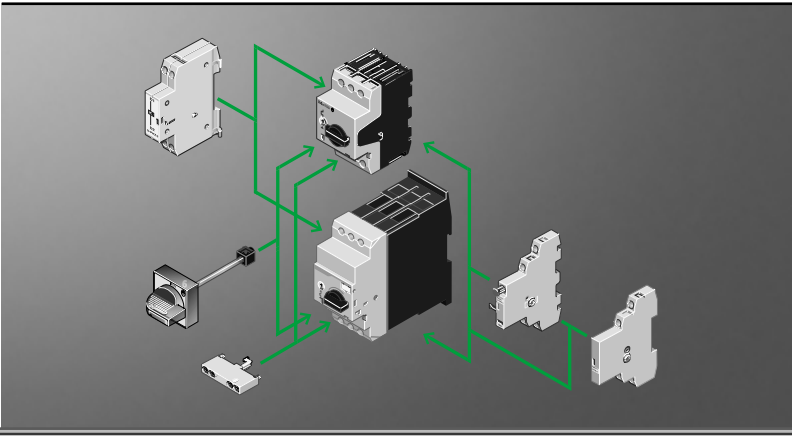
Xtra Combinations

Industrial Automation

Technical Guide

# Motor Protection

Claudia Pawlowski



MOELLER

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**Systematic Motor Protection**

Useful information on motor, system and cable protection with PKZ motor-protective circuit-breakers

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## Notes

# Foreword

Moeller GmbH has been producing motor-protective circuit-breakers for over 65 years (since 1932). Since then new developments have time and again led the way forward in the protection of electric motors. This includes, for example, the trend away from pressure actuation to rotary actuation.

However, what is a motor-protective circuit-breaker exactly and how does it work? What can its accessories do? It is questions like these that will be discussed in this brochure.

For which application fields can the motor-protective circuit-breaker be used? In what way are they different to other protective devices? These questions and others are dealt with in more detail in our specialist technical guide **FB1210+1280-0034**. The appendix of this book also contains several useful tables, formulae and notes that provide help in the use of motor-protective circuit-breakers.

## Notes

# Terms and Characteristics of Motor-Protective Circuit-Breakers

## Something about the motor

Unlike other consumers such as filament bulbs, fluorescent tubes and heating resistors, motors may be subject to overloads. These kinds of overloads arise for several reasons, for example,

- because the friction conditions of the driven machines change,
- because pumps have to work against different pressure heads,
- when the tool engages more powerfully and the transport carriage has a greater load,
- because startups or braking operations are too long,
- due to blocked rotors.

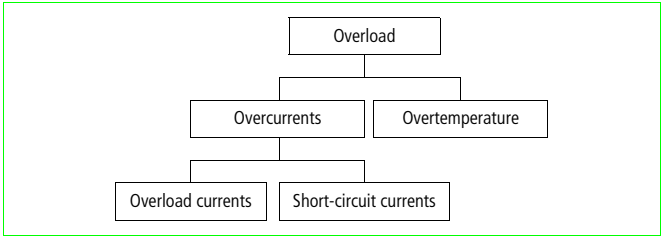



Figure 1: Different categories of overload

Motors that are designed for a specific relationship between the load, startup time and switch off time can also be overloaded if the startup time is lengthened or the switch off time is reduced whilst the current consumption is kept constant. These kinds of time changes can also change torque characteristics. If the torque increases, the current consumption increases as well, leading to an increase in motor temperature with every increase in current.

A long period of increased current consumption may damage or destroy the insulation of the motor windings.

The lifespan of motors depends very much on the observance of temperature limits. Examinations have shown that the lifespan of motors is considerably reduced with even the slightest continuous overtemperature above the permissible continuous temperature limit. As a rough guide it can be assumed that the lifespan of a winding insulation is reduced by 50 % with every overtemperature of 10 °C.

IEC 947 specifies the exact requirements of overload releases on motor-protective circuit-breakers or motor-protective relays in order to prevent the continuous thermal overload of the motor:

At a room temperature of 20 °C, an overload release must not trip within two hours starting from cold when there is a 5 % overcurrent on all three poles. If the current is then increased to 120 % of the rated current, the relay must trip within two hours. This requirement assumes a continuous loading of the rated current.

# Terms and Characteristics of Motor-Protective Circuit-Breakers

## Standards and regulations

### IEC/EN 60 947

The IEC/EN 60 947 international standard specifies the design features, functional properties and tests required for low-voltage switchgear, and has been in force since 1989. It's German equivalent is VDE 0660. PKZ motor-protective circuit-breakers meet the requirements of IEC/EN 60 947-1 (General Rules), IEC/EN 60 947-4-1 (Electromechanical Contactors and Motor Starters) and in part IEC/EN 60 947-2 (circuit-breakers).

### IEC/EN 60 204-1

IEC/EN 60 204 (VDE 0113) covers the electrical equipment of industrial machines. These regulations do not cover the device as such but function as a standard for electrical installations, specifying the properties that the product concerned needs to fulfill. This specifies, for example, the properties of a main switch, a supply disconnecting device or an emergency-stop switch.

## Terms and characteristics

**Rated uninterrupted current $I_u$** is the current that the motor-protective circuit-breaker can take in uninterrupted operation.

The **rated conditional short-circuit current $I_q$** is the short-circuit current that a switching device such as a contactor, protected by a short-circuit protective device such as a motor-protective circuit-breaker, can withstand for the duration of the tripping delay of the protected device (test in accordance with IEC/EN 60 947-4-1).

**Rated breaking capacity $I_{cs}$** is the prospective short-circuit current which, depending on the rated operational voltage, a circuit-breaker is capable of carrying repeatedly. After interrupting this short-circuit current value, the circuit-breaker must be capable of continuing to carry and disconnect in the event of an overload the rated uninterrupted current despite its own thermal level having increased (test in accordance with IEC/EN 60 947-2).

**Rated ultimate short-circuit breaking capacity $I_{cu}$** is the maximum short-circuit current that a circuit-breaker is capable of interrupting. After interrupting this short-circuit current value, the circuit-breaker must be capable of disconnecting in the event of an overload, but at a higher tolerance level (test in accordance with IEC/EN 60 947-2).

The **rated short-circuit making capacity $I_{cm}$** specifies the maximum short-circuit current that a circuit-breaker is capable of switching on at a rated operational voltage (+10 %), rated frequency and specified power factor without sustaining damage. This is expressed as the maximum prospective peak value.

The **rated short-circuit breaking capacity $I_{cn}$** is the maximum short-circuit current that a circuit-breaker is capable of breaking at a rated operational voltage (+10 %), rated frequency and specified power factor. This is expressed as the r.m.s. value of the AC component.

# Terms and Characteristics of Motor-Protective Circuit-Breakers

The term **inherently short-circuit proof** describes a switch with contacts and bimetal trips that have an inherent resistance large enough to restrict the short-circuit current to the switching capacity of the switch. The switch can then be said to offer protection itself within its own inherently stable range.

**Type 1 coordination** means that the contactor or motor starter must not present any risks to persons or installation in the event of a short-circuit. The starter does not have to be ready for renewed operation afterwards.

**Type 2 coordination** means like type 1 coordination that there should be no risk to persons or installation in the event of a short-circuit, and furthermore, that the motor starter must be capable afterwards of renewed operation. A slight welding of the main contacts of the contactor or starter is permissible.

**Temperature-compensated** means that a counteracting bimetal strip is fitted in the bimetal release of the overload device. This second bimetal does not carry any motor current but bends simply according to the ambient temperature.

In this way, the effect of the ambient temperature on the tripping response of the circuit-breaker is compensated.

**Single-phasing sensitivity** is the ability of overload releases (such as motor-protective circuit-breakers) to protect a motor from overload when running too long on two phases in the event that one feeder is interrupted by fast tripping. When running on two phases, the current will increase in the two phases concerned.

**Selectivity** describes the response in the event of a short-circuit of two or several circuit-breakers that are connected in series. The circuit-breaker directly upstream of the faulty current branch should trip. This tripping should be so fast that super-ordinate protective devices do not trip. This ensures that circuits that are not affected by a fault can continue to function, thus achieving greater system availability.

By **trip-free release** is meant the tripping of the circuit-breaker even if the drive is blocked or held in the ON position manually.

The **tripping class (CLASS)** of a thermal overload release defines the maximum tripping time starting from cold. This time refers to a symmetrical load on three poles at 7.2 times the set current. The number (e.g. CLASS 10) classifies the value for the maximum permissible tripping time in seconds. The trip blocks of the PKZ systems have tripping class 10A.

Table 1: Extract from IEC/EN 60 947-4-1

| Tripping class | Tripping time $T_P$ |
|---|---|
| 10A | $2 < T_P \leqq 10$ |
| 10 | $4 < T_P \leqq 10$ |
| 20 | $6 < T_P \leqq 20$ |
| 30 | $9 < T_P \leqq 30$ |

## Notes

# Modules and Functions of Motor-Protective Circuit-Breakers

## PKZM0 and PKZM4 motor-protective circuit-breaker series

**PKZM0 motor-protective circuit-breaker basic unit** in the range 0.1 A to 25 A and **PKZM4** in the range from 10 A to 63 A. The circuit-breakers have a rotary knob as a handle for ON/OFF switching and for clear switch position indication. The short-circuit release is permanently set to 14 times $I_n$, the bimetal release is set to the relevant motor current.

**PKZM0-T transformer protective circuit-breaker** in the range from 0.1 A to 20 A. The short-circuit release is permanently set to twenty times $I_n$, the bimetal release is set to the relevant operational current of the transformer.

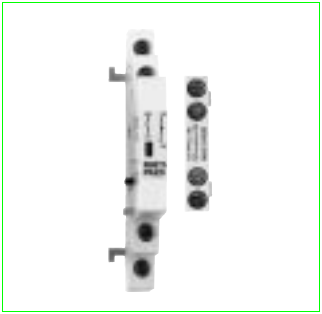
# Modules and Functions of Motor-Protective Circuit-Breakers

**PKM0 circuit-breakers for starter combinations** (or short-circuit circuit-breaker) as basic unit in the range from 0.1 A to 25 A. The basic unit does not have an overload release but does have a short-circuit release. The circuit-breakers are used in applications such as starter combinations with or without manual reset or AC-1 loads where an overload is not expected.

**(High-capacity) contact modules** are matching contactors for the **PKZM0** that can be fitted to its side. In combination with the motor-protective circuit-breaker they can form powerful motor-starter combinations for applications requiring type 1 and 2 coordination. The contact modules are available for either DC or AC operation. Unlike the standard contact module, the high-capacity contact module is fitted with additional current limiting contacts. A **base for separate mounting** also makes it possible to operate the contact module independently of the motor-protective circuit-breaker. The DC operated contact modules have an integrated **suppressor circuit.** External suppressors are available for AC operated contact modules. These suppressors attenuate any voltage peaks that may occur when the coil is switched off. The mechanical interlock enables two separately mounted contact modules to be interlocked with each other in order to create a reversing starter.

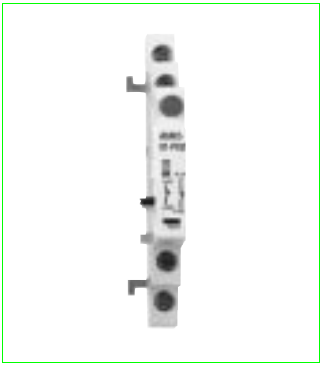
# Modules and Functions of Motor-Protective Circuit-Breakers

**Auxiliary contact modules** are available for both side and front mounting. These can be fitted to all circuit-breakers, contact modules or motor starters without any tools required. Different combinations of make and break contacts are available. These are suitable for interlocks, signalling or annunciation tasks. The modules for the PKZM0 and PKZM4 have the same design.



The **early-make auxiliary contacts** are fitted to the front of the **PKZM0** and **PKZM4** motor-protective circuit-breaker. The contacts of this auxiliary contact switch in advance of the main contacts. Their main task is to apply voltage to the undervoltage release before the main contacts are closed.

A **trip-indicating auxiliary contact** is available for providing the differentiated annunciation of a short-circuit and a general release. This unit is provided with a short-circuit indicator and two separately functioning auxiliary contacts. The indicator is used to indicate the trip on the device itself and is used for manual resets. An auxiliary contact signals a general release and the other one signals a short-circuit release.



# Modules and Functions of Motor-Protective Circuit-Breakers

Two different **voltage releases** are available for the motor-protective circuit-breaker series. The **shunt release** is used in interlock circuits or for remote OFF switching. The shunt release switches off the circuit-breaker as soon as voltage is applied. The **undervoltage release**, on the other hand, switches off the motor-protective circuit-breaker as soon as it's voltage is removed. They are mainly used for safety circuits. If the voltage for the installation is interrupted, the undervoltage release trips out to prevent accidental restarts after the voltage is restored. Both voltage releases can be fitted without tools together with auxiliary contacts to the **PKZM0** and **PKZM4**.

The CL-PKZ0 **current limiter** is provided to increase the switching capacity of the PKZM0, which is not inherently short-circuit proof, to 100 kA. With a rated operational current of 63 A the current limiter can also be used for group protection, i.e. the protection of several circuit-breakers.

A **sealing device** is used to prevent the setting dial from being tampered with. The small plate is fitted in the Test button and secured via a loop of standard sealing wire.

# Modules and Functions of Motor-Protective Circuit-Breakers

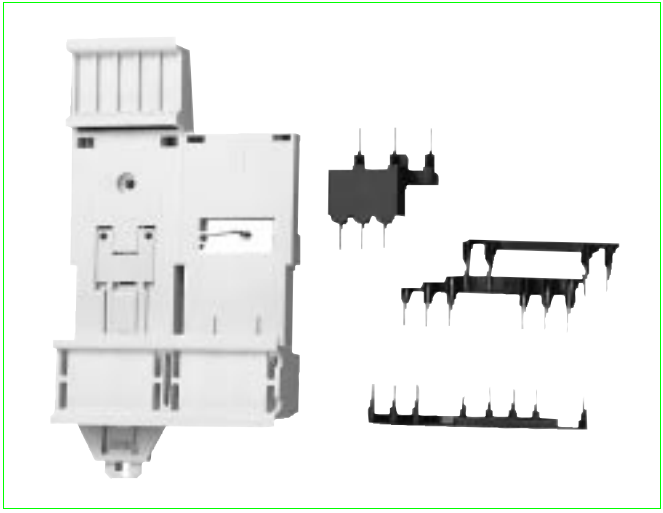
The **door coupling handle** enables the actuation of the motor-protective circuit-breaker outside of the control panel. IP65 ensures a high degree of protection. The handle is available in black and red/yellow, and is lockable in the 0 position with a door interlock. It is also available in an unlockable black version for exclusively external operation.


**Surface mounting enclosures** to IP55 are available either with black or red/yellow handles for use as enclosures with the **PKZM0** and **PKZM4** motor-protective circuit-breakers. For the **PKZM0** there are also surface mounting enclosures with a standard dimension aperture and with IP41 front protection, **flush mounting enclosures** with a standard dimension aperture and with IP41 front protection, as well as flush mounting enclosures with either a black or red/yellow handle with IP55 front protection.

In order to use the **PKZM0** or **PKZM4** as a main switch, the enclosures can be used with a **padlocking feature**. This is designed with a plate that allows the entire rotary handle to be locked way. In this way, optimum protection against tampering is guaranteed.

# Modules and Functions of Motor-Protective Circuit-Breakers

Motor-protective circuit-breakers are frequently used for the creating motor-starter combinations. A wide range of **mounting and wiring sets** are available for facilitating mounting and reducing the amount of time required. These sets can be used to create DOL, reversing and star-delta starters from **PKZM0** motor-protective circuit-breakers and DILM contactors in a third of the time required for conventional wiring.

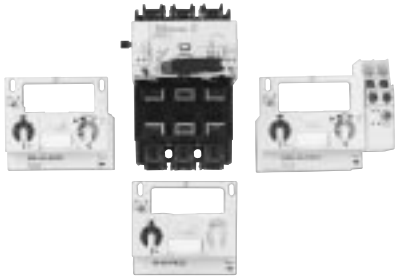


# Modules and Functions of Motor-Protective Circuit-Breakers

## PKZ2 motor-protective circuit-breaker

**Motor-protective circuit-breaker basic unit** in the range 0.4 A to 40 A. The circuit-breaker has a rotary knob as a handle for ON/OFF switching and for clear switch position indication. Depending on the trip block used, the short-circuit release of the PKZ2 can be set to 8.5 to 14 or 5 to 8.5 times the $I_n$, and the bimetal release is set to the relevant motor current.

The PKZ2 has interchangeable **trip blocks,** thus allowing more flexible use. The trip blocks are available in different versions. There are either blocks for motor protection (magnetic trip block adjustable from 8.5 – 14 × $I_n$) and for system protection (magnetic trip block adjustable from 5 – 8.5 × $I_n$).



# Modules and Functions of Motor-Protective Circuit-Breakers

The PKZ2 also has matching **(high-capacity) contact modules** which can be fitted to the **PKZ2**. In combination with the motor-protective circuit-breaker they can form powerful motor-starter combinations for applications requiring type 1 and 2 coordination. The contact modules are available for either DC or AC operation. Unlike the standard contact module, the high-capacity contact module is fitted with additional current limiting contacts.
A **base for separate mounting** also makes it possible to operate the contact module independently of the motor-protective circuit-breaker. The DC operated contact modules have an integrated **suppressor circuit**. External suppressors are available for AC operated contact modules. These suppressors attenuate any voltage peaks that may occur when the coil is switched off. The mechanical interlock enables two separately mounted contact modules to be interlocked with each other in order to create a reversing starter.

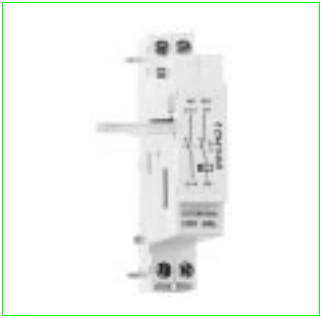
# Modules and Functions of Motor-Protective Circuit-Breakers

**Auxiliary contact modules** for side mounting are available in different make and break contact combinations. These are suitable for interlocks, signalling or annunciation tasks.

A **trip-indicating auxiliary contact** is also available here for providing a differential annunciation of a short-circuit and a general release. This unit is provided with two independently operating auxiliary contacts and is supplied together with a short-circuit indicator. The indicator is mounted separately on the PKZ2. It is used to indicate the trip on the device itself and is used for manual resets. One auxiliary contact of the trip-indicating auxiliary contact signals a general release and the other one signals a short-circuit release.

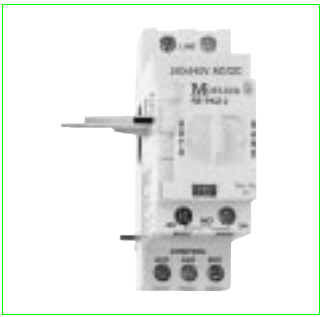
# Modules and Functions of Motor-Protective Circuit-Breakers

The PKZ2 system also offers two different **voltage releases.** The **shunt release** is used in interlock circuits and for remote off switching. It disconnects the circuit-breaker as soon as voltage is applied. The **undervoltage release**, on the other hand, switches off the motor-protective circuit-breaker as soon as it's voltage is removed. They are mainly used for safety circuits. If the voltage for the installation is interrupted, the undervoltage release trips out to prevent accidental restarts after the voltage is restored. Unlike the PKZM0 and PKZM4 systems, the PKZ2 system is available in different versions. The offer consists of a simple undervoltage release, an undervoltage release with auxiliary contacts, and one with integrated early-make auxiliary contacts.



The **CL-PKZ2** current limiter is provided to increase the switching capacity of the PKZ2, which is not inherently short-circuit proof, to 100 kA. The matching CL-PKZ2 is attached to the PKZ exactly in the same way as the contact module.

The PKZ2 system also features two remote operators for remote On/Off switching during normal operation. The RE-PKZ2 **remote operator** for standard applications has separate inputs for Line and Control with the same potential. The RS-PKZ2 has an additional potential isolation between these two inputs. Both remote operators can be run either in manual or automatic mode.



# Modules and Functions of Motor-Protective Circuit-Breakers

The **door coupling handle** enables the actuation of the motor-protective circuit-breaker outside of the control panel. IP65 ensures a high degree of protection. The handle is available in black and red/yellow, and is lockable in the 0 position with a door interlock. It is also available in an unlockable black version for exclusively external operation.


**Insulated enclosures** for **surface mounting** and **flush mounting** are available for enclosing the **PKZ2.** Both versions are available with IP40 and 41 with a standard dimension aperture, or IP54 with a special feature for the door coupling handle.

The system also provides a **padlocking feature** in order to lock the **PKZ2** with the control panel door opened when used as a main switch. This can be fitted to the front of the circuit-breaker and locked with three padlocks.

## The switch mechanism

The switch mechanism of a motor protective circuit-breaker or circuit-breaker keeps the switch in the ON position when it is switched on. The switch mechanism normally consists of a switch frame, a latching lever a link mechanism and the switch enclosure.

### Latching

The rotary movement when the motor-protective circuit-breaker is switched on causes the link mechanism to be tensioned and latched with the latching lever. At the same time the moving contacts are moved to the fixed contacts. The tightening of the link mechanism creates sufficient contact pressure to hold the contact pairs closed during normal operation.

### Releasing

The switch mechanism can be released in two ways. Firstly, by manually operating the lever the tilt point of the link mechanism is moved over and the circuit-breaker is therefore switched off. Secondly, the switch mechanism is unlatched by the release in the event of a

trip (→ Chapter "The thermal release" on page 22 and "The magnetic trip block" on page 23).

As required by IEC/EN 60 947-1 the switch mechanism of the PKZ also provides trip-free release. Holding the knob of the PKZ in position does not affect the opening movement of the contacts when the circuit-breaker is released. This device also provides the positive opening operation when used as a main switch as required by IEC/EN 60 204.

### The thermal release

A so-called bimetal is used as the tripping element for current-dependent delayed thermal overload release. This bimetal consists of at least two different metals with different thermal expansion coefficients. The thermal or length expansion coefficient $\alpha$ determines the expansion that a material is subjected to with a temperature increase of 1 K.

If, for example, a rotor is blocked, this increased current consumption will cause a considerable temperature rise on the current carrying elements of the motor-protective circuit-breaker. The metal with the higher thermal expansion coefficient will undergo more considerable expansion than the other. This causes the bimetal to bend.

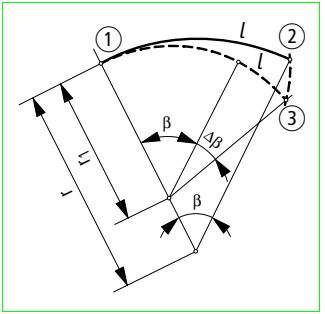



Figure 2: Bending of the bimetal
① Initial position
② Position before heating
③ Position after heating

This bending will then release the switch mechanism inside, so that the motor-protective circuit-breaker is then tripped. The main contactors of the circuit-breaker are opened and the motor feeder is then interrupted. This then enables the motor fault to be rectified without any danger. After the motor-protective circuit-breaker is switched back on, the motor starts up again.

### The magnetic trip block

The short-circuit disconnection is carried out on the motor-protective circuit-breaker by the magnetic overload release. This release consists of an electromagnet and a current coil. The current coil is not energized by a separate voltage source but directly from the main current.

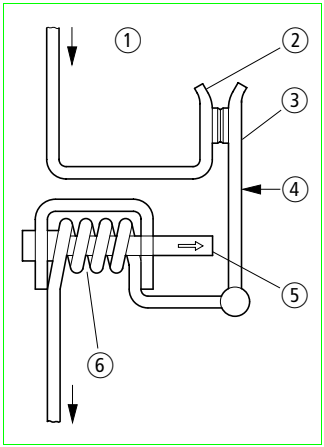



Figure 3: Magnetic overcurrent release
① Current coil
② Fixed contact element
③ Moving contact element
④ Contact pressure of switch mechanism
⑤ Striking armature
⑥ Electromagnetic release

In the event of a short-circuit, the current coil is energized with the large overcurrent. The magnetic field thus produced causes the striking armature to be drawn into the coil and strike the moving contact element. This and the dynamic response caused by the short-circuit current opens the contacts at high speed and reliably disconnects the short-circuit. The switch mechanism is unlatched at the same time. The circuit-breaker then stays in the OFF position after the short-circuit disconnection.

## Notes

# Typical Applications

## The PKZ, a device for world markets

The PKZ motor-protective circuit-breakers are sold in North America as industrial control equipment in accordance with UL 508 and CSA-C22.2 No. 14) and are primarily used in MCCs (**M**otor **C**ontrol **C**enters).

The rating specifications for them are stated in horse power (HP) on the rating plate. If they are used together with auxiliary contacts, they also have specifications on their type of usage as control equipment (pilot duties).

These motor-protective circuit-breakers have permanent or adjustable short-circuit releases and an adjustable bimetal release for overload protection.

The motor starters in compliance with UL 508 must also be protected against short-circuits by a separately mounted fuse, which can also be used for group protection.

UL 508 also requires motor-protective circuit-breakers and starters to be tested as Type E combination motor controllers. Up to the specified switching capacity, devices of this kind do not require the upstream short-circuit protective device.

In the PKZ2 system, the PKZ2/ZM-.../S-SP motor starters that have been tested according to these specifications can be used accordingly.

## Typical Applications

Table 2: Switching duty of auxiliary contacts in AC control circuits

| Auxiliary contacts in AC control circuits | Ref. no.[1] | Conv. therm. current | Maximum switching duty 120 V AC | |
|---|---|---|---|---|
| | | | On | Off |
| | | A | A | A |
| **Type of switching duty** | | | | |
| Heavy | A 150 | 10 | 60 | 6 |
| Pilot | A 300 | 10 | 60 | 6 |
| Duty[2] | A 600 | 10 | 60 | 6 |
| Standard | B 150 | 5 | 30 | 3 |
| Pilot | B 300 | 5 | 30 | 3 |
| Duty[3] | B 600 | 5 | 30 | 3 |

1) The values **150, 300** and **600** are the maximum voltage for which an auxiliary contact can be used.
2) **Heavy Pilot Duty** = High switching duty
3) **Standard Pilot Duty** = Normal switching duty





## Typical Applications

| Maximum switching duty | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 240 V AC | | 480 V AC | | 600 V AC | | ≦ 600 V AC | |
| On | Off | On | Off | On | Off | On | Off |
| **A** | **A** | **A** | **A** | **A** | **A** | **VA** | **VA** |
| – | – | – | – | – | – | 7200 | 720 |
| 30 | 3 | – | – | – | – | 7200 | 720 |
| 30 | 3 | 15 | 1.5 | 12 | 1.2 | 7200 | 720 |
| – | – | – | – | – | – | 3600 | 360 |
| 15 | 1.5 | – | – | – | – | 3600 | 360 |
| 15 | 1.5 | 7.5 | 0.75 | 6 | 0.6 | 3600 | 360 |

## Typical Applications

Table 3: Switching duty of auxiliary contacts in DC control circuits

| Auxiliary contacts in DC control circuits | Ref. no. | Conv. therm. current | Maximum switching duty | | Maximum switching duty | |
|---|---|---|---|---|---|---|
| | | | 125 V DC On/Off | 250 V DC On/Off | 310 ≦ 600 V DC On/Off | < 600 V DC On/Off |
| | | A | A | A | A | VA |
| **Type of switching duty** | | | | | | |
| Heavy | N 150 | 10 | 2.2 | – | – | 275 |
| Pilot | N 300 | 10 | 2.2 | 1.1 | – | 275 |
| Duty[1)] | N 600 | 10 | 2.2 | 1.1 | 0.4 | 275 |
| Standard | P 150 | 1.1 | – | – | 138 | – |
| Pilot | P 300 | 5 | 1.1 | 0.55 | – | 138 |
| Duty[2)] | P 600 | 5 | 1.1 | 0.55 | 0. | 138 |
| – | Q 150 | 2.5 | 0.55 | – | – | 69 |
| | Q 300 | 2.5 | 0.55 | 0.27 | – | 69 |
| | Q 600 | 2.5 | 0.55 | 0.27 | 0.1 | 69 |
| – | R 150 | 1 | 0.22 | – | – | 28 |
| | R 300 | 1 | 0.22 | 0.11 | – | 28 |

1) **Heavy Pilot Duty** = High switching duty
2) **Standard Pilot Duty** = Normal switching duty



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Typical Applications

# Typical Applications

## Thermistor protection – additional protection for difficult cases

The protection of motors against overload can be divided into two categories. The most common procedure is the indirect temperature monitoring of the motor current using bimetals carrying the current (→ Chapter "The thermal release" on page 22). Less common, however, offering no delay, is temperature measuring using thermistors in the motor windings. For this the motor must already be fitted with PTC sensors.

Both versions can be used independently of each other or combined for extensive motor protection.

### Advantages of direct temperature monitoring

Small motors up to approx. 15 kW are often stator-critical motors. Unlike rotor-critical motors, the stator winding reaches the critical limit temperature sooner than the rotor. Direct temperature monitoring is useful for these cases, since the overload can be detected and the motor protected earlier.

Other advantages of thermistor protection are its suitability for protection also in difficult and partly non-current related temperatures in and around the motor, as is the case with overload protection in uninterrupted operation, with high operating frequencies, heavy starting duty, restricted cooling with excessive ambient temperatures (e.g. in the event of thermal radiation) and high altitude installations with reduced air pressure.

Direct temperature monitoring is not frequency-dependent. This fact also makes it suitable for protecting motors with frequencies from 50 to 60 Hz.

# Motor Starters, More Than Just Motor Protection

The PKZ is also described as a manually operated motor starter. IEC/EN 60 947-1 (General Rules) describes the starter as the "combination of all the switching means necessary to start and stop a motor in combination with suitable overload protection". Unlike the use of PKZ as a motor starter, a combination made up of a contactor and overload protection offers remote on and off switching, a higher operating frequency and higher lifespan.

The conventional motor starter consists of a fuse, contactor and motor protective relay. A main switch is usually connected upstream of several starters and provides the isolating function.

These fused combinations have the disadvantage that the fuse has to be replaced after every short-circuit. Furthermore, different countries have different requirements with regard to fuse systems (such as BS in England), so that the fuse frequently has to be replaced for export.

## Fuseless motor starters

With fuseless starter combinations, as the name suggests, the device operates without the use of fuses. The short-circuit protection in this case is provided by a motor-protective or standard circuit-breaker. This obviates the need for an additional disconnector or main switch. The correct selection of motor-protective or standard circuit-breaker will also provide cable protection as well as motor protection.

Moeller's individual units of fuseless motor starters are suitable for the world market. This enables them to be used worldwide without having to be replaced.

## Coordination types

As previously mentioned, motor starters are used for motor switching applications. Smaller motors may require frequent On/Off switching. For this a motor-protective circuit-breaker must always be actuated manually and would soon reach the limits of its capabilities with switching frequencies of over 40 operations per hour. For this reason motor starters combine their protective devices with contactors, which then provide the switching under normal operating conditions. With a switching frequency of up to 4000 operations per hour and a lifespan of 1 to 1.5 million switching operations, usage is guaranteed over long periods.

If both units are combined, the reaction of the contactor in the event of a short-circuit must be tested. For this IEC/EN 60 947-4-1 specifies two coordination types and their corresponding tests.

Table 4: Coordination types

| "1" | "2" |
|---|---|
| The specified short-circuit current $I_q$ is disconnected safely. | The specified short-circuit current $I_q$ is disconnected safely. |
| No danger shall be caused to persons and installation. | No danger shall be caused to persons and installation. |
| After a short-circuit disconnection the starter must be examined before further use. The contactor and/or overload relay must be exchanged if necessary. | The starter should be suitable for further use after inspection without replacement of parts. Contact welding that can be easily separated is permissible. |

Both coordination types ensure that persons and installations are protected in the event of a short-circuit. They only differ in the procedure and state of the starter after a short-circuit disconnection.

A motor starter with type 1 coordination must be replaced after a short-circuit disconnection. This therefore would involve a long shutdown period, taking into account that the cause of the short-circuit also has to be traced. Nevertheless, type 1 coordination starters offer an economical solution for most applications.

Since the frequency of a short-circuit on all poles is very low, the motor starter very seldom has to be exchanged.

Type 2 coordination starters do not have to be replaced after a short-circuit disconnection. These starters can normally be restarted immediately, and are therefore recommended for processes requiring a high level of system availability.

# Motor Starters, More Than Just Motor Protection

## Networkable motor starters

Nowadays there is a growing trend towards the automation of machines and installations. As a result, they are increasingly provided with devices with I/O functions. Sensors and actuators supply additional detailed information about incoming commands, output signals and switching states.

When connected with conventional wiring, each individual contact of a device is connected in parallel to the interface module at the machine or control panel.

The result is a large number of screw terminals, input/output cards and cables, involving increased costs for planning, design and wiring.

These costs can, however, be reduced by networking each single device via a bus system. This approach allows a considerable reduction in wiring, in design work through the use of upstream modules, as well as considerably simplifying commissioning due to the smaller number of screw terminals required and the user-friendly addressing via the bus software.

### KLAS

For this type of application Moeller offers the KLAS load feeder system. This contains the fully wired motor starter based on the PKZM0 on the AS-Interface bus system.

The AS-Interface is a networking system for the lowest field level. The Actuator-Sensor Interface works like an "electronic wiring tool" that links sensors and actuators on an unshielded two-wire cable, or preferably a two-wire profiled flat cable. The AS-Interface bus system is designed for binary sensors (break contacts, make contacts and auxiliary contacts) and actuators (relays, contactors, lamps) on the lowest field level.

The KLAS load feeder system consists of an open solution for the control panel, and also provides DOL and reversing starters up to a rating of 7.5 kW. Control voltages of 230 V 50 Hz and 24 V DC are possible. The open solution can be adapted for direct mounting on busbar systems with a 60 mm spacing or mounted on the top-hat rail. The bus logic is integrated in a special housing between the switchgear and the top-hat rail so that it does not take up any additional space. The mounting width of the units is maintained. The motor starters are supplied from the factory with the bus logic already wired. The advantage of this is therefore a motor starter that just has to be fitted with no wiring required.

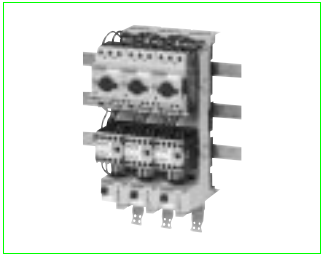

Figure 4: KLAS as an open system

The KLAS enclosed motor starter system offers an ideal solution when used locally, for example, on machines with small spatially distributed drives. This solution features the top quality design of the CI-K3 and CI-K4 enclosures in which the networked motor starters for the AS-Interface are mounted.

# Motor Starters, More Than Just Motor Protection

DOL and reversing starters up to 5.5 kW are also available in this version. The contactors are actuated via a 24 V DC AS-Interface cable. The IP65 design means that the starter modules can also be used in harsh environmental conditions. Like the open versions, these starters are fully wired and simply have to be mounted. The standard enclosures are provided with so-called power plugs which enable the power supply to be passed through from one module to the next. In this way, it is possible to carry out maintenance work on individual sections of the system without having to disconnect the other drives.

Figure 5: KLAS as an enclosed system

Two versions are available for actuating the motor-protective circuit-breaker. One uses a transparent flap cover, and the other uses a door coupling handle. In this way, the PKZ can be switched on/off easily from the outside. In both cases, the motor-protective circuit-breaker can be locked during maintenance work. The CI-K3 version also offers a variant with the handle of the PKZ housing. The enclosed solution offers even more. External devices such as indicating towers or position switches can be connected to each unused input and output. This also reduces wiring, since complete drive assemblies can be controlled and interrogated by means of a single data cable.

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