Innovative Power Distribution in Data Centers

Concept for profitable and safe power distribution
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Totally Integrated Power™

The power supply system is more or less the “vital artery” for all electrically operated building installations. If it works reliably and efficiently, the power flows are secured and thus so too is the operation of all electrical equipment. Electrical power distribution therefore requires integrated solutions. Our answer: Totally Integrated Power.

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Requirements and Trends in Data Centers

The steadily rising demand for IT support provided for existing and new business processes stimulates the growth in the number of servers and storage systems operated worldwide. Information technology and communications, and data centers in particular, are becoming more and more important for both economic as well as ecological aspects. Annually, the global market for IT services – and thus the space requirements in data centers – is growing by 50 to 60 percent.

Experts assume that power consumption of data centers, which currently amount to around 50,000 in Germany alone, was 8.67 TWh in 2006. This is equivalent to the annual electricity output of three medium-sized coal-fired power plants. Owing to this power consumption, the data centers caused CO₂ emissions of 5.6 million metric tons in the same year, a considerable emission level in relation to our climate.

If no effort is made towards greater energy efficiency in this area, an increase of data center power consumption is to be expected in Germany alone amounting to as much as 12.9 TWh in 2010. Compared to 2001, the CO₂ emissions in Germany caused by data centers would rise by approximately 50 percent by 2010.

The CO₂ issue in connection with the enormous power consumption of data centers places their operators more and more into the limelight of public attention.

This so-to-speak worldwide growth of data centers thus has direct consequences for global power consumption. According to current scientific investigations, power consumption in data centers amounts to about one percent of the total electricity consumption worldwide. Thus, the energy efficiency of data centers is of great economic importance to their operators.

Besides the tremendous energy cost, growing ecological awareness combined with statutory conditions on CO₂ emissions also plays a major part in this context. Business customers expect the highest of technical standards as well as maximum data security and availability from data centers – 24 hours a day. Absolutely reliable, uninterruptible power supply is the unconditional prerequisite for this.
Electric Power Supply in Data Centers

In data centers, electricity must be supplied to all relevant electrical components around the clock with the utmost reliability. Faults or even a power outage and the resulting data loss and interruptions of operations entail incalculable economic damage for data center operators.

Despite the high reliability of supply, power supply interruptions on the part of distribution network operators or power supply companies do take place from time to time. With less than one second, the majority of these faults are so short that a person won’t notice them. But even interruptions of more than 10 ms are capable of disturbing IT operation.

The manifold reasons for interruptions of operations demonstrate that integrated electric power supply backed by an uninterruptible power supply system (UPS) plays a crucial role in the data center.

EMC-friendly grid design in the data center is another urgent requirement. This makes the precise co-ordination of the power system, the treatment of the central grounding point and the connection of electric sub-networks by means of suitable switchgear (3- or 4-pole), so that conductive and inductive couplings will be avoided as far as possible, indispensable. Failure to observe this principle will considerably affect the entire infrastructure, starting from corrosion up to extensive disturbances of the data center facilities (computers, communication links, etc.). “Stray” currents caused by a faulty network configuration quite often lead to the partial destruction of IT equipment. Besides these material losses – caused by deficient planning of the central grounding point in the most unfavorable case – the problem may arise that the protective function of “disconnecting in the event of a fault” will fail. This may result in personal injury and endangering lives, with far-reaching consequences under civil law.

Therefore, it must be precisely defined in the planning stage which parts of the installation are to be supplied without interruption from the UPS: This includes IT consumers and their necessary infrastructure (servers, monitoring etc.), installation parts that can be operated with a short-time interruption (cooling, safety equipment for the building infrastructure) and consumers that do not cause any substantial impairment or far-reaching operational consequences in the event of a total loss.

Having been defined, the installation parts and consumers are mapped to their corresponding supply sub-grids. In order to establish the power demand for the UPS system and for the normal and safety/standby power supply, the following power demand quantities – related to a medium power density – can be estimated for data centers during the draft planning stage.

The supply sub-grids are accordingly designed to meet the different demands of operational safety. They are mapped to the power sources, which are laid out more or less redundantly.

In order to be able to classify the degree of operational safety provided, the standard classifications of Tier I to Tier IV have been defined for data centers (see page 12ff.) with Tier IV meeting the highest requirements of availability. Often, the entire data center is designed according to the highest level of availability required, although this would only be necessary for business-critical processes. This entails costs for an unnecessarily redundant infrastructure plus air conditioning and power supply systems, such costs being effective not only during the installation stage but also during subsequent operation. Increasing the level of supply redundancy often entails a reduction of energy efficiency, unless one focuses on the energy efficiency of the overall project.
Currently, only slightly more than half of the total power consumption of a data center can be attributed to the IT equipment itself.

- **IT equipment**
  Server, router, storage disks, switches

- **Cooling**
  Fans, pumps and compressors, including their control systems

- **Losses**
  UPS systems, power supply, including switchgear and switching devices, transformers

- **Other**
  Other infrastructure – lighting, elevators, HVAC equipment for offices, etc.
Energy efficiency of data centers

The power demand of a data center often amounts to megawatts. Thus, the costs of electricity are a substantial part of the operating costs, which is the reason why power losses must be minimized. To this end, it is necessary to keep consumption and the power losses of all installation parts in mind, since these losses are often unknown especially in the partial load range, which is the most common mode of operation. In order to be able to make accurate forecasts in this respect as a basis for counteraction, appropriately sensitive measurements and documentation of such partial energy consumption are mandatory. In this way, the potential for reducing energy consumption and costs can be revealed systematically.

Besides the absolute energy consumption of equipment and installation parts recorded in this way, their energy efficiency also plays an important part. To date, binding definitions of the energy performance of data centers and internationally uniform measuring standards do not exist. Other typical indicators, such as the energy consumption per square meter, are not meaningful in this context. This problem requires indicators evaluating the core functions and performance of data centers, i.e. data processing, data transmission and data storage.

One meaningful indicator is the power consumption of IT equipment (servers, storage devices, network equipment) in a data center, for example, which is stated in relation to the total power consumption of the data center. In this context, the power consumption of the IT equipment, which delivers the actual performance of the data center, is called “useful power”. The rest of the electricity consumed is used for the necessary infrastructure of the data center. Here, losses also result from the provision of uninterruptible power supply, power distribution, cooling, air conditioning etc.

This coefficient of data center energy efficiency has also been incorporated in the Green Grid initiative.
**Loss event costs**


**Statistics on the causes for interruptions of operation**

<table>
<thead>
<tr>
<th>Voltage deviations</th>
<th>47.6 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power failure / overvoltage</td>
<td>45 %</td>
</tr>
<tr>
<td>Failures due to damage in the overhead lines</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IT technology</th>
<th>15.9 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware / software faults</td>
<td></td>
</tr>
<tr>
<td>Network failure</td>
<td></td>
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<tr>
<td>Human failure / sabotage</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Exterior impacts</th>
<th>36.5 %</th>
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<tbody>
<tr>
<td>Storm damage</td>
<td></td>
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<tr>
<td>Fires / explosions</td>
<td></td>
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<tr>
<td>Floods / water damage</td>
<td></td>
</tr>
<tr>
<td>Earthquakes</td>
<td></td>
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<tr>
<td>Other causes</td>
<td></td>
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</tbody>
</table>

The Most Important Pillar of Power Supply in the Data Center

Uninterruptible power supply (UPS)
UPS systems are used in order to avoid possible, negative consequences of short power failures. They filter interferences, such as voltage surges or voltage dips and bridge interruptions in the grid. This helps to prevent transmission faults, computer crashes, program errors and data loss.

However, the systems typically used for bridging gaps can only take over supply for such critical loads for a limited amount of time, so that either interaction between the UPS and standby power generating system or the use of safe shutdown software is required for the targeted shutdown of data center applications.

Static UPS systems
Reliable monitoring and adjustment of the load current supply is the essential function of a UPS system. Static UPS types are divided into three categories, since they function differently in details in line with their differing technical design and since they provide different output voltage qualities. The European standard EN 62040-3 defines and describes the classification and the corresponding determination methods for static UPS systems.

Rotating (dynamic) UPS
A rotating UPS, also called dynamic UPS, is an alternative to static UPS systems. In this type of UPS, the load supply is implemented with the aid of a rotating machine plus inverter. Dynamic UPS systems can be used to handle all types of loads. If required, they can be easily expanded to ensure the best possible availability of power supply.

Standby power generating sets
If we are not dealing with a short-time interruption of power supply, standby power generating sets should be able to take over within seconds to ensure long-term power supply and hence the availability of IT systems. These are autonomous standby units for power generation. In most cases, these units are generators powered by diesel engines. In line with the desired bridging time, the storage of sufficient fuel reserves must be provided for.
Particular features to be observed

The following are important planning features for dimensioning and installing a UPS system:

- Nominal output power at required load power factor
- Connection values, such as the input and output voltage and output frequency
- Currents, conductor cross sections and connection possibilities for UPS inputs and outputs
- Efficiency ratio and power loss
- Data on UPS fusing for different operating modes
- Conducted interference on the network input and input power factor
- Maximally available battery bridging time at nominal load
- Data on the battery system and on battery charging / discharging
- Permissible ambient parameters, such as operating temperature, humidity, implemented degree of protection, fire protection requirements and air conditioning
- Noise
- EMC protection
- Dimensions and weights

Types of grid faults and matching UPS solutions acc. to EN 62040-3

<table>
<thead>
<tr>
<th>Line faults</th>
<th>Time</th>
<th>e.g.</th>
<th>IEC 62040-3</th>
<th>UPS solution</th>
<th>Arrester solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Power failures</td>
<td>&gt; 10 ms</td>
<td></td>
<td>VFD Voltage + Frequency Dependent</td>
<td>Classification 3 passive standby operation (offline)</td>
<td>–</td>
</tr>
<tr>
<td>2. Voltage fluctuations</td>
<td>&lt; 16 ms</td>
<td></td>
<td></td>
<td></td>
<td>–</td>
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<tr>
<td>3. Voltage peaks</td>
<td>4 ... 16 ms</td>
<td></td>
<td></td>
<td></td>
<td>–</td>
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<tr>
<td>4. Undervoltages</td>
<td>Continuous</td>
<td>VI Voltage + Independent</td>
<td>Classification 2 line interactive operation</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>5. Overvoltages</td>
<td>Continuous</td>
<td></td>
<td></td>
<td></td>
<td>–</td>
</tr>
<tr>
<td>6. Lightning strikes</td>
<td>Sporadic</td>
<td>VFI Voltage + Frequency Independent</td>
<td>Classification 1 doubleconversion operation (online)</td>
<td>Lightning and overvoltage protection (IEC 60364-5-534)</td>
<td>–</td>
</tr>
<tr>
<td>7. Surge</td>
<td>&lt; 4 ms</td>
<td></td>
<td></td>
<td></td>
<td>–</td>
</tr>
<tr>
<td>8. Frequency fluctuations</td>
<td>Sporadic</td>
<td></td>
<td></td>
<td></td>
<td>–</td>
</tr>
<tr>
<td>9. Voltage distortion (burst)</td>
<td>Periodic</td>
<td></td>
<td></td>
<td></td>
<td>–</td>
</tr>
<tr>
<td>10. Voltage harmonics</td>
<td>Continuous</td>
<td></td>
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<td>–</td>
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"Siemens has the knowledge and expertise. Every Cyber-Center is built with Siemens!“

Max Alias,
Program Manager CyberCenter Services, KPN
Schematic Representation of a Data Center according to its Classification in the Tier Topology

Tier I: Simple supply grid

Main features

• No redundant feed-in components and supply lines
• Faults in the supply system may cause an interruption in the IT components
• The system is susceptible to interruptions as a result of scheduled and non-scheduled events
• Complete shutdown for maintenance work at the supply system is necessary
• Availability: 99.67 %

Applications

• Smaller businesses using IT technology to cope with internal processes
• Businesses regarding their web presence mainly as a passive marketing tool
• Start-up businesses without the need of computer-based customer care

MVMD = Medium-voltage main distribution
LVMD = Low-voltage main distribution
UPS = Uninterruptible power supply
SD = Subdistribution system
G = Generator
RACU = Recirculated air cooling unit
IT room
The Uptime Institute in the United States has defined a so-called ‘tier classification’ for the data-center infrastructure. The four tier levels each indicate the high and ultra-high availability of data centers.

**Tier II: Supply grid with redundant feed-in components**

**Main features**
- Redundant UPS installations and generators are required
- No redundancy of the supply lines
- Faults in the supply system may cause an interruption in the IT components
- The system is susceptible to interruptions as a result of scheduled and non-scheduled events
- Shutdown for maintenance work on the system is necessary
- **Availability: 99.75 %**

**Applications**
- Smaller businesses mainly using the IT during normal business hours so that shutdown after work is possible without any problems
- Computer systems for software developers (taking account of night runs), CAD firms
- Businesses which, though using their Internet connection for business purposes, “merely” risk delays and data loss in case of IT non-availability but no business-critical delays
Main features

- Redundant UPS systems, transformers and generators are required
- Redundant supply lines to the IT components are required
- Every component of the feeder and the supply line can be switched to a non-operating state in a defined mode for the purpose of scheduled maintenance without shutdown, continuous supply is ensured by the redundant components or supply lines.
- The system is susceptible to interruptions as a result of non-scheduled events
- Dual power packs in the IT components or load transfer modules (LTM) in the grid between UPS and IT component required for continuous operation during maintenance work
- The risk of interruption increases during maintenance
- Faults in the supply grid may cause an interruption in the IT components
- Availability: 99.98 %

Applications

- Businesses or service providers that have to be ready for operation for their internal and/or external customers around the clock, such as service centers or emergency facilities which can however be accessed or are capable of working in another way if computers are off-duty during short periods of time (e.g. during maintenance)
- Businesses whose IT facilities are used for electronic business processes, but where service for customers is not impaired during maintenance or shutdown times
- Businesses operating in different time zones, but in such a way that different regional business hours do not result in any drawbacks
Main features

- Redundant UPS systems, transformers and generators are required
- Redundant supply lines to the IT components are required
- Every IT component has a dual power pack
- A single worst-case fault somewhere in the supply grid must not affect the IT component
- Every component of the feeder and the supply line can be switched to a non-operating state in a defined mode for the purpose of scheduled maintenance without shutdown, while supply is continued via the redundant components or supply lines
- Dual power packs in the IT components or load transfer modules (LTM) in the grid between UPS and IT component required for continuous operation during maintenance work or in the event of a fault
- Complementary systems and supply lines must be physically separated (barriers), so that single faults will not affect both systems
- The supply system is not susceptible to interruption as a result of a single scheduled or non-scheduled event
- The risk of interruption could increase during maintenance

Applications

- Businesses with an international market presence having to reliably provide a service during 24h, 365 days throughout the year to remain competitive
- Businesses based on e-commerce, electronic market transactions or financial services
- Globally operating businesses active in different time zones so that employees can access important resources and their customers can use the most up-to-date applications at any time
Establishing the availability rates for the individual tier topologies is based upon information on maintenance times and average failure rates of individual components or equipment. This is therefore a purely theoretical assessment and should only be utilized for the comparison of the individual tier topologies if the same boundary conditions apply to all topologies.

In practice, the availability of such a tier topology is basically determined by the following:

- Quality of the individual components
- Quality of component assembly into installations
- Electric power supply structures
- Design maturity of the individual technologies
- Experience gained with these technologies
- Operator staff and service quality
- Monitoring systems etc.

In an extreme case, even a Tier IV structure might be less well available than a Tier I structure.

For the planning engineer, as well as the installation company and the operator of such a supply grid, this means that only an evaluation and co-ordination of the whole complex of components, systems, technologies and human resources will create the optimum in terms of cost and benefit.

Availability of Tier Topologies
Integration is the Trump Card

In co-operation with the consultant for electrical engineering, Siemens develops solutions for power distribution in data centers that take into account all operator requirements from the outset. Here, a single supplier provides the well-matched products and systems for an integrated solution.

The following projects may serve as excellent models for the successful use and benefit of Totally Integrated Power for power distribution in data centers:

**Airbus Data Center, Hamburg, Germany**
- Renewal of the power supply for a data center
- Solution with communication-capable modules to integrate power supply into the building control system of the data center
- Use of busway systems instead of cables to reduce the fire load on the building
- Increased operational safety of power supply and thus better availability of the connected computers

**Info AG Data Center, Hamburg, Germany**
- Construction of a new data center
- Solution for power distribution using busway systems and integrating measuring instruments to monitor power supply
- Busway systems were laid horizontally in the floor area: Measuring instruments were placed on the busbar trunking using power tap-off units; this enables easy and cost-saving swapping of the instruments in case of changing requirements
- Customer requirements regarding a high degree of operational safety and monitoring of data center operation have thus been met
## Our complete range for electrical power distribution

### Medium-voltage switchgear

The supply network operator feeds medium voltage to the medium-voltage switchgear located in the basement. This ensures safe and cost-efficient power distribution in the building and distributes power to the transformer. Siemens offers gas- and air-insulated switchgear for all kinds of requirements and applications. They are type-tested in accordance with IEC 62271-200.

### SIPROTEC protection technology

Protection and bay control units protect the primary equipment by fast switching. They protect the power system, the generators and machines by selective fault tripping in the event of a fault. The complete SIPROTEC product family for line, motor and generator protection offers you an integrated solution with extensive protection and control functionality as well as extremely flexible communication options.

### Energy automation

Energy automation with the SICAM PAS (Power Automation System) substation control system meets high requirements in terms of immunity, reliability, isolation, real-time resolution and secure data transmission. SICAM PAS is an open system and is the first to support the new IEC 61850 as communication standard between field and substation level.

### GEAFOL transformers

Transformers convert medium voltage to the low voltage required to operate the power loads. GEAFOL transformers are flame-retardant and self-extinguishing and do not give off any toxic gases in case of fire. This makes them particularly suitable for use where distribution transformers in the immediate vicinity of human beings must guarantee maximum safety.

### SIVACON busbar trunking systems

Electrical power is distributed via cables or busbar trunking systems. Thanks to their high short-circuit strength and minimal fire load, busbar trunking systems are considerably safer than cables. If the use of space changes, flexible modifications and expansions during operation are possible.

### SIVACON switchboards

The low-voltage switchboards SIVACON S8 provide maximum safety for human beings and equipment thanks to design verification by verification test according to IEC 61439-2 and an arc fault test. In addition, a type-tested connection to the busbar trunking systems is available.

### ALPHA distribution board systems

ALPHA distribution boards as small, wall or floor-mounted distribution boards offer highly reliable and standards-compatible quality and safety in accordance with the relevant standards. They pass the current on to rooms and manufacturing sections.

### SENTRON protection devices

We offer a comprehensive protection concept with a broad, coordinated range of devices for line protection, personal and fire protection, lightning current and overvoltage protection, and device and system protection. The communication-capable air circuit breakers 3WL and the molded-case circuit breakers 3VL transmit important information for diagnostics, fault, maintenance or cost center management to a central control center via standardized bus systems.
<table>
<thead>
<tr>
<th><strong>SENTRON switching devices</strong></th>
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<tbody>
<tr>
<td>Manual SENTRON switching devices can be reliably used in electrical systems that are switched on and off manually. Where systems and loads are controlled by means of electrical signals, electronic switching devices such as remote control switches 5TT4, switching relays or insta contactors 5TT5 are used.</td>
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<tr>
<th><strong>SENTRON measuring devices</strong></th>
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<tr>
<td>The PAC power monitoring devices measure the energy values for the infeed, outgoing feeders or individual loads precisely, reliably and in a reproducible manner. They also provide important measured values for assessing the condition of the system and the quality of the network.</td>
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<table>
<thead>
<tr>
<th><strong>SENTRON monitoring devices</strong></th>
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<tbody>
<tr>
<td>High plant availability and low downtimes help keep costs low. The residual current monitors 5SV8 help detect and remedy faults before the plant is shut down. The automatic transfer switch 3KC9 increases the reliability of the power supply via automatic or manual switching between two power supply systems. The GSM alarm module 5TT7 enables faults and shutdowns to be reported and commands to be sent from anywhere.</td>
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<table>
<thead>
<tr>
<th><strong>Energy management system</strong></th>
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<tr>
<td>The powermanager software monitors, processes and archives measured values and displays them in a clearly laid-out manner. The data is provided by communication-capable low-voltage power distribution components such as PAC power monitoring devices and 3WL/3VL circuit breakers. Savings potentials can be identified and the availability of energy ensured due to the transparency in power distribution that is gained with the aforementioned technology.</td>
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<tr>
<th><strong>Energy management for industrial applications</strong></th>
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<tr>
<td>The SIMATIC powerrate add-on for WinCC and PCS 7 as well as device-specific block libraries make it possible to integrate various energy management functions such as a structured visualization and archiving of consumption data, cost center allocation or load management as well as low-voltage power distribution components into the systems of the process and manufacturing industry.</td>
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<tr>
<th><strong>DESIGO INSIGHT building automation system</strong></th>
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<tbody>
<tr>
<td>This building automation system for all types and sizes of buildings and all applications increases energy efficiency while providing convenient control over the room climate. Ease of use ensures maximum comfort. DESIGO INSIGHT permits significant energy and cost savings.</td>
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<tr>
<th><strong>GAMMA building management systems</strong></th>
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</thead>
<tbody>
<tr>
<td>With GAMMA building management systems based on the global KNX standard, lighting, sun protection and room climate can be implemented comfortably, flexibly and in an energy-efficient manner.</td>
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<tr>
<th><strong>DELTA switches and socket outlets</strong></th>
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<tbody>
<tr>
<td>The DELTA ranges of switches and socket outlets combine the widest possible array of design surfaces with innovative, safe technology – meeting virtually all global standards. They offer a wide variety of solutions for more safety and comfort.</td>
</tr>
</tbody>
</table>
Professional Planning Aids

More efficient planning with SIMARIS
The innovative SIMARIS® software family is setting new standards in electrical design support. With regard to planning and dimensioning the electrical power distribution and selecting the necessary devices and distribution boards, you can avoid large amounts of routine work and therefore save time. The tools in the SIMARIS family can be used for the entire electrical planning from the basic calculations right through to the tender process.

SIMARIS design
Based on the requirements of the corresponding electrical power distribution system, the dimensioning software SIMARIS design dimensions a secure solution from the broad product portfolio in accordance with recognized technological rules and applicable standards (VDE, IEC) – from the medium-voltage infeed right through to the loads. The right components are selected automatically. Time-consuming searches through catalogues for individual product data are a thing of the past.

SIMARIS project
With the free software tool SIMARIS project, you can create project documents quickly, easily and clearly based on the space and budget requirements for suitable electrical distribution boards with the corresponding protection and switching devices. You can also use the software to submit a completed list of specification texts in GAEB D81 or RTF format (available in German or English).

SIMARIS curves
The free SIMARIS curves software shows you the tripping characteristic (time-current characteristic) with tolerance bands for low-voltage protection devices and fuses (IEC) as well as the characteristic curves for the let-through current and let-through energy characteristics of various devices.

Easy, fast and safe
No special knowledge of Siemens products or systems is required to use the tools, as the software calculates these automatically based on the information supplied by the user. Each piece of software can be used on its own. To increase efficiency, project data can be exchanged between projects.

More information
www.siemens.com/simaris
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