

## Safety regulations

### **“Safety requirements for the construction and operation of different sizes of model railways”.**

#### **Preface**

For the majority of consumer products that a consumer uses, these consist of a self-contained system in which the user does not make any changes to the components used. The consumer can be confident that the manufacturer has met all the requirements for achieving maximum electrical safety in the purchased system.

Of course, this also applies to all components of the model railway, which individually correspond to the applicable specifications and regulations. The special feature of the model railway, however, is the wish of every model railway enthusiast to create an individual complete system tailored to his conditions, wishes and possibilities. This high number of different variation possibilities therefore requires the consideration and adherence to different rules in order not to restrict the electrical safety of the overall project.

In practice, the solutions which theoretically provide compliance with the standards may lead to a deterioration of the measured values in the case of another standard. Today's switching power supplies, which are necessary for the conversion of the mains voltage into a low voltage for the supply of the control system and loads on a model railway, require an interference suppression circuit to comply with the EMC regulations. However, this can lead to a leakage current flowing between the potential on a rail and a protective conductor of your domestic installation. If, for example, you connect the live rails with one hand and the protective conductor of the house installation with the other hand (e.g. metal back panels of computers or power tools can have this connection) or to an earthed object (e.g. a radiator), you close the circuit for this leakage current.

All Märklin supply units have been tested to ensure that the limit of 0.5 mA for such a leakage current, which is listed as safe and in many standards, is not exceeded. Sensitive people can, however, already feel such a current of this magnitude under certain circumstances as a tingling current flow at least in parts of the body.

As the number of electrical consumers on a system increases, so does the number of supply units used. In order to avoid unnecessary potential hazards from unsuitable combinations of devices, the following specifications for the construction of your individual system must be strictly adhered to. But you can also provide additional safety by adhering to the rules of conduct presented here.

The following system categories are ultimately determined primarily by the quantity of electrical consumers in the system and the potential output provided by the supply units. We therefore distinguish between the following four system types:

## Safety regulations

1. The entry-level or compact system
2. The ambitious hobby system for adults
3. The XXL hobby system with extensive play operations
4. The semi-professional or fully professional system with extremely high power requirements.

The classification of the system is therefore not based on the available floor space but on the number and type of supply devices:

Category	Designation	Maximum power	Maximum number of supply units
1	Entry-level / compact systems	120 VA	2
2	Hobby system (for adults)	300 VA	5
3	XXL hobby system (for adults)	600 VA	10
4	Semi-professional or fully professional system	Over 600 VA	Over 10

**What is a power supply unit?** By this we mean all devices that are connected to the domestic mains supply and have a low-voltage output for supplying the control devices or model railway items. There are two different technical systems here:

1. **Transformer:** Converts the mains voltage (e.g. 230 V in Europe or 120 V in various American countries) into a low voltage. The level of this low voltage shall not exceed 24 V. The maximum electrical power a device can deliver or the maximum output voltage can be read from the type plate.
2. Typical analogue driving device still available today: Transformer 32 VA No. 66471 (for 230 V), 6646 (for 120 V)



## Safety regulations

3. **Switching power supply:** Currently used supply units which generate a DC voltage from the mains voltage which is trouble-free for the supply of the model railway. The typical low voltage for Märklin switching power supplies is 19 V. If an AC voltage is absolutely necessary for an application, it can be generated via the Märklin Converter No. 60130 together with a switching power supply.
4. Typical devices for 230 V: 66360 (36VA) , 60061 (60 VA) or 60101 (100 VA)
5. Typical devices for 120 V: 66367 (36VA) or 60065 (50 VA).



## Safety regulations

To classify your system in these 4 categories, please add all the maximum output power or their number indicated on the nameplates of these supply units and check which of the 4 categories your system is to be classified in.

Some typical examples:

System supply	Category
All start sets (with IR hand control or MS 2)	1 (< 120 VA)
Start sets supplemented by a switching power supply for turnout supply	1 (< 120 VA)
Central Station 3 plus Booster 60175 (= 2 supply units 60061 á 60 VA)	1 (< 120 VA)
CS 3 (with 60061 á 60 VA) plus feedback module L88 (1 x 66360 á 36 VA)	1 (< 120 VA)
CS 3 with booster 60175 (= 2 x 60061 á 60 VA) plus L88 (1 x 66360 á 36 VA)	2 (120 VA – 300 VA)
CS 3+ with booster 60175 (= 2 x 60061 á 60 VA) plus s88 60881 on CS 3+	1 (< 120 VA)
CS 3 plus 4 x booster 60175 (= 5 x 60061 á 60 VA)	2 (120 VA – 300 VA)
CS 3 to track 1 system with 60101 á 100 VA	1 (< 120 VA)
CS 3 to track 1 system + 2 x booster 60175 (= 3 x 60101 á 100 VA)	2 (120 VA – 300 VA)
CS 3 plus 4 x booster 60175 (= 5 x 60061 á 60 VA) + L88 (= 1x 66360 á 36 VA)	3 (300 VA – 600 VA)
2 x CS 3+ and 4 x booster (= 6 x 60061 á 60 VA) and 2 x 60822 (= 2 x 66360 á 36 VA)	3 (300 VA – 600 VA)
3 x CS 3+ and 7 x booster (=10 x 60061 á 60 VA) and 3 x L88 (= 5 x 66360 á 36 VA)	4 (> 600 VA)
2 x CS 3+ and 5 x booster 60175 on track 1 system (= 7 x 60101 á 100 VA)	4 (> 600 VA)

Supplement: a CS 2 must be considered as a CS 3 in terms of performance. Starting with hardware version 4.x, the CS 2 versions can also be operated with 60101 when operating a track 1 system. Parallel use of a CS 3+ and a CS 2 is possible. A combination of CS 3 and CS2 is only possible from hardware version 4.x of CS 2.

**Important note:** These specifications have been valid since 01 November 2018. Information contained in previous Märklin manuals, books or other documents is only applicable to category 1 and category 2 systems. For larger systems, the special features listed in chapters 3 and 4 are binding.

Märklin Customer Service will be happy to answer any questions you may have about electrical safety. You can reach Märklin customer service at

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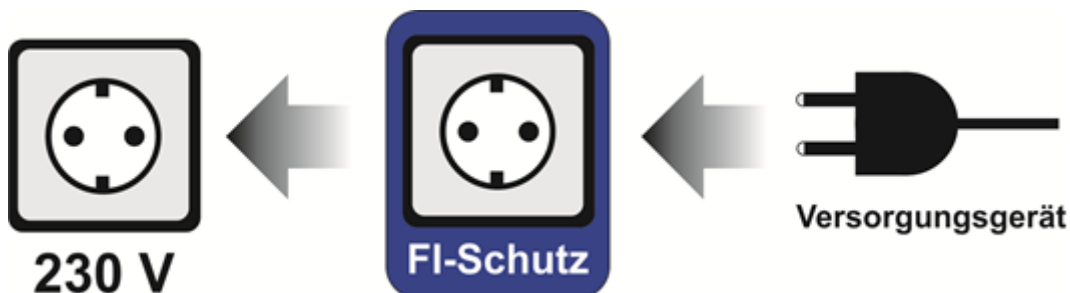


## Safety regulations

mobile station must never be connected to rail ground. A supply unit used to supply one of these devices shall not be used additionally as a supply device for any other application.

- Advise all players that the common ground return conductor must never come into contact with the earth conductor. Every player should always make sure that he does not touch the live rails. If new locomotives or wagons are put on track, the track supply (e.g. stop function) must always be switched off first.
- Always switch off the system supply when setting up or making changes, if this is not required. For this purpose, all mains plugs are always disconnected from the domestic mains supply.
- Supply units must never be connected in parallel.
- Please observe the additional basic rules of conduct for handling electrical current listed in chapter 5.

**Tip:** It is strongly recommended that you only use a domestic mains supply that is protected by an FI circuit breaker. If this is not the case, it is recommended to use a personal protection plug to increase safety, which is first plugged into the mains socket. The mains plug of the supply unit or the distributor strip is connected to this adapter plug. You will find more information on this in chapter 5 of this document.



FI-Schutz	FI protection
Versorgungsgerät	Supply unit

Graphic: Observe sequence: FI personal protection adapter plug into the mains socket. Supply unit into the connection of the FI personal protection adapter plug.

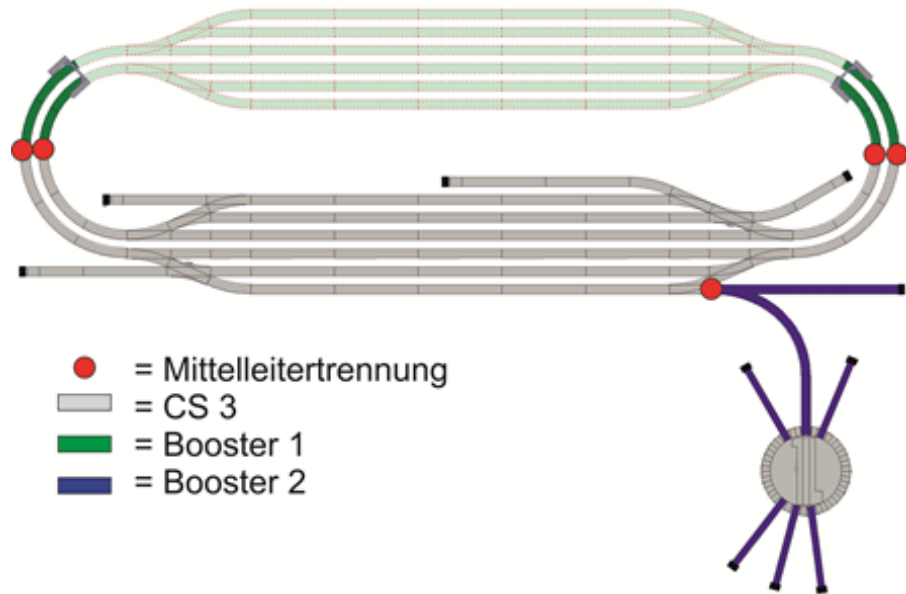
### 3. Construction and operation of a category 2 system

#### 4. (over 120 VA up to 300 VA power supply)

## Safety regulations

These systems are the maximum permissible size of a so-called **operating unit**. An operating unit is characterized by the maximum sum of the output power of all supply units of 300 VA. There may be a maximum of 5 supply units per operating unit.

- Within this operating unit, a common return conductor may be used for the various sub-areas. Example: One CS 3 and two boosters can use the rail ground as a common return conductor.
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- 



*Example: this system uses a total of 3 switching power supplies 60061 for the CS 3 and*

*the two boosters for the power supply. In total, this results in a possible total output of  $3 \times 60 \text{ VA} = 180 \text{ VA}$ . The insulation of the neutral conductor is sufficient at all transition points. In double-rail systems such as track 1, outward and return conductors are always separated here.*

Mittelleitertrennung	Neutral conductor separation
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## Safety regulations

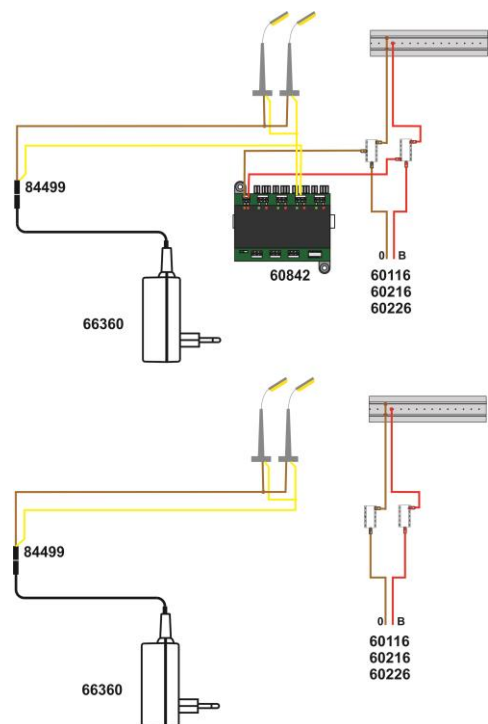
- Areas of the system that also function without a common return conductor should be set up as a separate system without an electrically conductive connection to any other area on the model railway. This supply unit then does not have to be taken into account in the size of the operating unit. Example: For operation house or street lighting does not require a connection to the return conductor of the drive operation. This can thus be executed as an autonomous system. If these consumers are to be switched digitally, this can be done via a decoder m84 (No. 60842). There is then no electrically conductive connection between the digital controller and the lighting. The current turnout lighting systems also have a separate connection for outward and return conductors and can therefore be implemented as an autonomous system.

Example top right: Lighting digitally switched via m84, but without ground connection to the other lighting system.

Down right: Lighting as a completely separate system.

**Important for track 1 systems:** With these systems, as with any double-rail system, each transition from one supply area to another (e.g. from CS 3 to booster or from one booster circuit to the next) must always be separated outward (B = traction current) and return conductor (0 = neutral conductor). However, a common feedback system can be used within a category 2 system.

- Advise all players that the common ground return conductor must never come into contact with the protective conductor. Every player should always make sure that he does not touch the live rails. If new locomotives or wagons are put on track, the track supply (e.g. stop function) must always be switched off first.
- Always switch off the system supply when setting up or making changes, if this is not required. Always disconnect all mains plugs from the domestic mains supply.
- Supply units must never permanently supply the same consumer in parallel.
  - It is absolutely essential that only mains sockets protected by FI circuit breakers are used to supply





## Safety regulations

the system. If the domestic installation does not have such an FI circuit breaker, a personal protection adapter plug must be used to increase safety, which is first connected to the mains socket. The mains plug of the supply unit or the distribution strip for several supply units is then connected to this adapter plug. Instead of a personal protection mains plug, a distribution strip with integrated FI circuit breaker can also be used. This must respond at a maximum of 10 mA.

- Please observe the additional basic rules of conduct for handling electrical current listed in chapter 5.

### 5. Construction and operation of a category 3 system

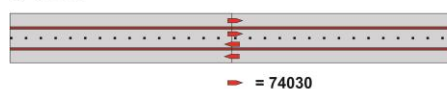
#### 6. (up to 600 VA power supply)

In category 3, the system must be divided into two operating areas. Each of these operating areas shall comply with the limits of an operating area in category 2.

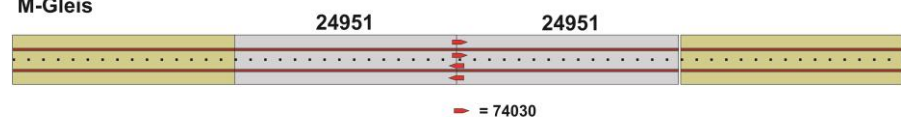
- At each transition point between these two operating areas, the return conductor (0 = brown cable, for Märklin H0 the neutral conductor = rail ground) must be disconnected as well as the outward conductor (B = red cable, for Märklin H0 the neutral conductor). In track 1 systems, this separation of outward and return conductors is mandatory for every transition from one supply area to another.
- With the C-track, 4 rail insulators 74030 (2 x B and 2 x 0) are required between two operating areas at each transition point.
- The M-track requires 2 tracks 24951 for the transition between 2 operating areas. On the C-track side of these two tracks, separate the outward and return conductors with 4 rail insulators 74030.
- The contact track 2295 can be used to separate the rail ground on the K-track. The separation of one track is on the left rail, while the separation of the other rail is on the right rail side. This differs from the use as a contact track, where the two separations are on the same rail side.

#### Trennung von Mittelleiter- und Schienenverbindung

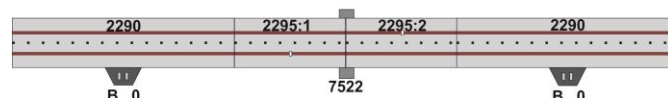
C-Gleis



M-Gleis



K-Gleis



Graphic above: Separation of outward and return conductors on the C-track with

## Safety regulations

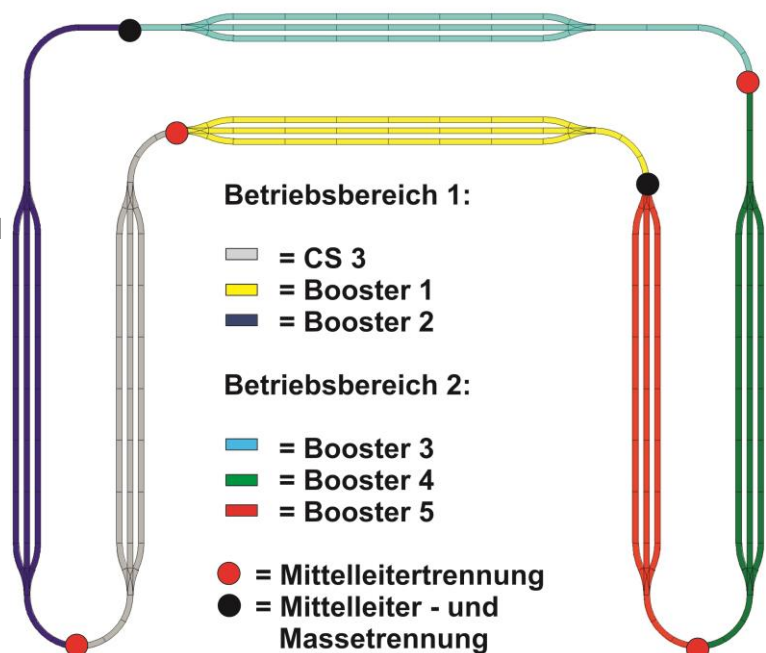
74030

Graphic centre: Separation at M-track by using 2 x 24951 and 74030

Graphic below: Separation at K-track with 7522 and contact track set 2295

- Please note that even feedback systems that use the neutral conductor as reference ground must not connect several operating areas. For each operating area you therefore need either a separate decoder L88 (No. 60883) or the connection for decoder s88 on a CS 3 or CS 2.
- The necessary ground connection from the L88 may only be established to a booster or a CS 3 in the corresponding operating area. A connection to another device leads to a common connection within the operating areas, which is not permitted.
- Here, too, areas of the system that also function without a common return conductor should be set up as a separate system without an electrically conductive connection to any other area on the model railway. This supply unit then does not have to be taken into account in the size of the operating unit.

### Aufteilung der Anlage in Betriebsbereiche



Aufteilung der Anlage in Betriebsbereich	Division of the system into operating areas
Betriebsbereich 1	Operating area 1
Mittelleitertrennung	Neutral conductor separation
Mittelleiter- und Massentrennung	Neutral conductor and ground separation

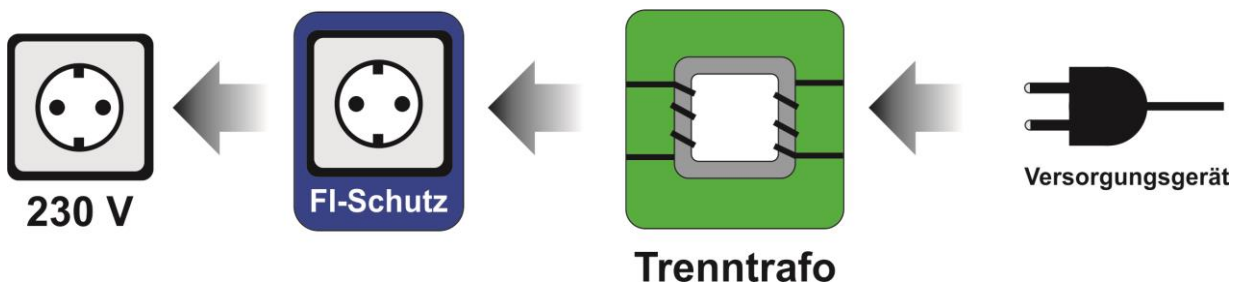
Graphic: System with 2 operating areas

- When dividing the two operating areas, they should be dimensioned as equal as possible. Example: A system with a total power requirement of 400 VA is divided into 2 equally sized operating areas of approx. 200 VA each and not into one operating area with 300 VA and another with 100 VA.
- Advise all players that the common ground return conductor must never come into contact with the earth conductor. Every player should always make sure that he does not touch the live rails. If new locomotives or wagons are put on track, the track supply (e.g. stop

## Safety regulations

function) must always be switched off first.

- Always disconnect the system supply from the mains during installation or when changes are made, unless this is required. For this purpose, all mains plugs are always disconnected from the domestic mains supply.
- Supply units must never be connected in parallel.
- It is essential that only domestic mains supply protected by FI circuit breakers are used. If the domestic installation does not have such an FI circuit breaker, a personal protection adapter plug must be used to increase safety, which is first connected to the mains socket. The mains plug of the supply unit or the distribution strip for several supply units is then connected to this adapter plug. Instead of a personal protection mains plug, a distribution strip with integrated FI circuit breaker can also be used. This must respond at a maximum of 10 mA.
- A further improvement in safety is achieved through the use of an isolating transformer. An isolating transformer does not change the level of the applied domestic voltage. However, it provides galvanic isolation from the domestic mains supply, so that further protection against unwanted leakage currents is provided.



FI-Schutz	FI protection
Trenntrafo	Isolating transformer
Versorgungsgerät	Supply unit

Graphic: The additional use of an isolating transformer increases electrical safety.

- Please observe the additional basic rules of conduct for handling electrical current listed in chapter 5.

## 7. Category 4 system (over 600 VA power supply)

Even with extremely large systems, the principle of division into operating areas, as presented in

## Safety regulations

chapter 3, must be applied. However, further protective measures are necessary. This includes the separation of the supply units from the domestic mains supply by using an isolating transformer.

- Ensure that no visitor to this system is able to touch the live tracks. This applies especially in areas where a device operated with the protective conductor or earthed objects can be touched at the same time.
- Beware of events in which different subsystems are usually used together temporarily in the form of modules. Clarify in advance which supply systems with which output power are used here. These systems must also comply with the limits for the operating areas described. At public events, make sure that no visitor can touch the live rails.
- If you are planning a large system, you are welcome to present the system electrics to Märklin customer service. There, the risks will be examined and further instructions given on how to set up such a system. For a system of this dimension, it is necessary that the installation of the system is monitored and checked by a qualified electrical engineering specialist<sup>1</sup>.
- You can reach Märklin customer service at

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## 8. Basic rules of conduct

The following safety rules are certainly known from many components in daily use, but their disregard is still one of the main causes of electrical accidents in the household or in leisure time. Therefore always follow these guidelines without restrictions:

- The switching power supply or the transformer may only be connected to a mains socket with the mains voltage specified on the type plate of the switching power supply.

## Safety regulations

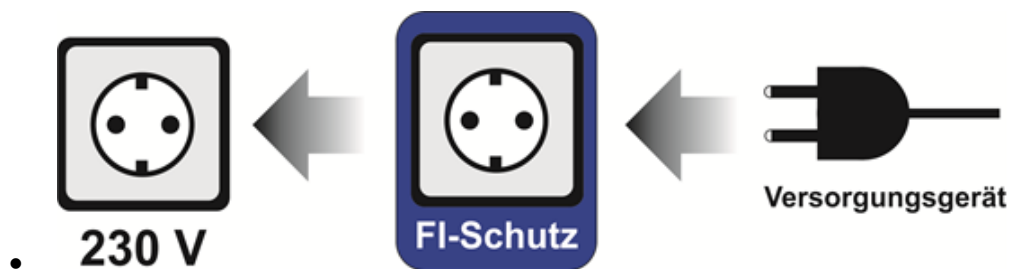
- The switching power supply or transformer is intended exclusively for use in dry rooms.
- The switching power supply is not a toy. It is used for the power supply of the model railway system.
- When transporting the switching power supply, it must never be held by the mains cable or the connection cable.
- **The mains cable and the connection cable to the system must not be changed, replaced or extended.**
- Regularly check the condition of the cable and the housing for damage. This optical check may only be carried out if the switching power supply is removed from the socket of the domestic mains supply. If there is the slightest suspicion of damage, the switching power supply may only be reused after a thorough inspection and repair by a specialist company (e.g. Märklin Repair Service).
- In this case, ensure that it is disposed of properly or send the switching power supply to Märklin Repair Service for replacement.
- If any new component is installed or dismantled on the model railway or if a change is made to the wiring of the installation, all existing supply units of the model railway must always be disconnected from the domestic mains supply.
- If play operation is terminated, all supply units must be disconnected from the mains connection at the latest after the electronic components have been shut down.
- Never touch the live tracks or overhead wires on the model railway when the power supply to the installation is switched on. Tip: With the stop function on the digital systems, the complete power supply on the track can be switched off. For safety reasons, this stop function must therefore be used before tracks can be touched.
- The use of a socket strip for common commissioning of the supply units is recommended. Socket strips must not be connected in series. Observe the maximum load capacity of the respective socket strip, which is specified on the socket strip by the respective manufacturer. Never rebuild or repair socket strips yourself. Such components must be replaced in the event of damage.
- As of category 2 systems, supply units such as switching power supplies or

### What is a FI circuit breaker?

In the case of a domestic socket, the current is transported to the consumer via a single conductor and fed back again via a single conductor. The FI protection circuit checks whether there is a difference in the current flow between the outward and return conductors. If this difference exceeds the preset limit value of e.g. 10 mA, the supply of the connected consumer is immediately interrupted. This can prevent the flow of a current over an unwanted path.

## Safety regulations

transformers must always only be connected to a domestic mains supply that is protected by a FI protection circuit. This protection should respond at a current of 10 mA = 0.01 A already. If your domestic mains supply is fused with a higher current (FI circuit breakers in domestic installations very often only react to 30 mA) or if you have no certainty whether the domestic mains supply has a corresponding protection, then you must insert an personal protection adapter plug between the domestic mains supply and the supply of the system or a socket strip with a built-in FI circuit breaker with a tripping threshold of max. 10 mA between the domestic mains supply and the supply of the system.



FI-Schutz	FI protection
Versorgungsgerät	Supply unit

*Graphic: Observe sequence: FI personal protection adapter plug into the mains socket. Supply unit into the connection of the FI personal protection adapter plug.*

- If several persons are employed on the system, all persons present must be informed before switching on the operating current on the system. The operating voltage may not be switched on until all those present have given their approval.
- **Do not use transformers or switching power supplies that have not been approved by Märklin for use with a model railway. Since we cannot estimate the compliance of third-party products with the technical standards, only Märklin equipment may be used.**
- Also, only install other electrical loads if they have been expressly approved for operation on model railways.
- Never pull the plug of a supply unit out of the mains socket when several power supply units are in use. Also be careful not to touch the metal parts of a power plug.
- Never carry out any measurements on the domestic mains supply. This is a task only for appropriately trained specialist personnel. Please also note that the usual multimeters used in the hobby area are not suitable for many measurement methods.
- **Tip:** Document exactly how your system is constructed. This can be more than only a help in case of malfunction. This is also the basis for safe implementation in the event of a later

## Safety regulations

enlargement.

- If a system is controlled by children, the following special behavioural measures apply:
  - Switching power supplies for toys are not suitable for use as toys. The use must take place under constant supervision of the parents. Parents must inform their children that a switching power supply should only be used in accordance with its intended use. Also make sure that your children are aware of the dangers of the domestic mains supply.
  - Check visually at regular intervals (depending on the frequency of play operation) at least once a week the switching power supply and its connecting cable for damage when disconnected from the domestic mains supply. If there is the slightest suspicion of damage, the switching power supply may only be used after repair by the Märklin Repair Service.

### What are the dangers of electric shock?

A current flow only occurs when the supply and return conductors of an electrical supply source are connected to each other via a conductive material. The human body is capable of doing just that. One then speaks of an electric shock, which the affected person suffers.

The damage that can occur depends on many factors:

- The level of the applied voltage
- The type of current and its frequency
- How much electricity flows
- The exposure time
- The path through the body
- Possibly existing technical components such as cardiac pacemakers

Voltages above 60 volts can cause life-threatening injuries in the event of an electric shock. The supply voltage of the model railway is therefore limited to a maximum of 24 V. No loads with a higher supply voltage may be used on the model railway.

The amount of current at which a current flow is perceived is between 0.01 mA and 4 mA, depending on the circumstances. Currents up to 0.5 mA are classified as harmless. Currents up to approx. 5 mA do not lead to injuries in a healthy adult, but they do mean an unpleasant perception of the current flow. If you comply with the requirements of this document, you can be sure that, according to the current state of knowledge, there is no danger of dangerous leakage currents in your system.

As already indicated, the maximum amount of current that can flow in the event of an electric shock can be limited by a FI protection circuit. In the case of domestic mains supplies, a limit of 0.03 A = 30 mA is a normal value in practice, which is below the life-threatening limit. For safety

## Safety regulations

reasons, a protective circuit must be used on model railways which switches off at the latest at a residual current of 10 mA.

In the event of an electric shock, the connection must be disconnected as quickly as possible unless protective measures are taken. However, helpers have to take care of their own protection.

Pacemaker wearers must exercise special caution to prevent damage to these devices.

**Attention:** Never conduct self-experiments with a deliberately induced electric shock. Even an electric shock below the deadly danger limit is not only an unpleasant experience but can also lead to at least temporary effects such as nervous trembling etc.