Totally Integrated Power

# Technical Series Edition 13.2

## Electric Power Distribution in the Data Center with Tap-Off Units

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# 1. Introduction: **Power distribution systems**

Short innovation cycles in the field of information technology and the change dynamics of customer requirements in the data center market complicate the operators' capacity planning. Apart from the demand for a high availability of the data center, these factors significantly influence the planning of electric power distribution. A spatially simple and quickly adaptable technology with standardized components is becoming increasingly important. In this context, it shall be possible to adapt the components, switchgear, and systems of electric power distribution to changed room structures, new customers and task definitions, as well as to desired load management demands. It is demonstrated in the following that busbar trunking systems are highly suitable to fulfill those requirements when used to design a line power distribution unit in the server rooms of the data center. For the sake of simplification, the line power distribution unit is abbreviated as L-PDU.

As opposed to costly and resource-intensive overdimensioning, a modular concept with a clear structure and a reduced number of compatible components lends itself to the purpose. On the example of a typical power demand in the range of 600 kVA for a server room, the systematic design of IT power supply (IT: information technology) is introduced for different rack configurations.

The most important aspect for data center operation is a high level of availability. IT availability can be increased, among others, by reducing dangers in the server room. This, in turn, can be achieved by reducing fire loads and improving the access and modification possibilities for power supply.

While power distribution is preferred by means of point power distribution units (PDUs and radially outgoing cable connections) in the American data center market, line power distribution units with busbar trunking systems (BTS with distributed tap-off units) are increasingly being used in the European data center market (Fig. 1). As illustrated in the following, the use of busbar trunking systems with variably deployable and standardized tap-off units is appropriate to obtain a flexible, modular system. In line with the PDU, this is defined here as L-PDU.

First, the advantages of power distribution by means of busbar trunking systems are introduced in comparison with a cable-based solution. Subsequently, the marginal conditions are described for the considered server room and power distribution to the racks. The functional concept for the design of a L-PDU is then implemented exemplarily for the considered server room, and a type list is deducted. In this process, the space requirements and the used standard elements are estimated for the different configurations. Finally, implementation examples with SIMARIS design are presented, and selectivity evaluations are performed. This clearly shows that the automated consideration of operation-related derating factors leads to more reliable results during dimensioning.

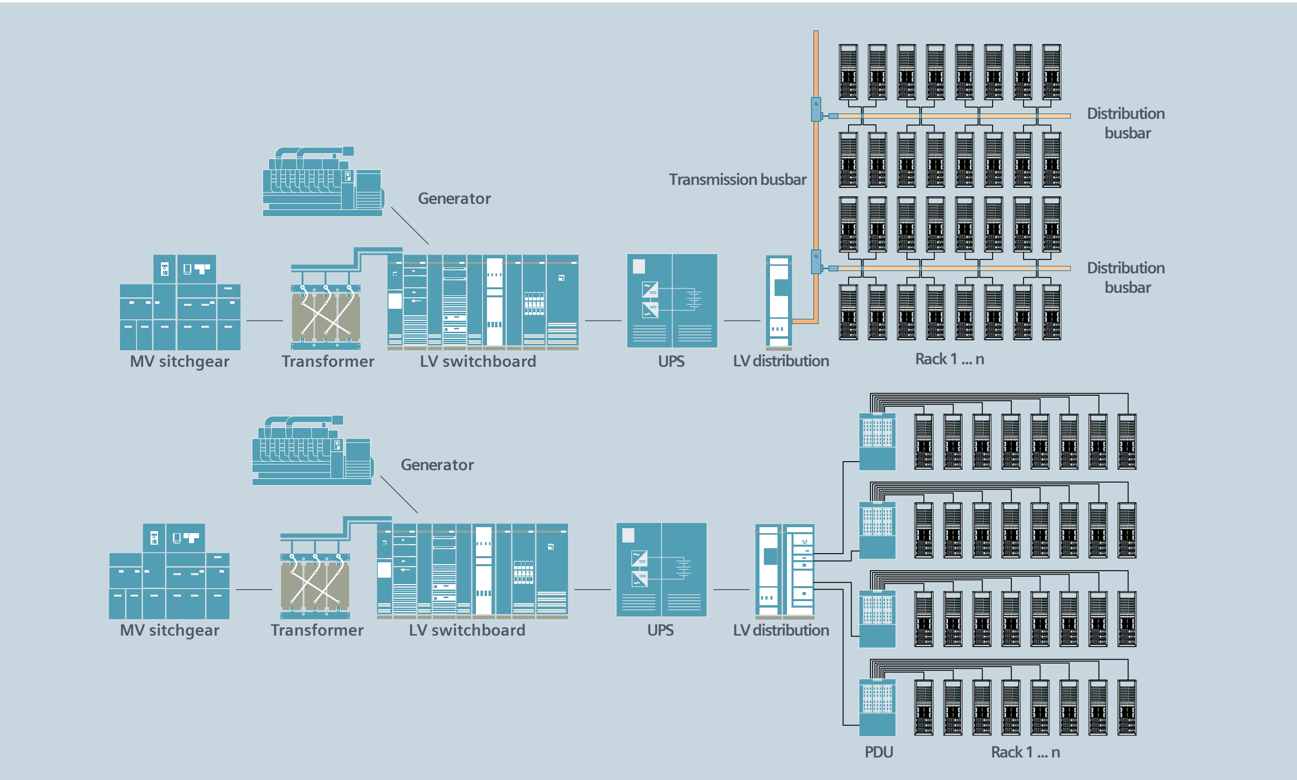


*Fig. 1:* **Comparison of power distribution solutions with cables or busbar trunking systems (BTS) in the data center**

# 2. Comparison of power supply solutions with BTS and with cables

Compared with classical cable installation, BTS offer many advantages in terms of grid and system technology, as the comparisons in Tab. 1 and Fig. 1 show. As a rule, any changes and modifications of the electric power distribution imply a significantly higher effort in terms of time and expenses for cable installations compared with a BTS solution.

Apart from considerable time savings during installation, BTS offer a higher level of flexibility for rack connection options during operation. When comparing costs between BTS and cable solutions, too, BTS can be expected to provide an advantage of up to 30 % [1]. One significant reason for this are the lower operating costs due to lower power losses when using BTS.

| Features | Busbar trunking system | Cable installation |
|---|---|---|
| Network configuration | Linear configuration with serially arranged load tap-offs via tap-off units | High cable accumulation at the infeed point due to the radial supply to the loads |
| Security of operation | Design verification according to IEC 61439-6 (VDE 0660-600) ensures a high current-carrying capacity and short-circuit withstand strength | Depending on the respective execution quality<br>More complicated verification of conformity with standards |
| Flexibility | - Flexible during expansions (additional tap-off units)<br>- Flexible during modifications (installation and removal of tap-off units)<br>- Flexible during maintenance (installation also possible while energized) | High effort due to splicing, clamping points, junctions, parallel cables, etc.;<br>Installation work only possible in de-energized state |
| Fire load | - Very low fire load, tested and certified: Possible fire resistance classes S 60, S 90, S 120 according to DIN 4102-9 and fire resistance classes EI 60, EI 90, EI 120 according to EN 13501-2 (system-dependent)<br>- Fire barrier is either pre-assembled at the factory (MIF) or mounted on site (MOS)<br>- Suitable for solid walls/ceilings and lightweight walls<br>- Easy handling and installation | - Higher fire load: PVC cables: up to 10 times higher fire load compared with BTS PE cables: up to 30 times higher fire load compared with BTS<br>- Increased effort when installing the fire barrier<br>- Project-specific design, depending on the quantity and cross-section of the cables |
| Electromagnetic compatibility (EMC) | Design-related benefits for EMC thanks to the metal enclosure and special arrangement of conductors | Strong interference in case of standard cables;<br>in case of single-core cables, the EMC strongly depends on the type of bundling (see [1]) |
| Current-carrying capacity | Due to system design, higher current-carrying capacity compared with cables of the same cross-section | Installation type, accumulation and operating conditions determine the permissible current-carrying capacity |
| Halogen-free / PVC-free design | On principle, trunking units are halogen-free | Standard cables are not halogen-free and PVC-free;<br>halogen-free cables are expensive |
| Space requirements | Compact design due to high current-carrying capacity, standard angle and offset elements | High space requirements due to bending radii, installation type, accumulation, as well as current-carrying capacity (consideration of derating factors) |
| Weight | Weight reduction to half or even a third compared with cables | Up to 3 times the weight of a comparable BTS |
| Installation | Easy installation possible with simple auxiliary tools and short installation times | Complicated installation is only possible with numerous auxiliary tools; significantly longer installation times (also especially for the installation of the cable bracket systems) |

*Tab. 1:* **Comparison of characteristic features of BTS and cable installation**

A power supply solution with BTS in the server room also has advantages over a cable solution in the event of a subsequent power increase in the individual racks. By opening the distribution busbar systems, followed by a simple and fast exchange with prepared tap-off units, and then doubling the transport busbars as shown in Fig. 2, the power of the racks can be doubled quickly and safely in part with the existing material. In case of a cable solution, the entire power distribution of the server room (all cables and PDUs) must be exchanged and reconnected again.

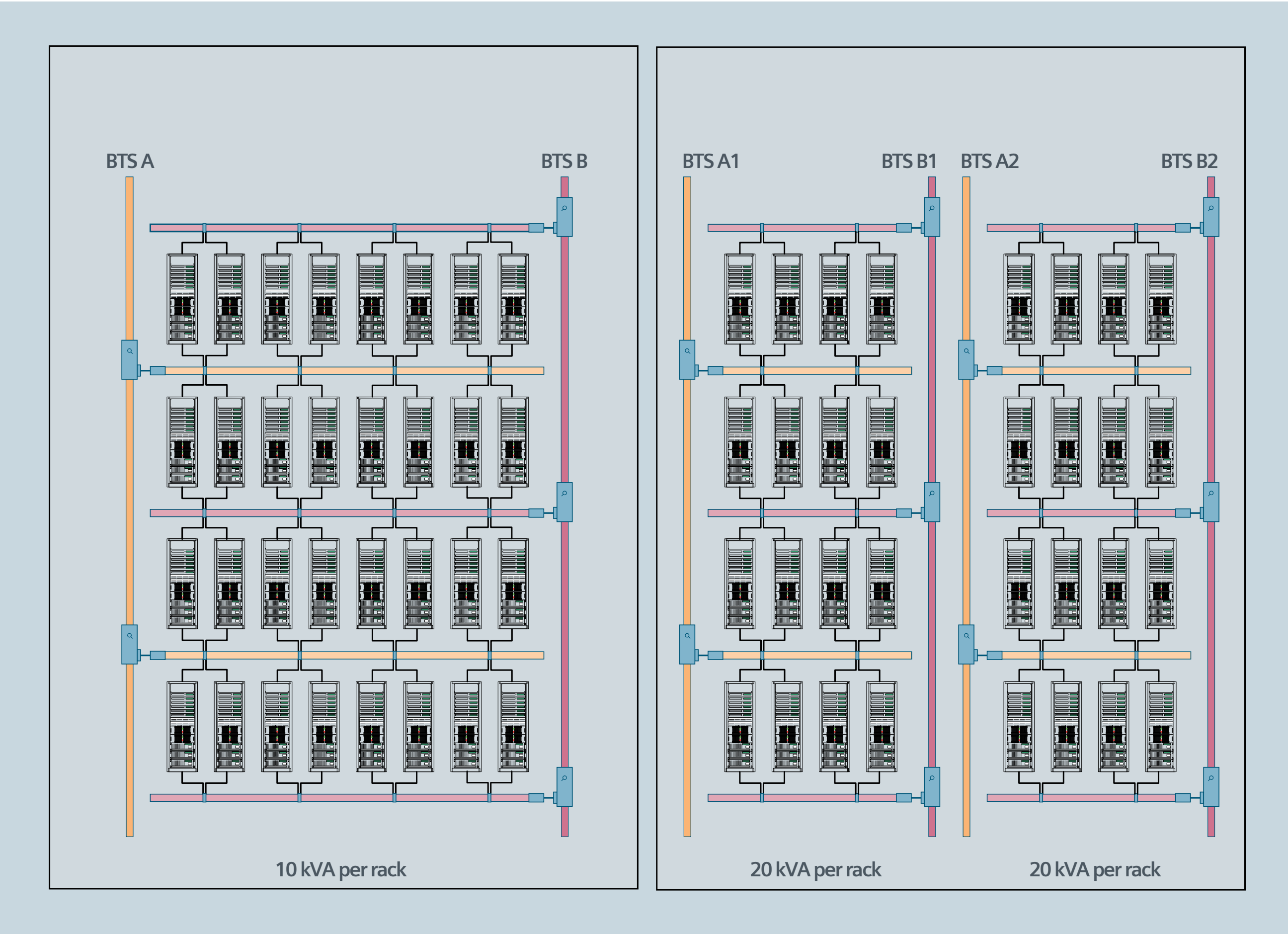


*Fig. 2:* **Doubling of power with BTS in the server room**

# 3. Design of a modular busbar trunking system for data centers

In the data center, servers and IT equipment with different performance requirements are usually connected to the power supply. In addition, frequent changes to the structuring and use of the server room must be reckoned with in the data center, which makes a variable and modular concept for power supply in the server room an advantage. The design of BTS with standardized tap-off units [2] is ideal for their use in such a concept.

Such a concept from the medium-voltage level down to the connection of the servers and their end consumers is described in the application manual [1] for one or more server rooms with a power demand of 600 kVA.

Accordingly, these are the selected marginal conditions for the power supply modules:

- For a server room, an electric power demand in the range of 600 kVA is assumed.
- The power transport to and within the server room is done using a transport busbar system which is also called "backbone" distribution unit in the server room (comparable with the spinal column of the human nervous system, the central data cable harness is called "backbone" in IT). In case of a redundant supply system, two transport busbar systems (A/B) are commonly laid through the server room.
- Power distribution from the transport busbar to the server racks is done either
  using 4 busbar runs (standard BTS with an operational current of 250 A each) at a rack power demand of less than 10 kVA,
  or
  using 2 busbar runs (standard BTS with an operational current of 630 A each) at a rack power demand of greater than or equal to 10 kVA.

| Modular component | Product series |
|---|---|
| Power transport into the server room | SIVACON 8PS, LI system |
| Fuse protection of transport tap-off units | Molded-case circuit-breakers (MCCBs, e.g. 3VA) |
| Measurement / monitoring in the transport tap-off units | 7KM PAC2200 measuring devices |
| Power distribution from the transport busbar to the server racks | SIVACON 8PS, BD2 system |
| Distribution tap-off units [2]<br>(respective versions:<br>- with / without measuring device<br>- with / without switching the N conductor) | - up to a rack power of 3.6 kVA:<br>BVP: 662638, 662640, 662654, 662656<br>- up to a rack power of 7.2 kVA:<br>BVP: 662642, 662644, 662658, 662660<br>- up to a rack power of 11 kVA:<br>BVP: 662639, 662641, 662655, 662657<br>- up to a rack power of 22 kVA:<br>BVP: 662643, 662645, 662659, 662661 |

*Tab. 2:* **Recommended product series for the design of an L-PDU**

# 4. Typical configurations for server rooms with a power demand of approx. 600 kVA

Up to a rack power of 7.2 kVA, it is recommended to supply the server racks with 1-phase alternating current. This brings with it the advantage of lower short-circuit currents compared with those for a corresponding 3-phase supply. This is advantageous for personnel and equipment safety as well as for system availability due to more favorable selectivity conditions. Another advantage of the alternating current version is that, in the case of the 1-phase fuse protection, the two phases not affected by the fault and the racks connected to them remain in operation in the case of fault. Beyond 10 kVA, power supply for the racks commonly becomes economically viable with three-phase current.

With the four ratings of tap-off units (3.6 / 7.2 / 11 and 22 kVA) for the busbar trunking system BD2 [2], the server racks can be supplied with a correspondingly different power demand. To do this, tap-off units with measurement and switchable N conductor are selected. The following two examples show an exemplary design for modular power supply systems in a server room which are equipped with racks that amount to a total power demand of approximately 600 kVA. The space requirements for racks depend significantly on the access and service possibilities, and less on the power and air conditioning demand of the servers in the rack.

➡ Assumption for determining the space requirements of the server room: 3 m2 surface per rack
(consideration of necessary surfaces, for example, for aisles and cooling equipment)

## *4.1 Version 1 with 1-phase tap-off units up to a rack power demand of 3.6 kVA (Fig. 3)*

In a server room with racks featuring a maximum power demand of 3.6 kVA each, there are 168 racks which can absorb a total power of 604.8 kVA. When installed in 4 rows, 42 racks are lined up in each row.
Space requirement F for 168 racks:
F (3.6 kVA) = 168 · 3 m² = 504 m²

The racks are to be supplied redundantly. The components for power transport and power distribution in the server room are to be determined according to Tab. 2 (Fig. 3):
- 2 transport busbar systems
- 8 tap-off units with MCCBs
- 8 distribution busbar systems
- 112 tap-off units

i) Power transport into the server room:

Minimum rated current of the BTS:
$I_n$ = 604.8 kVA / ( √3 · 400 V) = 873 A
Selected busbar trunking system: **LI-A1000**
MCCB for tap-off units (250 A): **3VA22**

ii) Power distribution from the transport busbar to the server racks:

Minimum rated current of the BTS:
$I_n$ = 873 A / 4 = 218 A
Selected busbar trunking system: **BD2A-2-250** Selected tap-off unit: **BVP:662638**
(see [2]; 3.6 kVA, 3 socket outlets, 1-phase, 16 A, characteristic C with measurement + N conductor switching)

## *4.2 Version 2 with 3-phase tap-off units up to a rack power demand of 22 kVA (Fig. 4)*

In a server room with racks featuring a maximum power demand of 22 kVA each, there are 28 racks which can absorb a total power of 616 kVA. When installed in 2 rows, 14 racks are lined up in each row.
Space requirement F for 28 racks:
F (22 kVA) = 28 · 3 m² = 84 m²

The racks are to be supplied redundantly. The components for power transport and power distribution in the server room are to be determined according to Tab. 2 (Fig. 4):
- 2 transport busbar systems
- 4 tap-off units with MCCBs
- 4 distribution busbar systems
- 56 tap-off units

i) Power transport into the server room:

Minimum rated current of the BTS:
$I_n$ = 616 kVA / ( √3 · 400 V) = 890 A
Selected busbar trunking system: **LI-A1000**
MCCB for tap-off units (500 A): **3VA24**

ii) Power distribution from the transport busbar to the server racks:

Minimum rated current of the BTS:
$I_n$ = 890 A / 2 = 445 A
Selected busbar trunking system: **BD2A-3-630** Selected tap-off unit: **BVP: 662643**
(see [2]; 22 kVA, 1 socket outlet, 3-phase, 32 A, characteristic C with measurement + N conductor switching)

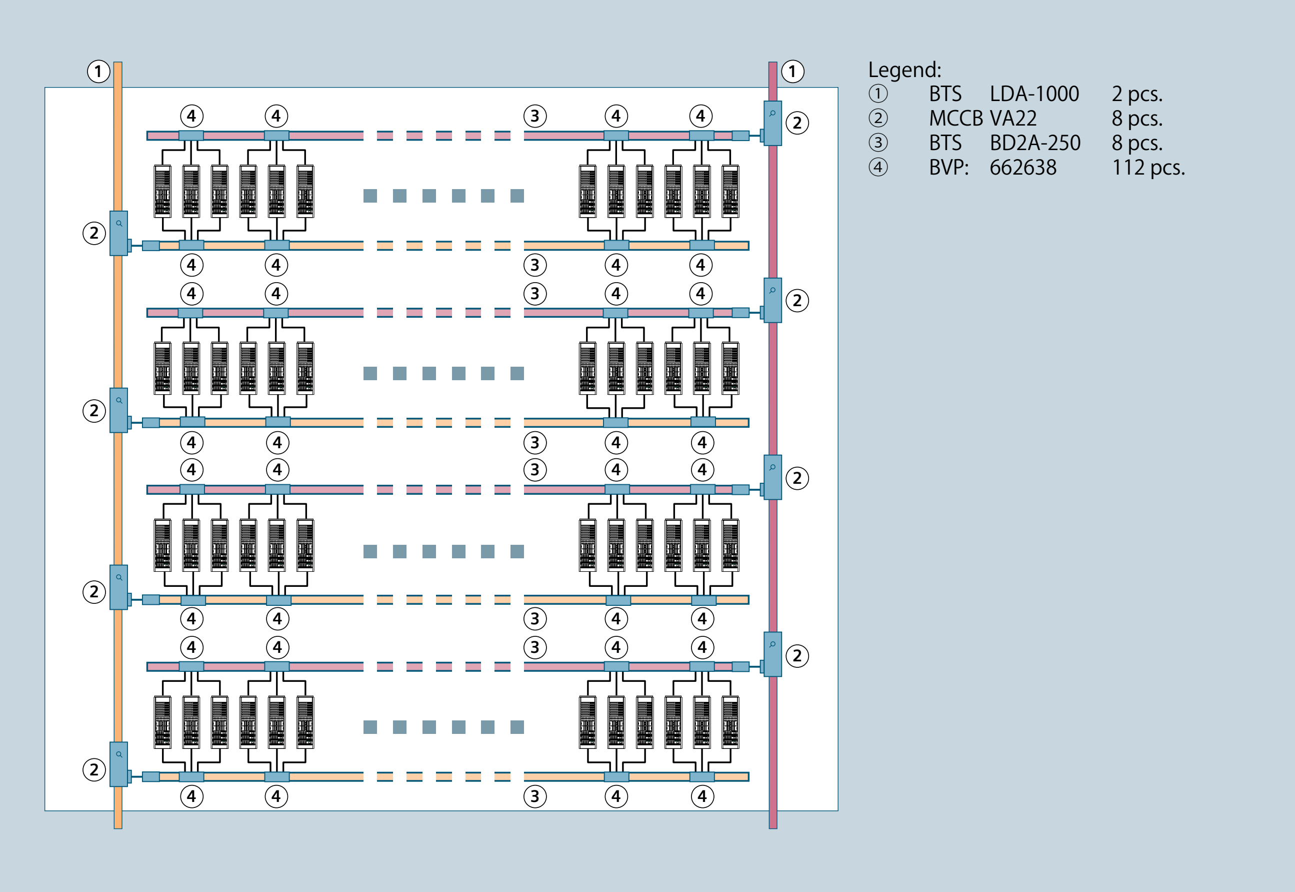


*Fig. 3:* **Version 1: Server room (approx. 600 kVA) with 1-phase rack supply (maximum rack power demand of 3.6 kVA)**

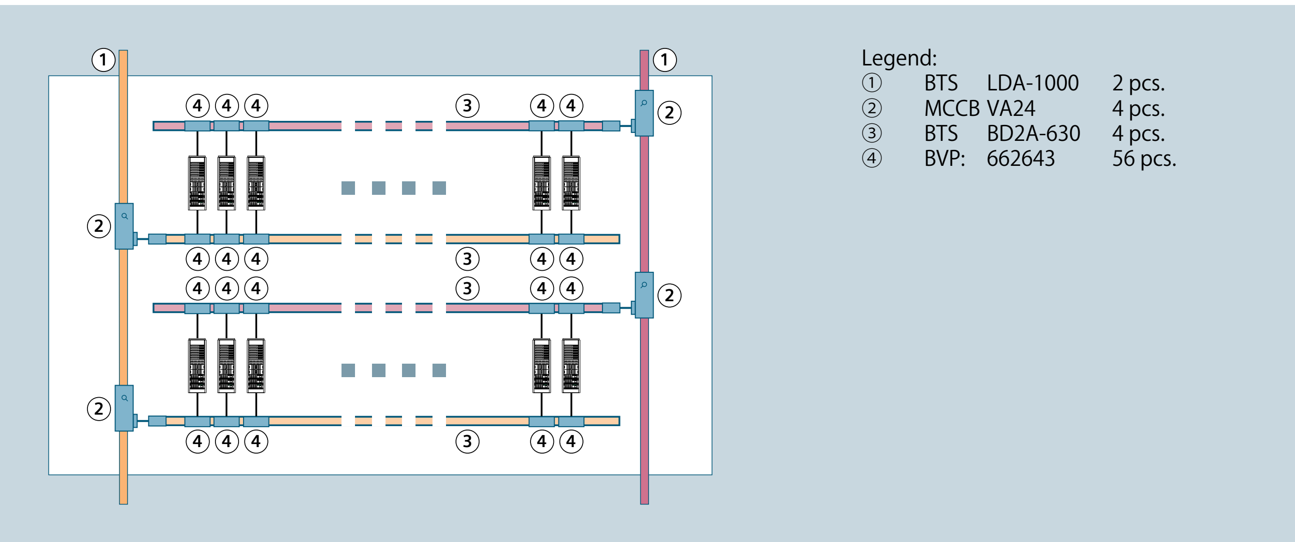


*Fig. 4:* **Version 2: Server room (approx. 600 kVA) with 3-phase rack supply (maximum rack power demand of 22 kVA)**

# 5. Dimensioning with SIMARIS design and selectivity considerations

The dimensioning of both L-PDU power distribution arrangements in Fig. 3 and 4 can be verified with SIMARIS design. In Figs. 5 and 6, the single-line representations from SIMARIS design are displayed with a simple network infeed via a GEAFOL transformer.

The selectivity evaluations (green boxes in Figs. 5 and 6) prove that the molded-case circuit-breakers 3VA22 and 3VA24 were chosen fully selectively. For the selectivity evaluation, the professional version of SIMARIS design must be used. For the 3 socket outlets of each tap-off unit in Fig. 5 (gray tint), a minimum distance of 0.25 m must be selected for the busbar trunking system in SIMARIS design.

For the configurations in chapter 4, free ambient conditions were assumed for the miniature circuit-breakers (MCBs) (e.g. an ambient air temperature of 20 °C according to IEC 60898-1). In SIMARIS design, the temperature is adjusted to 45 °C according to the installation in the distribution boards. The permissible load currents are determined automatically and considered for the calculations:

- MCB 5SY75167: $I_{n,zul}$=14.56A at 45°C ($I_{n,max}$=16A)
- MCB 5SY75367: $I_{n,zul}$=30.08A at 45°C ($I_{n,max}$=32A)

That is why the permissible rack power ratings are reduced to 3.3 kVA and 20 kVA for the standard tap-off units. Accordingly, more realistic total power ratings for the server rooms are 554.4 kVA (Fig. 5: 168 racks with 3.3 kVA) resp. 560 kVA (Fig. 6: 28 racks with 20 kVA).

Additional information or support for the use of the SIMARIS tools is provided by TIP Consultant Support of Siemens:

www.siemens.com/tip

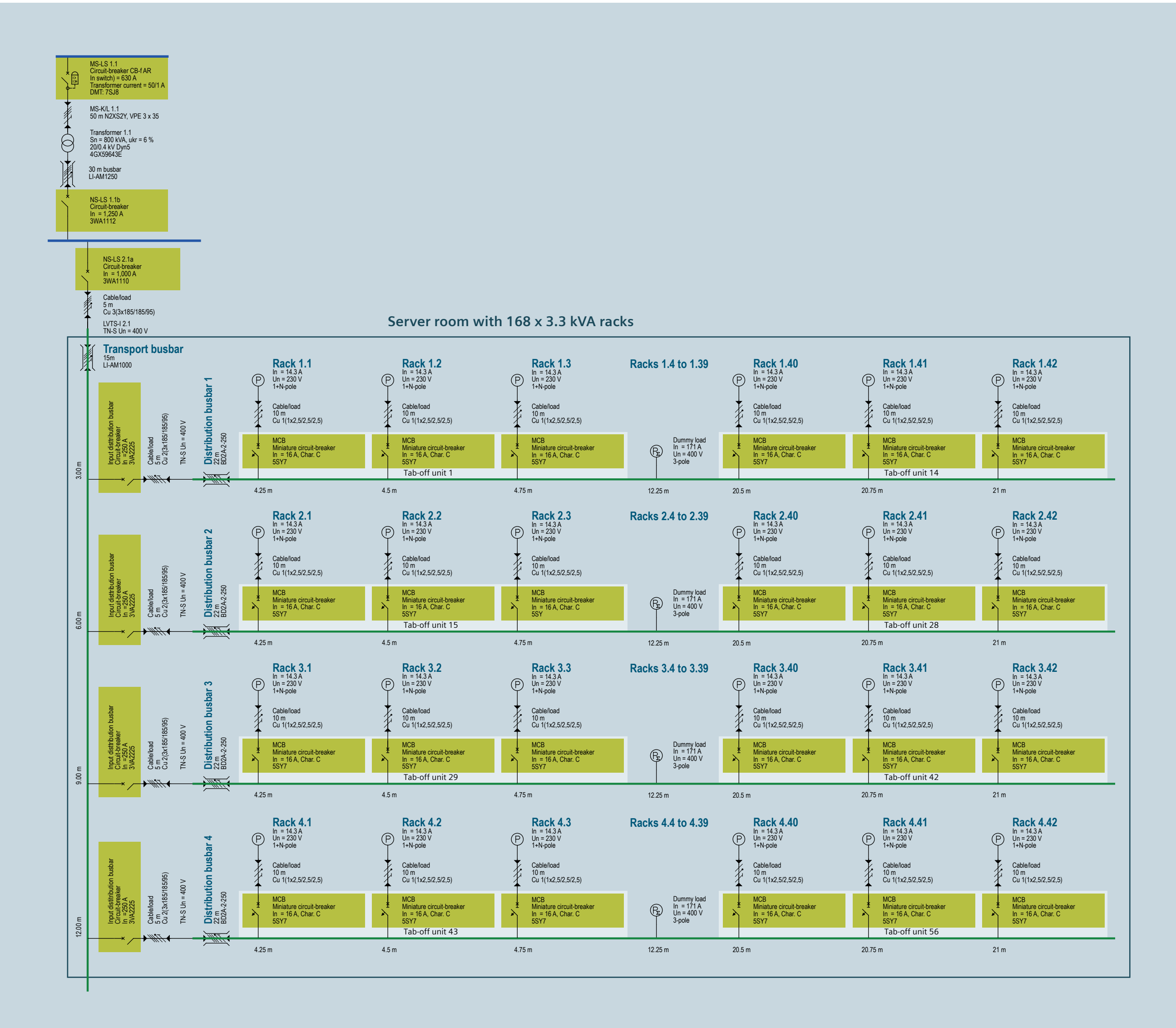


*Fig. 5:* **Version 1: Server room (approx. 554.4 kVA) with 1-phase rack supply (maximum rack power demand of 3.3 kVA)**

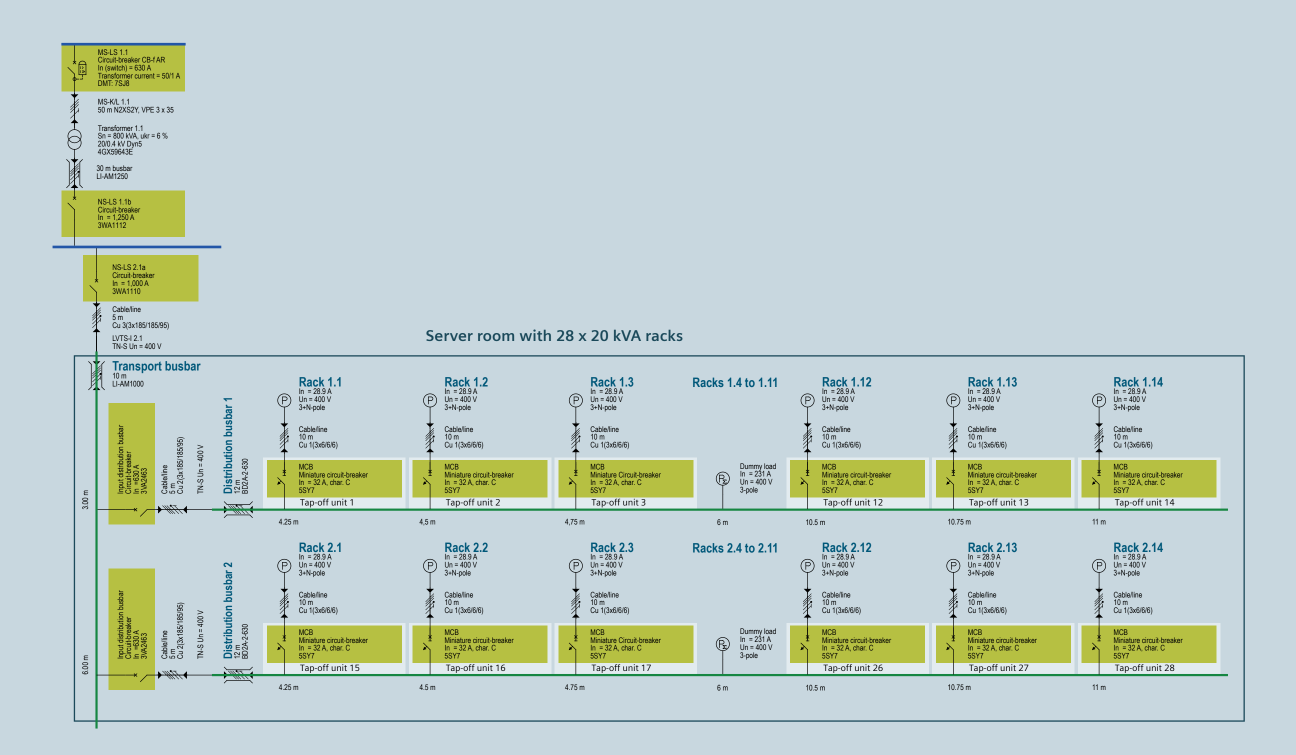


*Fig. 6:* **Version 2: Server room (approx. 560 kVA) with 3-phase rack supply (maximum rack power demand of 20 kVA)**

## 6. Conclusion

The preconfigured modules described in here for electric power distribution in server rooms simplify planning and constitute a flexible and cost-efficient solution at the same time. As demonstrated, coordinated products and systems are indispensable in order to fulfill the high demands regarding security of supply and selectivity in the data center. The verification with SIMARIS design makes it clear that safety factors have to be considered for simple rough calculations.

If there are any questions, please contact your local partner:

www.siemens.com/tip/contact

## 7. References


[1] Siemens AG, 2013, Application Models for Power Distribution – Data Centres, Order No.: IC1000-G320-H148

[2] Siemens AG, 2023, Busbar trunking systems SIVACON 8PS, catalog LV 70 Order-No. E86060-K1870-A101-B1


## 8. Sample files for SIMARIS design

Two sample files are attached to this PDF file which can be opened in SIMARIS design 11 (professional version for selectivity considerations):

- TS_13_2_Tap-off_units_28x32_en.sdx
- TS_13_2_Tap-off_units_56x16_en.sdx

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