WHITE PAPER

System plus system (2N) electrical distribution
Data Center Design IEC

0.5 MW IT load design
1. Introduction

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 documents:
1) Single line diagram of the power distribution design
2) ABB Ability EDCS 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.

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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 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, CRACs, pumps
- Critical loads: fire protection systems, telecommunication systems, security systems
- Non-critical loads: service

The electrical load has a total power of 441 kW as shown in Table 1 below.

### Table 1. Data center maximum load breakdown

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

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

The IT devices inside the racks can be designed with:

a) Dual input feed, which allows power supply from both redundant RPDUs at the same time
b) 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 RDU 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 CRAC 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 configura-
tion and 6 CRAC units of 15 kW in N+1 configuration are needed.

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.

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**Figure 4. Data center cooling system example**
3. Data Center Power Distribution

Figure 5 (see below) represents a detailed single line diagram (SLD) 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

<table>
<thead>
<tr>
<th></th>
<th>Tier I</th>
<th>Tier II</th>
<th>Tier III</th>
<th>Tier IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum capacity components to support the IT Load</td>
<td>N</td>
<td>N+1</td>
<td>N+1</td>
<td>N</td>
</tr>
<tr>
<td>Distribution paths-electrical power backbone</td>
<td>1</td>
<td>1</td>
<td>1 Active and 1 Alternate</td>
<td>2 Simultaneously Active</td>
</tr>
<tr>
<td>Critical power distribution</td>
<td>1</td>
<td>1</td>
<td>2 Simultaneously Active</td>
<td>2 Simultaneously Active</td>
</tr>
<tr>
<td>Concurrently maintainable</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Fault tolerance</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Compartmentalization</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Continuous cooling</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
3. Data Center Power Distribution

3.1 Remote Power Panels (RPPs)

Figure 6. 0.5 MW IT load modular data center configuration - PDUs
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 SMISLINE TP busbar system.

Using the SMISLINE 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.
3. Data Center Power Distribution

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

The measurement units connect to the CMS-700, 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.

CMS-700 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. In Figure 8, a single line diagram of a RPP supplying 21 server racks can be seen.
3.2 Secondary distribution board

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 9).

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.

Figure 10. Single line diagram of a secondary distribution board supplied by a UPS cabinet and supplying 3 RPPs and critical loads
3. Data Center Power Distribution

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.

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.

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.

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

For critical applications such as data centers, 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.

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 11. 0.5 MW IT load modular data center configuration – 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 CRAC units
3. **Power Scale 30 kVA** for supplying other critical loads

#### 3.3.1 DPA 500 UPS

**Figure 12. UPS system for supplying IT loads**

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

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.

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). 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 excluded.

3.3.2 DPA UPScale S2 ST 120 for supplying CRAC units

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.
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, CRAC 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.

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

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 guaranty 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 15. 0.5 MW IT load modular data center configuration – main distribution board

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 (MC-CBs) (See Section 3.2).

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 CRAC units. In this project, the TruONE ATS is used as it meets all the set requirements.
3. Data Center Power Distribution

3.5 Other secondary distribution boards

Figure 17. 0.5 MW IT load modular data center configuration – other distribution boards

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

Figure 18. CRAC 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 CRAC unit’s power and energy consumption, it is possible to precisely identify if one of the CRAC units is loaded more than the others and thus if the data center cooling system is not performing efficiently enough (See Figure 18). 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 19. 0.5 MW IT load modular data center configuration – transformers

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; Sn=1250 kVA; vcc=6%

This transformer is connected to the main distribution board trough 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 Sk=750 MVA, with the following data for the phase to ground short circuit current: Ce=5.569 μF, R=381.1 Ω, L=606.5 mH.
3. Data Center Power Distribution

3.7 Generators

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

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

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.

Below is a sample wiring diagram (Figure 21) for Side A of the data center showing the communications to be implemented to allow connection to the local monitoring system and/or the transmission of information to the cloud-based ABB Ability EDCS platform. The same communication should also be realized for Side B of the data center in order to have comprehensive monitoring and redundancy.

Figure 21. Wiring diagram for data center communication and cloud monitoring (for more detail, scan the QR code)
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 ABB Ability EDCS platform. ABB Ability EDCS 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 EDCS 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

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) CRACs
5) TruONE 250A
6) TruONE 200A
7) UPS DPA UPScale S2 St 120 20 kW modules

For each modularity step, there is no need to interrupt power distribution from either Side A or from Side B, which means that there is no decrease in redundancy/reliability during the upgrade procedures. Of course, the protection devices on Side A and Side B upstream of the added component must be switched off to guarantee the safety of personnel installing the new component.

The modularity is made possible without switching off any of the two redundant power distribution sides because of product and solution features such as: hot swappable UPS modules, touch-proof SMISSLINE technology and other previously described functionalities.

<table>
<thead>
<tr>
<th>Steps</th>
<th>Maximum number of racks</th>
<th>Maximum IT Load [kW]</th>
<th>Minimum number of DPA 500 100kW UPS modules</th>
<th>RPPs number (kVA)</th>
<th>Minimum number of chillers + TruONE 250A (N+1)</th>
<th>Minimum number of CRAC units + TruONE 200A (N+1)</th>
<th>Minimum number of DPA UPScale S2 St 20kW modules (N+N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>84</td>
<td>1+1 (100 kW + 100 kW)</td>
<td>1+1</td>
<td>1+1</td>
<td>1+1</td>
<td>2+2 (40 kW + 40 kW)</td>
</tr>
<tr>
<td>2</td>
<td>21</td>
<td>147</td>
<td>2+2 (200 kW + 200 kW)</td>
<td>1+1</td>
<td>1+1</td>
<td>2+1</td>
<td>3+3 (60 kW + 60 kW)</td>
</tr>
<tr>
<td>3</td>
<td>42</td>
<td>294</td>
<td>3+3 (300 kW + 300 kW)</td>
<td>2+2</td>
<td>2+1</td>
<td>4+1</td>
<td>4+4 (80 kW + 80 kW)</td>
</tr>
<tr>
<td>4</td>
<td>57</td>
<td>399</td>
<td>4+4 (400 kW + 400 kW)</td>
<td>3+3</td>
<td>2+1</td>
<td>5+1</td>
<td>4+4 (80 kW + 80 kW)</td>
</tr>
<tr>
<td>5</td>
<td>63</td>
<td>441</td>
<td>5+5 (500 kW + 500 kW)</td>
<td>3+3</td>
<td>2+1</td>
<td>5+1</td>
<td>4+4 (80 kW + 80 kW)</td>
</tr>
</tbody>
</table>
7. Bibliography

[1] Uptime Institute, Data Center Site Infrastructure Tier Standard: Topology, Uptime Institute, 2018

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