All about Motors

All about Motors

All about Motors
Motor protection

Selection aids

The Moeller selector slide enables you to determine quickly and reliably which motor starter is your most suitable for the application . All you need the operating voltage, the motor rating, the various short-circuit ratings and coordination types.

The selector slide can be used for dimensioning devices with short-circuit coordination types 1 and 2. Standard cable cross-sections and permissible cable lengths are stated for the tripping of protective devices in compliance with standards. They can vary according to the installation requirements. The selector slide has several variants of the movable section with numerical values for DOL and reversing starters or star-delta starters. The selector slide can be obtained free of charge. If you prefer to use the selector slide online, this is available on the Internet at:

www.moeller.net/en/support/slider/index.jsp

Overload relay with manual reset

These should always be used where continuous contact devices are required (e.g. pressure and position switches), to prevent automatic restarting. The reset button can be fitted as an external feature in order to make it accessible to all personnel. Moeller overload relays are always supplied with manual reset but can be converted to automatic reset by the user.

Overload relays with automatic reset

These can be used only with pulsed contact devices (three-wire control) such as pushbuttons etc., because on these, the cooling of the bimetal strips cannot lead to automatic reconnection.

Special circuitry

Special circuitry such as is found in star-delta starters, individually compensated motors, current transformer-operated relays etc. may require that the relay setting deviates from the rated motor current.

Frequently recurring operating cycles

These make motor protection difficult. The relay should be set higher than the rated motor current in view of its shorter time constant. Motors which are rated for a high frequency of operation will withstand this setting to a certain degree. Although this will not ensure complete protection against overload, it will nevertheless provide adequate protection against non-starting.

Backup fuses and instantaneous releases

These are needed to protect not only the motor, but also the relay, against the effects of short circuits. Their maximum rating is shown clearly on every relay and must be adhered to without fail. Higher ratings – chosen for instance according to the cable cross-section – would lead to the destruction of the motor and relay.

The following important questions and answers give a further guide to the behaviour of an installation with motor protection.

To what current must the overload relay be set?

To the rated motor current - no higher, no lower. A relay set to too low will prevent the full utilization of the motor; set too high, it will not guarantee full overload protection. If a correctly set relay trips too frequently, then either the load on the motor should be reduced or the motor should be exchanged for a larger one.

When is it right for the overload relay to trip?

Only when the current consumption of the motor increases due to mechanical overloading of the motor, undervoltage or phase failure when the motor is at or nearly full load, or when the motor fails to start due to a stalled rotor.

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When does the overload relay fail to trip in good time although the motor is at risk?

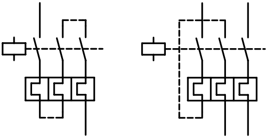
With changes in the motor which do not cause an increase in current consumption: Effects of humidity, reduced cooling due to a reduction in speed or motor dirt, temporary additional external heating of the motor or bearing wear.

What causes destruction of the overload relay?

Destruction will take place only in the event of a short circuit on the load side of the relay when the back-up fuse is rated too high. In most cases, this will also endanger the contactor and motor. Therefore, always adhere to the maximum fuse rating specified on every relay.

3-pole overload relays should be so connected in the case of single-phase and DC motors so that all three poles of the overload relay carry the current, whether in single-pole or 2-pole circuits.

1 pole **2 pole**



An important characteristic feature of overload relays conforming to IEC/EN 947-4-1 are the tripping classes (CLASS 10 A, 10, 20, 30). They determine different tripping characteristics for the various starting conditions of motors (normal starting to heavy starting).

All about Motors

Motor protection

Pick-up times

Response limits of time-delayed overload relays at all-pole load.

Type of overload relay	Multiple of current setting						Reference ambient temperature
	A *t* > 2 h starting from cold state of relay	B *t* ≦ 2 h	C Tripping class 10 A 10 20 30	 Tripping time in minutes ≦ 2 ≦ 4 ≦ 8 ≦ 12	D Tripping class 10 A 10 20 30	 Tripping time in seconds 2 < T ≦ 10 4 < T ≦ 10 6 < T ≦ 20 9 < T ≦ 30	
Non-ambient temperature compensated thermal relays and magnetic relays	1.0	1.2	1.5		7.2		+ 40 °C
Ambient temperature compensated relay	1.05	1.2	1.5		7.2		+ 20 °C

In the case of thermal overload relays with a current setting range, the response limits must apply equally to the highest and the lowest setting of the associated current.

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Motor protection

Response limits of 3-pole thermal overload relays at 2-pole load

Type of thermal overload relay	Multiple of current setting				Reference ambient temperature
	A $t > 2$ h, starting from cold state of relay		B $t \leqq 2$ h		
Ambient temperature compensated, without phase-failure sensitivity	3 poles	1.0	2 poles 1 pole	1.32 0	+ 20 °C
Non-ambient temperature compensated, without phase-failure sensitivity	3 poles	1.0	2 poles 1 pole	1.25 0	+ 40 °C
Ambient temperature compensated, with phase-failure sensitivity	2 poles 1 pole	1.0 0.9	2 poles 1 pole	1.15 0	+ 20 °C

In the case of thermal overload relays with a current setting range, the response limits must apply equally to the highest and the lowest setting of the associated current.

Overload capacity

Overload relays and releases have heating coils which can be thermally destroyed by overheating. The making and breaking currents of the motor flow in thermal overload relays which are used for motor protection. These currents are between 6 and 12 × I_e (rated operational current), depending on the utilization category and the size of the motor.

The point of destruction depends on the frame size and design and is usually approximately 12 to 20 × I_e.

The point of destruction is the point of intersection between the projected tripping curves and the multiple of the current.

Short-circuit rating of the main circuit

With currents that exceed the breaking capacity of the motor starter in relation to the utilization category (EN 60947-1), it is permissible for the current flowing during the operating time of the protective device to damage the motor starter.

The permissible behaviour of starters under short-circuit conditions is defined in the so-called types of co-ordination (1 and 2). It is common practice to state in the details of protective devices which type of co-ordination is ensured by them.

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Motor protection

Type 1 coordination
In the event of a short circuit the starter must not endanger persons and installations. It does not have to be fit for renewed operation without repair.

Type 2 coordination
In the event of a short circuit the starter must not endanger persons and installations. It must be fit for renewed operation. There is a risk of contact welding for which the manufacturer must give maintenance instructions.

The tripping characteristic of the overload relay must not differ from the given tripping curve after a short circuit.

Short-circuit withstand strength of the auxiliary switch

The manufacturer details the required overcurrent protective device. The combination is subjected to three test disconnection's at 1000 A prospective current with a power factor between 0.5 and 0.7 at rated operational voltage. Welding of the contacts may not occur (EN 60947-5-1, VDE 0660 Part 200).

Motor protection in special applications

Heavy starting duty
An adequate tripping delay is essential in order to allow a motor to start up smoothly. In the majority of cases, overload relays ZB, motor-protective circuit-breakers PKZ(M) or circuit-breakers NZM can be used. The tripping delays can be taken from the tripping characteristics in the Moeller Main Catalogue, Industrial Switchgear.

In the case of especially high-inertia motors, whose run-up time exceeds the tripping delay of the above devices, it would be completely wrong to adjust an overload relay which tripped out before the run-up time expired, to a current level higher than the rated motor current. This would, it is true, solve the starting problem, but the motor would no longer be adequately protected during normal operation. However, there are other solutions to the problem:

Current transformer-operated overload relays ZW7
The ZW7 consists of three special saturable core current transformers, supplying an overload relay Z.... It is used principally for medium and large motors.

Up to two times rated current I_e, the transformation ratio I_1/I_2 of the saturable core current transformers is practically linear. Within this range it does not differ from the normal overload relay, i.e. it provides normal overload protection during normal operation. However, within the transformer characteristic range ($I > 2 \times I_e$) , the secondary current no longer increases proportionally to the primary current.

This non-linear increase in the secondary current produces an extended tripping delay if overcurrents greater than twice rated current occur, and hence permits longer starting times.

Adjusting the current transformer-operated overload relay ZW7 for lower rated motor current
The setting ranges quoted in the Moeller Main Catalogue, Industrial Switchgear apply when the incoming cable is looped once through the transformer relay.

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All about Motors
Motor protection

If the current transformer-operated overload relay ZW7 is required to provide protection to a motor of below 42 A rating (minimum value in the setting range of 42 A to 63 A), the necessary range adjustment is achieved by looping the incomer several times through the aperture in the relay. The change in the rated motor current quoted on the rating plate is inversely proportional to the number of loops.

Example:
With the ZW7-63 relay, which has a setting range from 42 A to 63 A, a motor rating of 21 A to 31.5 A can be accommodated by looping the leads twice through the relay.

Bridging of motor protection during starting

For small motors the bridging of the motor protection during starting is more economical. Because of the additional parallel contactor, the overload relay does not carry the full current during starting. Only when the motor has reached full speed is the bridging contactor switched off and the full motor current is then carried by the overload relay. Provided it has been set correctly to the rated motor current, this will ensure full motor protection during operation. Starting must be monitored.

The motor is a limiting factor with regard to the tripping delay of the current transformer-operated relay and the bridging period. One must ensure that the motor is able to tolerate the high temperature generated by direct starting, for the prescribed starting time. Motor and starting procedure have to be selected carefully when dealing with machines having a very large rotating mass, which are practically the only ones subject to this problem when direct starting is used.

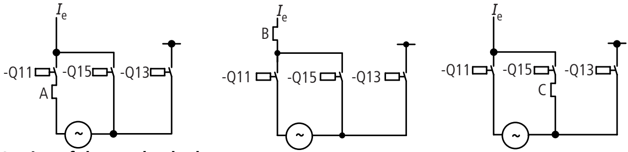
Depending on the operating conditions adequate protection of the motor winding may no longer be given by an overload relay. In that case it must be weighed up whether an electronic motor-protective relay ZEV or a thermistor overload relay EMT 6 in conjunction with an overload relay Z meets the requirements.

Star-delta starter (Y Δ)

1 operating direction

Changeover time with overload relay in position

A: < 15 s — B: > 15 < 40 s — C: > 40 s



Setting of the overload relay

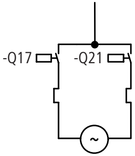
A	B	C
$0.58 \times I_e$	$1 \times I_e$	$0.58 \times I_e$
Full motor protection in Y (star) position	Only partial motor protection in Y position	Motor not protected in Y (star) position

All about Motors

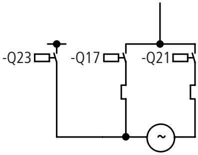
Motor protection

Multi-speed switches

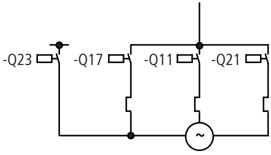
2 speeds
2 separate windings



One tapped winding



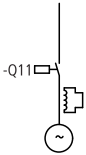
3 speeds
1 × tapped winding
+ 1 winding



Attention must be paid to short-circuit protection of the overload relays. Separate supply leads should be provided if required.

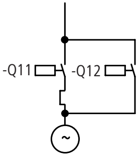
Heavy starting duty

Current transformer-operated overload relays ZW7



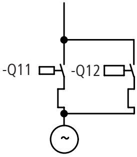
For medium and large motors

Bridging of motor protection during starting



For small motors; no protection during starting

Bridging during starting using bridging relay



Automatic cut out

All about Motors

Motor protection

Individually compensated motor

I_e = Rated motor operational current [A]
I_w = Active current } Proportion of motor
I_b = Reactive current } rated operational current [A]
I_c = Rated capacitor current [A]

I_{EM} = Setting current of overload relay [A]
cos φ = Motor power factor
U_e = Rated operational voltage [V]
P_c = Rated capacitor output [kvar]
C = Capacitance of capacitor [μF]

$$I_w = I_e \times \cos\varphi \,[A]$$

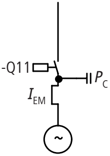
$$I_b = \sqrt{I_e^2 - I_w^2}\,[A]$$

$$I_c = U_e \times \sqrt{3} \times 2\pi f \times C \times 10^{-6}\,[A]$$

$$I_c = \frac{P_c \times 10^3}{\sqrt{3} \times U_e}$$

Capacitor connected

to contactor terminals

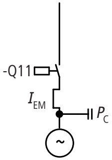


Setting I_{EM} of overload relay

$$I_{EM} = 1 \times I_e$$

Capacitor does not relieve loading of cable between contactor and motor.

to motor terminals



$$I_{EM} = \sqrt{I_w^2 + (I_b - I_c)^2}$$

Capacitor relieves loading of cable between contactor and motor; normal arrangement.

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Thermistor overload relay for machine protection

Thermistor overload relays are used in conjunction with temperature-dependent semiconductor resistors (thermistors) for monitoring the temperature of motors, transformers, heaters, gases, oils, bearings etc.

Depending on the application, thermistors have positive (PTC thermistors) or negative (NTC thermistors) temperature coefficients. With PTC thermistors the resistance at low temperature is small. From a certain temperature it rises steeply. On the other hand, NTC thermistors have a falling resistance-temperature characteristic, which does not exhibit the pronounced change behaviour of the PTC thermistor characteristic.

Temperature monitoring of electric motors

Thermistor overload relays EMT6 comply with the characteristics for the combination of protective devices and PTC sensors to VDE 0660 Part 303. They are therefore suitable for monitoring the temperature of series motors.

When designing motor protection, it is necessary to differentiate between stator-critical and rotor-critical motors:

- **Stator-critical motors**
  Motors whose stator winding reaches the permissible temperature limit quicker than the rotor. The PTC sensor fitted in the stator winding ensures that the stator winding and rotor are adequately protected even with a stalled rotor.
- **Rotor-critical motors**
  Squirrel-cage motors whose rotor in the event of stalling reaches the permissible temperature limit earlier than the stator winding. The delayed temperature rise in the stator can lead to a delayed tripping of the thermistor overload relay. It is therefore advisable to supplement the protection of rotor-critical motors by a conventional overload relay. Three-phase motors above 15 kW are usually rotor-critical.

Overload protection for motors in accordance with IEC/EN 60204. These standards specify that motors above 2 kW used for frequent starting and stopping should be adequately protected for this type of duty. This can be achieved by fitting temperature sensors. If the temperature sensor is not able to ensure adequate protection with stalled rotors, an overcurrent relay must also be provided.

Generally, where there is frequent starting and stopping of motors, intermittent operation and excessive frequency of operation, the use of overload relays in conjunction with thermistor overload relays is to be recommended. In order to avoid premature tripping out of the overload relay in these operating conditions, it is set higher than the predefined operational current. The overload relay then assumes stalling protection; the thermistor protection monitors the motor winding.

Thermistor overload relays can be used in conjunction with up to six PTC sensors to DIN 44081 for direct monitoring of temperatures in EEx e motors compliant to the ATEX directive (94/9 EC). Copies of PTB certification are available on request.

All about Motors

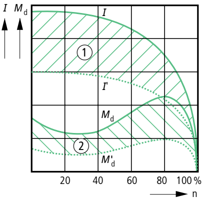
Motor protection

Protection of current and temperature-dependent motor-protective devices

Protection of the motor under the following conditions	Using bimetal	Using thermistor	Using bimetal and thermistor
Overload in continuous operation	+	+	+
Extended starting and stopping	(+)	+	+
Switching to stalled rotor (stator-critical motor)	+	+	+
Switching on stalled rotor (rotor-critical motor)	(+)	(+)	(+)
Single-phasing	+	+	+
Intermittent operation	–	+	+
Excessive frequency of operation	–	+	+
Voltage and frequency fluctuations	+	+	+
Increased coolant temperature	–	+	+
Impaired cooling	–	+	+

+ Full protection
(+) Partial protection
- No protection

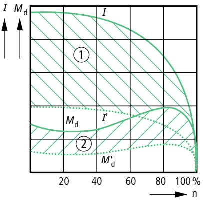
Three-phase automatic starters



Automatic stator starters three-phase current with startup resistors

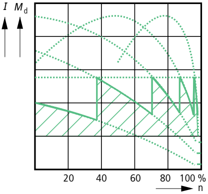
Single or multi-step resistors are connected upstream of the three-phase squirrel-cage motors to reduce the starting current and torque.

With single-step starters, the starting current is approximately three times the motor full-load current. With multi-step starters, the resistors can be so designed that the starting current is only 1.5 to 2 times the motor full-load current, with a very low level of starting torque.



Three-phase autotransformer starters with starting transformers

This type of starting is preferable where the same starting torque is to be obtained as with the primary resistance starters but the starting current taken from the mains is to be further reduced. A reduced voltage U_a (approximately 70 % of the rated operational voltage) is supplied to the motor when starting via the starting transformer. Thus, the current taken from the mains is reduced to approximately half the direct starting current.



Three-phase automatic rotor starters with starting resistors

Resistors are connected in the rotor circuit of the motor to reduce the starting current of motors with slip-ring rotors. The current taken from the mains is thus reduced. In contrast to stator resistance starters, the torque of the motor is practically proportional to the current taken from the mains. The number of steps of the automatic starter is determined by the maximum permissible starting current and by the type of the motor.

I: Line current

M_d: Torque

n: Speed

① Reduction of the line current

② Reduction of the torque

All about Motors
Engineering notes

Important data and features of three-phase automatic starters

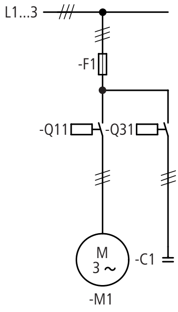
1) Type of starter	Stator resistance starter (for squirrel-cage motors)			Rotor starter (for slipring rotors)
2) Type of starter	Star-delta switches	With starting resistors	With starting transformers	Rotor resistance starter
3) Number of starting stages	1 only	Normally 1	Normally 1	Selectable (no longer selectable when current or torque have been determined)
4) Voltage reduction at the motor	0.58 × rated operational voltage	Selectable: a × rated operational voltage (a < 1) e.g. 0.58 as with ⋎△ starter	Selectable: 0.6/0.7/0.75 × U_a (transformer tappings)	none
5) Starting current taken from mains	0.33 × inrush current at rated operational voltage	a × inrush current at rated operational voltage	Selectable (see 4) 0.36/0.49/0.56 × inrush current at rated operational voltage	Selectable: from 0.5 to about 2.5 × rated current
5a) Starting current at the motor			Selectable (see 4) 0.6/0.7/0.75 × I_e	
6) Starting torque	0.33 × tightening torque at rated operational voltage	a^2 × tightening torque at rated operational voltage	Selectable (see 4) 0.36/0.49/0.56 × tightening torque at rated operational voltage	Selectable (see 5) from 0.5 to pull-out torque
7) Current and torque reduction	Proportional	Current reduction less than torque reduction	Proportional	Current reduction much greater than torque reduction. From pull-out torque to rated speed almost proportional
8) Approximate price (for similar data). DOL starting = 100 (with overload relay, enclosed)	150 – 300	350 – 500	500 – 1500	500 – 1500

8

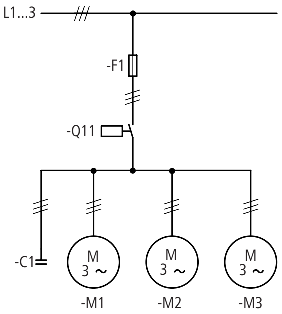
Switching of capacitors

DIL contactors for capacitors – individual switching

Individual compensation



Group compensation



When capacitors are switched on, contactors are heavily stressed by transient current peaks. When a single capacitor is switched on, currents up to 30 times the rated current can occur; these can, however, be reliably switched by Moeller DIL contactors.

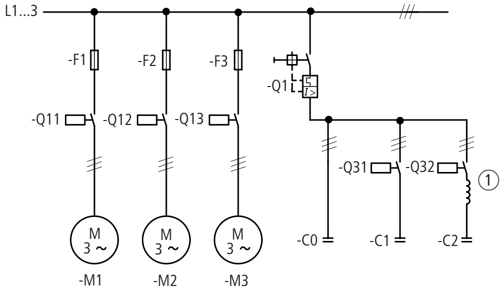
When installing capacitors, the VDE specification 0560 part 4 (Germany) and the standards which apply to each country should be observed. According to these, capacitors not directly connected to an electrical device which forms a discharge circuit, should be equipped with a rigidly connected discharge device. Capacitors connected in parallel to the motor do not require a discharge device, since discharging is performed via the motor winding. No switch-disconnectors or fuses must be installed between the discharge circuit and the capacitor.

A discharge circuit or discharge device must reduce the residual voltage of the capacitor to less than 50 V within a minute of the capacitor being switched off.

All about Motors
Engineering notes

Contactor for capacitor DILK… – Individual and group compensation

Group compensation



① Additional inductance with standard contactor

In the case of group compensation where capacitors are connected in parallel, it must be noted that the charging current is taken not only from the mains but also from the capacitors connected in parallel. This produces inrush current peaks which can exceed 150 times the rated current. A further reason for these peak currents is the use of low-loss capacitors as well as the compact construction, with short connecting elements between contactor and capacitor.

Where standard contactors are used, there is danger of welding. Special contactors for capacitors such as those available from Moeller in the DILK… range, which can control inrush current peaks of up to 180 times the rated current, should be used here.

If no special contactors are available, the inrush currents can be damped by additional inductance's. This is achieved either by longer incoming leads to the capacitors or by inserting an air-cored coil with a minimum inductance of approximately 6 µH (5 windings, diameter of the coil approximately 14 cm) between contactor and capacitor. The use of series resistors is another way of reducing high inrush currents.

Use of reactors

Frequently the capacitors in group compensation are provided with reactors to avoid harmonics. The reactors also act to limit the inrush current and normal contactor can be used.

All about Motors
Circuit documents

General

Circuit documents serve to explain the function of circuits or electrical connections. They provide information for the construction, installation and maintenance of electrical installations.

The supplier and the operator must agree on the form in which the circuit documents are to be produced: paper, film, diskette, etc. They must also agree on the language or languages in which the documentation is to be produced. In the case of machines, user information must be written in the official language of the country of use to comply with EN 292-2.

The circuit documents are divided into two groups:

Classification according to the purpose

Explanation of the mode of operation, the connections or the physical position of the components. This support covers:

- Explanatory circuit diagrams,
- Block diagrams,
- Equivalent circuit diagrams,
- Explanatory tables or diagrams,
- Flow diagrams, tables
- Time flow diagrams, tables
- Wiring diagrams,
- Device wiring diagrams,
- Interconnection diagrams,
- Terminal diagrams,
- Assignment diagrams.

Classification according to the type of representation

Simplified or detailed

- Single-line or multi-line representation
- Connected, semi-connected or separate representation
- Topographical representation

In addition to this, there is the process-orientated representation with the function chart (see previous pages).

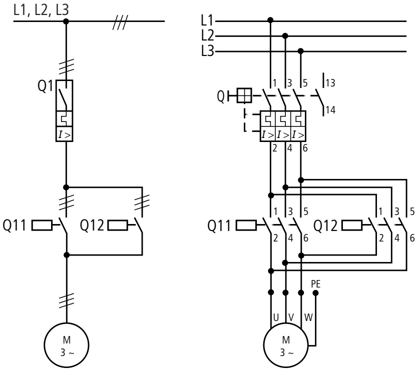
Examples for drawing up circuit documents are given in IEC 1082-1, IEC/EN 61082-1.

Circuit diagrams

Diagrams indicate the voltage-free or current-free status of the electrical installation. A distinction is drawn between:

- Block diagram: Simplified representation of a circuit with its main parts, which shows how the electrical installation works and how it is subdivided.
- Circuit diagram: Detailed representation of a circuit with its individual components, which shows how the electrical installation works.
- Equivalent circuit diagram: Special version of an explanatory circuit diagram for the analysis and calculation of circuit characteristics.

All about Motors
Circuit documents



Circuit diagram: 1-pole and 3-pole representation

8

Wiring diagrams

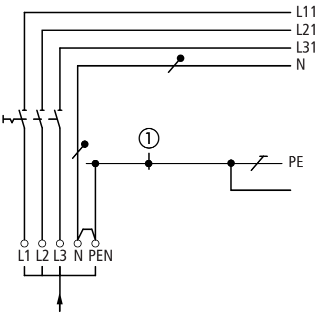
Wiring diagrams show the conductive connections between electrical components. They show the internal and/or external connections but, in general, do not give any information about the mode of operation. Instead of wiring diagrams, wiring tables can also be used.

- Unit wiring diagram: Representation of all the connections within the device or combination of devices.
- Interconnection diagram: Representation of the connections between the device or combination of devices within an installation.
- Terminal diagram: Representation of the connection points of an electrical installation and the internal and external conductive connections connected to them.
- Assignment diagram (location diagram). Representation of the physical position of the electrical equipment, which does not have to be to scale.

You will find notes on the marking of electrical equipment in the diagram as well as further diagram details in the section “Specifications, Formulae, Tables”.

All about Motors
Power supply

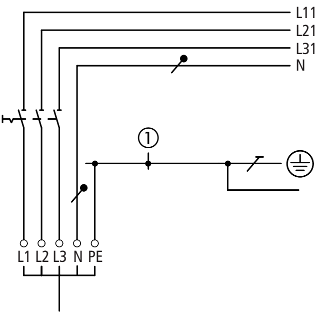
4-conductor system, TN-C-S



① Protective earth conductor
Protective earth terminal in enclosure (not totally insulated)

Overcurrent protective device in the supply is required for compliance to IEC/EN 60204-1

5-conductor system, TN-S

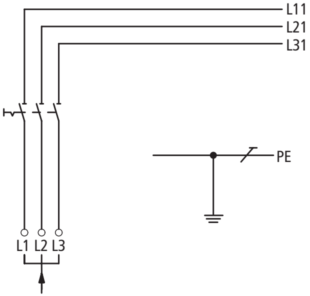


① Protective earth conductor
Protective earth terminal in enclosure (not totally insulated)

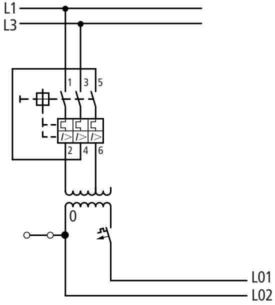
Overcurrent protective device in the supply is required for compliance to IEC/EN 60204-1

All about Motors
Power supply

3-conductor system, IT



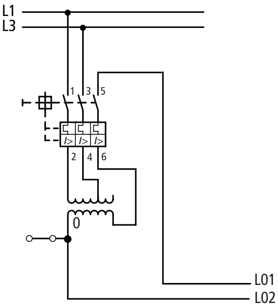
Overcurrent protective device is required in the supply for compliance to IEC/EN 60204-1
For all systems: use the N conductor only with the agreement of the user



Separate primary and secondary protection

Earthed control circuit. In non-earthed control circuit, remove link and provide insulation monitoring.

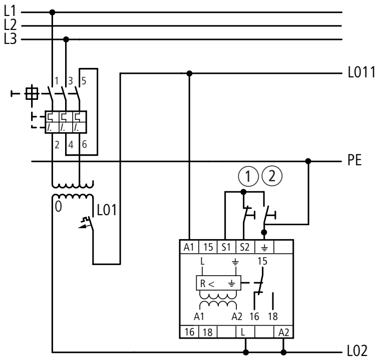
All about Motors
Power supply



Combined primary and secondary protection

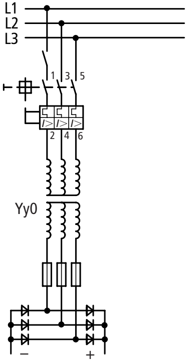
Earthed control circuit. In non-earthed control circuit, remove link and provide insulation monitoring.
Maximum ratio of U1/U2 = 1/1.73
Circuit not to be used with STI/STZ (safety and isolating transformers).

All about Motors
Control circuit supply



Separate primary and secondary protection, with insulation monitoring on the secondary side

① Clear button
② Test button



DC power supply with three-phase bridge rectifier

All about Motors

Contactor markings

The contactors in contactor combinations have, in accordance with EN 61346-2 for equipment and function, the code letter Q, as well as numerical identification, which shows the function of the component (e.g. Q22 = mains contactor with anticlockwise rotation for high speed).

The following table shows the marking used in this Wiring Manual and in Moeller circuit documentation.

Type of component	Mains contactors						Step contactors			
	Standard motor		2 speed/4 speed							
	3 speed									
	One speed		Low speed		High speed					
	Forward Up Hoist	Reverse Down Lower	Forward Up Hoist	Reverse Down Lower	Forward Up Hoist	Reverse Down Lower	Star	Delta	Starting stage	Notes
DIL (/Z)	Q11									
DIUL (/Z)	Q11	Q12								
SDAINL (/Z)	Q11						Q13	Q15		
SDAIUL (/Z)	Q11	Q12					Q13	Q15		
UPIL (/Z/Z)			Q17		Q21		Q23			
UPIUL (/Z/Z)			Q17	Q18	Q21	Q22	Q23			
UPSDAINL (/Z)			Q17		Q21		Q23	Q19		
U3PIL (/Z/Z/Z)	Q11		Q17		Q21		Q23			
UPDIUL (/Z)			Q17		Q21					
ATAINL (/Z)	Q11						Q13		Q16 to Qn	1-n starting stages
DAINL	Q11									
DDAINL	Q11									
DIL + discharge resistors	Q11								Q14	
DIGL + discharge resistors	Q11									

With contactor combinations which are made up of several basic types, the basic type is always maintained. Thus, the circuit diagram for a reversing star-delta starter, for example, is formed by combining the basic circuit of the reversing contactor and that of the standard star-delta starter.

All about Motors

Direct-on-line start of three-phase motors

Typical circuits with DIL contactors

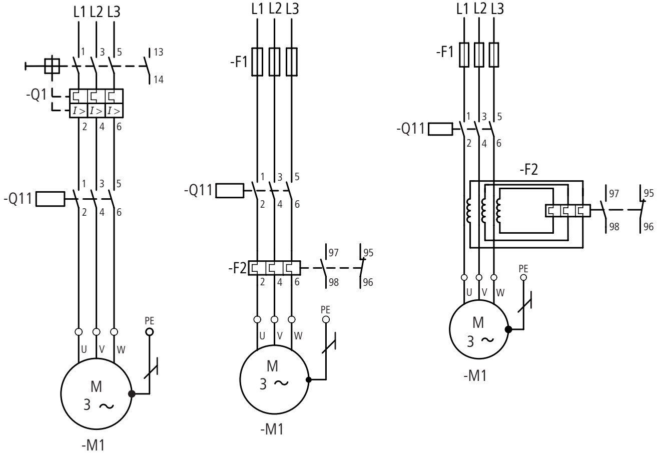
Fuseless without overload relay

Short-circuit protection1) and overload protection by means of PKZM motor-protective circuit-breaker or NZM circuit-breaker.

Fuses with overload relay

Short-circuit protection2) for contactor and overload relay by means of fuses F1.

Short-circuit protection3) for contactor by means of fuses F1.



1) Protective device in the supply line in accordance with Moeller Main Catalogue, Industrial Switchgear or AWA installation instructions.

2) Fuse size in accordance with data on the rating plate of the overload relay.

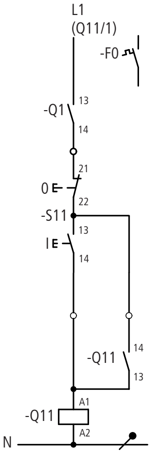
3) Fuse size in accordance with Moeller Main Catalogue, Industrial Switchgear (Technical data for contactors)

All about Motors

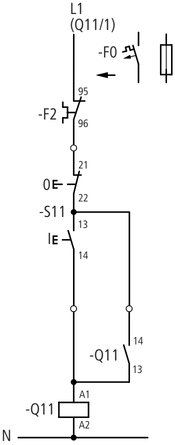
Direct-on-line start of three-phase motors

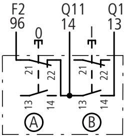
Typical circuit with bridging of overload relay during starting

Without overload relay



with overload relay





The short-circuit capacity of the contacts in the circuit has to be considered when selecting F0.

Double actuator

Control circuit device

I: ON

0: OFF

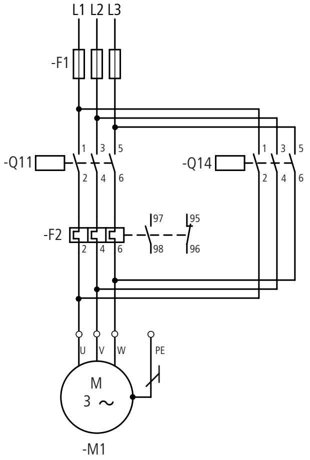
For connection of further control circuit devices → section "Pulse encoder", page 8-37

Method of operation: Actuation of pushbutton I energizes the coil of contactor Q11. The contactor switches on the motor and maintains itself after the button is enabled via its own auxiliary contact Q11/14-13 and pushbutton 0 (three-wire control contact). Contactor Q0 is de-energized, in the normal course of events, by actuation of pushbutton 11. In the event of an overload, it is de-energized via the normally closed contact 95-96 on overload relay F2.

All about Motors

Direct-on-line start of three-phase motors

Application on drive motors with heavy starting duty

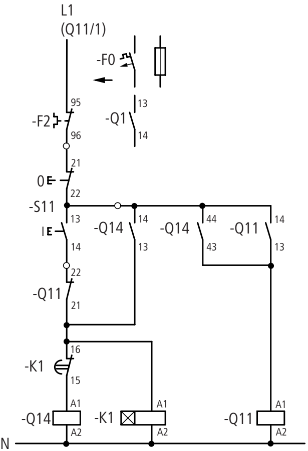


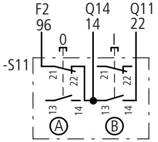
For connection when used with motor-protective circuit-breakers PKZM... and circuit-breakers NZM(H)... → section "Fuses with overload relays", page 8-29

All about Motors

Direct-on-line start of three-phase motors

Q14:Bridging contactor
K1: Timing relays
Q11:Mains contactor





Control circuit device

I: ON

0: OFF

For connection of further control circuit devices → section "Pulse encoder", page 8-37

Function

Actuation of pushbutton I energizes bridging contactor Q14 which then maintains itself via Q14/13-14. At the same time, voltage is applied to the timing relay K1. The mains contactor Q11 is closed via Q14/44-43 and maintains itself via Q11/14-13. When the set time has elapsed, which corresponds to the starting time of the motor, bridging contactor Q14 is disconnected by K1/16-15. K1 is likewise disconnected and, exactly like Q14, cannot be energized again until after the motor has been switched off by pressing pushbutton 0. The normally closed contact Q11/22-21 prevents Q14 and K1 closing whilst the motor is running. In the event of an overload, normally closed contact 95-96 on overload relay F2 effects de-energization.

All about Motors

Direct-on-line start of three-phase motors

Two directions of rotation, DIUL reversing contactor

Fuseless without overload relay

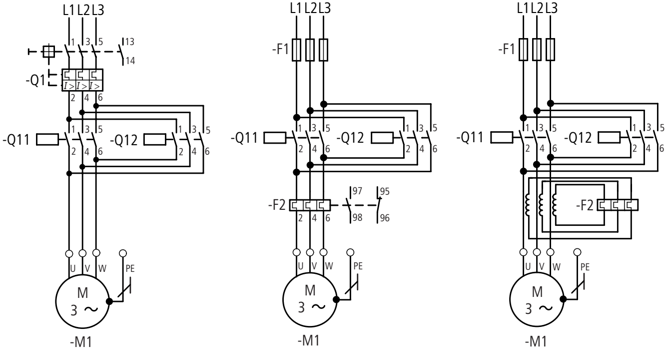
Short-circuit protection and overload protection by means of motor-protective circuit-breaker PKZM or circuit-breaker NZM.

Fuse size in the supply line in accordance with Moeller Main Catalogue, Industrial Switchgear or AWA installation instructions.

Fuses with overload relays

Short-circuit protection[1)] for contactor and overload relay by means of fuses F1.

Short-circuit protection[1)] for contactor by means of fuses F1.

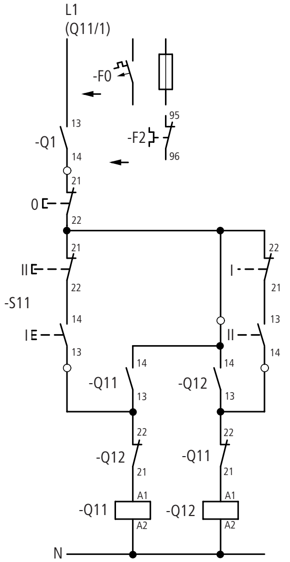


[1)] Fuse size in accordance with data on the rating plate of the overload relay F2

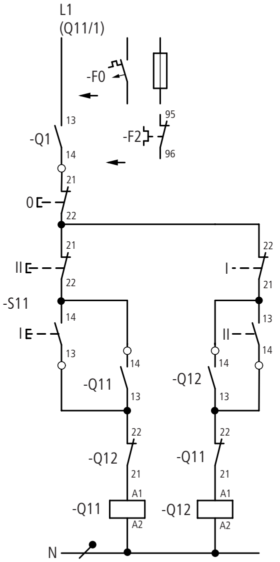
All about Motors

Direct-on-line start of three-phase motors

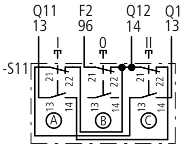
Changing direction of rotation **after** actuation of the 0 push-button



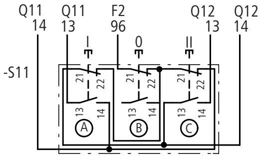
Changing direction of rotation **without** actuation of the 0 push-button



Q11: Mains contactor, clockwise
Q12: Mains contactor, anticlockwise



Control circuit device
(three-way pushbutton)
I = Clockwise
0 = Stop
II = Anticlock-wise



All about Motors

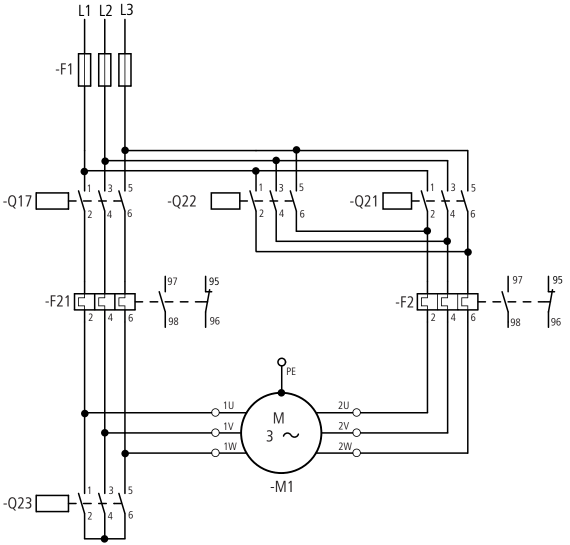
Direct-on-line start of three-phase motors

Operating principle: Actuation of pushbutton I energizes the coil of contactor Q11. It switches on the motor running clockwise and maintains itself after pushbutton I is enabled via its own auxiliary contact Q11/14-13 and pushbutton 0 (three-wire control contact). The normally closed contact Q11/22-21 electrically inhibits the closing of contactor Q12. When pushbutton II is pressed, contactor Q12 closes (motor running anticlockwise). Depending on the circuit, direction can be changed from clockwise to anticlockwise either after pressing pushbutton 0, or by directly pressing the pushbutton for the reverse direction. In the event of an overload, normally closed contact 95-96 of overload relay F2, normally open contact 13-14 of the motor-protective circuit-breaker or the circuit-breaker will switch.

Operating direction and two speeds (reversing contactor)

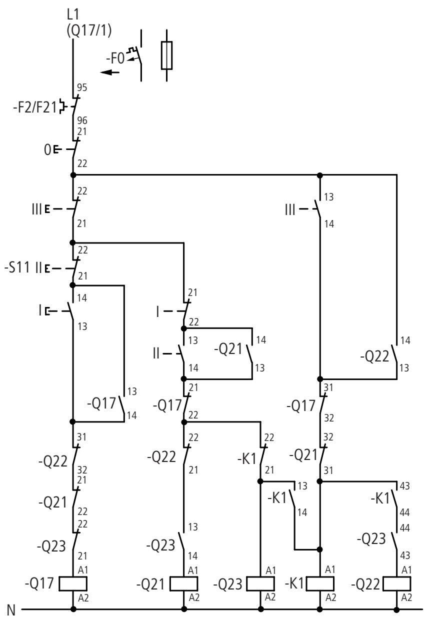
Special circuit (tapped winding) for feed drives, etc.

FORWARD: feed or high speed
RETRACT: high speed only
STOP: tapped winding



All about Motors

Direct-on-line start of three-phase motors



0: Stop
I : Low speed – FORWARD (Q17)
II: High speed – FORWARD (Q21 + Q23)
III: High speed – BACK (Q22 + Q23)

Q17: Feed forward
Q21: High speed forward
Q23: Star contactor
K1: Contactor relay
Q22: Retract high speed

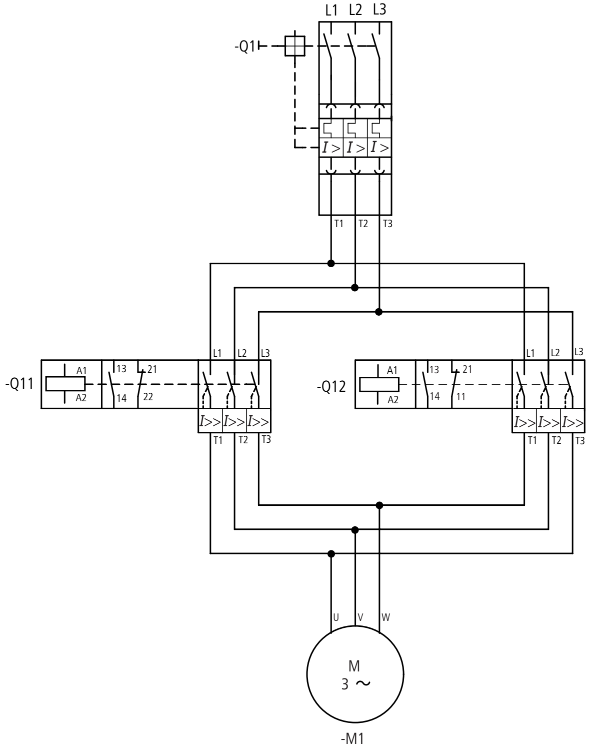
Operating principle: Forward travel is initiated by pressing pushbutton I or II according to the speed required. Pushbutton I switches on the feed motion via Q17, which maintains itself via its normally open contact 13-14. If the feed movement is to occur at high speed, star contactor Q23 is energized via pushbutton II which energizes high speed contactor Q21 via its normally open contact Q23/13-14. Both contactors are maintained via Q21/13-14. A direct switch over from feed to high-speed during the forward travel is possible.

High speed reverse is initiated by pushbutton III. Contactor relay K1 picks up and energizes star contactor Q23 via K1/14-13. High-speed contactor Q22 is energized via normally open contacts K1/43-44 and Q23/44-43, and is maintained via Q22/14-13. The reverse motion can only be stopped via pushbutton 0. Direct changeover/reversal is not possible.

All about Motors

Direct switch-on with PKZ2 motor-protective circuit-breaker

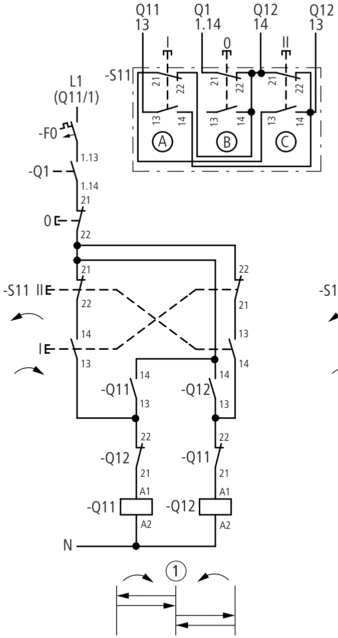
Reversing

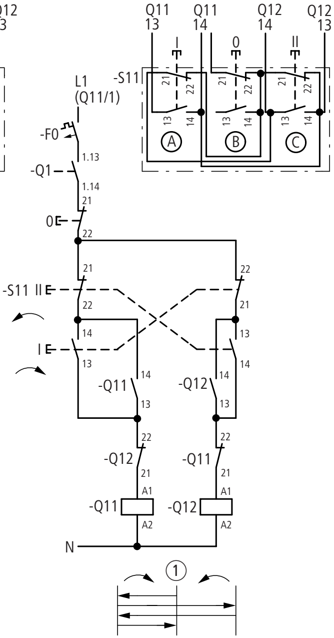


Instead of the high-capacity contact modules S-PKZ2, contact module SE1A…-PKZ2 can also be used provided a switching capacity of the circuit-breaker of 30 kA/400 V is sufficient.

All about Motors

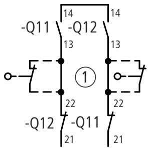
Direct switch-on with PKZ2 motor-protective circuit-breaker





① Stop

S11	RMQ-Titan, M22-…
Q1	PKZ2/ZM-…
Q12	S/EZ-PKZ2
Q11	S/EZ-PKZ2
F0	FAZ

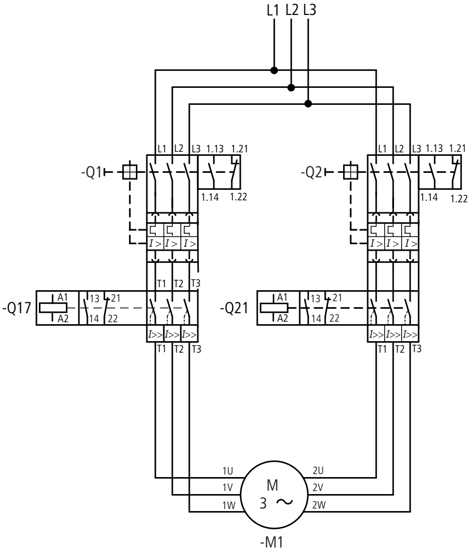


① remove links with position switches

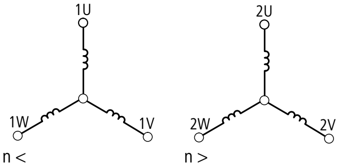
All about Motors

Direct switch-on with PKZ2 motor-protective circuit-breaker

Two speeds



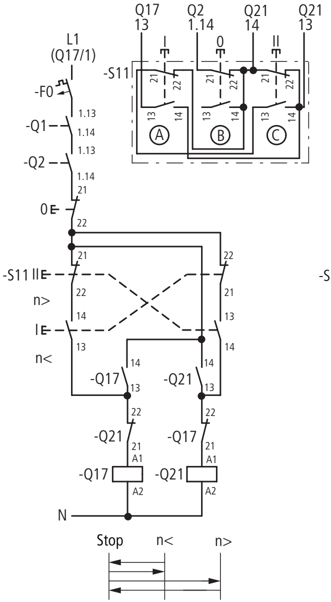
Instead of the high-capacity contact modules S-PKZ2, contact module SE1A…-PKZ2 can also be used provided a switching capacity of the circuit-breaker of 30 kA/400 V is sufficient.



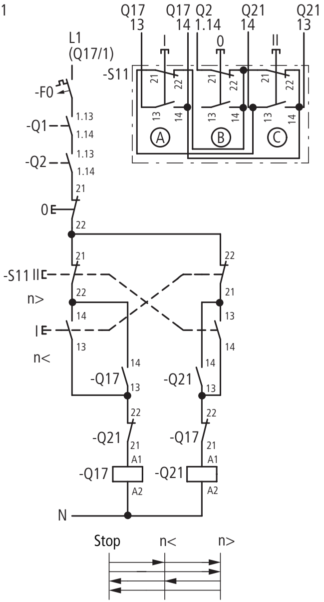
All about Motors

Direct switch-on with PKZ2 motor-protective circuit-breaker

Version 1



Version 2



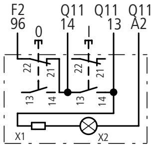
S11	RMQ-Titan, M22-…	–
Q1, Q2	PKZ2/ZM-…/S	–
Q21	S-PKZ2	n >
Q17	S-PKZ2	n <
S11	RMQ-Titan, M22-…	–

All about Motors

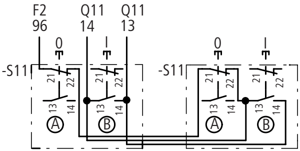
Control circuit devices for direct-on-line start

Typical example of circuits with contactors DILM…

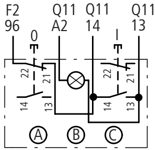
Pulse encoder



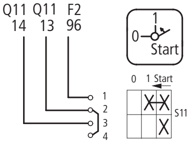
Illuminated pushbutton actuators



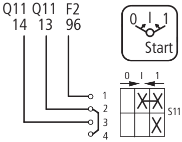
Two two-way pushbuttons



Double actuator pushbutton with indicator light

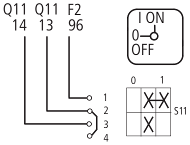


T0-1-15511 spring-return switch with automatic return to position 1

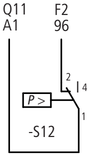


T0-1-15366 spring-return switch with automatic return to rest position

Maintained contact sensors



Changeover switch T0-1-15521 with fleeting contact in the intermediate position



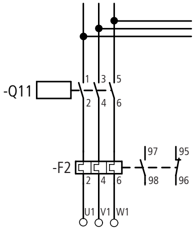
MCS pressure switches

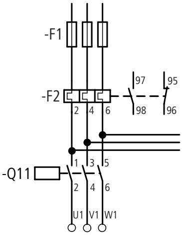
8

All about Motors

Star-delta switching of three-phase motors

Star-delta starters with overload relay





Arrangement in the motor line

In a standard circuit configuration, the star-delta starter with overload relay, including a thermally delayed overcurrent relay are situated in the cables leading to the motor terminals U1, V1, W1 or V2, W2, U2. The overload relay can also be operated in a star circuit as it is usually connected in series with the motor winding and the relay current flowing through it = rated motor current $\times$ 0.58.

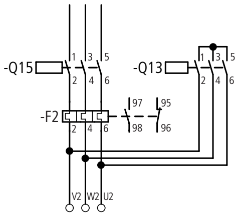
For the complete circuit diagram → section "Automatic star-delta starters SDAINL", page 8-40.

Arrangement in the mains supply line

Instead of the arrangement in the motor line, the overload relay can be placed in the **mains supply line**. The section shown here indicates how the circuit differs from that on → section "Automatic star-delta starters SDAINL", page 8-40. For drives where the F2 relay trips out when the motor is starting in the star circuit, the F2 relay rated for the **rated motor current can be switched in the mains line**. The tripping delay is thus increased by approximately four to six times. In the star circuit the current also flows through the relay but here the relay does not offer full protection since its limit current is increased to 1.73 times the phase current. It does, however, offer protection against non-starting.

All about Motors

Star-delta switching of three-phase motors



Configuration in the delta circuit

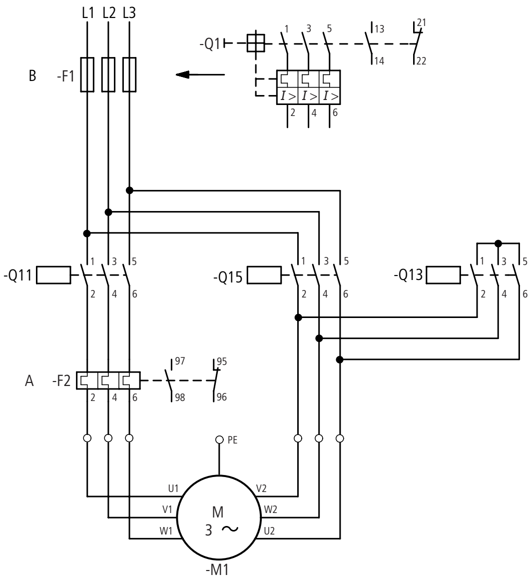
Instead of the arrangement in the motor line or mains supply line, the overload relay can be placed in the delta circuit. The section shown here indicates the modified circuit diagram from → section "Automatic star-delta starters SDAINL", page 8-40. When heavy, long-starting procedures are involved (e.g. for centrifuges) the F2 relay, rated for relay current = rated motor current × 0.58, can also be connected in the connecting lines between delta contactor Q15 and star contactor Q13. In the star circuit no current then flows through relay F2. This circuit is used wherever exceptionally heavy and long starting procedures are involved and when saturable core current transformer-operated relays react too quickly.

8

All about Motors

Star-delta switching of three-phase motors

Automatic star-delta starters SDAINL



Arrangement and rating of protective devices

Position A	Position B
F2 = 0,58 × I_e with F1 in position B t_a ≦ 15 s	Q1 = I_e t_a > 15 – 40 s
Motor protection in ⋎ and △ configuration	Only partial motor protection in ⋎ configuration

Rating of switchgear

Q11, Q15 = 0.58 × I_e

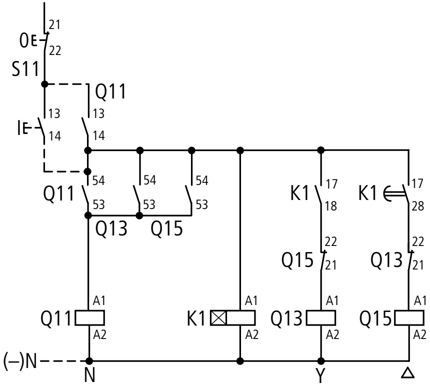
Q13 = 0.33 × I_e

All about Motors

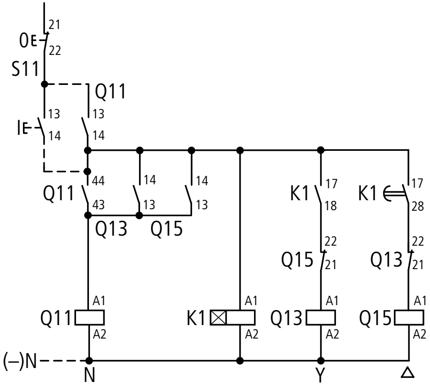
Star-delta switching of three-phase motors

Further notes on the configuration of the overload relay → section "Automatic star-delta starters SDAINL", page 8-40.

SDAINLM12 to SDAINLM55



SDAINLM70 to SDAINLM260



Pushbutton actuators

K1: Timing relay approx. 10 s
Q11: Mains contactor
Q13: Star contactor
Q15: Delta contactor
Double actuator

Function

Pushbutton I energizes timing relay K1. The normally open contact K1/17-18 (instantaneous contact) which applies voltage to star contactor Q13, which closes and applies voltage to mains contactor Q11 via normally open contact Q13/14-13.

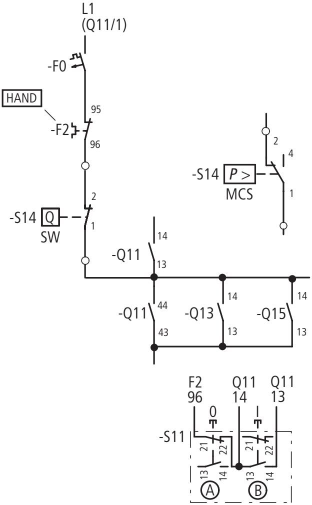
Q11 and Q13 maintain themselves via the normally open contacts Q11/14–13 and Q11/44–43. Q11 applies voltage to motor M1 in star connection.

All about Motors

Star-delta switching of three-phase motors

SDAINLM12 to SDAINLM260
Two-wire control

For connection of further control circuit devices → section "Control circuit devices for star-delta starting", page 8-51



Double actuator
Control circuit device
I = ON
0 = OFF

All about Motors

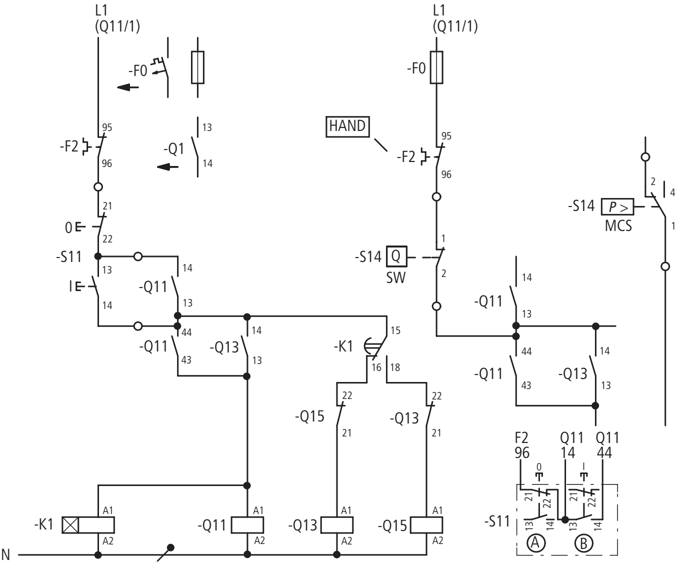
Star-delta switching of three-phase motors

When the set changeover time has elapsed, K1/17-18 opens the circuit of Q13 and after 50 ms closes the circuit of Q15 via K1/17-28. Star contactor Q13 drops out. Delta contactor Q15 closes and switches motor M1 to full mains voltage. At the same time, normally closed contact Q15/22-21 interrupts the circuit of Q13 thus interlocking against renewed switching on while the motor is running. The motor cannot start up again unless it has previously been disconnected by pushbutton 0, or in the event of an overload by the normally closed contact 95-96 of overload relay F2, or via normally open contact 13-14 of the circuit-breaker.

Automatic star-delta starters SDAINL EM

Pushbutton actuators

Maintained contact sensors



K1: Timing relay approx. 10 s
Q11: Mains contactor
Q13: Star contactor
Q15: Delta contactor

Double actuator

Control circuit device

I = ON
0 = OFF

All about Motors

Star-delta switching of three-phase motors

For connection of further control circuit devices → section "Control circuit devices for star-delta starting", page 8-51

Function

Pushbutton I energizes star contactor Q13, normally open contact Q13/14-13 applies voltage to mains contactor Q11, which closes and applies mains voltage to motor M1 in star connection. Q11 and Q13 maintain themselves via normally open contact Q11/14-13 and Q11 additionally via Q11/44-43 and pushbutton 0. Timing relay Q11 is energized at the same time as mains contactor K1. When the set changeover time has elapsed, K1 opens the circuit of Q13 via changeover contact 15-16 and closes the circuit of Q15 via 15-18. Star contactor Q13 drops out.

Delta contactor Q15 closes and switches motor M1 to full mains voltage. At the same time, normally closed contact Q15/22–21 interrupts the circuit of Q13, thus interlocking against renewed switching on while the motor is running.

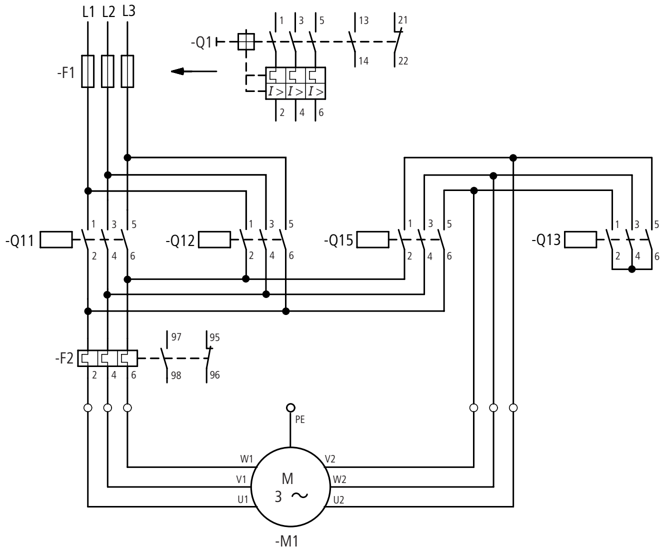
The motor cannot be started up again unless it has previously been disconnected by pushbutton 0, or in the event of an overload, by normally closed contact 95–96 of overload relay F2, or via the normally open contact 13–14 of the circuit-breaker.

All about Motors

Star-delta switching of three-phase motors

Automatic reversing star-delta starter SDAIUL

Reversing



Rating of switchgear

Q11, Q12: I_e

F2, Q15 : 0,58 × I_e

Q13 : 0,33 × I_e

The maximum motor output is limited by the upstream reversing contactor, and is lower than with automatic star-delta starters for only one direction of operation

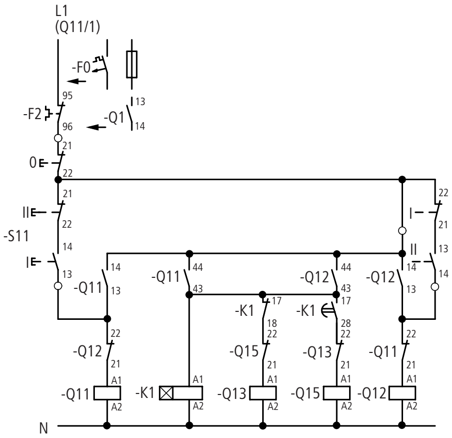
Standard version: Relay current = motor rated current × 0.58

For other arrangements of overload relay → section "Star-delta starters with overload relay", page 8-38

All about Motors

Star-delta switching of three-phase motors

Changing direction of rotation after actuation of the 0 pushbutton



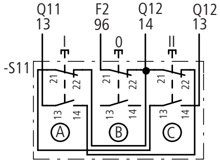
Three-way pushbutton

Control circuit devices

I = Clockwise

0 = Stop

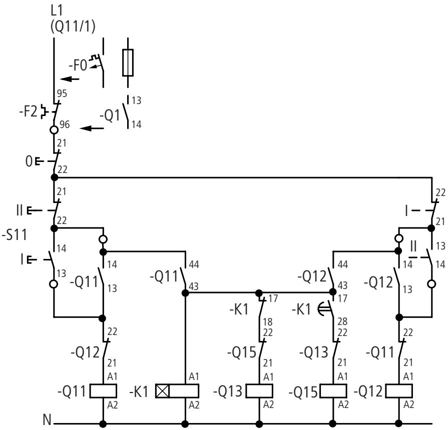
II = Anticlockwise



All about Motors

Star-delta switching of three-phase motors

Changing direction of rotation without actuation of the 0 pushbutton



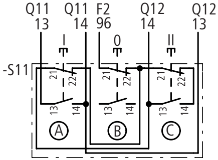
Three-way pushbutton

Control circuit devices

I = Clockwise

0 = Stop

II = Anticlockwise



For connection of further control circuit devices → section "Control circuit devices for star-delta starting", page 8-51

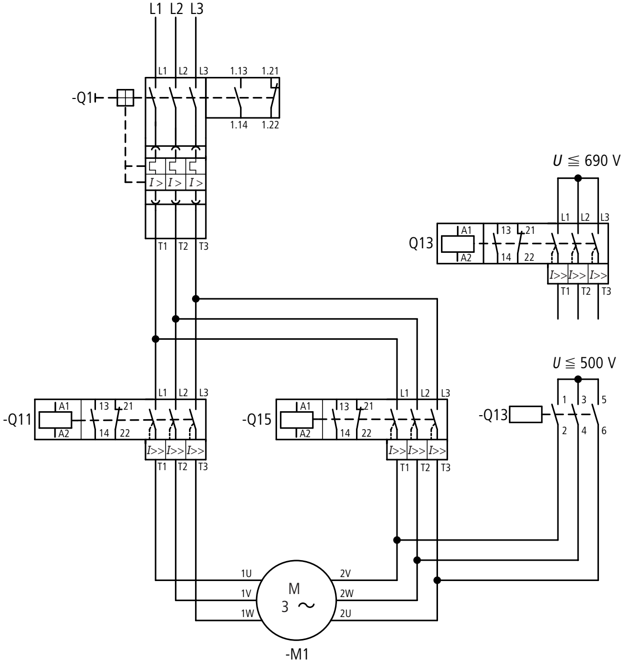
Function

Pushbutton I energizes contactor Q11 (e.g. clockwise). Pushbutton II energizes contactor Q12 (e.g. anticlockwise). The contactor first energized applies voltage to the motor winding and maintains itself via its own auxiliary contact 14-13 and pushbutton 0. Normally open contact 44-43 fitted to each mains contactor energizes star contactor Q13, which energizes and switches on motor M1 in the star connection. At the same time, timing relay K1 is triggered. When the set changeover time has elapsed, K1/17-18 opens the circuit of Q13, which drops out. K1/17-28 closes the circuit of Q15.

Delta contactor Q15 energizes and switches motor M1 to the delta configuration, i.e. full mains voltage. At the same time, normally closed contact Q15/22–21 interrupts the circuit of Q13, thus interlocking against renewed switching on while the motor is running. Motor direction can be changed, either after pressing pushbutton 0, or by direct actuation of the reverse button, depending upon the circuit. In the event of an overload, disconnection is effected by normally closed contact 95–96 of overload relay F2.

All about Motors

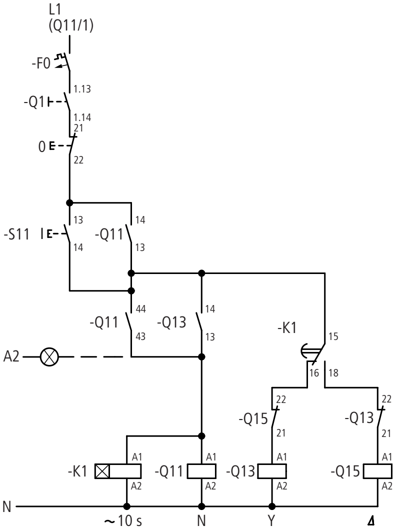
Star-delta starting with motor-protective circuit-breakers PKZ2



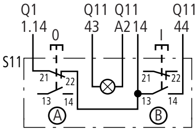
With $I_{cc} > I_{cn}$ short-circuit proof installation required.

All about Motors

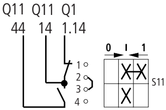
Star-delta starting with motor-protective circuit-breakers PKZ2



2 × RMQ-Titan, M22-… with indicator light M22-L…



T0-1-8 rotary switch



All about Motors

Star-delta starting with motor-protective circuit-breakers PKZ2

S11	RMQ-Titan, M22-…
Q1	PKZ2/ZM-…
△Q15	S/EZ-PKZ2
⋎Q13	DILOM U_e ≦ 500 V AC
⋎Q13	S/EZ-PKZ2 U_e ≦ 660 V AC
K1	ETR4-11-A
Q11	S/EZ-PKZ2
F0	FAZ

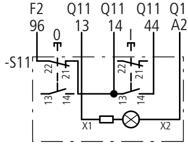
t	*t* ⋎ (s)	15 – 40
N	Motor protection	(⋎) + △
	Setting	*I*

All about Motors

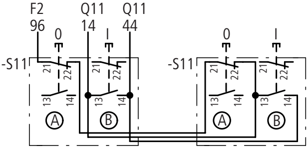
Control circuit devices for star-delta starting

Automatic star-delta starters SDAINL

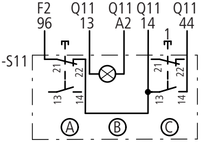
Pulse encoder



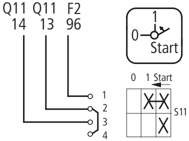
Illuminated pushbutton actuators



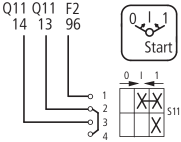
Two two-way pushbuttons



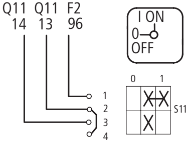
Double actuator pushbutton with indicator light



Spring-return switch T0-1-15511 with automatic return to position 1.

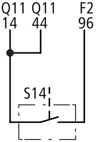


Spring-return switch T0-1-15366 with automatic return to rest position.



Changeover switch T0-1-15521 with fleeting contact in the intermediate position

Two-wire control

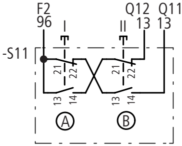


e.g. selector switch
Rotary switch T
LS position switches
MCS pressure switches

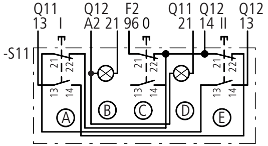
All about Motors

Control circuit devices for star-delta starting

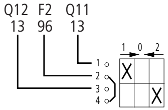
Three-phase reversing contactor DIULRR
Reversing star-delta starter SDAIUL

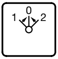


Two-way pushbutton[1] without self-maintaining circuit (inching) for use only with reversing contactors



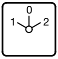
Three-way pushbutton with indicator light. Reversing after actuation of pushbutton 0





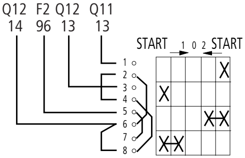
FS 4011

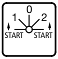
Spring-return switch[1]
T0-1-8214, without self-maintaining circuit (inching)
automatic return to 0 only for reversing contactors



FS 684

Changeover switch[1]
Switch T0-1-8210 remains in position 1 or 2

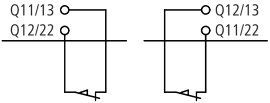




FS 140660

Spring-return switch
T0-2-8177 with automatic return to position 1 or 2

Position switches
Connected by removing the links between contactor terminals Q11/13 and Q12/22 and between Q12/13 and Q11/22 and interposing the position switches.



[1] Overload relays always with manual reset

All about Motors
Pole-changing motors

The speed is determined by the number of poles on induction motors. Several speeds can be obtained by altering the number of poles. The usual types are:

2 speeds 1:2	1 reversible tapped winding
2 speeds	2 separate windings
3 speeds	1 reversible tapped winding 1:2, 1 separate winding
4 speeds	2 reversible tapped windings 1:2
2 speeds	Tapped winding

The various tapped winding configurations give differential output ratios for the two speeds

Type of connection	△/Y Y	Y/Y Y
Output ratio	1/1,5–1,8	0,3/1

The △/Y Y configuration comes nearest to satisfying the most common requirement for constant torque. It has the additional advantage that, because nine terminals are available, Y/△ starting can be used to provide smooth starting or to reduce the starting current for the low speed condition (→ section "Motor windings", page 8-56).

The Y/Y Y is preferred for better matching of the motor to machines in which the torque increases by a quadratic factor (pumps, fans, rotary compressors). Moeller multi-speed starters can be used for both types of connection.

2 speeds – separate windings

In theory, motors with separate windings allow any combination of speed and any output ratio. Both windings are arranged in Y connection and are completely independent of one another.

Preferred speed combinations are:

Motors with tapped winding	1500/3000	–	750/1500	500/1000
Motors with separate windings	–	1000/1500	–	–
Number of poles	4/2	6/4	8/4	12/6
Code no. low/high	1/2	1/2	1/2	1/2

The code numbers are prefixed to the main notations to denote increasing speed. Example: 1U, 1V, 1W, 2U, 2V, 2W. Comparable to EN 60034-8.

8

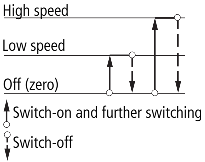
All about Motors

Pole-changing motors

Motor circuit

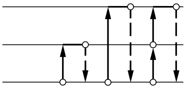
Circuit A

Selection of low and high speed only from zero. No return to low speed, only to zero.



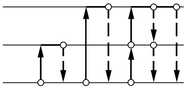
Circuit B

Selection of either speed from zero. Switching from low to high speed possible. Return only to zero.



Circuit C

Selection of either speed from zero. Switching back and forward between low and high speed (high braking torque). Return also to zero.



3 speeds

The 1:2 speeds - tapped windings - are supplemented by the speed of the separate winding. This speed can be below, between or above the two tapped winding speeds. The circuit must consider it (→ figure, page 8-84).

Preferred speed combinations are:

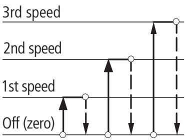
Speeds	1000/1500/3000	750/1000/1500	750/1500/3000	= separate winding (in the circuit diagrams)
Number of poles	6/4/2	8/6/4	8/4/2	
Connectio n	X	Y	Z	

All about Motors
Pole-changing motors

Motor circuit

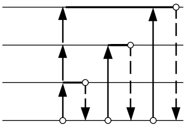
Circuit A

Selection of any speed only from zero. Return only to zero.



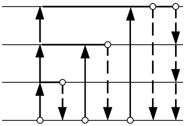
Circuit B

Selection of any speed from zero and from low speed. Return only to zero.



Circuit C

Selection of any speed from zero and from low speed. Return to low speed (high braking torque) or to zero.



4 speeds

The 1:2 speeds - tapped windings - can follow in sequence or overlap, as the following examples show:

1st winding	500/1000	2nd winding	1500/3000 = 500/1000/1500/3000
or 1st winding	500/1000	2nd winding	750/1500 = 500/750/1000/1500

For motors with 3 or 4 speeds the non-connected winding has to be opened at certain pole ratios to avoid inductive circulating currents. This is achieved with additional motor terminals. A range of rotary switches is equipped with this connection (→ section "Multi-Speed Switches", page 4-7).

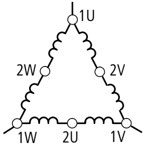
All about Motors
Motor windings

Tapped winding
2 speeds

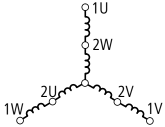
Motor circuit
2 speeds
2 separate windings

Tapped winding
with Y△ starting at
low speed

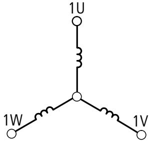
Low speed △



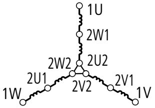
Low speed Y



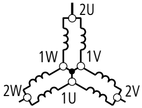
Low speed



Low speed Y

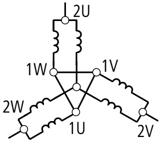


High speed YY



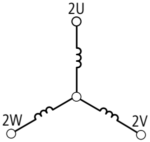
→ figure, page 8-61

High speed YY



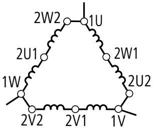
→ figure, page 8-61

High speed

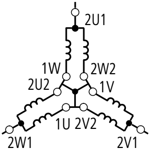


→ figure, page 8-65

Low speed △



High speed YY



→ figure, page 8-74

All about Motors

Motor windings

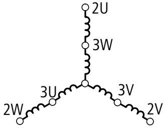
Tapped winding

3 speeds

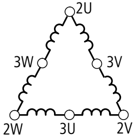
Motor circuit X

2 windings, medium and high speed – tapped winding

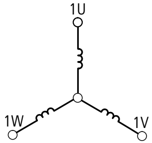
2



or 2



Low speed
Separate winding
1

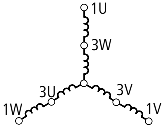


→ figure, page 8-83

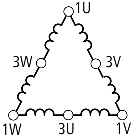
Motor circuit Y

2 windings, low and high speed – tapped winding

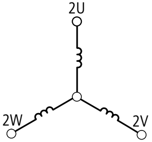
2



or 2



Medium speed
Separate winding
1

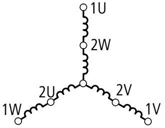


→ figure, page 8-85

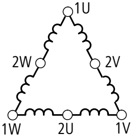
Motor circuit Z

2 windings, low and medium speed – tapped winding

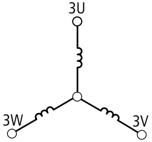
2



or 2



High speed
Separate winding
1



→ figure, page 8-87

Notes

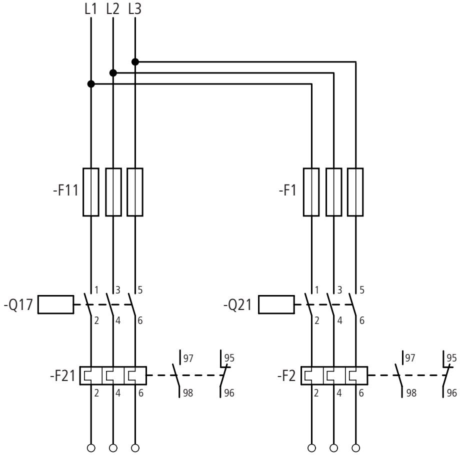
All about Motors
Multi-speed contactors

Certain operating sequences for multi-speed motors may be necessary, or undesirable, depending on the nature of the drive. If, for example, the starting temperature rise is to be reduced or high inertia loads are to be accelerated, it is advisable to switch to low speed first and then to high speed.

It may be necessary to prevent switching from high to low speed in order to avoid oversynchronous braking. In other cases, it should be possible to switch each speed on and off directly. The operating sequence and indexing facilities of rotary switches allow for these possibilities. Multi-speed contactor starters can achieve these circuits by interlocking with suitable control circuit devices.

Fuse protection of the overload relays

When a common fuse is used in the supply line, it must not be larger than the back-up fuses specified on the rating plate of either overload relay, otherwise each relay must be protected by its own back-up fuse, as shown in the diagram.

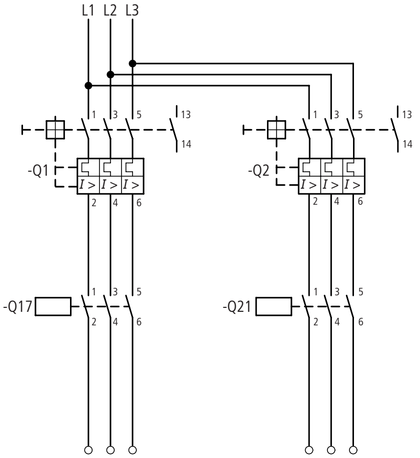


All about Motors

Multi-speed contactors

Fuseless surface mounting

Multi-speed motors can be protected against short circuits and overloads by motor-protective circuit-breakers PKZ or circuit-breakers NZM, which provide all the advantages of a fuseless circuit. Normally, the fuse in the supply line protects the switches from welding.

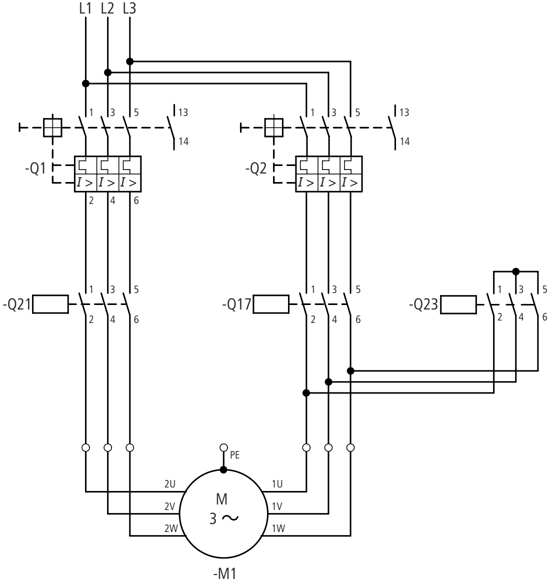


All about Motors

Multi speed switches of three-phase motors

Tapped winding, non-reversing, 2 speeds

Multi-speed contactors UPIL
Fuseless, without overload relay, with motor-protective circuit-breaker or circuit-breaker.



→ section "Motor windings", page 8-56

Synchronous speeds
One multi-speed winding

All about Motors

Multi speed switches of three-phase motors

Motor terminals	1U, 1V, 1W	2U, 2V, 2W
Number of poles	12	6
rpm	500	1000
Number of poles	8	4
rpm	750	1500
Number of poles	4	2
rpm	1500	3000
Contactors	Q17	Q21, Q23

Rating of switchgear

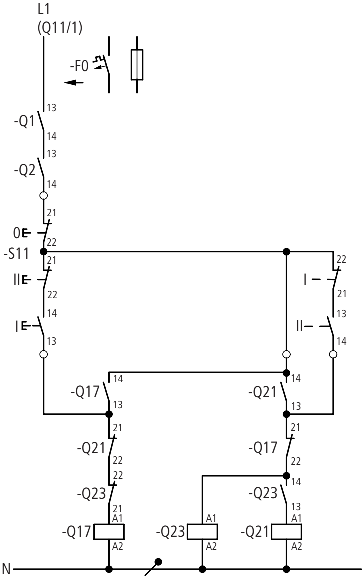
Q2, Q17: I_1 (low speed)
Q1, Q21: I_2 (high speed)
Q23: $0.5 \times I_2$

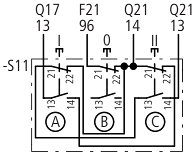
All about Motors

Multi speed switches of three-phase motors

Circuit A (→ figure, page 8-55)

One three-way pushbutton





Three-way pushbutton
I: Low speed (Q17)
0: Stop
II: high speed (Q21 + Q23)
Q17: Mains contactor, low speed
Q23: Star contactor
Q21: Mains contactor, high speed

For connection of further control circuit devices → figure, page 8-69, → figure, page 8-70, → figure, page 8-71

Function

Pushbutton I energizes mains contactor Q17 (low speed), wich maintains itself via its normally open contact 13-14. Pushbutton II energizes star contactor Q23 and via its normally open contact 13-14 mains contactor Q21. Q21 and Q23 maintain themselves via normally open contact 13-14 of Q21.

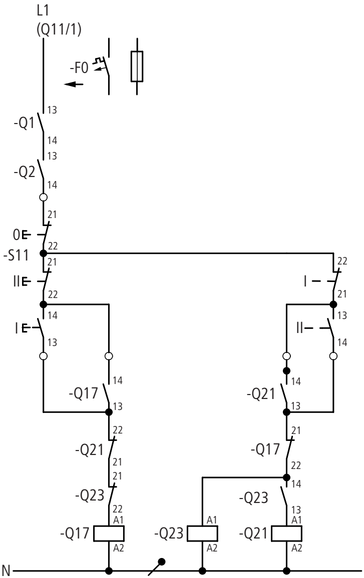
Speed can be changed either after pressing pushbutton 0 (circuit A) or directly by pressing the appropriate pushbutton (circuit C), depending upon the circuit. The motor can be switched off either by pressing pushbutton 0, or in the event of an overload, by normally open contact 13–14 of the circuit-breaker.

All about Motors

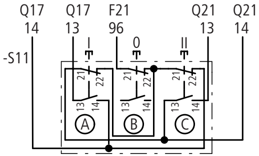
Multi speed switches of three-phase motors

Circuit C (→ figure, page 8-55)

One three-way pushbutton



Three-way pushbutton
I: Low speed (Q17)
0: Stop
II: High speed (Q21 + Q23)



Q17: Mains contactor, low speed
Q23: Star contactor
Q21: Mains contactor, high speed

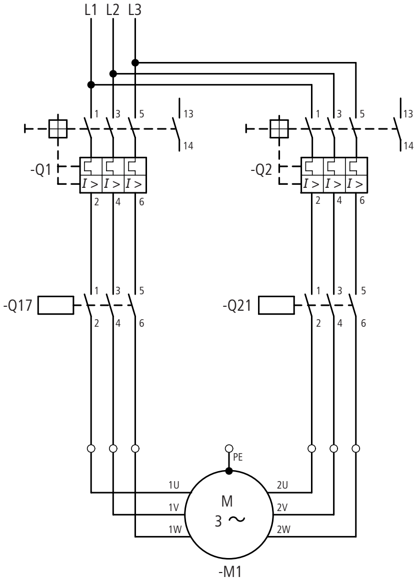
For connection of further control circuit devices → figure, page 8-72

All about Motors

Multi speed switches of three-phase motors

Two separate windings, non-reversing, two speeds

Multi-speed contactor UPDIUL, fuseless without overload relay



Rating of switchgear

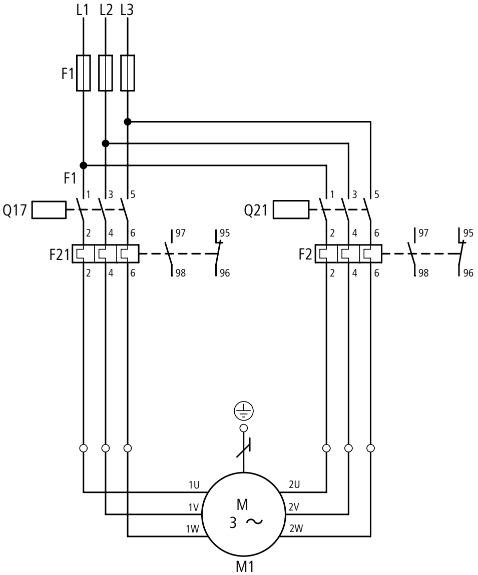
Q1, Q17 = I_1 (low speed)
Q2, Q21 = I_2 (high speed)

Motor windings → section "Motor windings", page 8-56.

All about Motors
Multi speed switches of three-phase motors

Two separate windings, non-reversing, two speeds

Multi-speed contactor UPDIUL, with fuses and overload relay



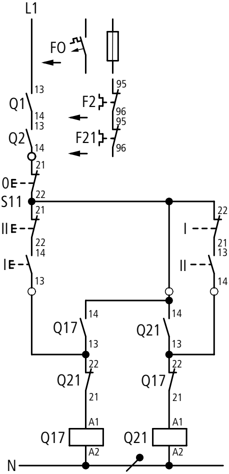
Fuse size in accordance with data on the rating plate of overload relays F2 and F21. If overload relays F2 and F21 cannot be protected by a common fuse, then use circuit → figure, page 8-59.

Motor windings → section "Motor windings", page 8-56.

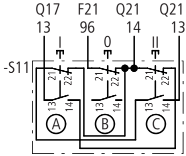
All about Motors

Multi speed switches of three-phase motors

Circuit A (→ figure, page 8-55)
One three-way pushbutton

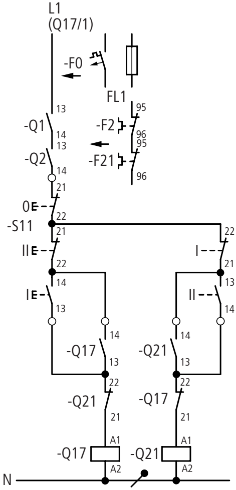


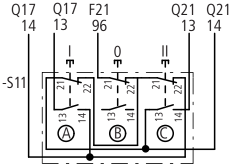
Q17: Mains contactor, low speed
Q21: Mains contactor, high speed



Three-way pushbutton
I: Low speed (Q17)
0: Stop
II: High speed (Q21 + Q23)

Circuit C (→ figure, page 8-55)
One three-way pushbutton





For connection of further control circuit devices → figure, page 8-73.

All about Motors
Multi speed switches of three-phase motors

Operating principle
Actuation of pushbutton I energizes the coil of contactor Q17,which switches on the low speed of the motor and, after pushbutton I is released, maintains itself via its auxiliary contact 13-14 and pushbutton 0.

Speed can be changed either after pressing pushbutton 0, or directly by pressing the appropriate pushbutton, depending upon the circuit. The motor is switched off either by pressing pushbutton 0, or in the event of an overload, by normally closed contact 95–96 of overload relays F2 and F21.

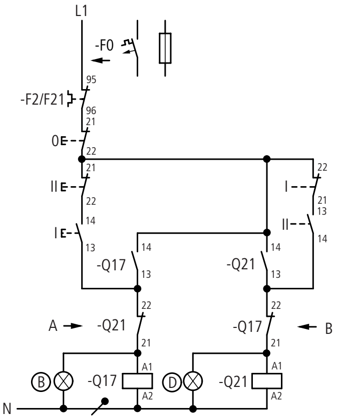
All about Motors

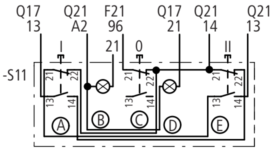
Control circuit devices for UPDIUL multi-speed contactors

Two separate windings, non-reversing, two speeds

Circuit A (→ figure, page 8-55)

One three-way pushbutton with indicator lights





Control circuit devices

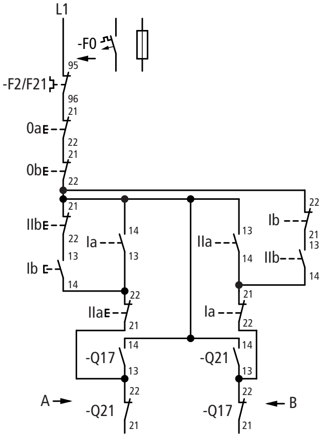
I : Low speed (Q17)
0: Stop
II : High speed (Q21)

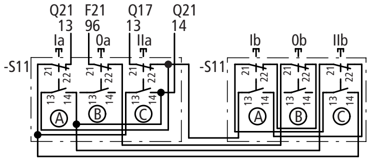
All about Motors

Control circuit devices for UPDIUL multi-speed contactors

Circuit A (→ figure, page 8-55)

Two three-way pushbuttons





Control circuit devices

I: Low speed (Q17)

0: Stop

II: High speed (Q21)

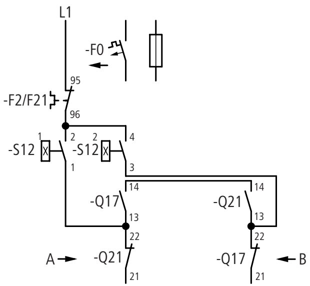
Remove existing links and rewire

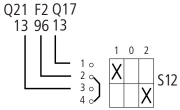
All about Motors

Control circuit devices for UPDIUL multi-speed contactors

Circuit A (→ figure, page 8-55)

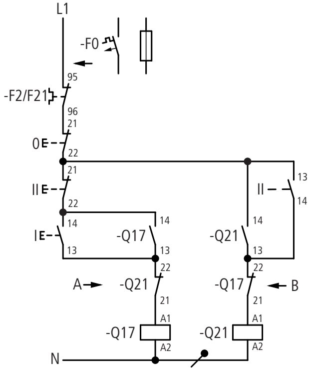
T0-1-8210 changeover switch
Always set overload relay to manual reset





Circuit B (→ figure, page 8-55)

One three-way pushbutton

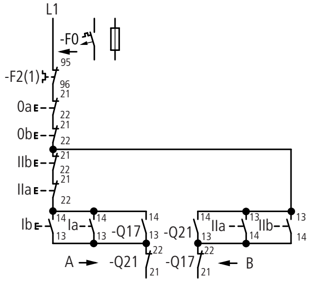


All about Motors

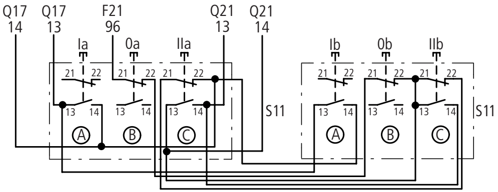
Control circuit devices for UPDIUL multi-speed contactors

Circuit B(→ figure, page 8-55)

Two three-way pushbuttons



Control circuit device for circuit B

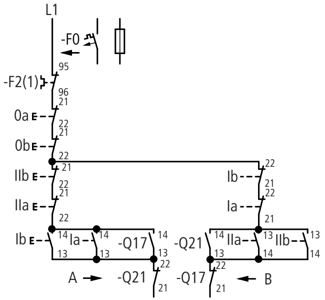


All about Motors

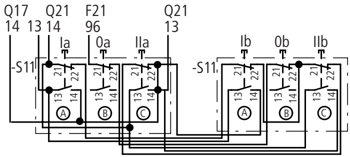
Control circuit devices for UPDIUL multi-speed contactors

Circuit C (→ figure, page 8-55)

Two three-way pushbuttons



Control circuit device for circuit C



All about Motors

Multi speed switches of three-phase motors

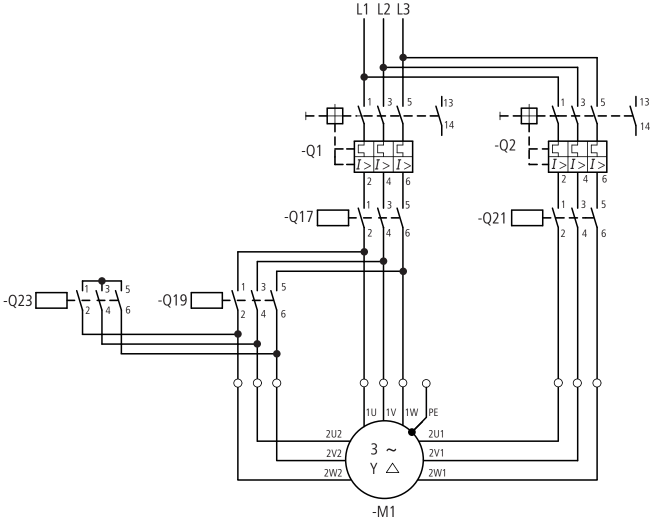
Tapped winding, non-reversing, 2 speeds

Multi-speed contactors UPSDAINL

Star-delta starting at low speed

Fuseless

Without overload relay



Rating of switchgear

Q1, Q17 $= I_1$

(low speed)

Q2, Q21 $= I_2$

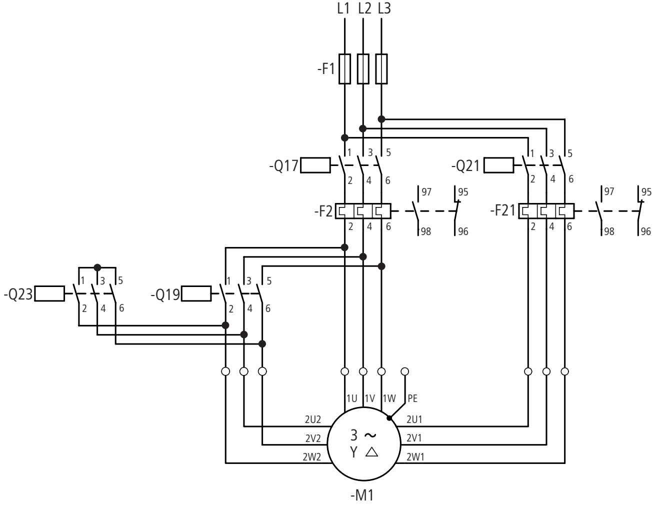
(high speed)

Q19, Q23 $= 0{,}5 \times I_2$

All about Motors

Multi speed switches of three-phase motors

With **fuses** and overload relays



Rating of switchgear

F2, Q17 $= I_1$

(low speed)

F21, Q21 $= I_2$

(high speed)

Q19, Q23 $= 0{,}5 \times I_2$

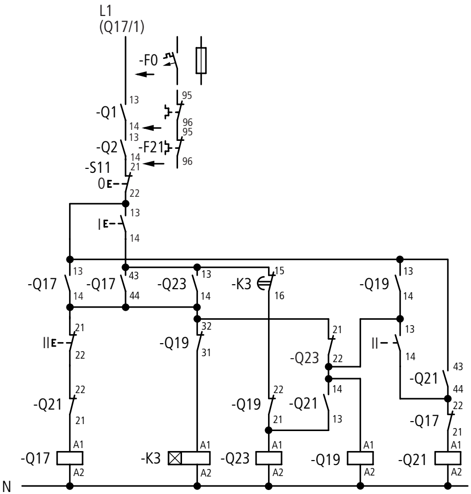
F1 $= I_2$

Overload relays F2 and F21 are not used on multi-speed contactors without motor protection. If F2 and F21 cannot be protected by a common fuse, then use circuit on → figure, page 8-59.

Motor windings → section "Motor windings", page 8-56.

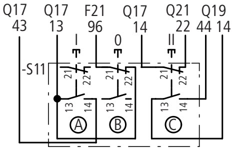
All about Motors

Multi speed switches of three-phase motors



Q17: Mains contactor, low speed
K3: Timimg relays
Q23: Star contactor

Q19: Delta contactor
Q21:Mains contactor, high speed



Circuit

Low speed selected only from zero, high speed only via low speed without actuation of the Stop button.
Three-way pushbutton
I: Low speed (Q17, Q19)
0: Stop
II: High speed (Q21, Q19, Q23)

Function

Actuation of pushbutton I energizes the coil of star contactor Q23. Its normally open contact 13-14 energizes the coil of contactor Q17. The motor runs in star at low speed. The contactors are maintained via auxiliary contact Q17/13-14. At the same time, timing relay K3 is triggered. When the set time has elapsed, K3/15-16 opens the circuit of Q23, which drops out, the coil of delta contactor Q19 is energized and maintains itself via Q19/13-14. The timing relay is de-energized via normally closed contact Q19/32-31.

The motor runs in delta at low speed. Actuation of pushbutton II de-energizes the coil of Q17 and via Q17/22–21 energizes the coil of Q21. This state is maintained by Q21/43–44: The coil of star contactor Q23 is re-energized by normally open contact Q21/14–13. The motor runs at high speed.
Pushbutton 0 (= Stop) effects disconnection.

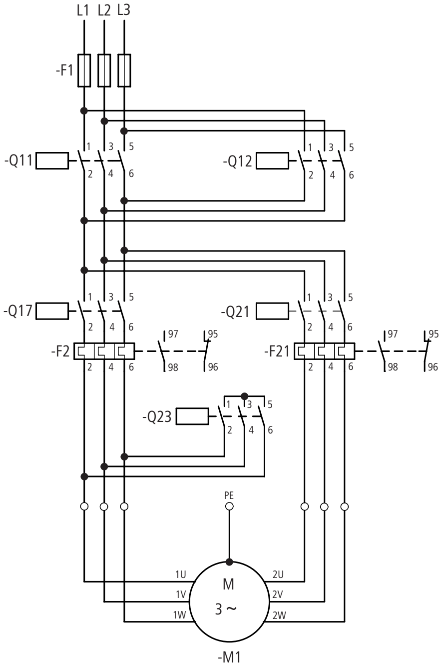
All about Motors

Multi speed switches of three-phase motors

Tapped winding, reversing, 2 speeds (direction preselected)

Multi-speed contactors UPIUL

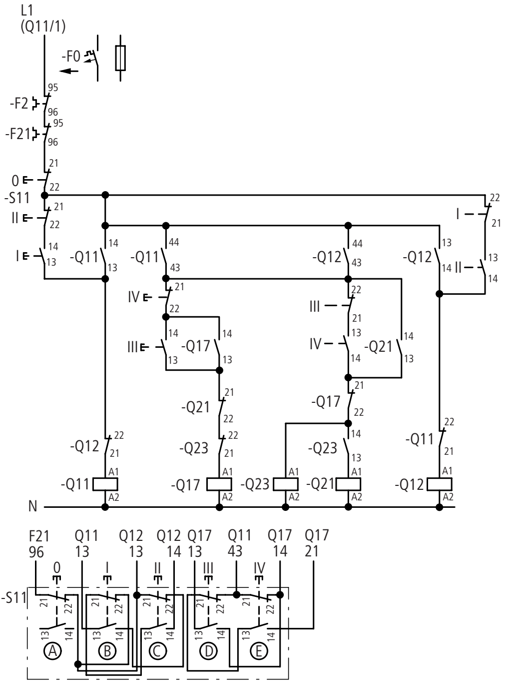
Overload relays F2 and F21 are not used on multi-speed contactors without motor protection.



Rating of switchgear
Q11, Q12 = I_2 (low and high speed)
F2, Q17 = I_1 (low speed)
F1, Q21 = I_2
Q23 = 0.5 × I_2 (high speed)

All about Motors

Multi speed switches of three-phase motors



Five-way pushbutton

Connection

Change of direction FORWARD–REVERSE after actuation of Stop button, optionally followed by SLOW–FAST with no return to low speed.

Control circuit device

0: Stop
I: Forward (Q11)
II: Back (Q12)
III: Slow (Q17)
IV: Fast (Q21 + Q23)

Function

Contactor Q11 is energized by pressing pushbutton I. Contactor Q11 selects the direction, and maintains itself after release of pushbutton I via its auxiliary contact 14–13 and pushbutton 0. Speed-selection buttons III and IV are made operative by Q11/44–43.

Pushbutton III energizes Q17, which maintains itself via its contact 14–13. Pushbutton IV energizes high-speed contactors Q23 and Q21. Auxiliary contact Q17/14–13 makes low-speed pushbutton III inoperative. Pushbutton 0 must be pressed before any change in speed or direction.

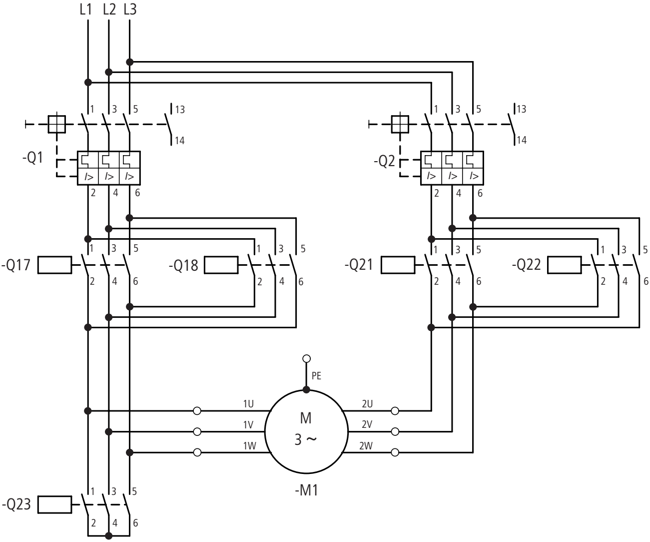
All about Motors

Multi speed switches of three-phase motors

Tapped winding, reversing, 2 speeds (Direction and speed selected simultaneously)

Multi-speed contactor UPIUL

Fuseless without overload relay



Rating of switchgear

Q1, Q17, Q18 = I_1
(low speed)

Q2, Q21, Q22 = I_2

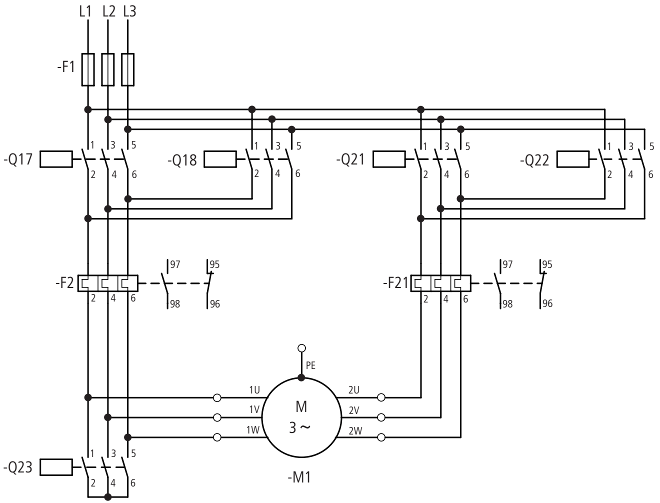
Q23 = 0.5 × I_2
(high speed)

All about Motors

Multi speed switches of three-phase motors

Multi-speed contactor UPIUL

With **fuses** and overload relays



Rating of switchgear

F2, Q17, Q18 = I_1
(low speed)

F21, Q21, Q22 = I_2

Q23 = 0.5 × I_2
(high speed)

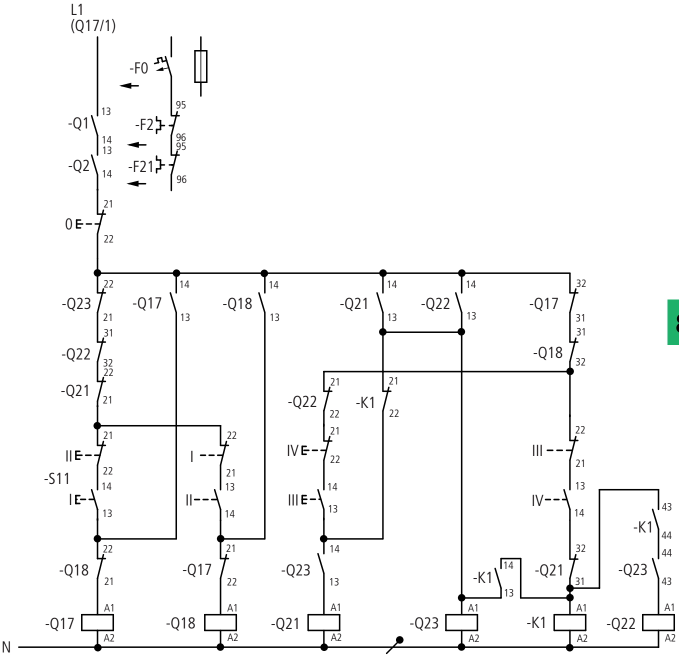
Overload relays F2 and F21 are not used on multi-speed contactors without motor protection

All about Motors

Multi speed switches of three-phase motors

Circuit

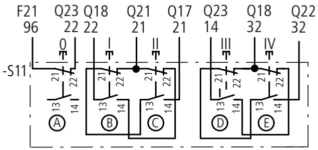
Simultaneous selection of direction and speed via one pushbutton. Always operate Stop button before changeover.



Q17:Slow forward
Q18:Slow back
Q21:Fast forward
Q23:Star contactor
K1: Contactor relay
Q22:Fast back

All about Motors

Multi speed switches of three-phase motors



Five-way pushbutton

Control circuit device

0: Stop
I: Slow forward (Q17)
II: Slow back (Q18)
III: Fast forward (Q21 + Q23)
IV: Fast back (Q22 + Q23)

Function

Desired speed and direction can be selected by actuation of the appropriate pushbutton. Contactors Q17, Q18, Q21 and Q23 maintain themselves by their contact 14–13 and can be de-energized only by actuation of pushbutton 0. Contactors Q21 and Q22 can maintain themselves only when Q23 has picked up and contact Q23/13/13–14 or 44–43 is closed.

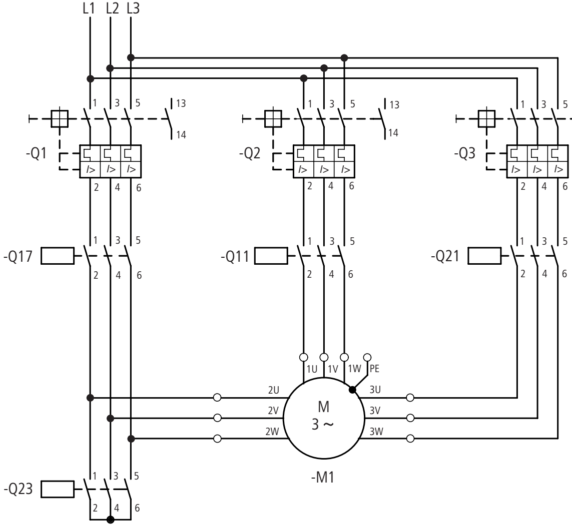
All about Motors

Multi speed switches of three-phase motors

Tapped winding, medium and high speed, Non reversing, 3 speeds, 2 windings

Multi-speed contactor U3PIL

Multi-speed contactor U3PIL **with** overload relay → figure, page 8-85



Synchronous speed

Winding	**1**	**2**	**2**
Motor terminals	1U, 1V, 1W	2U, 2V, 2W	3U, 3V, 3W
Number of poles	12	8	4
rpm	500	750	1500
Number of poles	8	4	2
rpm	750	1500	3000

Number of poles	6	4	2
rpm	1000	1500	3000
Contactors	Q11	Q17	Q21, Q23

Rating of switchgear

Q2, Q11 : I_1 (low speed)

Q1, Q17 : I_2 (medium speed)

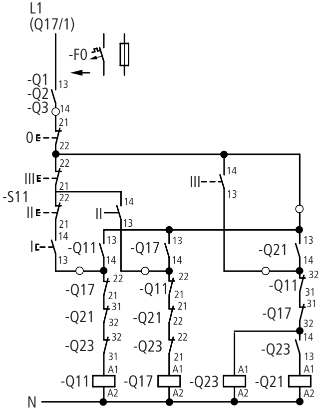
Q3, Q21 : I_3 (high speed)

Q23 : $0.5 \times I_3$

All about Motors

Multi speed switches of three-phase motors

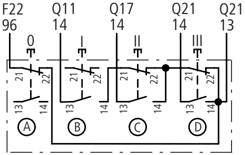
Circuit of motor winding: X
Circuit A



Q11: Low speed winding 1
Q17: Medium speed winding 2
Q23: High speed winding 2
Q21: High speed winding 2

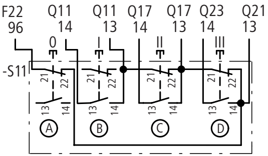
Circuit A

Selection of any speed only from zero. No return to low speed, only to zero.



Circuit B

Selection of any speed from zero or from low speed. Return only to zero.



4-way pushbutton
0: Stop
I: Low speed (Q11)
II: Medium speed (Q17)
III: High speed (Q21 + Q23)

Function

Pushbutton I energizes mains contactor Q11 (low speed), pushbutton II mains contactor Q17 (medium speed), pushbutton III star contactor Q23 and via its normally open contact Q23/14–13 mains contactor Q21 (high speed). All contactors maintain themselves by their auxiliary contact 13–14. Speed sequence from low to high is optional. Switching in steps from high to medium or low speed is not possible. The motor is always switched off by pressing pushbutton 0. In the event of an overload, normally open contact 13–14 of the motor-protective circuit-breaker or circuit-breaker can also switch off.

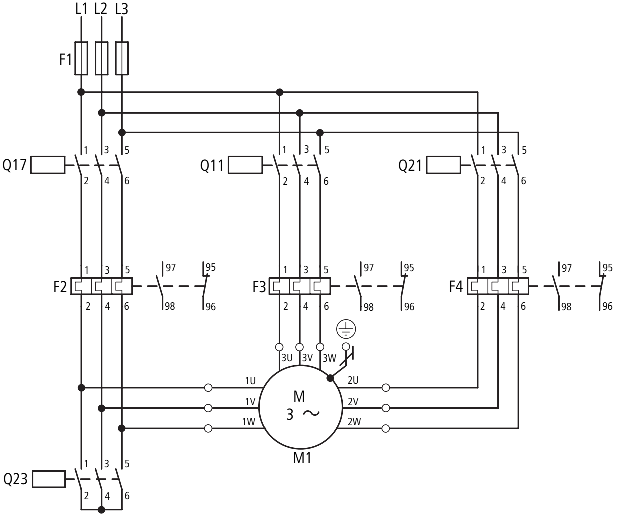
All about Motors

Multi speed switches of three-phase motors

Tapped winding, low and high speed, Non-reversing, 3 speeds, 2 windings

Multi-speed contactor U3PIL

Multi-speed contactor U3PIL **without** overload relay → figure, page 8-83



Synchronous speed

Winding	**2**	**1**	**2**
Motor terminals	1U, 1V, 1W	2U, 2V, 2W	3U, 3V, 3W
Number of poles	12	8	6
rpm	500	750	1000
Number of poles	8	6	4

rpm	750	1000	1500
Contactors	Q17	Q11	Q21, Q23

Rating of switchgear

F2, Q17: I_1 (low speed)

F3, Q11: I_2 (medium speed)

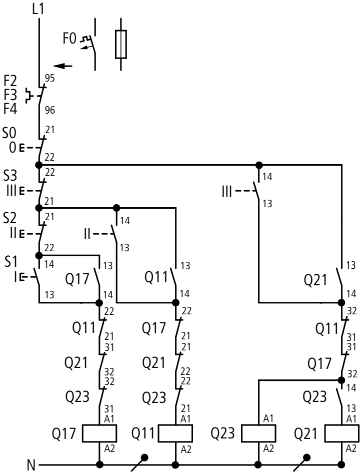
F4, Q21: I_3 (high speed)

Q23: $0.5 \times I_3$

All about Motors

Multi speed switches of three-phase motors

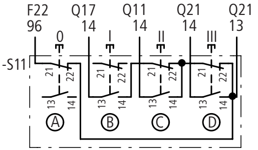
Circuit of motor winding: Y
Circuit A



Q17: Low speed winding 1
Q11: Medium speed winding 1
Q23: High speed winding 2
Q21: High speed winding 2

Circuit A

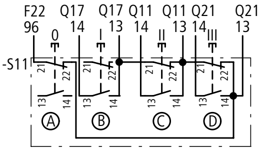
Selection of any speed only from zero.
No return to low speed, only to zero.



Circuit B

Selection of any speed from zero or from low speed. Return only to zero.
4-way pushbutton

0: Stop
I: Low speed (Q17)
II: Medium speed (Q11)
III: High speed (Q21 + Q22)



Function

Pushbutton I energizes mains contactor Q17 (low speed), pushbutton II mains contactor Q11 (medium speed), pushbutton III star contactor Q23 and via its normally open contact Q23/14–13 mains contactor Q21 (high speed). All contactors maintain themselves by their auxiliary contact 13–14.

Speed sequence from low to high is optional. Switching in steps from high to medium or low speed is not possible. The motor is always switched off by pressing pushbutton 0. In the event of an overload, normally closed contact 95–96 of overload relays F2, F21 and F22 can also switch off.

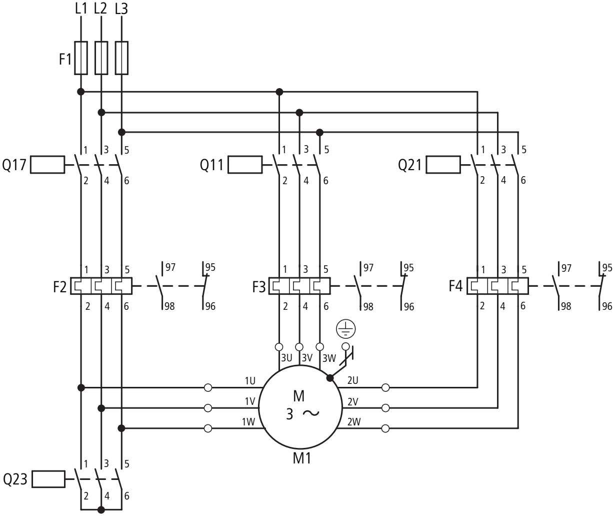
All about Motors

Multi speed switches of three-phase motors

Tapped winding, low and medium speed, Non-reversing, 3 speeds, 2 windings

Multi-speed contactor U3PIL

Multi-speed contactor U3PIL **without** overload relay → figure, page 8-59



Synchronous speed

Winding	2	2	1
Motor terminals	1U, 1V, 1W	2U, 2V, 2W	3U, 3V, 3W
Number of poles	12	6	4
rpm	500	1000	1500
Number of poles	12	6	2
rpm	500	1000	3000

Number of poles	8	4	2
rpm	750	1500	3000
Contactors	Q17	Q21, Q23	Q11

Rating of switchgear

F2, Q17: I_1 (low speed)

F4, Q21: I_2 (medium speed)

F3, Q11: I_3 (high speed)

Q23: $0.5 \times I_3$

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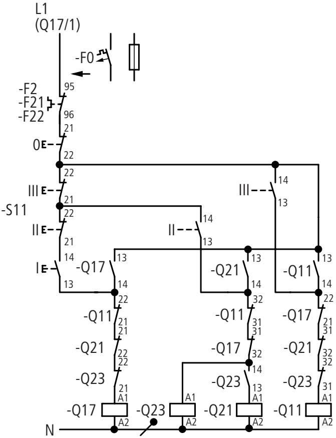
All about Motors

Multi speed switches of three-phase motors

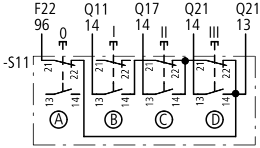
Circuit of motor winding: Z
Circuit A



Q17: Low speed winding 1
Q23: Medium speed winding 2
Q21: Medium speed winding 2
Q11: High speed winding 1

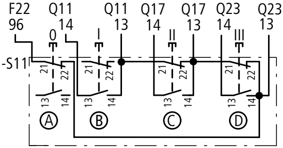
Circuit A

Selection of any speed from zero. No return to low speed, only to zero.



Circuit B

Selection of any speed from zero or from low speed. Return only to zero.



4-way pushbutton
0: Stop
I: Low speed (Q17)
II: Medium speed (Q21 + Q23)
III: High speed (Q11)

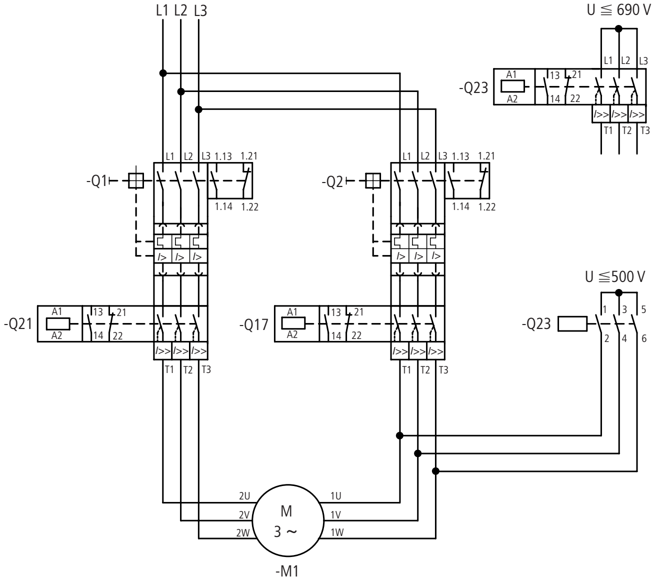
Function

Pushbutton I energizes mains contactor Q17 (low speed), pushbutton II mains contactor Q23 (low speed) and via its normally open contact Q23/14-13 mains contactor Q21 (high speed), pushbutton III mains contactor Q11. All contactors maintain themselves by their auxiliary contacts 13-14.

Speed sequence from low to high is optional. Switching in steps from high to medium or low speed is not possible. The motor is always switched off by pressing pushbutton 0. In the event of an overload, normally closed contact 95–96 of overload relays F2, F21 and F22 can also switch off.

All about Motors

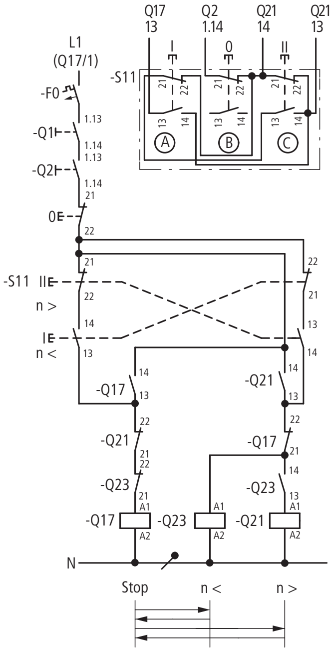
Multi speed switch with motor-protective circuit-breakers PKZ2



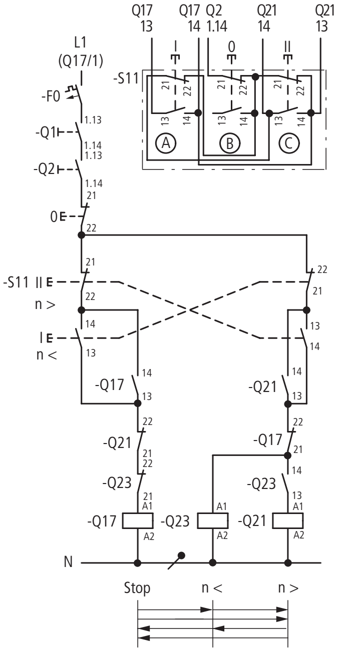
Number of poles	12	6
rpm	500	1000
Number of poles	8	4
rpm	750	1500
Number of poles	4	2
rpm	1500	3000

All about Motors

Multi speed switch with motor-protective circuit-breakers PKZ2



Circuit A → figure, page 8-55



Circuit C → figure, page 8-55

S11	RMQ-Titan, M22-…	–	–	–
Q1, Q21	PKZ2/ZM-…/S	*n*>	–	–
Q2, Q17	PKZ2/ZM-…/S	*n* <	–	–
Q23	DILOM	Y n > U_e ≦ 500 V	–	–
Q23	S/EZ-PKZ	Y n > U_e ≦ 660 V	F0	FAZ

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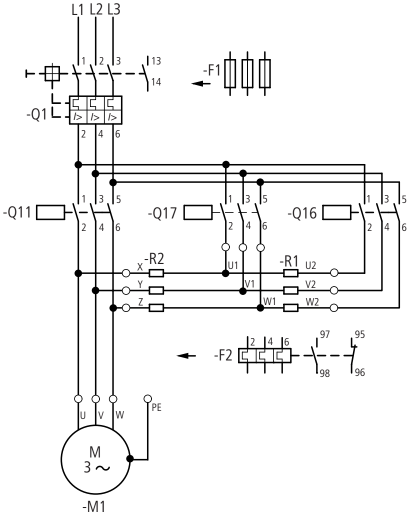
All about Motors

Three-phase current-automatic stator starters

Three-phase automatic stator resistance starter DDAINL with mains contactor and resistors, 2-stage, 3-phase version



When using F1 instead of Q1, use F2.

Rating of switchgear:

Starting voltage:	0.6 × U_e
Inrush current:	0.6 × direct switching system
Tightening torque:	0.36 × direct switching system
Q1, Q11:	I_e
Q16, Q17:	0.6 × I_e

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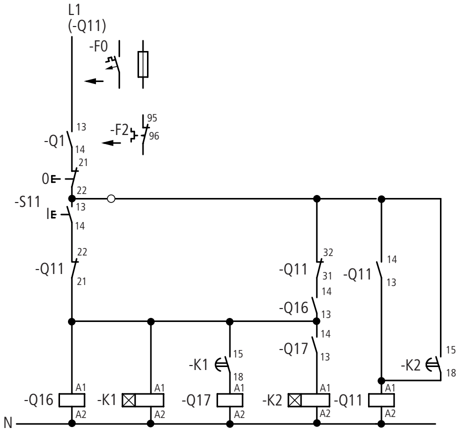
All about Motors

Three-phase current-automatic stator starters

DDAINL three-phase automatic stator resistance starter with mains contactor and resistors, 2-stage, 3-phase version

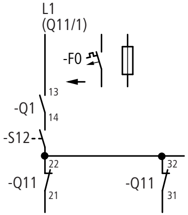


Q16: Step contactor
K1: Timing relay
Q17: Step contactor

K2: Timing relay
Q11: Mains contactor

Two-wire control

Always set overload relay to manual reset

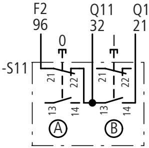


All about Motors

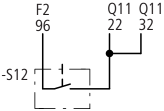
Three-phase current-automatic stator starters

Three-wire control

Double actuator
I = ON
0 = OFF



Two-wire control



Function

Pushbutton I energizes step contactor Q16 and timing relay K1. Q16/14-13 – self-maintaining through Q11, Q11/32-31 and pushbutton 0. The motor is connected to the supply with rotor resistors R1 + R2. When the set starting time has elapsed, normally open contact K1/15-18 energizes Q17. Step contactor Q17 bypasses the starting stage R1. At the same time, normally open contact Q17/14-13 energizes K2. When the set starting time has elapsed, K2/15-18 energizes mains contactor Q11. This bypasses the second starting stage R2, and the motor runs at the rated speed. Q11 maintains itself via Q11/14-13. Q16, Q17, K1 and K2 are de-energized by normally closed contacts Q11/22-21 and Q11/32-31. The motor is switched off with pushbutton 0. In the event of an overload, normally closed contact 95-96 of the overload relay F2 or normally open contact 13-14 of the motor-protective circuit-breaker switch off the motor.

Step contactor Q17, resistor R2 and timing relay K1 are omitted in single-stage starting circuits. Timing relay K2 is connected directly to Q16/13 and resistor R2 is connected by means of its terminals U1, V1 and W1 to Q11/2, 4, 6.

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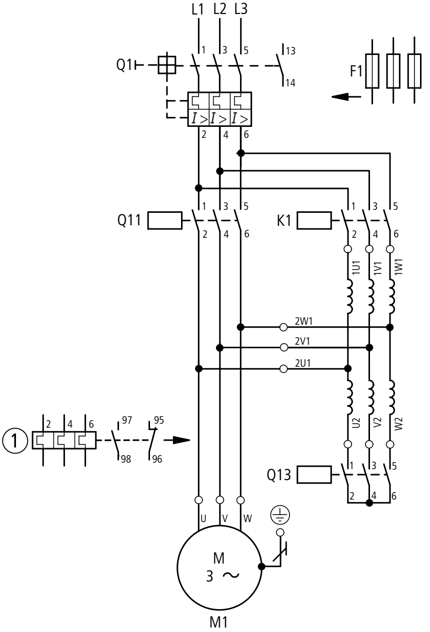
All about Motors

Three-phase current-automatic stator starters

Three-phase automatic stator resistance starter ATAINL with mains contactor and starting transformer, 1-stage, 3-phase



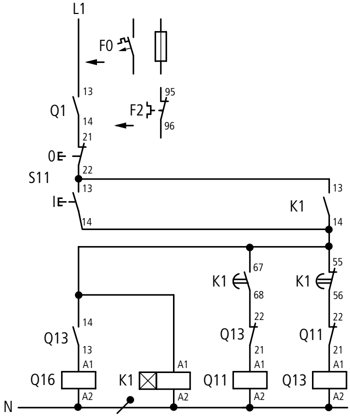
When using F1 instead of Q1, use F2.

Rating of switchgear

Starting voltage	= 0.7 × U_e (typical value)	Tightening torque	= 0.49 × direct switching system
Inrush current	= 0.49 × direct switching system	Q1, Q11	= I_e
I_A/I_e	= 6	Q16	= 0.6 × I_e
t_A	= 10 s	Q13	= 0.25 × I_e
Ops/h	= 30		

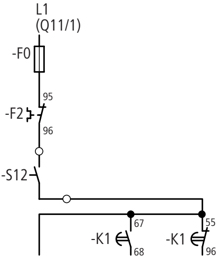
All about Motors

Three-phase current-automatic stator starters



Two-wire control

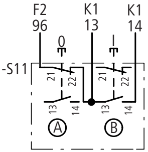
Always set overload relay to manual reset (automatic reset)



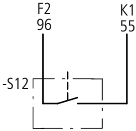
Q16: Step contactor
K1: Timing relay
Q11: Mains contactor
Q13: Star contactor

Three-wire control

I: ON
0: OFF



Two-wire control



Function

Pressing pushbutton I simultaneously energizes star contactor Q13, timing relay K1 and, via normally open contact Q13/13–14, step contactor Q16, and are maintained via K1/13-14. When K1 has elapsed, normally closed contact K1/55–56 de-energizes star contactor Q13, and – via normally open contact Q13/13–14 – Q16 de-energizes: The starting transformer is disconnected, and the motor runs at the rated speed.

The motor cannot start up again unless previously switched off by actuation of pushbutton 0, or in the event of an overload, by normally closed contact 95–96 of the overload relay F2. With two-wire control, overload relay F2 must always be set to manual reset. If the motor has been switched off by F2, the motor cannot start up again unless the manual reset is released.

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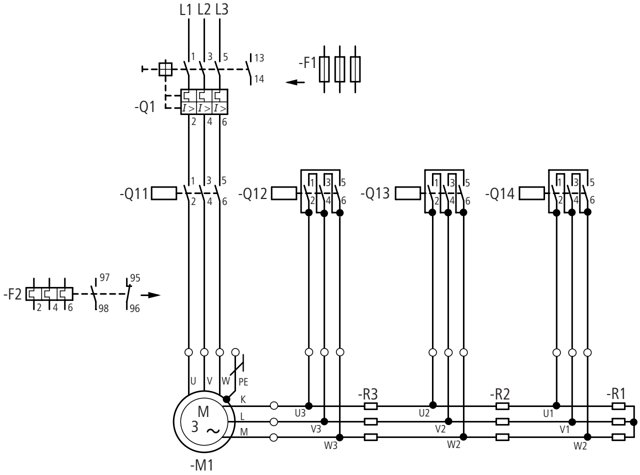
All about Motors

Three-phase automatic rotor starters

DAINL three-phase automatic rotor starters

Three stage, rotor three phase

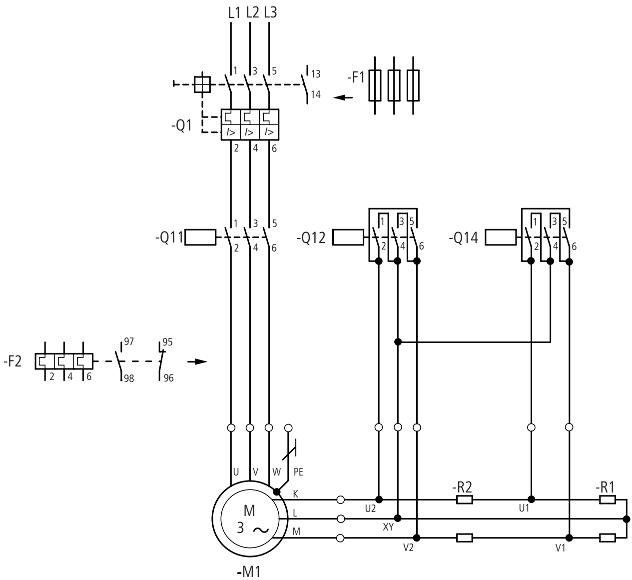


When using F1 instead of Q1, use F2.

All about Motors

Three-phase automatic rotor starters

2-stage, rotor 2-phase



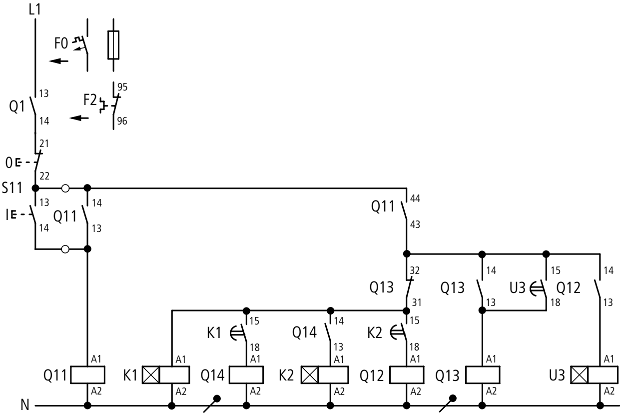
When using F1 instead of Q1, use F2.
Rating of switchgear

Inrush current	= 0.5 – 2.5 × I_e
Tightening torque	= 0.5 to pull-out torque
Q1, Q11	= I_e
Step contactors	= 0.35 × I_{rotor}
Final step contactors	= 0.58 × I_{rotor}

All about Motors

Three-phase automatic rotor starters

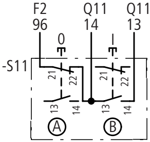
With mains contactor, style 3-stage, rotor 3-phase



Q11: Mains contactor
K1: Timing relay
Q14: Step contactor
K2: Timing relay

Q12: Step contactor
Q13: Final step contactor
K3: Timing relay

Double actuator
I: ON
0: OFF



For connection of further control circuit devices:
→ section "Control circuit devices for star-delta starting", page 8-51

All about Motors
Three-phase automatic rotor starters

Function

Pushbutton I energizes mains contactor Q11: normally open contact Q11/14–13 transfers the voltage, Q11/44–43 energizes timing relay K1. The motor is connected to the supply with rotor resistors R1 + R2 + R3 in series. When the set starting time has elapsed, normally open contact K1/15–18 energizes step contactor Q14, which short-circuits starting stage R1 and via Q14/14–13 energizes timing relay K2. When the set starting time has elapsed, K2/15–18 energizes step contactor Q12, which short-circuits starting stage R2 and via Q12/14–13 energizes timing relay K3. When the set starting time has elapsed, K3/15–18 energizes final step contactor Q13, which is maintained via Q13/14–13. Step contactors Q14 and Q12 as well as timing relays K1, K2 and K3 are de-energized via Q13. Final step contactor Q13 short-circuits the rotor slip rings: the motor operates at the rated speed.

The motor is switched off either by pushbutton 0, or in the event of an overload, by normally closed contact 95–96 of the overload relay F2 or normally open contact 13–14 of the motor-protective circuit-breaker or circuit-breaker.

Step contactor Q13 and Q12 with their resistors R3, R2 and timing relays K3, K2 are omitted in single-stage or two-stage starting circuits. The rotor is then connected to the resistance terminals U, V, W2 or U, V, W1. The references for step contactors and timing relays in the wiring diagrams are then changed from Q13, Q12 to Q12, Q11 or to Q13, Q11 as appropriate.

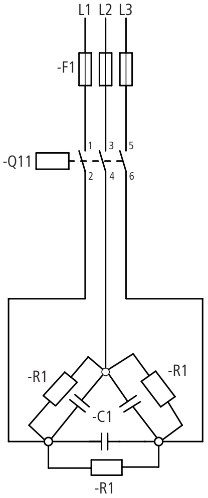
When there are more than three stages, the additional step contactors, timing relays and resistors have appropriate increasing designations.

All about Motors

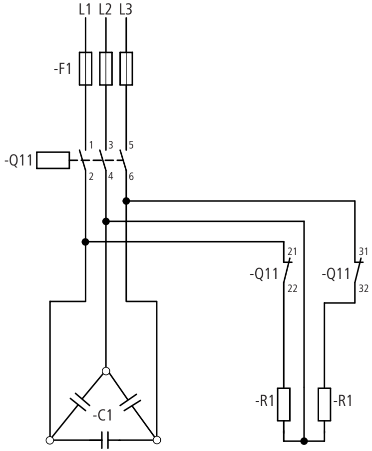
Switching of capacitors

Contactors for capacitors DIL

Individual circuit without quick-discharge resistors



Individual circuit with quick-discharge resistors

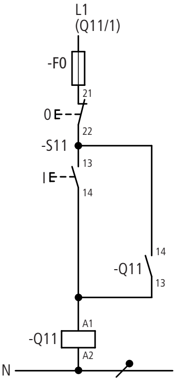


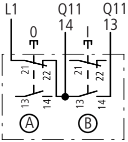
R1 discharge resistors fitted in capacitor

R1 discharge resistors fitted to contactor

All about Motors

Switching of capacitors





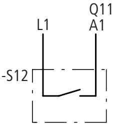
Double actuator

For connection of further control circuit devices:

→ section "Control circuit devices for star-delta starting", page 8-51

Maintained contact sensors

In the case of actuation by means of power factor correction relay, check that this has sufficient power to actuate the contactor coil. Interpose a contactor relay if necessary.



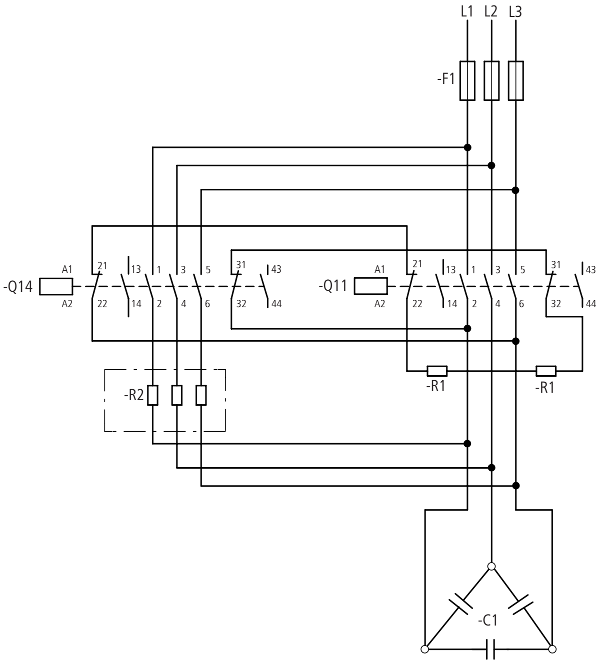
Function

Pushbutton I actuates contactor Q11, which picks up and maintains itself via its own auxiliary contact 14-13 and pushbutton 0. Capacitor C1 is thus energized. Discharge resistors R1 are not active when contactor Q11 is energized. Actuation of pushbutton 0 effects de-energization. Normally closed contacts Q11/21–22 then switch discharge resistors R1 to capacitor C1.

All about Motors
Switching of capacitors

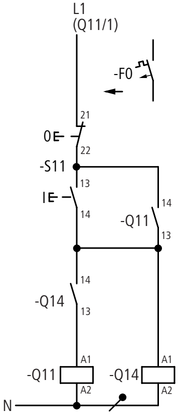
Capacitor contactor combination

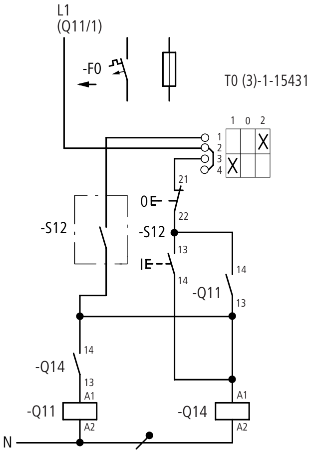
Capacitor contactor with pilot contactor and series resistors. Individual and parallel circuit with and without discharge resistors and with series resistors.



On the version without discharge resistors, resistors R1 and the connections to the auxiliary contacts 21–22 and 31–32 are omitted.

All about Motors
Switching of capacitors





Q11: Mains contactor
Q14: Pilot contactor
Actuation by two-way pushbutton S11

Actuation by selector switch S13, two-wire control S12 (power factor correction relay) and two-way pushbutton S11

Function

Actuation by two-way pushbutton S11. Pushbutton I energizes pilot contactor Q14, which switches capacitor C1 in with bridged series resistors R2. Normally open contact Q14/14-13 energizes mains contactor Q11. Capacitor C1 is then switched in with bridged series resistors R2. Q14 is maintained via Q11/14-13 when Q11 has closed.

Discharge resistors R1 are not operative when Q11 and Q14 are energized. Pushbutton 0 effects de-energization. Normally closed contacts Q11/21–22 and 31–32 then switch discharge resistors R1 to capacitor C1.

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All about Motors

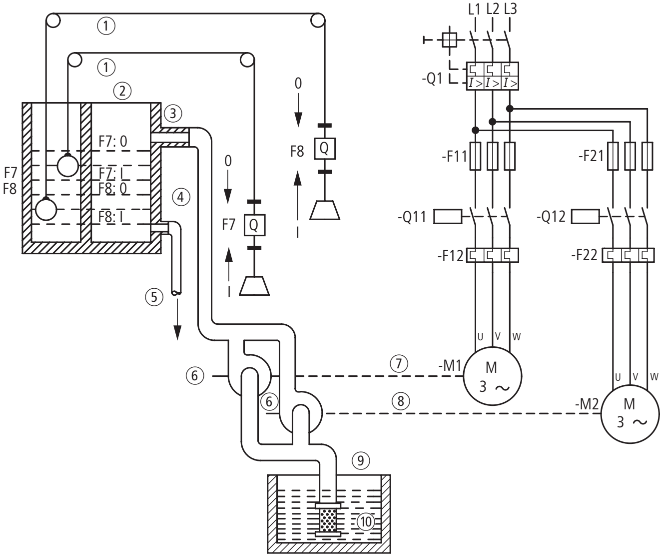
Duplex pump control

Fully automatic control with two pumps

Starting sequence of pumps 1 and 2 can be selected by control switch S12

Control circuit wiring with two float switches for basic and peak loads (operation is also possible with two pressure switches)

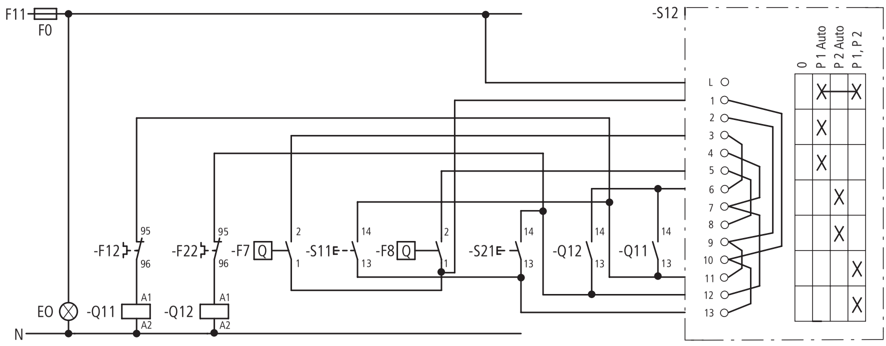
P1 Auto	=	Pump 1 constant load, Pump 2 peak load
P2 Auto	=	Pump 2 constant load, Pump 1 peak load
P1 + P2	=	Direct operation independent of float switches (or pressure switches)



1. Cable with float, counterweight, pulleys and clamps
2. Storage tank
3. Inlet
4. Pressure pipe
5. Outlet
6. Centrifugal or reciprocating pump
7. Pump 1
8. Pump 2
9. Suction pipe with filter
10. Well

All about Motors

Duplex pump control



T0(3)-4-15833

Float switch F7 closes before F8

Q11: Pump 1 mains contactor

Q12: Pump 2 mains contactor

Function

The duplex pump control is designed for operation of two pump motors M1 and M2. Control is via float switches F7 and F8.

Operating mode selector switch S12 in position P1 auto: The system operates as follows:

When the water level in the storage tank falls or rises, F7 switches pump 1 on or off (basic load). If the water level drops below the range of F7 (discharge is greater than intake), F8 starts pump 2 (peak load). When the water level rises again, F8 is deactivated. Pump 2 continues running until F7 stops both pumps.

The operating sequence of pumps 1 and 2 can be determined using operating mode selector switch S12: Position P1 auto or P2 auto.

In position P1 + P2, both pumps are in operation, independent of the float switches (Caution! Tank may possibly overflow).

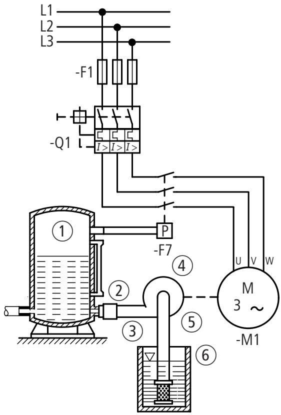
On the version of duplex pump control with automatic load sharing (T0(3)-4-15915), S12 has a further position: the sequence of operations is automatically reversed after each cycle.

8

All about Motors

Fully automatic pump control

With pressure switch for air tank and domestic water supply without water failure (run dry) safety device



With 3-pole pressure switch MCSN (main circuit)

F1: Fuses (if required)
Q1: Motor-protective switch, manual (z. B. PKZ)
F7: Pressure switch MCSN, 3-pole
M1: Pump motor
① Air or pressure tank
② Non-return valve
③ Pressure pipe
④ Centrifugal (or reciprocating) pump
⑤ Suction pipe with filter
⑥ Well

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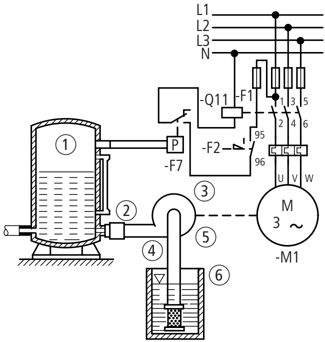
All about Motors

Fully automatic pump control

With single-pole pressure switch MCS (control circuit)

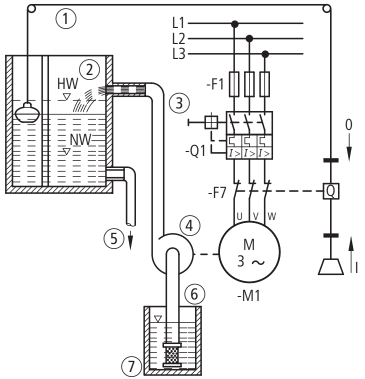


F1: Fuses
Q11:Contactor or automatic star-delta starter
F2: Overload relay with reclosing lockout
F7: Pressure switch MCS, 1-pole
M1:Pump motor
① Air or pressure tank
② Non-return valve
③ Centrifugal (or reciprocating) pump
④ Pressure pipe
⑤ Suction pipe with filter
⑥ Well

All about Motors

Fully automatic pump control

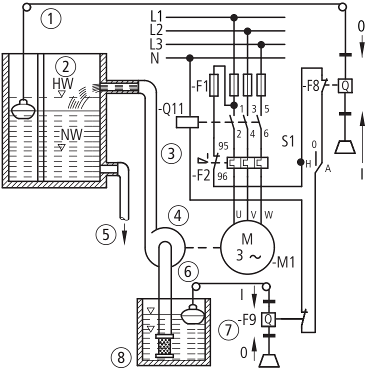
With 3-pole float switch SW (main circuit)



F1: Fuses (if required)
Q1: Motor-protective circuit-breakers, manual (z. B. PKZ)
F7: Float switch 3-pole (circuit: pump full)
M1: Pump motor
HW: Highest level
NW: Lowest value
① Cable with float, counterweight, pulleys and clamps
② Storage tank
③ Pressure pipe
④ Centrifugal (or reciprocating) pump
⑤ Outlet
⑥ Suction pipe with filter
⑦ Well

All about Motors
Fully automatic pump control

With 1-pole float switch SW (control circuit)

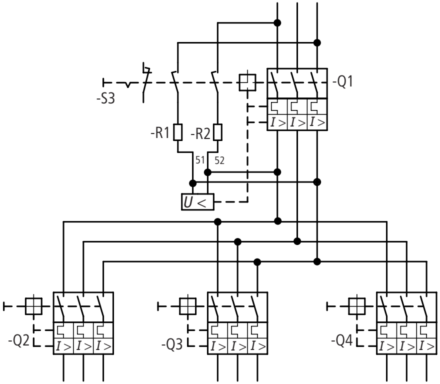


F1: Fuses
Q11:Contactor or automatic star-delta starter
F2: Overload relay with reclosing lockout
F8: Float switch 1-pole (circuit: pump full)
S1: Changeover switch MANUAL-OFF-AUTO
F9: Float switch 1-pole (circuit: pump full)
M1:Pump motor
① Cable with float, counterweight, pulleys and clamps
② Storage tank
③ Pressure pipe
④ Centrifugal (or reciprocating) pump
⑤ Outlet
⑥ Suction pipe with filter
⑦ Water-failure monitoring by means of a float switch
⑧ Well

All about Motors
Off position interlock of the loads

Solution using NZM circuit-breakers

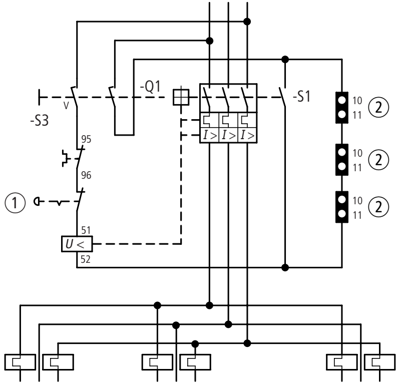
Off position interlock for control switches (Hamburg circuit) with auxiliary contact VHI (S3) and undervoltage release. Cannot be used with motor operator.



All about Motors

Fully automatic main transfer switch with automatic reset

Off position interlock for control or master switches by means of auxiliary contacts VHI (S3), NHI (S1) and undervoltage release. Cannot be used with motor operator.



① Emergency-Stop

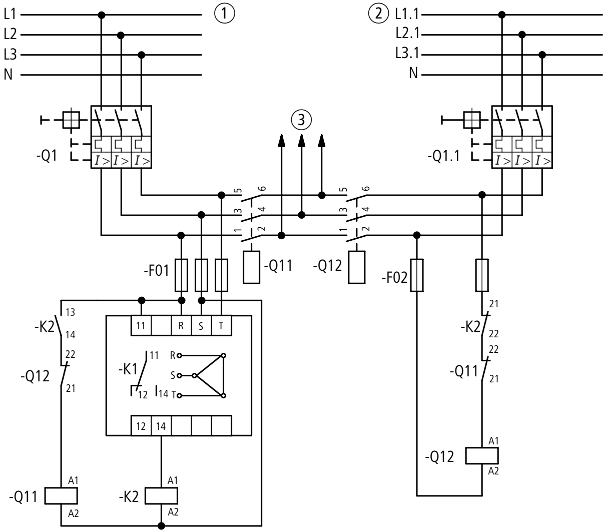
② Off position interlock contacts on the control or master switches

All about Motors

Fully automatic main transfer switch with automatic reset

Changeover device to DIN VDE 0108 – Power systems and safety power supply in buildings for public gatherings:

Automatic resetting, the phase-monitor is set to:	Pick-up voltage	$U_{an} = 0{,}95 \times U_n$
	Drop-out voltage	$U_b = 0{,}85 \times U_{an}$



① Main supply
② Auxiliary supply
③ To load

Function

Main switch Q1 is closed first, followed by main switch Q1.1 (auxiliary supply).

Phase monitor K1 is energized via the main supply and immediately energizes contactor relay K2. Normally closed contact K2/21–22 blocks the circuit. Contactor Q12 (auxiliary supply) and normally open contact K2/13-14 closes the circuit of contactor Q11, which energizes and switches the mains supply on the load. Contactor Q12 is also interlocked against mains supply contactor Q11 via normally closed contact Q11/22-21.