WHITE PAPER

The changing world of building **electrical systems**

The demands placed on the electrical infrastructure in buildings have grown steadily more complex in recent decades. This is primarily due to the nature and quantity of electrical loads being connected to the grid. While the average household used to hold around eight electrical loads requiring power feed, that number today – due to conveniences such as microwave ovens, dishwashers, and consumer electronics – often tops 70. Yet, that's just one of many changes to the general conditions demanded of modern building electrical systems. This white paper aims to explain these challenges and present some options that provide solutions.

SIEMENS

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Modern electrical loads pose new requirements

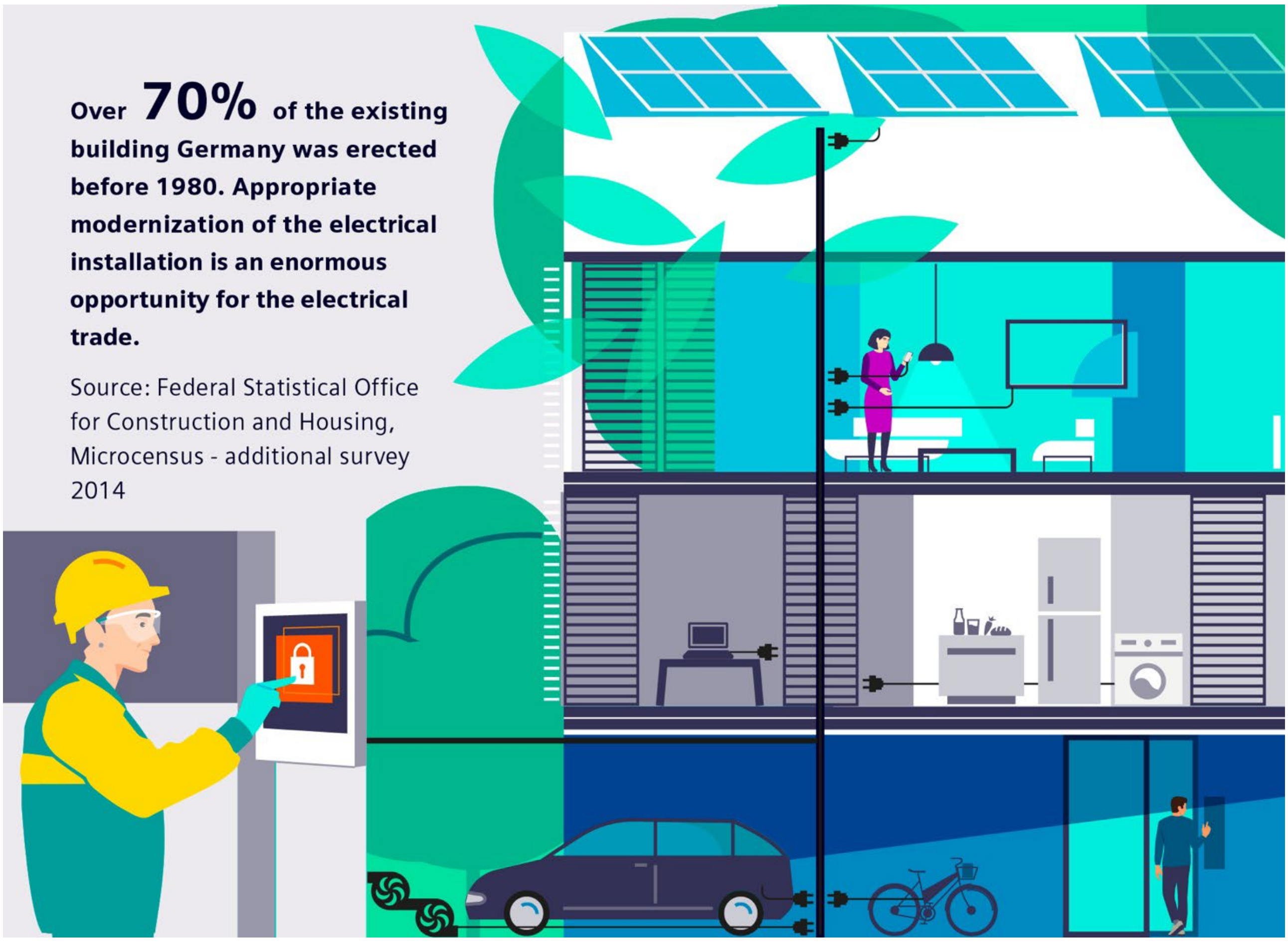
Besides the shear quantity of electrical loads, the nature of these power consumers has also changed. With governments subsidizing energy efficiency measures today, it makes sense to use modern, efficient electrical devices. In addition, renewable energy sources like photovoltaic solar power systems or additional electrical loads such as electric vehicles are being integrated into household electricity power distribution systems. What's more, the rising price of raw materials like oil that comes with carbon taxation increases the cost of operating older heating systems, and makes alternatives such as heat pumps economically sensible, even in existing buildings.

However, while such equipment promises gains in efficiency, these electrical loads pose more demanding characteristics in terms of their electrical current draw. This is why distinctions must be made between equipment types when selecting a residual current circuit breaker (RCCB). If a fault occurs, the frequency converter of a heat pump with inverter technology, for instance, can generate high-frequency residual currents and smooth residual currents. This is why a "conventional" type A RCCB would no longer trip under these fault conditions, thereby failing in its protective function. Many energy-efficient and flexible electrical loads use such frequency converters and generate mixed frequencies. They therefore cannot be safely operated with obsolete building electrical systems. This is because the types of residual current circuit breakers installed in older systems are not designed to deal with residual currents arising from high- and mixed-frequency current.

If an electrical cable is inadvertently pinched or crushed, hit by negligent use of a drill or otherwise damaged by external impacts, an RCCB compliant with the relevant codes and standards will trip and prevent any serious consequences, including fire. According to fire statistics of the German Institute for Loss Prevention and Loss Research of Public Insurers (IFS), 30 percent of all fires in buildings in Germany are caused by defective electrical systems. The statistics in other countries are similar to Germany's. An outdated electrical system equipped with RCCBs incompatible with the connected electrical loads can no longer ensure the intended protection and safety.

Building electrical systems must keep pace with the continuously advancing technical state of the art. This includes, besides the afore-noted new types of electrical loads, the increasing automation of building infrastructure. Moreover, decarbonization measures put high demands on modern, futureproof safety and protection concepts. In future, fewer and fewer cars will fill their tanks at service stations, rather they will be recharged with electric power at home in your garage, just like e-bikes. New forms of distributed power generation such as wind farms, photovoltaic power installations, and combined heat and power (cogeneration) plants, associated energy storage systems and other applications entail the need to expand and adapt building electrical systems. While (historical) building preservation regulations apply in this domain as well – only when buildings are renovated or modifications made to their electrical systems do these systems have to be renovated to the state of the art – safeguarding of new electrical loads with adequate RCCBs is, for safety reasons alone, always a wise choice.

Relevant technical standards such as the DIN VDE 0100 series in Germany are likewise being adapted, step by step, in line with these new challenges. This has consequences not just for the construction of new buildings. Owners and operators of existing legacy properties, too, will have to invest in suitable modernization of their building electrical systems. Considering the numbers involved, these needs present enormous opportunities for the electrical trade.



Criteria for selecting the right residual current device

Protective electrical circuit breakers protection devices are used to protect people, animals, and material assets against the dangers that can arise from electrical systems carrying up to 1000 V AC or 1500 V DC. It's important to select and install the right electrical equipment to disconnect, connect, control, and monitor electric power. These choices are based on ensuring that the necessary protective measures are in place and the electrical system functions properly. Systems and devices for protecting against electrical injury shock, such as residual current devices (RCD), must be defined in accordance with the given electrical equipment and its specific application.

There have been changes in this field that affect the selection of fitting RCCBs for specific electrical loads, the use of type F RCCBs, and the distribution of electrical circuits over multiple residual current devices (RCDs) within a single system. The use of multiple RCDs can ensure, in case of an incident, that the only part of the system that fails will be that part in which the residual current actually occurs.

Short-time delayed RCCBs are recommended for new electrical load situations such as LED lighting, as these prevent any false trips that can occur if a standard, conventional RCCB is used.

The choice of the right RCCB depends on the connected electrical loads, the types of residual currents associated with that equipment, and the site of installation. Mixed frequencies can occur due to the steadily broader use of electronic components in electrical loads and of single-phase frequency converters in e.g. vacuum cleaners, washing machines and other household appliances. Type F RCCBs trip when these residual currents of mixed frequencies arise. If a standard type A RCCB fails to trip within the required time due to functional impairment, it may be necessary to use a type F RCCB. Type F RCCBs are designed for short time delay as a standard feature, which ensures additional failsafe capacity.

In most cases, it's helpful to take a look at the electrical load's operating instructions to aid in making the right choice of residual current circuit breaker. It's sensible in any case to do futureproof planning so that requirements governing the choice of RCCB do not depend alone on the electrical loads presently in use. The maximum safety objective is always achieved when using a type B RCCB – even if the electrical load characteristics or possibly the site of installation are unknown in advance or may possible change over time.

The right RCD

For any application

Type B

Like type F, additionally:
- Smooth DC residual currents
- Action value up to 2 kHz

Application examples:
- Photovoltaic systems
- Escalators/Elevators
- UPS systems
- Charging infrastructure for E-Cars
- Consumer with 3-phas.
- Converter

Type F

Like type A, additionally:
- Residual current by frequency mixture

Application examples:
- Consumer with single phase frequency converter
  - Washing machine
  - Vacuum cleaner
  - Ventilation systems
  - Energy-saving pumps
- Induction fields

Type A

- Sinusoidal AC residual currents
- Pulsating DC residual currents

Application examples:
- In Germany for standard applications

Type AC

- Sinusoidal AC residual currents

Not allowed in Germany

Type B+

Like type B, additionally:
- Tripping value up to 20 kHz
- Tripping within the frequency range and below 420 mA

Application examples:
- Fire threatened premises
- Additional fire protection
- Agriculture
- Wood processing industry

RCCBs make especially good sense where current draw is high. For example, any washing machine, dryer, dishwasher, electric kettle, toaster or other electrical appliance drawing high input power is a corresponding hazard source. Protection with a fitting RCCB is particularly important in such cases, as many of these devices are used in the kitchen where no smoke detectors are installed.

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Electrical loads such as LED lighting also pose particular demands on building electrical systems. When switched on, they can cause operationally high leakage currents which, in case of instantaneous RCCBs, would lead to unwanted trips.

For this reason, it is recommended to use short-time delayed RCCBs to prevent false trips caused by new electrical load situations.

Device

Selective

S

Group switches, for selective trip versus instantaneous and super-resistant

Super-resistant

K

Short-time delayed, prevent unnecessary trips

Electrical ballast | **LED lighting** | **Cooling devices**

SIGRES

SIGRES

For harsh ambient conditions

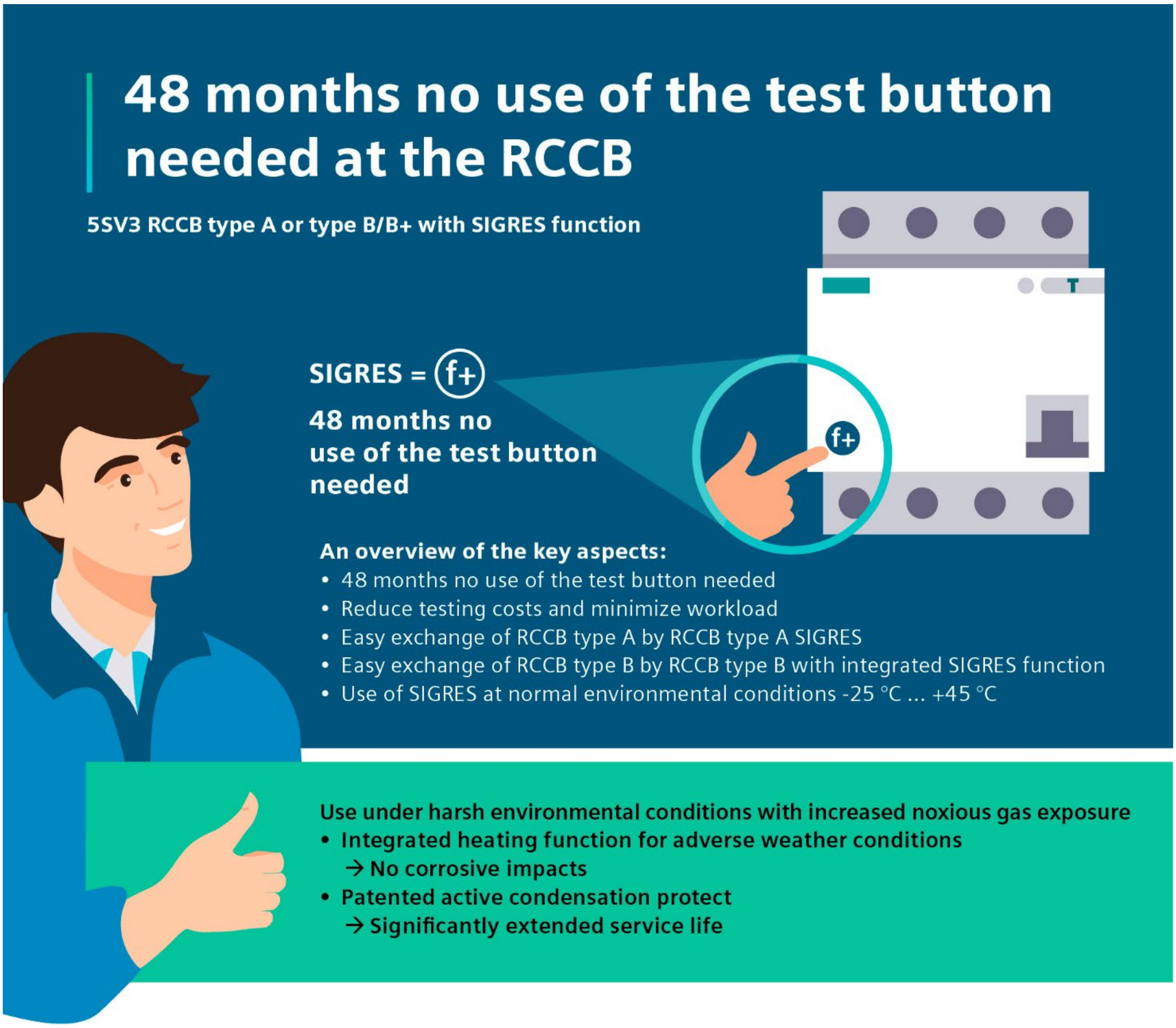
Indoor swimming pool facilities | **Agriculture** | **Industry** | **Marinas**

Long service life under harsh conditions

The SIGRES functionality is integrated in type B RCCBs as a standard feature, and is also available for type A RCCBs as a special series. It provides patented, active condensation protection that also guarantees a high level of safety and long service life under harsh ambient conditions. The heating function integrated into the holding magnet release renders the circuit breaker RCCB resistant to weather conditions such as dew condensation, making it well suited for use in cold storage facilities or outdoor installations, e.g. in port facilities. They can also be used to monitor components of the increasingly important electric vehicle charging infrastructure such as wallbox chargers.

The RCCB's components do not corrode and can even be used in environments exposed to corrosive gas such as indoor swimming pool facilities (chlorine gas and ozone), agriculture (ammonia) and industry (sulfur oxides). Because they're designed to withstand harsh ambient conditions, RCCBs with SIGRES functionality enjoy even longer service lives when used in less demanding operating environments. When installed under normal ambient conditions, you can dispense with pressing the test button for 48 months, as there's no need to interrupt work for RCCB testing. The inspection interval reference guide value for testing electrical installations or stationary electrical equipment is 48 months.

Extending this functional testing interval reduces the work scope for operators as well as the cost of testing and related documentation. Thanks to the uniformity of their size, replacing existing RCCBs with devices designed with SIGRES functionality poses no problem whatsoever.



Besides this SIGRES functionality, there are other, additional factors that allow longer intervals between functional tests. The holding magnets of modern Siemens RCCBs are equipped with gold-plated anchors. Two advantages are gained by using gold: Gold is highly resistant to corrosion and conducts electricity very efficiently. Whereas switching locks are conventionally greased, Teflon as a lubricant prevents moving parts from gumming up. What's more, process reliability in production settings is steadily rising, facilitated by digitalization and automation. These and other developments are contributing to continuous quality improvement that can also be demonstrated statistically by evaluating returned circuit breakers.

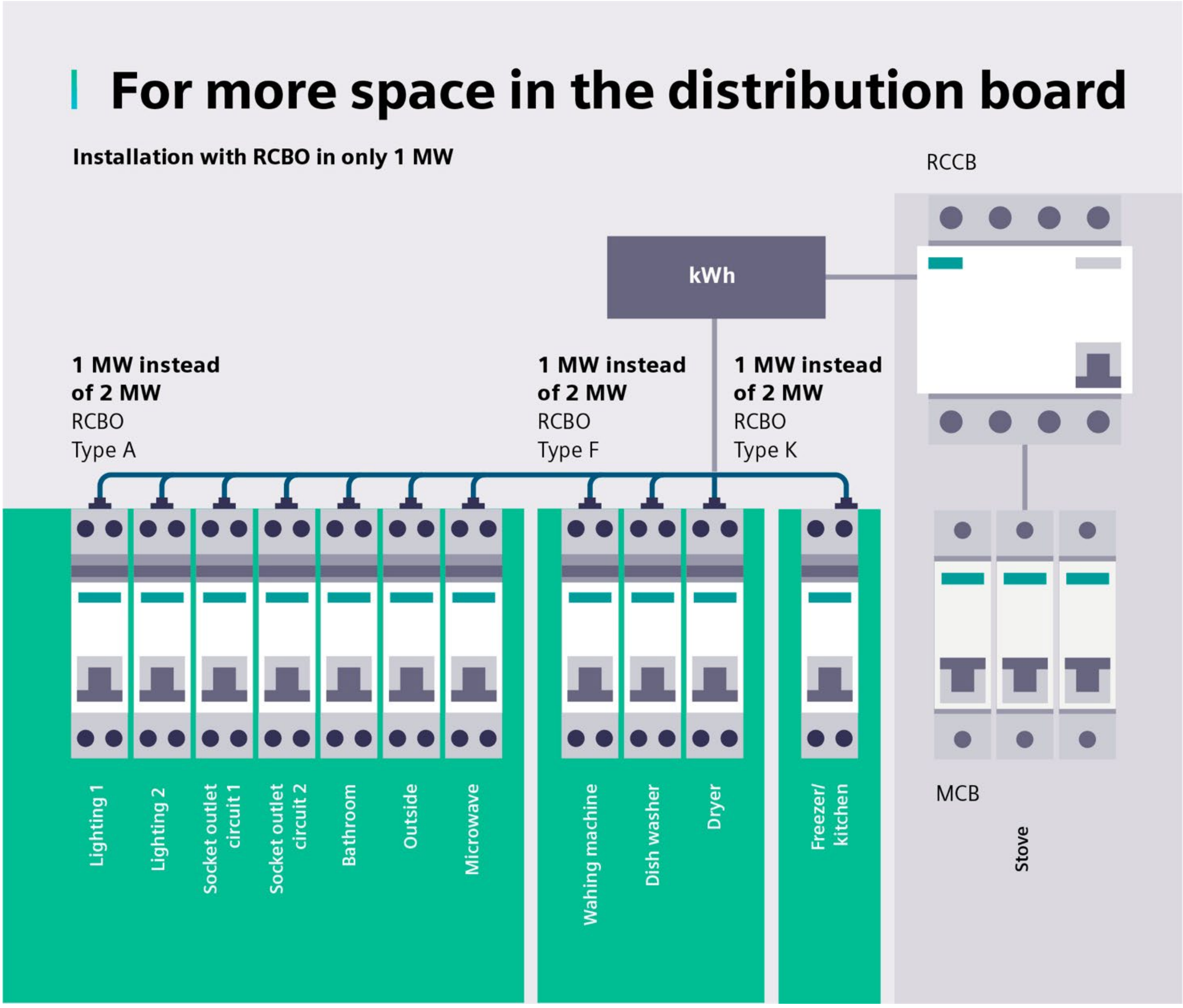
Combined protection within a single modular width (MW)

In RCBO (residual current circuit breaker with overcurrent protection, RCBO) sind Fehlerstromerfassung und In residual current circuit breakers with overcurrent protection (RCBOs), residual current detection and overcurrent protection are combined in a single device, uniting personal safety with line protection. Although RCBOs are a single modular unit, most of them take up two modular widths (MW) when installed.

That can be problematic if, as part of building automation, an RCBO needs to be installed in an existing distribution cabinet board with too little space.

With its 5SV1 RCBO, Siemens has brought a product to market that needs only 1 MW in the distribution cabinet board. The 5SV1 RCBO functions electromagnetically and is therefore the first electromechanical RCBO that's only 1 MW wide and fulfills all IEC market requirements. The RCCB part is offered with rated residual currents of 30 mA and 300 mA in types A, A (short-time delayed), and F. For the miniature circuit breaker (MCB) part, the characteristic B or C can be selected.

Electrical fitters benefit from another advantage offered by the 5SV1 RCBO's compact format: In combination with the 5SM6 arc fault detection device (AFDD), preventive fire protection is additionally ensured internationally. In only 2 MW, these two protective devices from the SENTRON portfolio thus provide complete protection against residual currents, overcurrents, short circuits, and arc faults.



Protection against thermal effects

Electrical fires can be prevented by measures for preventing arc faults, thereby minimizing risks to persons, animals, and material assets. This applies for new installations as well as extensions of existing building electrical systems. Fire protection devices in the form of arc fault detection devices (AFDD) detect parallel as well as serial arc faults. Existing buildings retrofitted with new equipment as part of modernization projects pose particular demands on these devices.

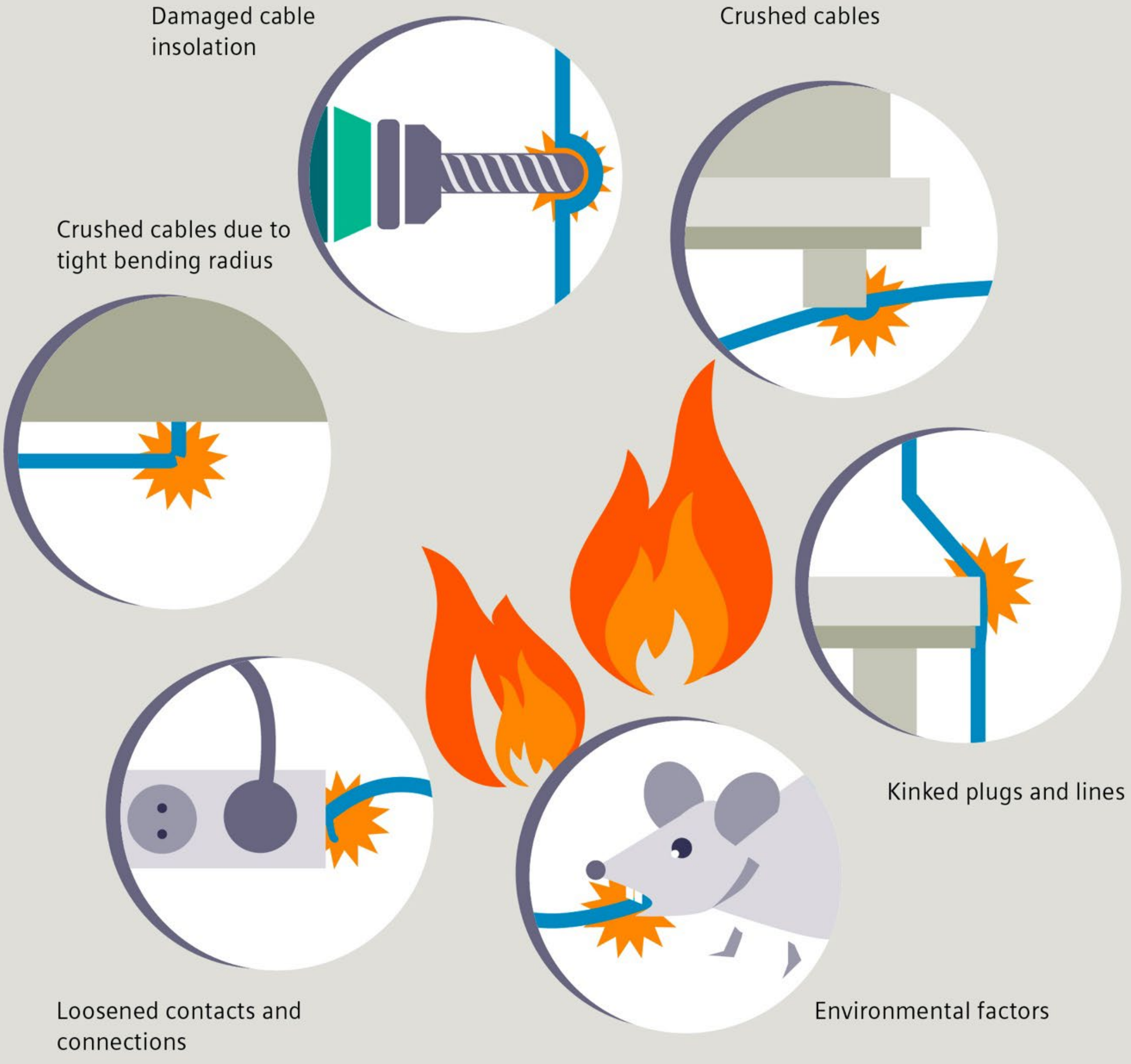
AFDDs are recommended for the final circuits in the following spaces and locations:

- Rooms and locations in structures containing flammable substances (smaller than Fire Class F30/fire-retardant): Wooden houses, timber roof trusses, wooden carports and barns, etc.
- Rooms housing sleeping facilities (irrespective of construction materials): Children daycare centers, senior citizens' homes, hospitals, apartment buildings of solid and prefabricated construction, etc.
- Rooms and locations where irreplaceable goods are at risk: museums, archives, data centers, (listed) historic buildings, etc.
- Rooms and locations with particular fire hazards, and business premises posing fire hazards (in accordance with the Model Building Regulations): Hay storage facilities, wood processing plants, paper and textile factories, other rooms and locations for manufacturing, processing or storage of combustible materials.

Fire protection against every type of arc flashover

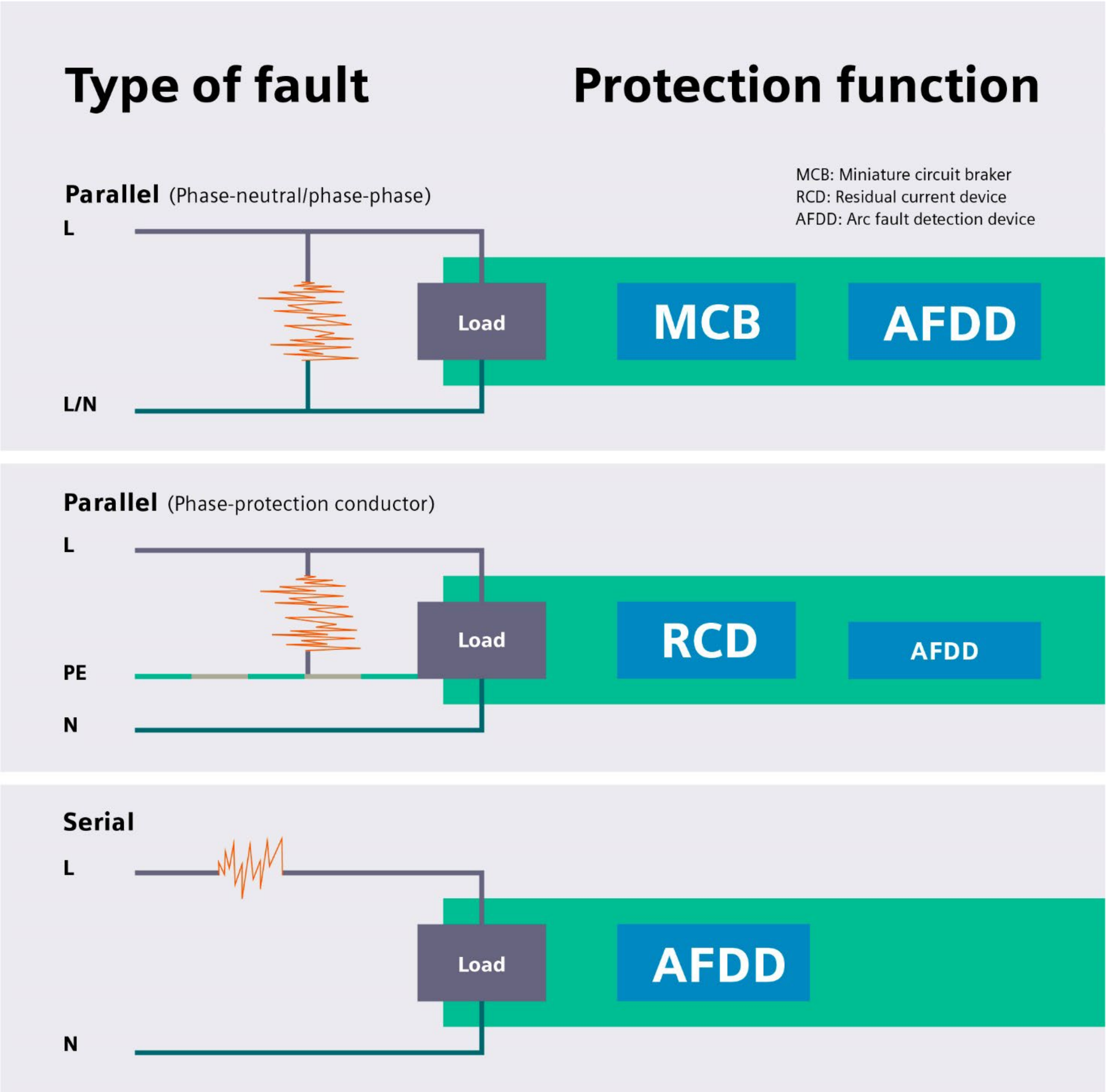
An arc fault is an unwanted voltage flashover between two potentials. The discharge generates extensive heat that can ignite nearby flammable material and thereby cause a fire. In building electrical systems, a distinction is made between parallel and serial arc faults. Parallel arc faults occur when adjacent conductors come into contact with one another, for example due to pinched or crushed cables, or where cables are bended too narrowly. This causes a short circuit between two phases, between phase and neutral conductor, or between phase and protective conductor. In contrast, serial arc faults occur when a conductor is interrupted or due to loose contacts.

What causes an arc fault?



Potentially hazardous defects in cables, plugs, or switches can have many causes:

- Damaged cable insulation (caused e.g., by nails, screws, or mounting clamps that have been driven in too tightly)
- Pinched or crushed cables (e.g., when laid through open doors or windows)
- Cable breaks due to excessively tight bending radii
- Snapped off plugs and lines (e.g., caused by carelessly shoved furniture)
- Loosened contacts and connections in switches or power socket outlets
- Environmental influences such as heat, damp and humidity, gases, UV radiation, gnawing by rodents, or undesired contact with electrically conductive contaminants, pollutants or condensation water.

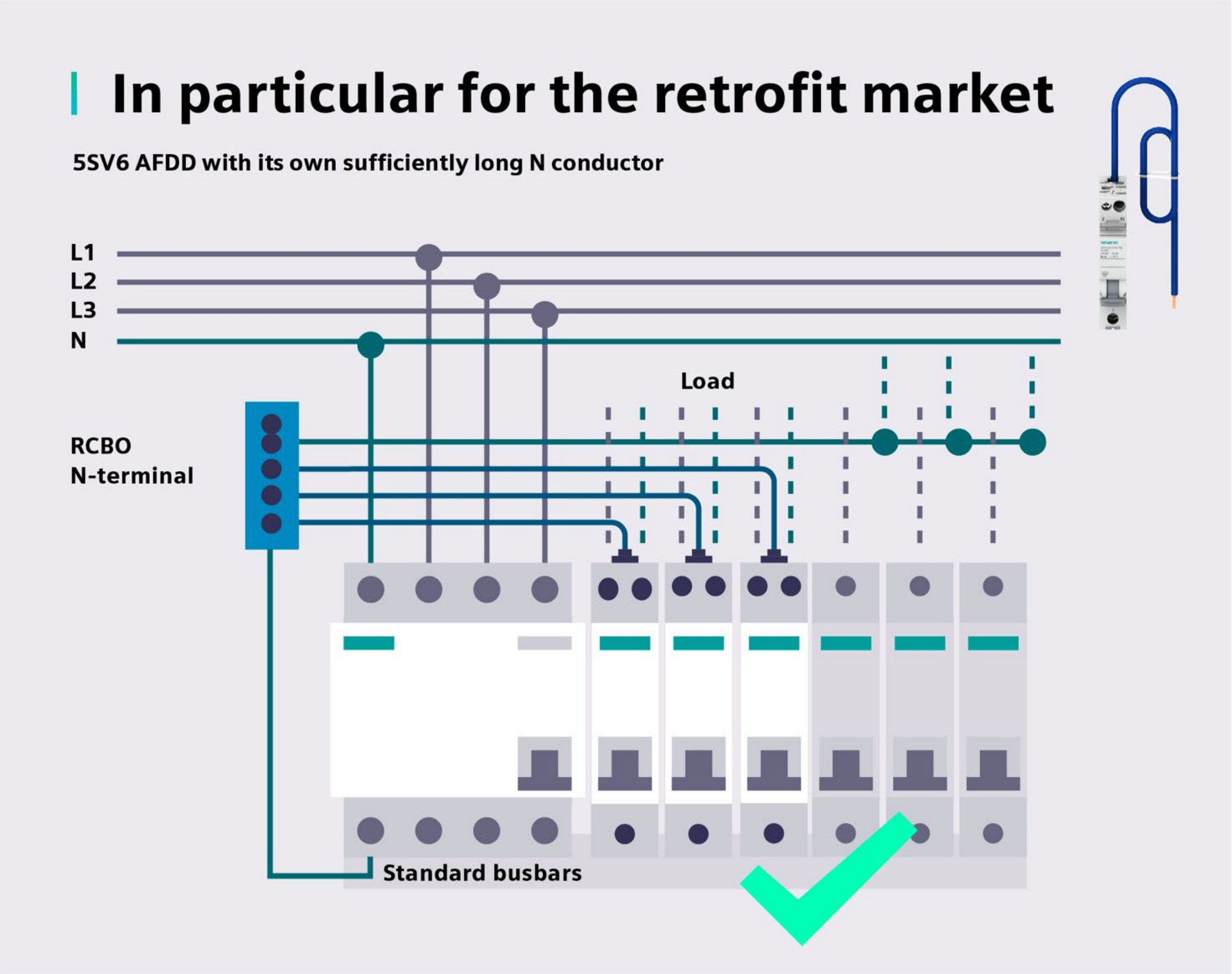


A building electrical system can only be thoroughly protected by intermeshing protective components that safeguard persons and cables and provide preventive fire protection. If parallel arc faults arise between two phases or between phase and neutral conductor, a miniature circuit breaker provides adequate protection. Parallel arc faults between phase and protective conductor or ground can be detected by RCCBs or RCBOs, and the circuit can be interrupted. Serial arc faults, however, lead to neither residual current nor excessive load current, which is why MCBs and RCDs are ineffective in such cases. This protection gap is closed by an arc fault detection device (AFDD) for fire protection.

Space-saving fire protection with the 5SV6 arc fault detection device
If new final circuits are installed in a building or existing ones are expanded, it's recommended as a first step that a distinction be made between lighting circuits and socket outlet circuits. The separate protection provided for these two electrical circuits prevents lighting systems from failing if a RCCB in a socket outlet current circuit trips.

An RCCB may already be built into any electrical circuit feeding power to socket outlets. If one is installed, then it suffices to retrofit the circuit with a 5SV6 arc fault detection device. This is an arc fault detection device combined with a miniature circuit breaker within a single modular width (MW). If a circuit is not already fitted with an RCCB, the installation of a 5SM6 AFDD and a 5SV1 RCBO in 2 MW will provide comprehensive protection for persons and lines along with fire protection. For any other electrical circuits of up to 16 A, the addition of a 5SV6 AFDD is recommended.

The 5SV6 arc fault detection device can be used to implement the highest protection level in the electrical systems of new buildings, and to upgrade the protection level in existing legacy properties. With their patented SIARC detection methodology, arc fault detection devices from Siemens detect not only current and voltage, but also the level, stability and duration of high-frequency noise. If the integrated microcontroller detects an arc fault based on the measured values, the electrical circuit is safely and reliably disconnected from the network within fractions of a second. The microcontroller interprets harmless interfering signals that arise due to the operational conditions for example of vacuum cleaners or drills as simply that – harmless, and ignores them. The 5SV6 AFDD is effortless to install and, taking up only 1 MW, a real space-saver. What's more, a 1000 volt ISO test can be performed without having to disconnect the conductors.



Siemens has developed a special version for the retrofit market that can simply replace the previously installed miniature circuit breaker, as the 5SV6 AFDD already has an integrated miniature circuit breaker built right in. The existing pin busbar is also retained. The Pigtail arc fault detection device is equipped with a long neutral conductor connecting cable that extends outward at the power infeed end. For installation, the conductor is simply connected to the N busbar of the RCCB. Preventive fire protection can thus be retrofitted to existing electrical systems, too, without the need for additional space, and with little wiring effort.

Conclusion

Inhabitants and users of a large share of the existing building stock around the globe are inadequately protected against hazards posed by obsolete building electrical systems. Their electrical systems were planned and installed in a time when substantially fewer electronic devices were used in households – and when devices had significantly simpler current-draw characteristics than today's electrical loads. Siemens is stepping up to meet these changing needs by developing new protective devices that allow technologies such as single-phase frequency converters and LED lighting systems to be reliably monitored and safely operated. The pertinent standards are being revised in line with technical progress, and countering new hazards with innovative circuit breaker concepts.

Ultimately, it depends on the electrical handiwork whether this know-how of which circuit breakers are right for modern electrical loads is actually implemented in the power distribution box. Besides new buildings, existing building stocks must be re-equipped to comply with standards and rendered future-proof: Germany alone has some 29 million households without RCCBs. In the retrofit market, skilled electricians can call on perfectly tailored solutions that take into account the challenges of renovating existing buildings. The combined 5SV1 RCBO from Siemens, for example, can be retrofitted in the distribution cabinet for residual current protection and not take up any more space than before. And the 5SV6 arc fault detection device, thanks to its extending neutral conductor connecting cable, is ideally suited for modernizing aging building electrical systems.

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Siemens AG
Smart Infrastructure
Electrical Products
Siemensstraße 10
93055 Regensburg, Germany

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