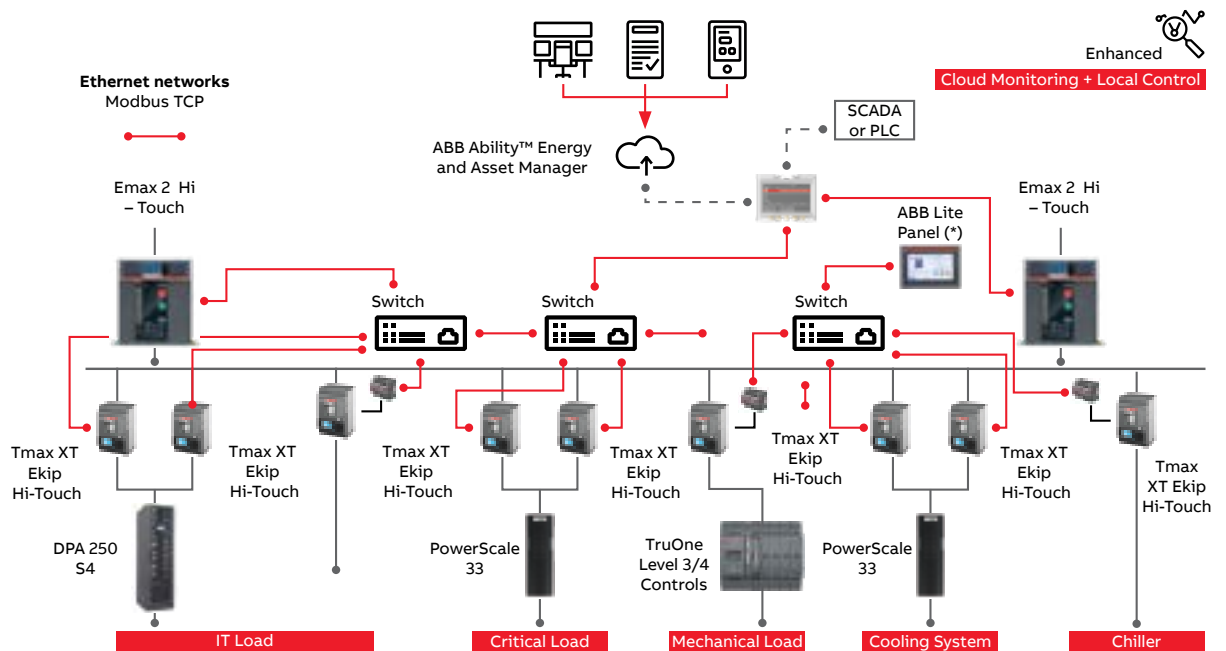


Single line diagram of
a power distribution
design and ABB Ability™
Energy and Asset
Manager wiring diagram

Figure 14. Supporting communication protocols



Cyber Security





Data center
Energy efficiency
and management

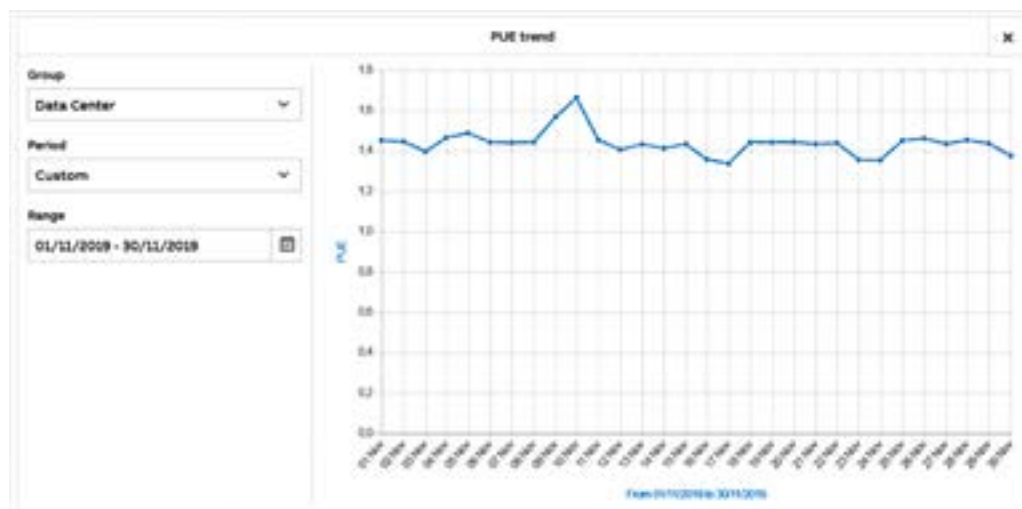
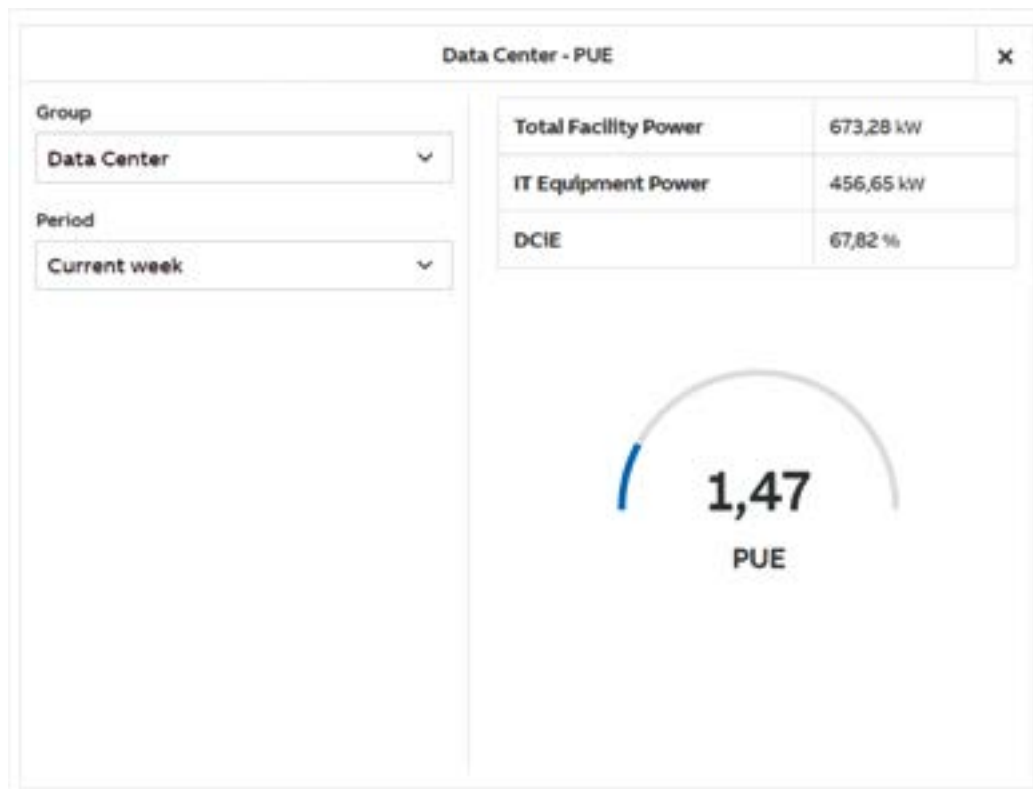
Once the Modbus network is realized, monitoring of PUE, device status, predictive maintenance and much more can be set up in around 10 minutes – the time it takes to commission the cloud-based Ability™ Energy and Asset Manager platform. Ability™ Energy and Asset Manager does not require any customization or additional programming: the user is able to complete the commissioning and installation.

Partnership between ABB, Microsoft and an IT security expert, ABB Ability™ Energy and Asset Manager means guaranteed state-of-the-art cyber security. Furthermore, control is not possible from the cloud, making it impossible to control or change any parameters for any of the

electrical distribution devices. The monitoring is also performed only for electrical distribution equipment down to the MCBs inside the RPPs.

Additional levels of flexibility can also be gained, as the products can be equipped with different communication protocols to the one used in this example, which can also be redundant. In this way parallel connections to multiple monitoring systems and redundancy is enabled.

More details about the metering capabilities of the products, and what is required in the design can be found in the separate documents in this package.



5. Data Center Selectivity



Emax 2
Adaptive
protections

For the reference design, total selectivity is guaranteed between different protection zones.

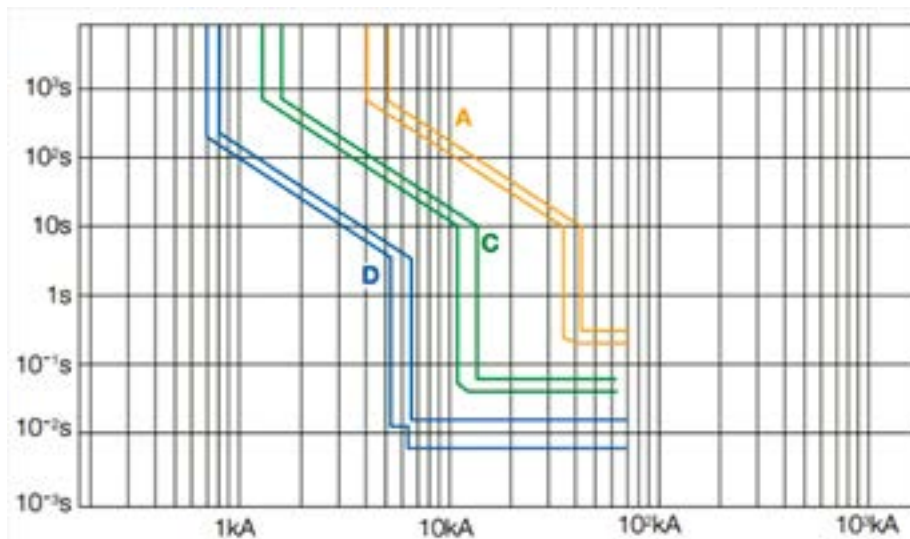
This means that any type of fault in any position in the distribution will trip only the first device upstream of the fault, thus always minimizing how much of the data center is influenced by a fault.

Thanks to adaptive protection features embedded inside the protection devices, it is possible to set two different selectivity curves to guarantee selectivity in any type of network configuration.

For example, when there is an outage of the main power distribution, the circuit-breaker automatically switches to the second protection setting in order to ensure selectivity when the data center is supplied from the generators.

The same is applicable to the protection of the UPSs when the critical load is supplied from batteries. It is possible to switch to different protection settings in order to guarantee maximum protection of the UPS inverter.

It is always necessary to check the status of the fuses inside the UPS in case there is a tripping of any other device.



6. Data Center Modularity

In most cases, data center IT load increases gradually over time as new servers and racks are inserted.

This trend requires all data center equipment to be upgraded gradually as data center load grows. This principle is called modularity.

As a key data center product, ABB UPSs are

designed according to the modularity principles explained in Section 3.3.

The same modularity is also provided by other ABB power distribution equipment.

Table 5 provides information on how data center modularity can be achieved and what devices and components to add when increasing the data center load.

The devices being added are:

- 1) UPS DPA 500 100kW modules
- 2) RPPs and miniature circuit-breakers associated to racks
- 3) Chillers
- 4) CRAHs
- 5) TruONE 250A
- 6) TruONE 200A
- 7) UPS DPA UPScale S2 St 120 20 kW modules



Thanks to modular structure of components installed both on side A and on side B, there is no need to interrupt supply of data center during upgrade phase. Only for installation of new components is required the switch-off of upstream protection devices to guarantee safety of maintenance personnel.

Table 5. Data Center Modularity

The modularity is made possible without

Steps	Maximum number of racks	Maximum IT Load [kW]	Minimum number of DPA 500 100kW UPS modules	RPPs number (N+N)	Minimum number of chillers + TruONE 250A (N+1)	Minimum number of CRAH units + TruONE 200A (N+1)	Minimum number of DPA UPScale S2 ST 120 20kW modules (N+N)
1	12	84	1+1 (100 kW + 100 kW)	1+1	1+1	1+1	2+2 (40 kW+ 40 kW)
2	21	147	2+2 (200 kW + 200 kW)	1+1	1+1	2+1	3+3 (60 kW+ 60 kW)
3	42	294	3+3 (300 kW + 300 kW)	2+2	2+1	4+1	4+4 (80 kW+ 80 kW)
4	57	399	4+4 (400 kW + 400 kW)	3+3	2+1	5+1	4+4 (80 kW+ 80 kW)
5	63	441	5+5 (500 kW + 500 kW)	3+3	2+1	5+1	4+4 (80 kW+ 80 kW)



7. Bibliography

- [1] Uptime Institute, Data Center Site Infrastructure Tier Standard: Topology, Uptime Institute, 2018
- [2] The Green Grid Association and ASHRAE, PUE: A Comprehensive Examination of the Metric, Atlanta, GA: ASHRAE Datacom Series, Book 11, 2014.

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