

A photograph of a car body on an assembly line. The car is illuminated with a bright blue light, highlighting its metallic structure. In the background, there are industrial robotic arms and factory infrastructure.

# Innovative Power Distribution in the Automotive Industry

Cost-effective and reliable  
power distribution

## Totally Integrated Power

Answers for infrastructure.

**SIEMENS**

# Requirements and Trends in the Automotive Industry

Manufacturers are fiercely competitive. Cost savings in investment and operation therefore play an exceptional part in the automotive industry.

Standardization between the manufacturer's plants also results in cost savings and minimizes operational risks. Several sites thus rely on proven solutions.

Fast model changes and the flexible production set-up involved are supported by the a power distribution that is equally flexible in adjustment. Load-center substations (which are placed in the respective load center required) contributes to this as much as a power supply by busbars which allows for a flexible rearrangement of power tap boxes.

## General description of power supply in the automotive industry

Siemens develops and implements solutions for power distribution systems for the automotive industry which cater for all areas of production from the start – from a single source and as a turnkey project.

Which connection exists to the public grid? What is the power quality like? These important data in the planning stage are the basis for an optimal design of the power supply network.

From the press shop to the final assembly – electricity must perform a lot on the road to the finished car. Every automotive plant places very individual requirements on an optimal power supply.

In this context, we consider the 110-kV feed-in down to the low-voltage distribution as a whole system from a single mold. From the beginning, we integrate subsequent expansions in our planning by consistently focusing on the principle of redundancy and high availability.



As a matter of course, we include the supply of the respective facilities in our planning, i.e. the suppliers for water, waste water and compressed air systems. In addition, we develop matching solutions for protection and communication as well as emergency power concepts for the entire network.

This way we do not only ensure that your plant's power demand is perfectly tailored to the performance potential of the public grid, but also that the quality of power supply can be reliably maintained in your production sites even at load peaks.

Integrated power distribution from the feed-in to the power consumer

A uniform power supply concept ensures safe and profitable power supply for all areas of production. In addition, there is the option to adapt in-process power demand flexibly and quickly to ever faster model changes.

Not only will you profit from an rise in plant availability – the quality of your products and the service life of your machinery will also increase noticeably. This way optimal power supply helps ensure the efficiency and profitability of your automotive production.

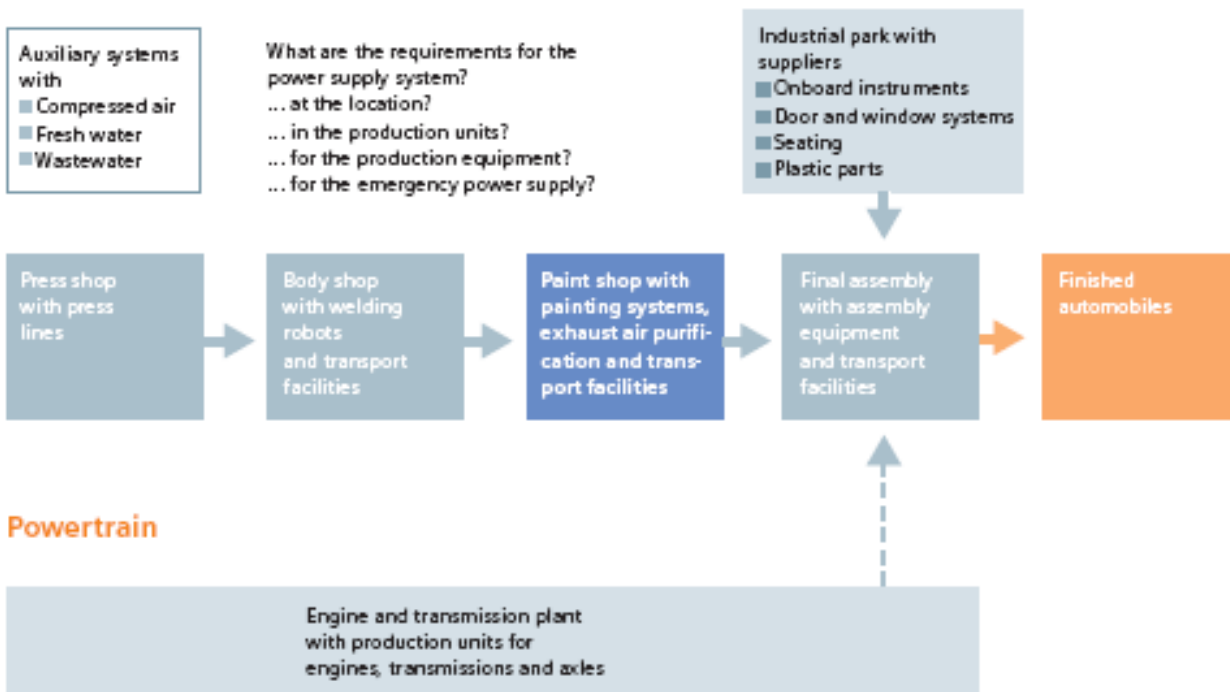
### The pillars of automotive production and their auxiliary plants

The process of automotive production is divided into the two main pillars:

- ▶ Automobile production
- ▶ Engine and gearbox production

We create separate supply solutions for these sectors and their auxiliary plants ranging from the primary supply and emergency supply to protection technology including communication.

## Automotive manufacturing



### Load optimization and fault identification

Energy saving, load optimization and fault identification play an important part in a modern automotive production process.

Siemens provides suitable control and power monitoring systems for this purpose.

By using protection relays (SIPROTEC 7SJ62), analog / digital input and output modules (SIMATIC ET 200) for integrating the transformer load center substations, universal power meters (SIMEAS P100) and the SICAM PAS power monitoring system, important electro-technical parameters are visualized and switching operations are performed.

The end-to-end integration of all voltage levels and the additional integration of further important signals from the plant environment enables a fast overview of the power supply status in the automotive plant at a central location, in which all states, measured quantities and alarms are displayed. This supports fast fault identification and troubleshooting. More-over, the use of industry-tested components ensures high plant availability and operational safety. A plant expansion involving additional event signaling and measured values can be integrated into the visualization system without any problem.

### Energy saving

Energy saving can be attained by using efficiency-improved components or improved processes. The first includes inverters which are capable of energy recovery, energy saving motors and transformers.

SIMATIC WinCC powerrate, the power management system, serves to improve processes. The SENTRON PAC 3200 multi-function measuring instrument acquires measured electrical quantities and operating data in the low-voltage network. The are processed in the SIMATIC WinCC powerrate or SIMATIC PCS 7 powerrate software applications. Cost center allocation makes energy cost transparent, a comparison with similar processes can demonstrate saving potential. The load curves recorded allow fore-casts and thus more favorable conditions of procurement.

Continuous, seamless acquisition of all energy-relevant data provides the maximum of transparency, and in addition, with the aid of standard evaluations, it allows to draw conclusions of the energy consumption behavior and possible saving potential.

The modern communication-capable switches, such as SENTRON circuit-breakers, can be integrated into the power management system. Load feeders can be connected into or disconnected from supply accordingly with load optimization in sight.



## Redundancy

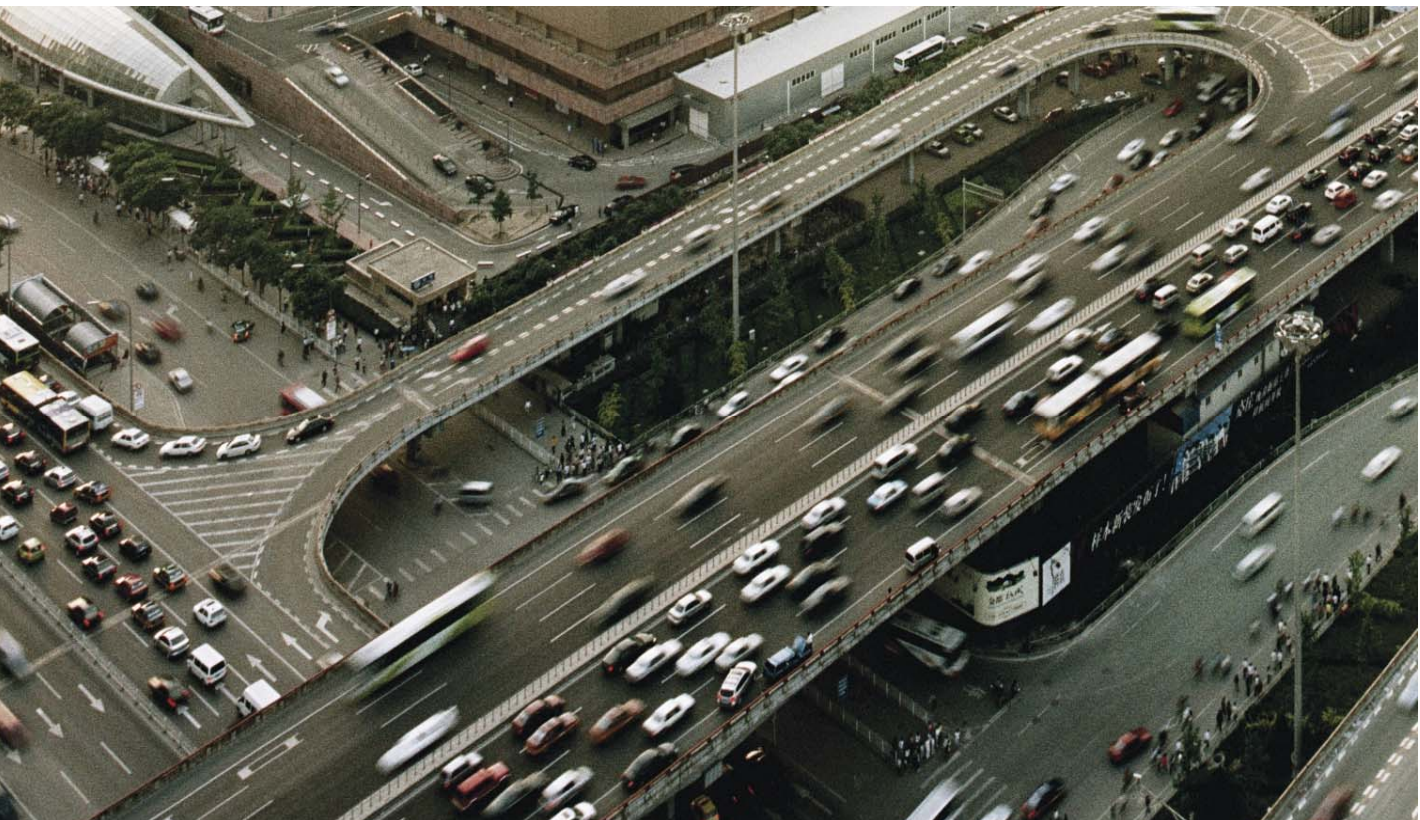
Redundancy and reliability of supply are two of the most important requirements in automobile production. High redundancy and availability are attained at the high and medium voltage level through ring-main networks and different separate feed-in systems from the transformer substations. The “n minus 1” principle (if one feeding source fails the remaining units can ensure supply of the total demand) for transformer utilization points the way in this context.

Another important requirement in the automotive industry is meshing the load center substations at the low-voltage side in order to ensure a very stable reliability of supply for the production facilities. This meshing of individual substations is performed through busbar systems as a ring-main network. In many cases, this meshing must also provide for the basic power supply of large power consumers in the respective production section.

As a result, the following aspects are dominant:

- ▶ Very high level of supply reliability (redundancy)
- ▶ Stable and rigid power system conditions
- ▶ High short-circuit strength and resistance to accidental arcs
- ▶ High degree of protection
- ▶ Flexibility of power tapping options
- ▶ Load feeders close to the load
- ▶ Many feeder locations
- ▶ Adjustability of the tap boxes under no-load conditions with busbar in operation (live plugging)

The user’s technical departments shall perform the concept planning and define standards, they will be supported by Siemens.



## Requirements and trends

### EMC compatibility and protection against personal injury

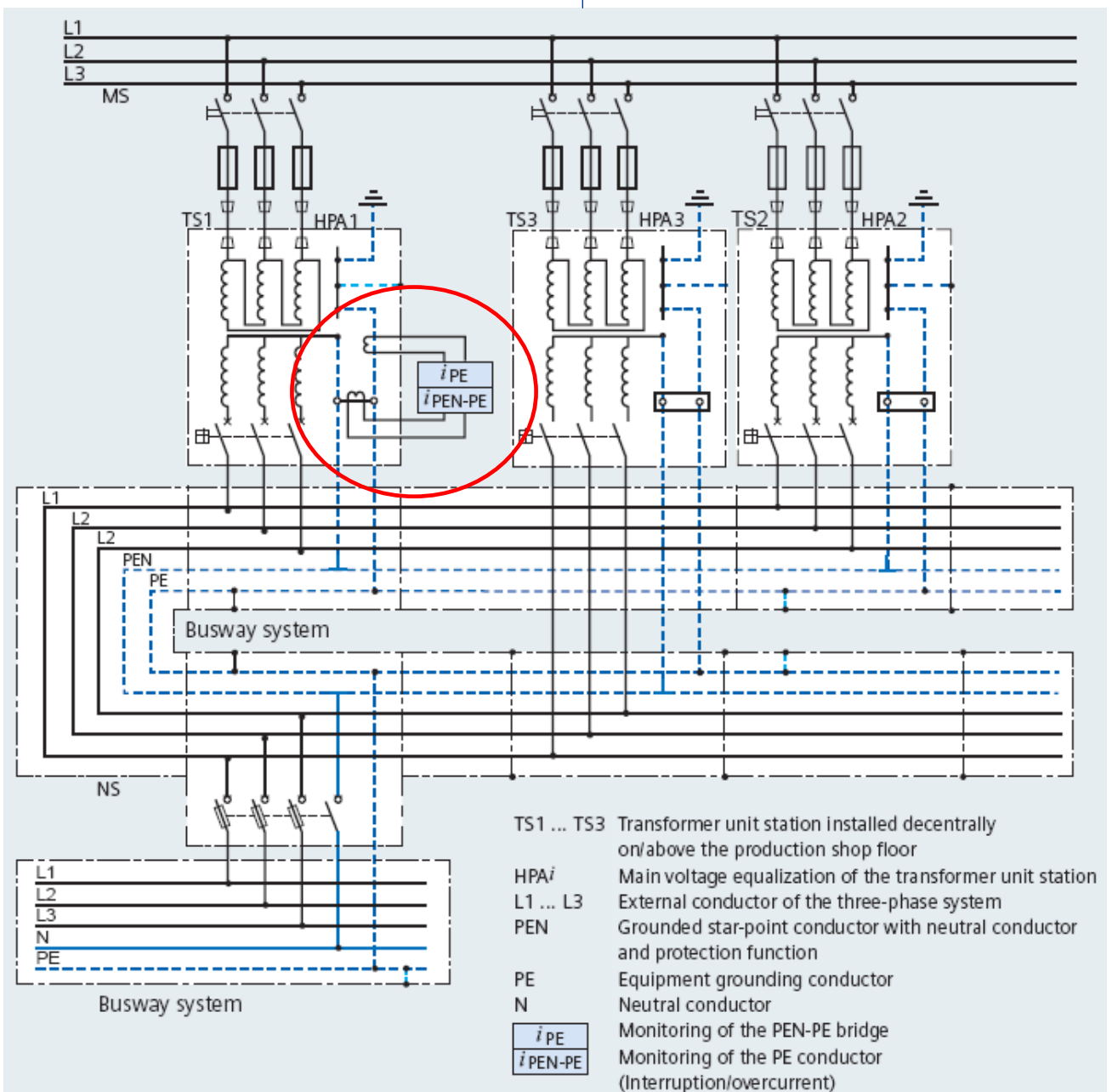
Modern production processes can only work reliably and safe if all kinds of EMC faults are ruled out. The use of 1-pole consumers in TN-C systems (a system with common protective earth and neutral conductor) results in asymmetric load and thus in a raise in potential of the common PE and neutral conductor. Electronic equipment as used in modern production cannot function reliably in such an environment.

Only TN-S systems (systems with separate protective earth and neutral conductor) provide sufficient protection against EMC faults due to conductive coupling.

Here, the goal is a separate protective earth conductor which is completely unaffected by the operating current. When TN-S systems with distributed multiple feed-in are designed, it is, however, difficult to harmonize high electro-magnetic compatibility with a high level of operator safety.

Appropriate planning measures such as a central grounding point, or 4-pole coupling switches between system feed-ins with several grounding points ensure EMC plus protection against personal injury in industrial low-voltage networks with distributed multiple feed-in. Thus all requirements of protection against electric shock are met in compliance with standards.

#### Multiply fed low-voltage network with central grounding point and protective earth monitoring



## Power quality in terms of energetic recovery and harmonics

A lot of inductive consumers, mainly drives which are speed-controlled by frequency inverters, are used in modern automobile production facilities. This creates system perturbations in the form of harmonics. This means in detail:

The frequency inverter current is composed of a mixture of sine-shaped currents, a harmonic content with the system frequency and a number of harmonic waves whose frequency is a multiple of the system frequency. The harmonic currents are forced upon the three-phase system. For this reason, harmonic voltages are generated at the system impedances which overlay the fundamental component and result in a distortion of the system voltage. This leads to system disturbances and the failure of other consumers.

IEC 1000 defines the most important determinations and compatibility levels regarding power quality.

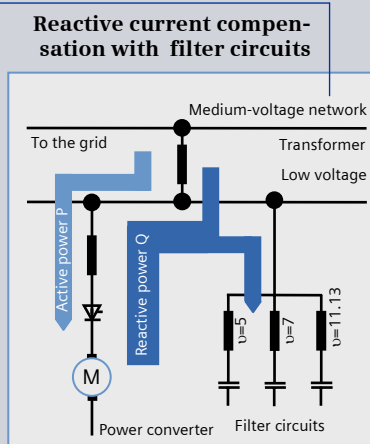
Filter circuits which are placed directly at the low-voltage side can largely keep harmonic currents away from the higher-level network. Filter circuits are built up from series resonant circuits which consist of capacitors with upstream-connected reactors. The resonant circuits are tuned in such a way that they act as resistors for the individual harmonic currents, these resistances are near zero and thus smaller than the resistances in the rest of the system.

Therefore, the harmonic currents of the power converters are largely absorbed by the filter circuits. Only a small remainder flows into the higher-level three-phase system, it hardly distorts the voltage at all and does not affect other loads. As filter circuits always form a capacitive resistance for the fundamental component of the three-phase system, they also absorb a capacitive fundamental component current besides the harmonic currents. This way they contribute to the reactive power compensation of the power converters and other installed loads in the system.

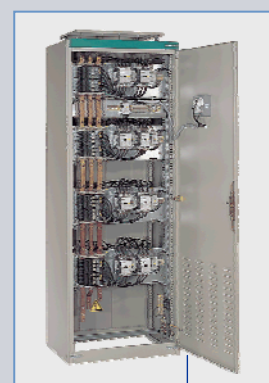
In order to avoid resonances, it is necessary to use choked capacitors for reactive power compensation. These capacitors are designed like filter circuits, but their resonance frequency is below the harmonic of the 5th order. This way the capacitor unit becomes inductive for all harmonics present in the power converter current. Resonance locations cannot be energized any more. By using choked capacitors in reactive power compensation units, a uniform energy concept is compensated wherever the proportion of harmonic producing loads is more than 20% of the total load. This ensures an optimal power quality regarding harmonic waves for all load requirements in the power system.



The DC blocks of the power converter consist of the fundamental component and the overlaid harmonic components



Choked power-factor correction unit 400 kVA



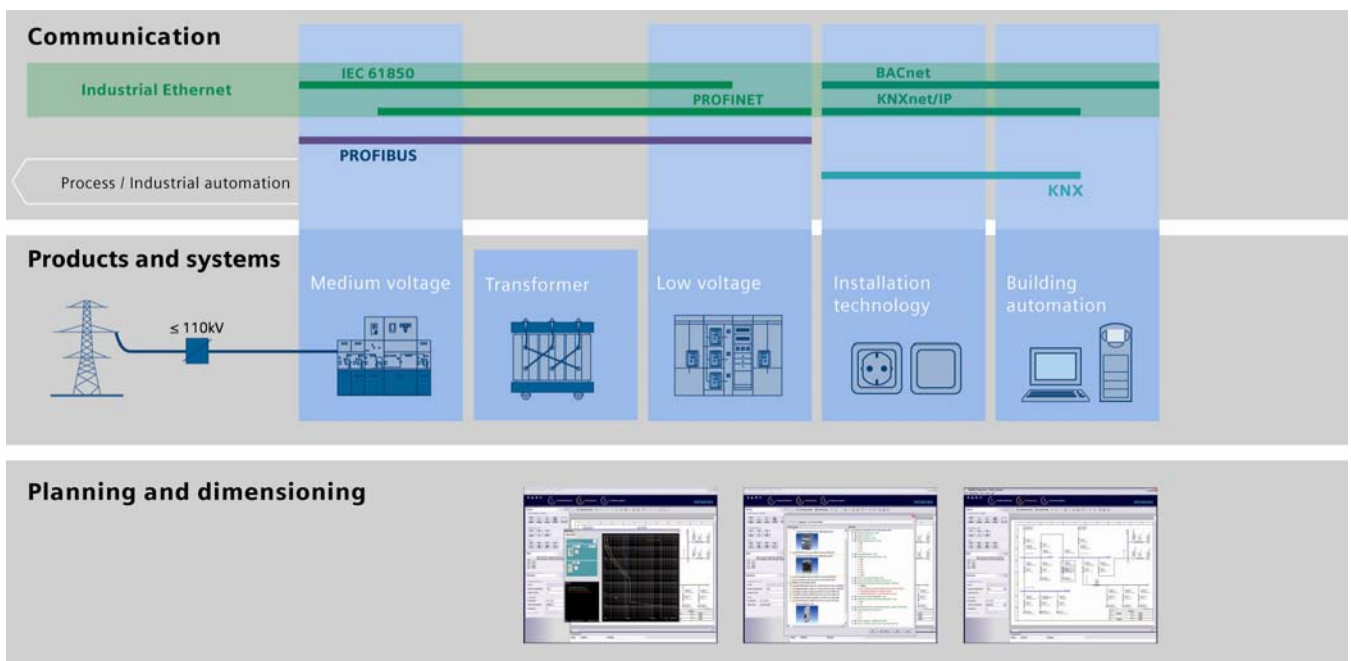
# Technology Platform Totally Integrated Power

## Integrated power distribution from the feed-in to the consumer

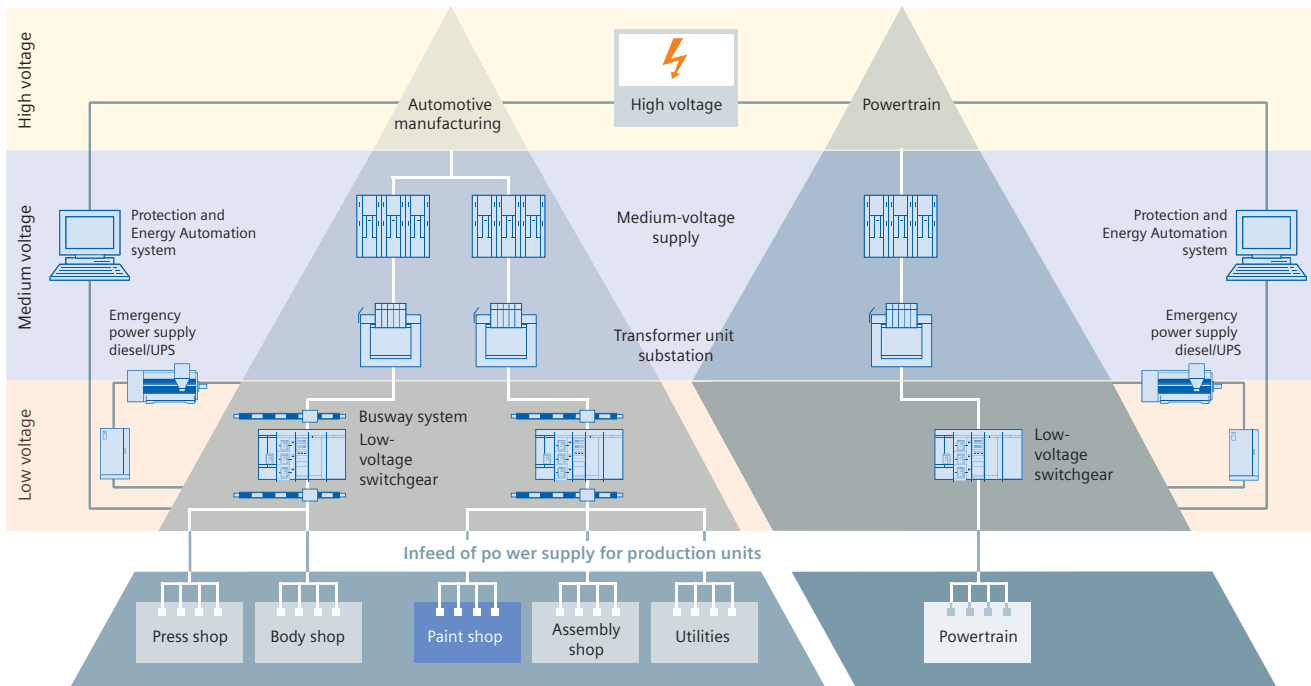
Totally Integrated Power™ (TIP) refers to integrated electrical power distribution in commercial and industrial buildings; from the medium voltage supply fed in by the utility company right up to the final electrical consumer.

Totally Integrated Power is underpinned by an array of helpful tools and support for accurate design, dimensioning and configuration of electrical power distribution within buildings. A coordinated product and systems portfolio for the construction of these systems is rounded off by standardized interfaces between the system components and the higher-level human-machine interface systems as well as for the connection to control and management systems.

In this way considerable savings can be made across the whole project cycle – from the planning stage, installation and start-up right through to operation. The necessary investments in the electrical infrastructure of the automotive plant can be optimized in line with demand and also with subsequent operating costs in mind. This optimization potential represents significant added value for everyone involved in the project.



## Totally Integrated Power in the automotive plant



### Your advantage of using the Totally Integrated Power technology platform in all project stages

Investments must pay off: for this purpose the dimensioning of the installation is optimized. With the aid of the SINCAL software tool different load flows at the top-level power system and the supply rings are simulated and components are then optimized accordingly. The lower-level spur lines are optimized with the SIMARIS design dimensioning software.

Necessary adaptations of the production lines in case of production conversions are also supported by these tools (SINCAL, SIMARIS design).

Network calculations in case of modifications result in reduced investments, because unnecessary reserves are not provided for.

End-to-end type-testing of switchgear and busbars ensures an unproblematic integration of installation parts especially with regard to the required safety of persons. The safety proofs were provided by the manufacturer. The system properties of the integrated portfolio are known and kept in the software tools so that integration works smoothly. Many of the protective settings are already available through the system simulation. This speeds up commissioning. Upon customer request, Siemens will take over the complete installation contract.

In addition, Siemens supports electrical consultants with personal consultations in almost every planning stage.

# Power System Structure

## Level 1: primary supply

We provide all-in-one solutions for the supply of production units from the feed-in to the power consumer, ensuring optimal quality of supply – and thus a reliable and highly productive process operation.

Tailor-made to the requirements of the respective plant, we design the primary supply in such a way that all requirements from production are accounted for: the present electricity demand as much as the forecasted one plus the system perturbations and load profiles of the machinery and equipment in the individual shops and the required short-circuit strength. All of our systems are designed for service friendliness. This way you can easily expand your production facilities with our modular and standardized system components – while enjoying the freedom of flexibly adjusting the power supply to your demand.

## Level 2: protection and communication

Another challenge that we meet in conjunction with power supply is the protection of man and machinery. Within the scope of our solutions we ensure that conditions for disconnection from supply are observed at any time and that neither man nor machinery will be harmed.

On the one hand, you will protect your facilities against possible damage by our tailor-made solutions for automating power supply, with the main focus on protection and power quality, substation automation and power management, on the other hand, we thus guarantee a constant quality of the electrical energy and hence the production processes. In addition, automating power supply ensures that unforeseen events can be quickly responded to and a possible interruption of supply can be avoided.

## Level 3: emergency power supply

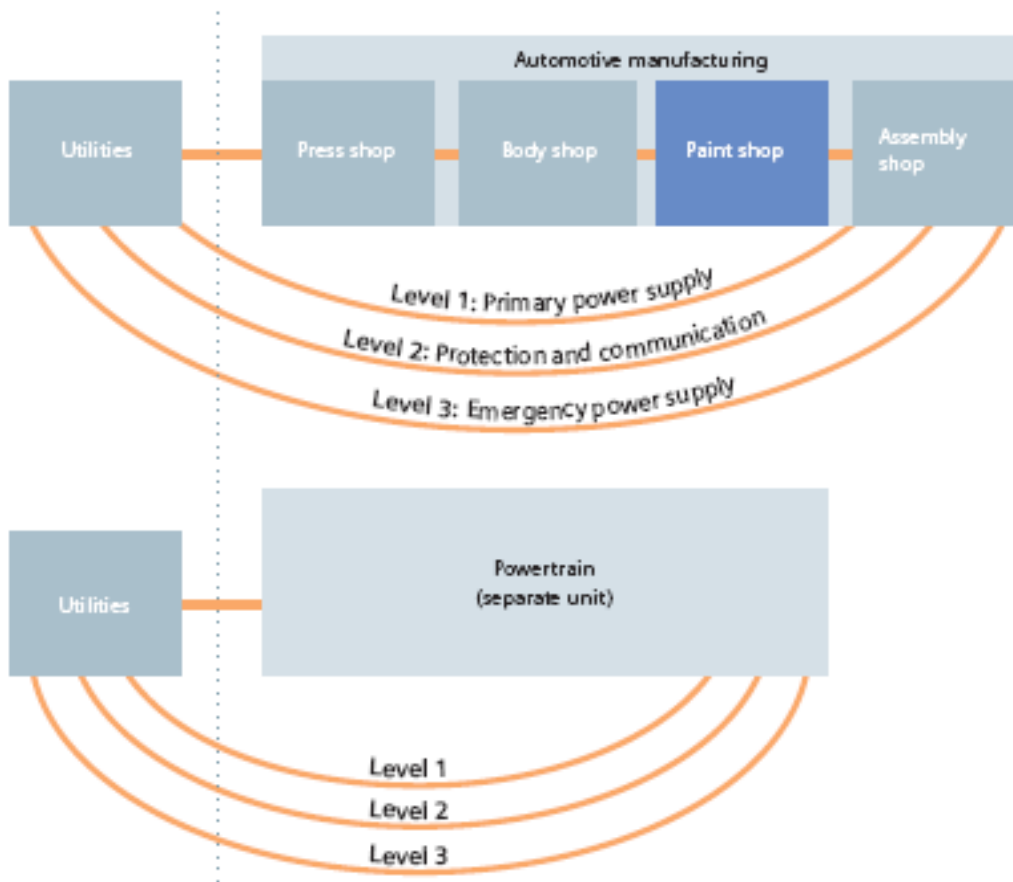
What if power supply really fails one day? In this case it pays that the emergency power supply of the machinery and facilities has been tuned to your real demand.

Which areas of production have to be supplied uninterruptedly? Where is a short interruption of power supply permissible / not permissible? When planning emergency power supply in line with these requirements, we make sure that it is designed in such a way – with uninterruptible power supply units, batteries and diesel generators – that a blackout has as little effect as possible and your vital processes continue to work.

Our project teams take over all tasks within the framework of planning and implementation. This way you do not only avoid problems caused by more than one interface, since all components are perfectly matched, the availability of your plant will also rise.

Thanks to our competence and long-standing experience in numerous projects in the automotive industry, we are capable of meeting all demands on a safe and totally reliable power supply. At the same time, our experienced teams ensure fast and smooth project administration for you that also takes into account your plant engineering manufacturers and OEMs. So that you can produce and supply the market faster.

## The three levels of a power supply solution



# Power Supply Scheme in the Automotive Industry

The block diagram below describes the power supply scheme in the automotive industry. It shows the separate supply of the two main pillars, automobile production and engine and gearbox production. Power supply is viewed from the high-voltage level down to the feed-in for the production machinery.

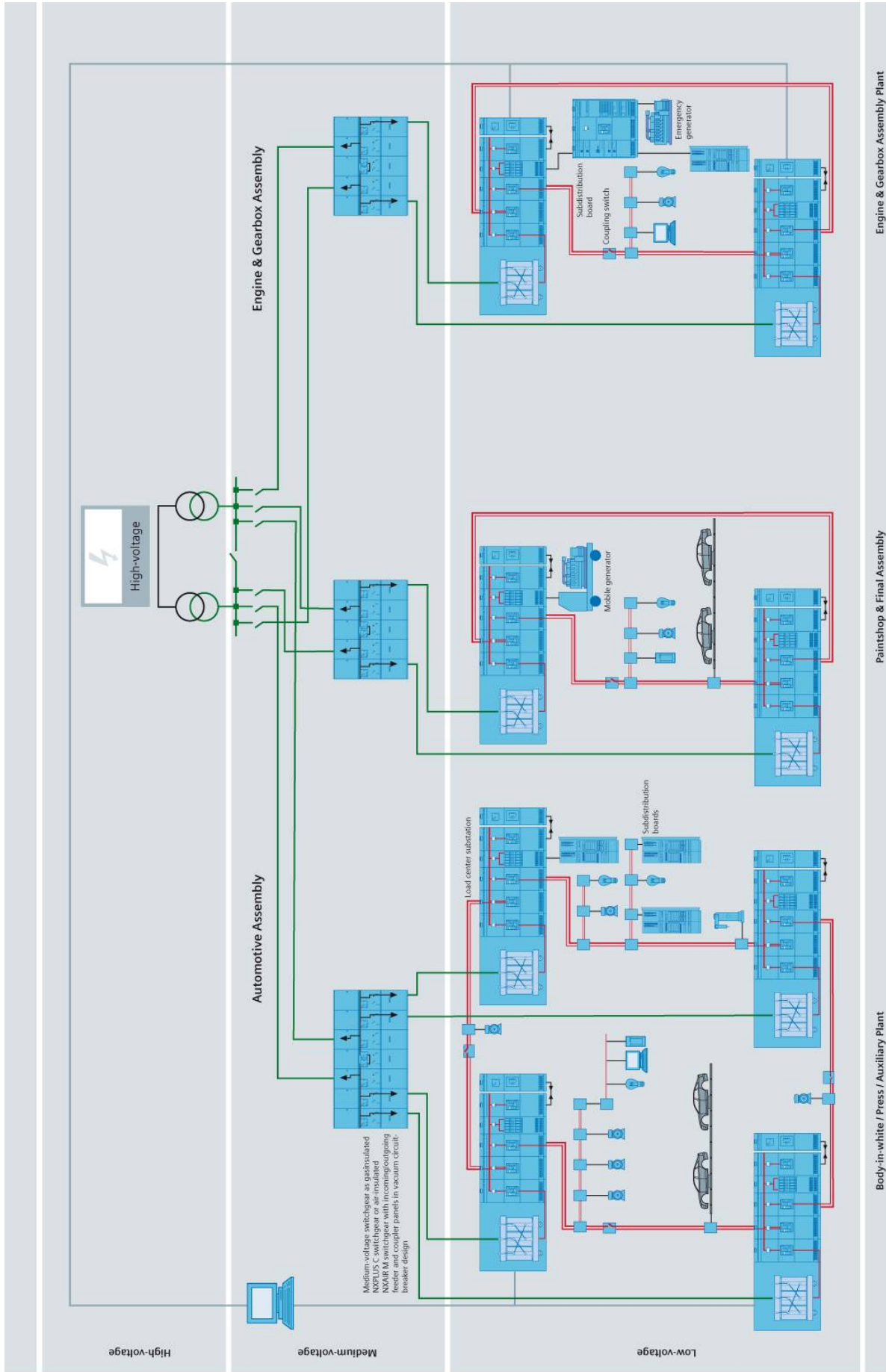
System configurations are described which are typical for automotive production, such as changeover possibilities at the high and medium-voltage level – which are necessary to create redundancy – and the typical meshed low-voltage ring provided by a high-current busbar system that can be coupled.

The diagram points up load-center substations with their typical panel variants, such as transformer box, low-voltage feed-in panel, busbar meshing panels, in-line LV HRC fuse-switch-disconnector panels and the choked reactive power compensation unit. As this switchgear is placed directly within the production area, very high requirements are imposed on its resistance to accidental arcs.

Siemens provides system solutions for the individual production steps of an automotive plant (such as body-in-white production, paint shop, assembly etc.). At the low-voltage side, the corresponding load-center substations are connected to each other by LD-type busbars (2,500 A to 3,200 A). In order to limit the short-circuit power to a maximum of 100 kA, suitable coupling switches are built into the busbar route which divide the supply ring into network sections. If one load-center substation is off – due to a fault or maintenance – the missing power demand can be covered by another network section by closing the corresponding coupling switch. These busbars often run at a height of four to thirteen meters along the walls of the production halls or in the heading course.

Besides their task of building up a meshed-ring system, these high-current busbars (LD busbar system) also supply large power consumers in the production sections, such as robot groups, main distribution boards or smaller busbar supply systems via tap boxes. Busbar systems for medium currents (type BD2: 160 to 1,250 A) supply subdistribution boards or equipment in this area in a flexible way. Power distribution for the supply of small and ultra-small consumers (16 A to 100 A) is performed by the busbar system types BD01 and CD-K. Using busbars which are matched to the requirements of automotive production provides the following advantages:

- ▶ Safe transmission of high currents
- ▶ Significant reduction of cabling
- ▶ Low fire load
- ▶ Fast installation / dismantling
- ▶ Unproblematic dismantling when equipment is moved
- ▶ Fast extension possible
- ▶ Low planning expense involved compared to cable installation
- ▶ High flexibility when the technology structure is changed
- ▶ Tap points close to the consuming equipment
- ▶ Transparency of power distribution
- ▶ Reduction of subdistribution boards
- ▶ Transparency of distribution regarding power consumers
- ▶ Easy extension by standardized tap boxes
- ▶ Unproblematic change of power consumers
- ▶ Option for metering power consumption in the tap box



**Legend**

- Low voltage
- Medium-voltage

- SIVACON Busbar systems:
- 8PS - 1yp/Type LD
  - 8PS - 1yp/Type BD2
  - 8PS - 1yp/Type CD-K

**Body-in-white / Press / Auxiliary Plant**

**Paintshop & Final Assembly**

**Engine & Gearbox Assembly Plant**

**Load center substation**

- Transformer box with GEAFOL transformer, cast-resin-insulated
- Incoming feeder panel
- Meshing panel
- Outgoing feeder panel with fuse combination units
- Choked compensation unit, cable connected
- CB outgoing feeder panel

# Presentation of the Portfolio Components Applied

## Compact 110-kV GIS 8DN8 switchgear



Features	Advantages
Small, compact design	Low space requirements, low property cost
Short planning, delivery and installation times	High flexibility, easy planning
High availability, low maintenance expense	No interruptions of production
Long service life (> 50 years)	Future-proof investment

## NXAIR medium-voltage switchgear



Features	Advantages
Modular design	Higher availability through easy module replacement
Draw-out vacuum circuit-breaker	Simple, safe and comfortable handling
Current transformer principle and pressure-resistant compartmentalization	Selective disconnection in case of internal module faults
Ergonomic design and self-explaining operating logic	Simple and user-friendly handling
Reliable protection of the load-center substations by means of switch-disconnector and fuse combinations (selection and rating in compliance with IEC 62271-105)	High safety for operators and machinery (arc flash energy < 30 kW)
Integrated SIPROTEC protection relays	High flexibility combined with the utmost of safety and quality

## NX PLUS C medium-voltage switchgear

Features	Advantages
Small, compact dimensions	Low investment in buildings owing to compact dimensions and independence of climatic impact
Independent of environmental and climatic impact	Maximized reliability of supply
Maintenance free	Minimum life cycle cost
Live parts hermetically enclosed, arc fault test	Maximum operator safety
Low risk of fire	Reduced operating cost – no additional maintenance cost

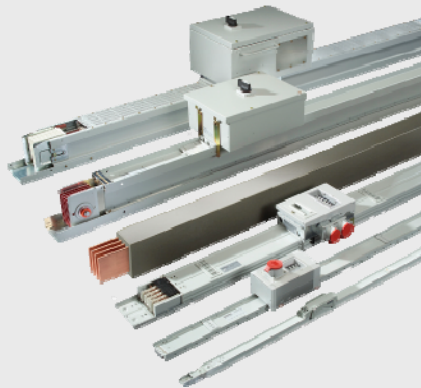


## Medium-voltage switchgear with integrated SIPROTEC protection technology and SICAM energy automation technology

Features	Advantages
End-to-end solution covering all voltage levels	Higher availability thanks to fast identification and rectification of problems
Scalable solution for protection, control monitoring and automation	Future-proof, simple adaptation to customer-specific requirements
Central operator control and monitoring	Higher availability thanks to short response times
Use of standard components	Interfacing to other systems possible, components can be replaced, high safety



## Power supply of a welding line with SIVACON 8PS low-voltage busbar systems and tap boxes



Features	Advantages
High-current range 800 A to 6,300 A	Safe transmission of high currents
Low-current range 25 A to 800 A	Significant reduction of cabling
Tap boxes with fuse-switch-disconnectors or circuit-breakers	Low fire load
Arc-fault-tested tap boxes in compliance with IEC 1641 and VDE 60439	Fast installation & dismantling
	Unproblematic dismantling when equipment is moved
	Fast extension possible
	Lower planning expense involved compared to cable installation
	High flexibility when the technology structure is changed
	Tap points close to the consuming equipment
	Transparency of power distribution
	Reduction of subdistribution boards
	Transparency of distribution regarding power consumers
	Easy extension thanks to standardized tap boxes
	Unproblematic change of power consumers
	Option for metering power consumption in the tap box

### SIVACON S8 low-voltage switchgear

Features	Advantages
Type-tested switchgear	Highest safety and quality
Standardized modules	Simple component replacement and high system availability
High packing density with up to 40 withdrawable units per panel	Extremely compact design with low space requirements
SENTRON circuit-breakers and SIMOCODE pro motor management system	Integrated protection technology communicating via PROFIBUS DP
Resistant to accidental arcs	Utmost of safety for man and machinery



### SITRABLOC transformer load-center substation

Features	Advantages
Type-tested transformer load-center substations	Utmost safety and quality of the transformer module
Non-flammable GEAFOL dry-type transformers	Use in the load centers of production processes
Temperature control by specific cooling	Maximum operator safety
Arc-fault-tested	Up to 140% overload



**Emergency power supply using MASTERGUARD uninterruptible power supply and associated low-voltage distribution boards**



Features	Advantages
Double converter technology in compliance with VFI-SS-111 from 0.7 to 6,400 kVA	Uninterruptible operation and “Class 1” supply quality
High efficiency ratios	Low heat dissipation and favorable operating cost
Digital signal processors and vector control for real-time control	Optimized load protection in case of power system or load-side faults
Parallel switching capacity for UPS systems $\geq 6$ kVA output power	Modular expansion possible and higher availability owing to redundancy

**Diesel generators for emergency power supply**



Features	Advantages
Intelligent complement to existing power supply	Supplies in critical situations
Versions available from 25 kVA up to 5.000 kVA	Worldwide availability in compliance with regional requirements and regulations
Part of a well-matched all-in-one solution for a UPS system from a single supplier	Integrated in the total solution of the power supply system

# Professional Planning Aids

Planning electrical power distribution for commercial and industrial buildings has never been as complex as it is today. The planning process demands a great deal of specialized knowledge and experience. With an experienced partner at their side, electrical engineering consultants can implement their conceptual expertise more quickly and easily and concentrate on the important things. SIMARIS design and technical manuals from Siemens offer comprehensive support, from the preliminary planning stage right through to implementation planning.

### SIMARIS design

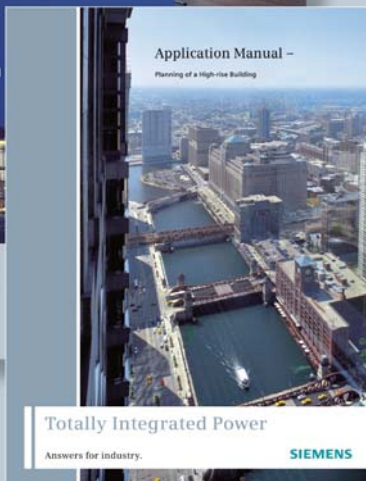
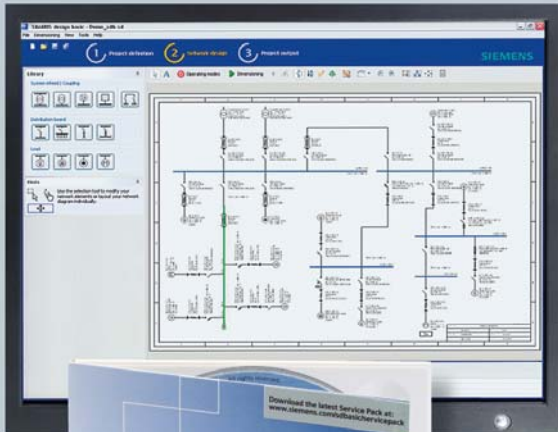
The SIMARIS design dimensioning software supports our complete, integrated and high-quality portfolio from medium voltage technology through to wall outlets. The user-friendly TÜV-certified tool also generates the necessary selectivity verification, for instance for emergency power supply systems. It also lightens the load enormously in routine work such as implementing changes and considering variants.

### Application manuals

Siemens application manuals offer electrical engineering consultants a wide knowledge and information base to draw on when designing electrical power distribution systems.

There are three volumes, available from regional Siemens contact partners ([www.siemens.com/tip/support](http://www.siemens.com/tip/support)):

- ▶ The application manual “Basic Data and Preliminary Planning of Power Distribution Systems” provides electrical designers with in-depth information to support them in their work during these two phases.
- ▶ The application manual “Draft Planning of Power Distribution Systems” provides useful information on this project phase.
- ▶ The application manual “Planning a High-Rise Building” documents concrete applications of the power distribution products and systems using the example of an office tower.



## Further information

You can find more information on  
Totally Integrated Power on the Internet at:  
[www.siemens.com/tip](http://www.siemens.com/tip)

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