

All about Motors

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Motor protection

Overload relay with manual reset

They should always be used where continuous contact devices (two-wire control) are concerned (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

They 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

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

Back-up fuses and instantaneous releases

They 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 properly be set?

To the rated motor current - no higher, no lower. A relay set to too low a figure 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 under full load or thereabout, 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 endangered?

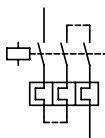
With changes in the motor which do not cause an increase in current consumption: Effects of humidity, reduced cooling due to a reduction in speed or motor dirt, temporary additional external heating of the motor or bearing wear.

What causes destruction of the overload relay?

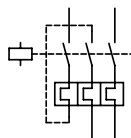
Destruction will take place only in the event of a short circuit on the load side of the relay when the back-up fuse is rated too high. In most cases, this will also endanger the contactor and motor. Therefore, always adhere to the maximum fuse rating specified on every relay.

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 (10 A, 10, 20, 30). They determine different tripping characteristics for the various starting conditions of motors (normal starting to heavy starting).

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Response values

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 $t \leq 2$ h	C Tripping class	Tripping time in minutes	D Tripping class	Tripping time in seconds	
			10 A	≤ 2	10 A		
			10	≤ 4	10	$2 < T \leq 10$	
			20	≤ 8	20	$4 < T \leq 10$	
			30	≤ 12	30	$6 < T \leq 20$	
						$9 < T \leq 30$	
Non-ambient temperature compensated thermal relays and magnetic relays	1.0	1.2	1.5		7.2		+ 40 °C
Ambient temperature compensated thermal relays	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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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 $t > 2 \text{ h}$, starting from cold state of relay		B $t \leq 2 \text{ h}$		
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

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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 $12 \times I_e$ (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 $20 \times I_e$.

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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Type "1" co-ordination

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" co-ordination

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 contact

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).

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 relay ZW7

The ZW7 consists of three special saturable core current transformers, supplying an

overload relay Z00. 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 relay ZW7 for lower motor ratings

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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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.

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Star-delta starter (YΔ)

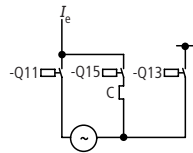
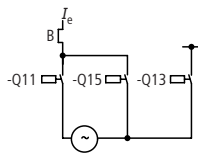
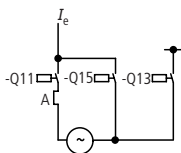
Non-reversing

Changeover time with overload relay in position

A: < 15 s

B: > 15 < 40 s

C: > 40 s



Setting of the overload relay

$0.58 \times I_e$

Full motor protection in Y (star) position

$1 \times I_e$

Only partial motor protection in Y (star) position

$0.58 \times I_e$

Motor not protected in Y (star) position

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Motor protection

Multi-speed switch

2 speeds

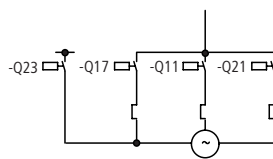
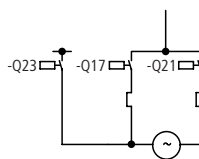
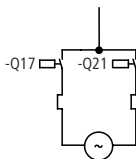
2 separate windings

One tapped winding

3 speeds

1 \times tapped winding

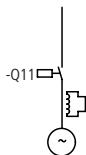
+ 1 winding



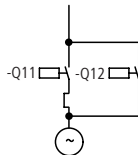
Attention must be paid to short-circuit protection of the overload relays.
Separate supply leads should be provided if required.

Heavy starting duty

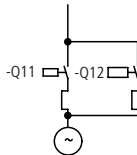
Current transformer-operated relay ZW7



Bridging of motor protection during starting



Bridging during starting using bridging relay



For medium and large motors

For small motors; no protection Automatic cut out during starting

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Motor protection

Individually compensated motor

I_e = Rated motor operational current [A]

$$I_w = I_e \times \cos \varphi [\text{A}]$$

I_w = Active cur. } Proportion of motor

I_b = Reactive cur. } rated operational current [A] $I_b = \sqrt{I_e^2 - I_w^2} [\text{A}]$

I_c = Rated capacitor current [A]

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

I_{EM} = Setting current of overload relay [A]

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

$\cos \varphi$ = Motor power factor

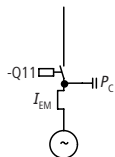
U_e = Rated operational voltage [V]

P_c = Rated capacitor output [kvar]

C = Capacitance of capacitor [μF]

Capacitor connected

to contactor terminals

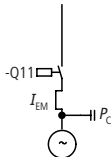


Setting I_{EM} of overload relay

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

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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Motor protection

Thermistor relay for machine protection relays

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 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

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.

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Motor protection

Protection of current and temperature-dependent motor-protective devices

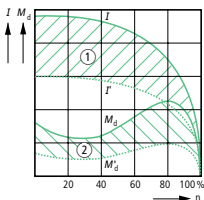
Protection of the motor under the following conditions	Using bimetal	Using thermistor	Using bimetal and thermistor
Overload in continuous operation	+	+	+
Extended starting and stopping	(+)	+	+
Switching to stalled rotor (stator-critical motor)	+	+	+
Switching on stalled rotor (rotor-critical motor)	(+)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

- + Full protection
- (+) Partial protection
- No protection

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Notes on engineering

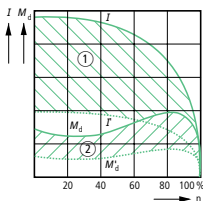
Three-phase automatic starters



Three-phase automatic stator resistance starters with starting resistors

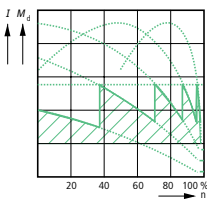
Single or multi-step resistors are connected upstream of the three-phase squirrel-cage motors to reduce the starting current and torque.

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 automatic stator resistance 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

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Notes on engineering

Important data and features of three-phase automatic starters

1) Style of starter	Stator resistance starter (for squirrel-cage motors)			Rotor starter (for slipping 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	$0.58 \times$ rated operational voltage	Selectable: $a \times$ rated operational voltage ($a < 1$) e.g. 0.58 as with $\nabla \Delta$ starter	Selectable: $0.6/0.7/0.75 \times U_a$ (transformer tappings)	None
5) Starting current taken from mains	$0.33 \times$ inrush current at rated operational voltage	$a \times$ inrush current at rated operational voltage	Selectable (see 4) $0.36/0.49/0.56 \times$ inrush current at rated operational voltage	Selectable: from 0.5 to about $2.5 \times$ rated current
5a) Starting current at the motor	As above	As above	Selectable (see 4) $0.6/0.7/0.75 \times I_e$	As above
6) Starting torque	$0.33 \times$ tightening torque at rated operational voltage	$a^2 \times$ tightening torque at rated operational voltage	Selectable (see 4) $0.36/0.49/0.56 \times$ 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

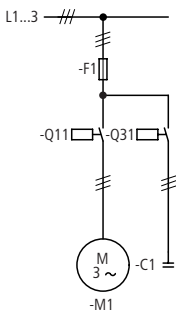
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Notes on engineering

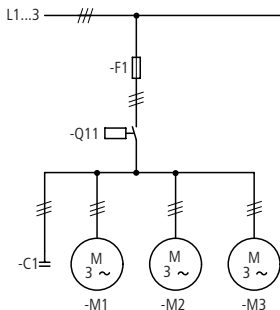
Switching of capacitors

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.

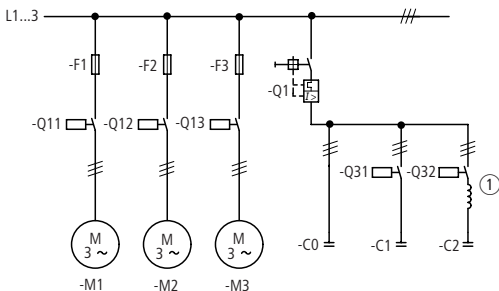
A discharge circuit or discharge device must reduce the residual voltage of the capacitor to less than 50 V within a minute of the capacitor being switched off.

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Notes on engineering

Contactor for capacitor DIL...K – Individual and group compensation

Group compensation



- ① Additional inductance with standard contactor

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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 DILMK... 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 $6 \mu\text{H}$ (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.

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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. These include:

- 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/EN 61082-1.

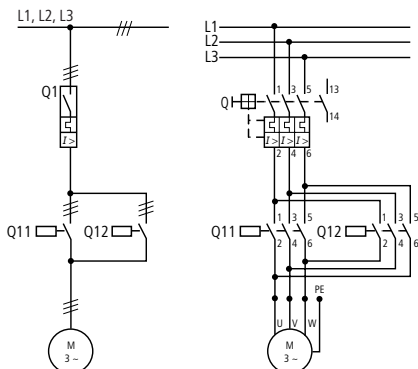
Circuit diagrams

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.

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Circuit documents



Circuit diagram: 1-pole and 3-pole representation

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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 on 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.

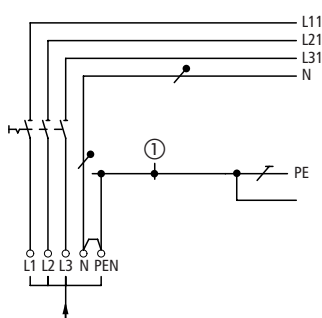
- Terminal diagram: representation of the connection points of an electrical installation and the internal and external conductive connections connected to them.
- Assignment diagram (location diagram). representation of the physical position of the electrical equipment, which does not have to be to 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".

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Power supply

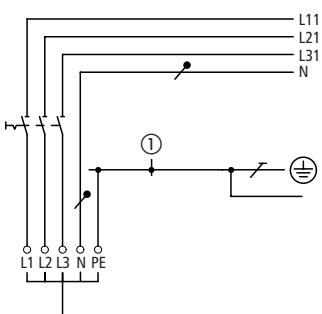
4-conductor system, TN-C-S



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

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

5-conductor system, TN-S supply system



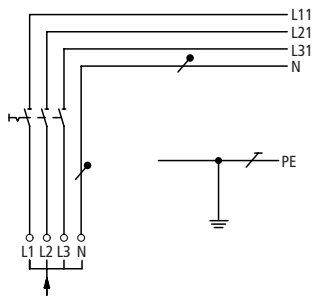
- ① Protective earth conductor
Protective earth terminal in enclosure
(not totally insulated)

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

All about Motors

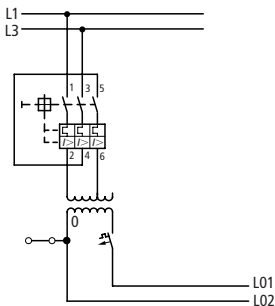
Power supply

3-conductor system, IT supply system



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

8

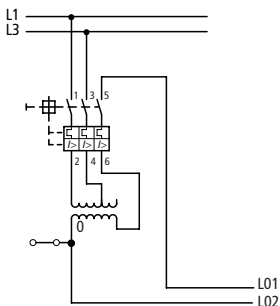


Separate primary and secondary protection

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

All about Motors

Power supply

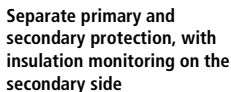


Combined primary and secondary protection

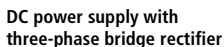
Earthed control circuit. In non-earthed control circuit, remove link and provide insulation monitoring.

Maximum ratio of $U1/U2 = 1/1.73$

Circuit not to be used with STI/STZ (safety and isolating transformers).



- ① Clear button
- ② Test button



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	Remarks
DIL (/Z)	Q11									
DIUL (/Z)	Q11	Q12								
SDAINL (/Z)	Q11						Q13	Q15		
SDAIUL (/Z)	Q11	Q12					Q13	Q15		
UPIUL (/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 start- ing 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.

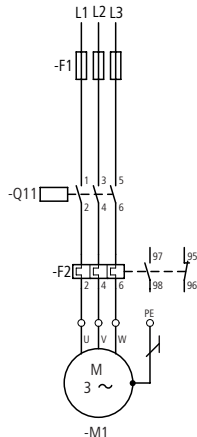
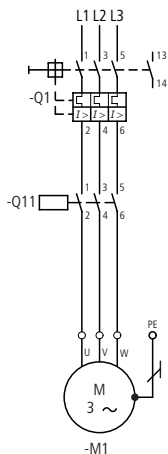
All about Motors

Direct-on-line start of three-phase motors

Typical circuits with DIL contactors

Fuseless without overload relay

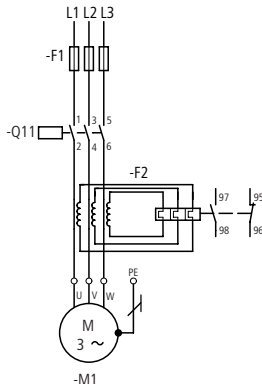
Short-circuit protection¹⁾ and overload protection by means of PKZM motor-protective circuit-breaker or NZM circuit-breaker



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

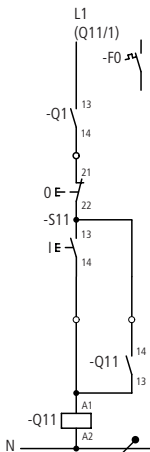
³⁾ Fuse size in accordance with Moeller Main Catalogue, Industrial Switchgear (Technical data for contactors)

All about Motors

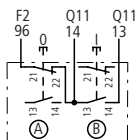
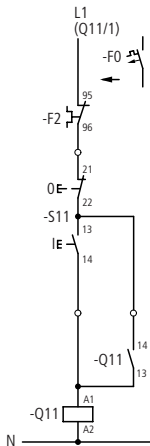
Direct-on-line start of three-phase motors

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.

Two-way pushbutton

Control circuit device

I: ON

O: OFF

For connection of further control circuit devices → section "Three-wire control", page 8-36

Method of operation: Actuation of pushbutton I energizes the coil of contactor Q11. The contactor switches on the motor and

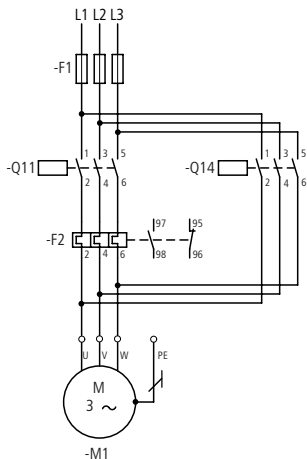
maintains itself after the button is enabled via its own auxiliary contact Q11/14-13 and pushbutton 0 (three-wire control contact). Contactor Q11 is de-energized, in the normal course of events, by actuation of pushbutton 0. In the event of an overload, it is de-energized via the normally closed contact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

All about Motors

Direct-on-line start of three-phase motors

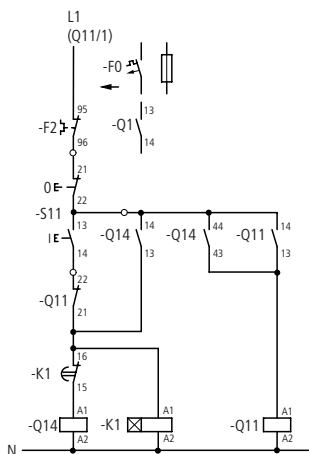
Application on drive motors with severe starting duty

For connection when used with
motor-protective circuit-breakers
PKZM... and circuit-breakers NZM(H)...
→ section "Fuses with overload relay",
page 8-28



All about Motors

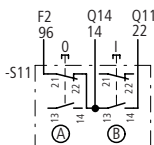
Direct-on-line start of three-phase motors



Q14: Bridging contactor

K1: Timing relay

Q11: Mains contactor



Control circuit device

I: ON

O: OFF

For connection of further control circuit devices → section "Three-wire control", page 8-36

Method of operation

Actuation of pushbutton I energizes the 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 by Q14/44-43 and maintains itself via Q11/14-13. When the set time - which corresponds to the starting time of the motor - has elapsed, the bridging contactor Q14 is disconnected by K1/16-15. K1 is likewise disconnected and, exactly as Q14, can only be energized again after the

motor has been switched off by pressing pushbutton O. 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 the overload relay F2 effects de-energization.

All about Motors

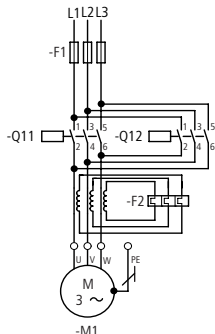
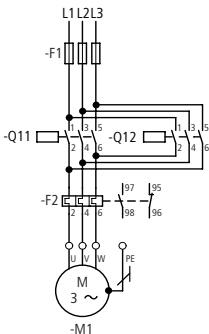
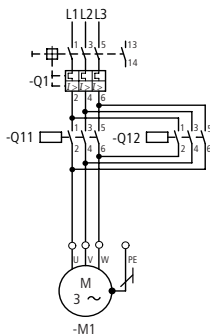
Direct-on-line start of three-phase motors

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.

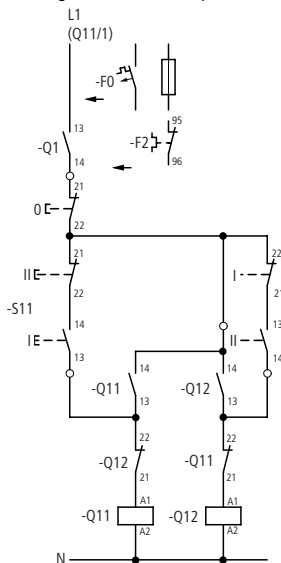


¹⁾ Fuse size in accordance with data on the rating plate of the overload relay F2

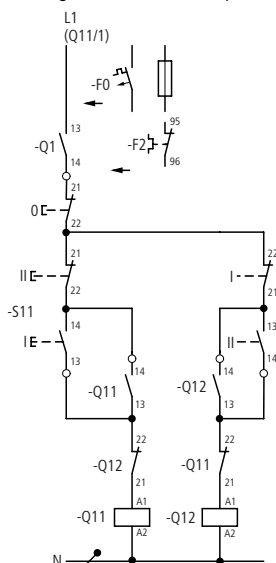
All about Motors

Direct-on-line start of three-phase motors

Reversing **after** actuation of pushbutton 0

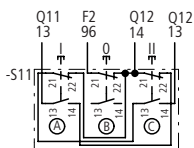


Reversing **without** actuation of pushbutton 0



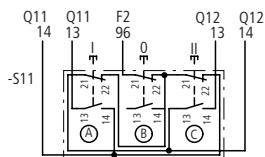
Q11: Mains contactor, clockwise

Q12: Mains contactor, anticlockwise



Control circuit device (three-way pushbutton)

I = Clockwise
0 = Stop
II = Anticlockwise



All about Motors

Direct-on-line start of three-phase motors

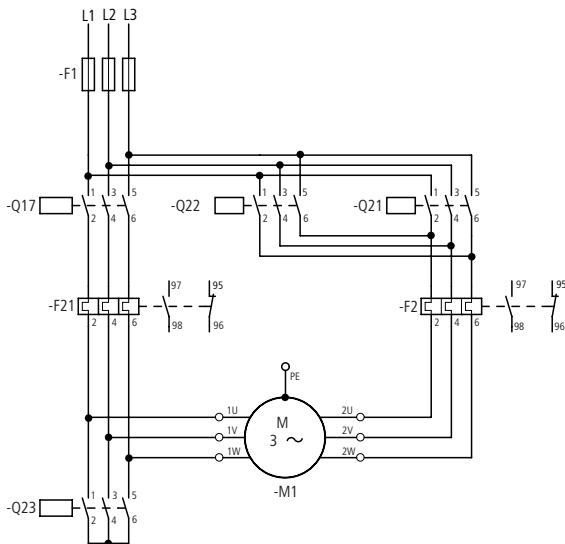
Method of operation: Actuation of pushbutton I energizes the coil of contactor Q11. It switches on the motor running clockwise and maintains itself after button I is enabled via its own auxiliary contact Q11/14-13 and pushbutton 0 (three-wire control contact). The normally closed contact Q11/22-21 electrically inhibits switch on of contactor Q12. When pushbutton II is pressed, contactor Q12 closes (the motor runs in the

anticlockwise direction). 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 the overload relay F2 or normally open contact 13–14 of the motor-protective circuit-breaker or circuit-breaker will switch.

Reversing and two speeds (reversing contactor)

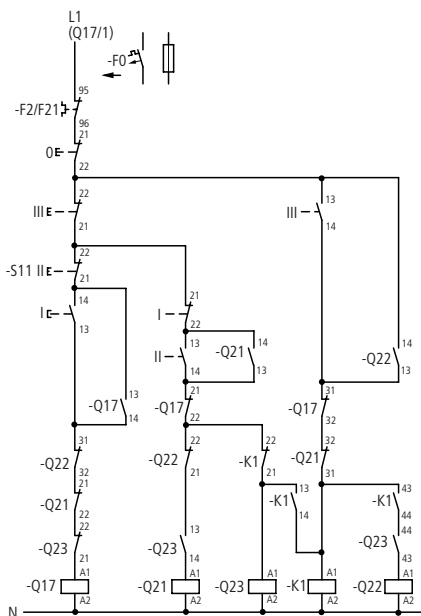
Special circuit (tapped winding) for feed drives, etc.

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 – FORWARD (Q22 + Q23)

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

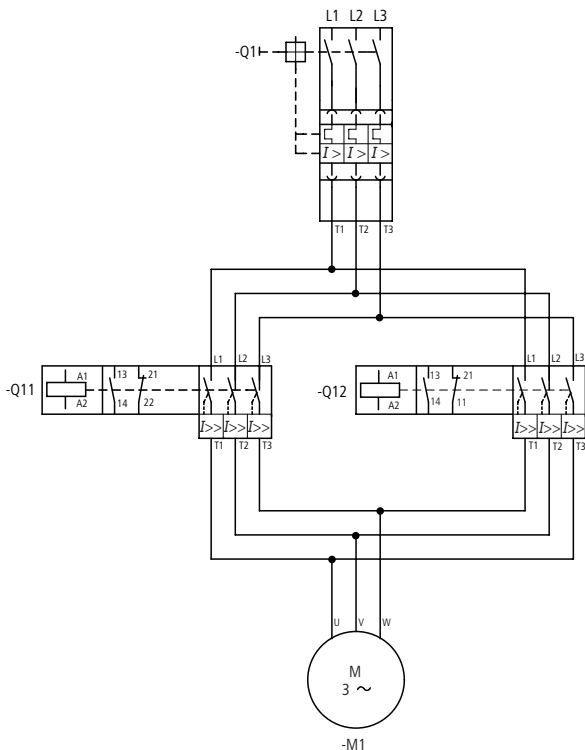
Method of operation: Forward travel is initiated by pressing pushbutton I or II according to the speed required. Pushbutton I switches on the feed motion via Q17. Q17 maintains itself via its normally open contact 13-14. If the feed movement is to occur at high speed star contactor Q23 is energized via pushbutton II which energizes the high speed contactor Q21 via its normally open contact Q23/13-14. Both of the contactors are maintained via Q21/13-14. A direct switch over from feed to high-speed during the process 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 the normally open contacts, K1/43-44 and Q23/44-43, and are maintained via Q22/14-13. The reverse action can only be stopped via pushbutton 0. Direct changeover/reversal is not possible.

All about Motors

Direct-on-line start with motor-protective circuit-breaker PKZ2

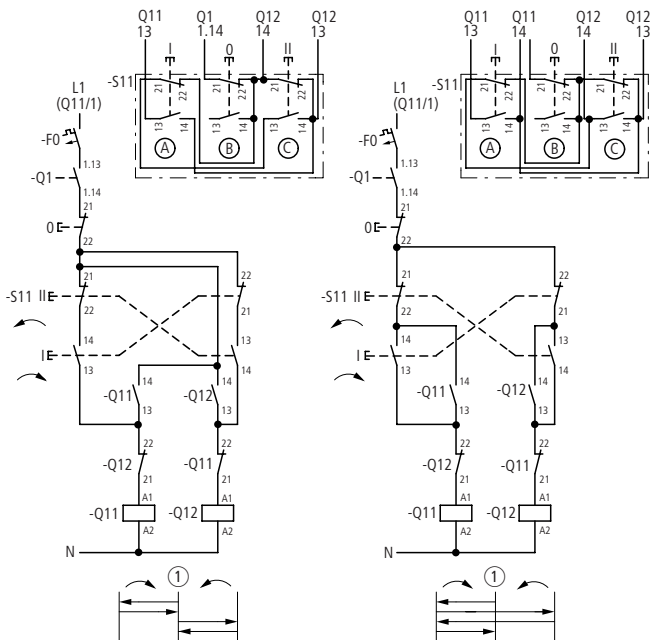
Reversing



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

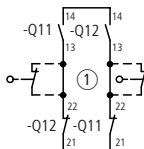
Direct-on-line start with motor-protective circuit-breaker PKZ2



8

① Stop

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

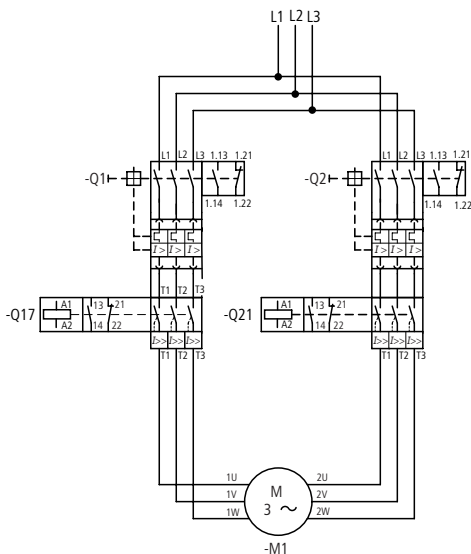


① remove links with position switches

All about Motors

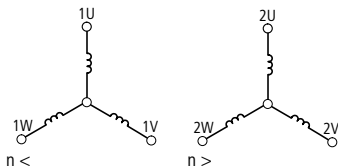
Direct-on-line start with motor-protective circuit-breaker PKZ2

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.

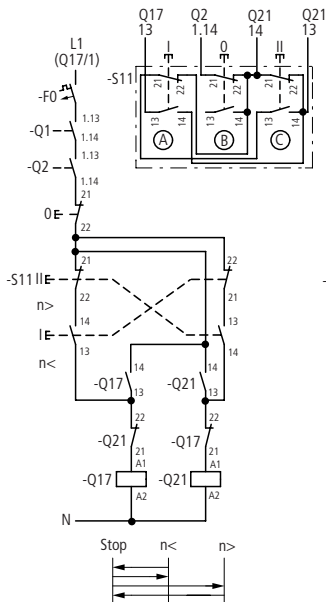
8



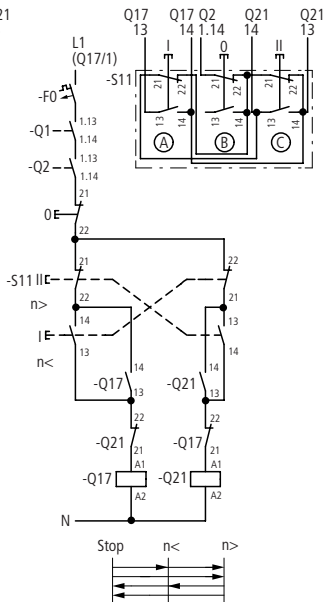
All about Motors

Direct-on-line start with motor-protective circuit-breaker PKZ2

Version 1



Version 2



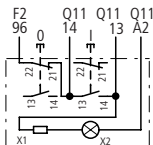
S11	RMQ-Titan, M22-...	—
Q1, Q2	PKZ2/ZM-.../S	—
Q21	S-PKZ2	n >
Q17	S-PKZ2	n <
S11	RMQ-Titan, M22-...	—

All about Motors

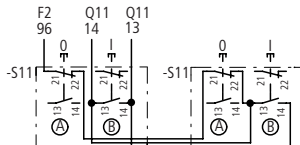
Control circuit device for direct-on-line start

Typical example of circuits with contactor DILM...

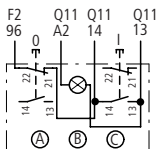
Three-wire control



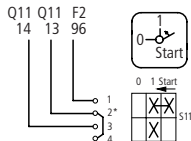
Illuminated pushbutton



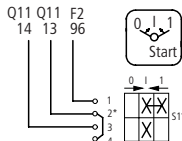
Two two-way pushbuttons



Two-way pushbutton with indicator light



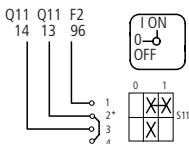
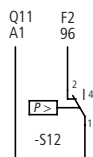
T0-1-15511 spring-return switch with automatic return to position 1



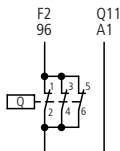
T0-1-15366 spring-return switch with automatic return to position of rest

8

Two-wire control

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

Pressure switch MCS

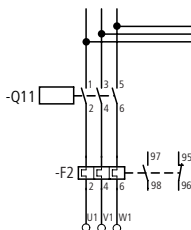


Float switch SW

All about Motors

Star-delta switching of three-phase motors

Star-delta starters with overload relay



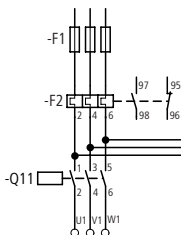
Arrangement in the motor line

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

The complete circuit diagram → section "Automatic star-delta starters SDAINL", page 8-39.

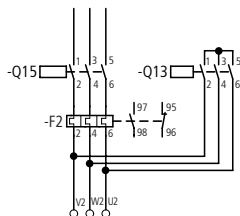
Arrangement in the mains supply line

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 8-39. 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



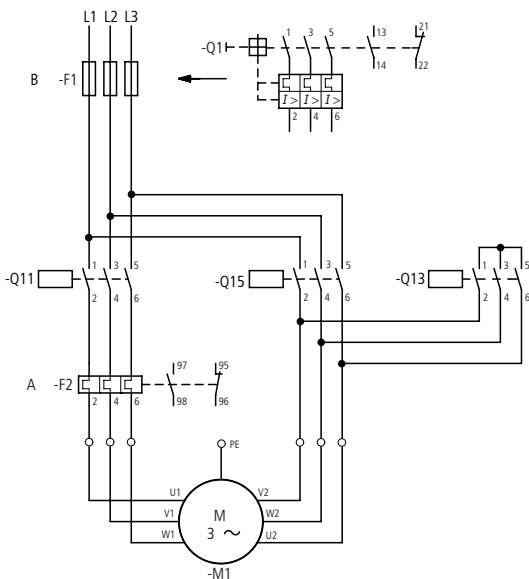
Configuration in the delta circuit

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 8-39. When heavy, long-starting procedures are involved (e.g. for centrifuges) the F2 relay, rated for relay current = rated motor current $\times 0.58$, can also be connected in the connecting lines between the delta contactor Q15 and the star contactor Q13. In the star circuit no current then flows through the F2 relay. The motor is therefore not protected when starting. This circuit is always used when exceptionally heavy and long starting procedures are involved and when saturable core current transformer-operated relays react too quickly.

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
$F2 = 0.58 \times I_e$ with F1 in position B $t_a \leq 15$ s	$Q1 = I_e$ $t_a > 15 - 40$ s
Motor protection in Υ and Δ configuration	Only partial motor protection in Υ configuration

Rating of switchgear

$Q11, Q15 = 0.58 \times I_e$

$Q13 = 0.33 \times I_e$

All about Motors

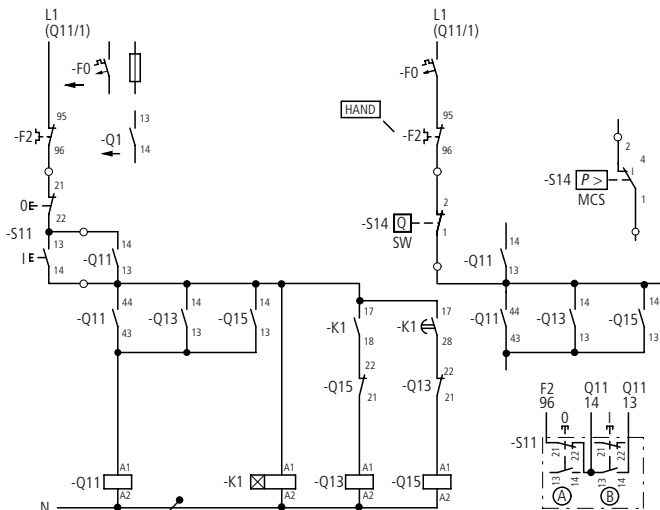
Star-delta switching of three-phase motors

Further notes on the configuration of the overload relay → section "Automatic star-delta starters SDAINL", page 8-39.

Automatic star-delta starters SDAINL00AM to 4AM250

Pushbutton

Two-wire control



Q11: Mains contactor

K1: Timing relay approx. 10 s

Q13: Star contactor

Q15: Delta contactor

Two-way pushbutton

Control circuit device

I = ON

0 = OFF

For connection of further control circuit devices → section "Control circuit devices for star-delta starting", page 8-49

Method of operation

Pushbutton I energizes timing relay K1, the normally open contact K1/17–18 (instantaneous contact) which applies voltage

to star contactor Q13. Q13 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

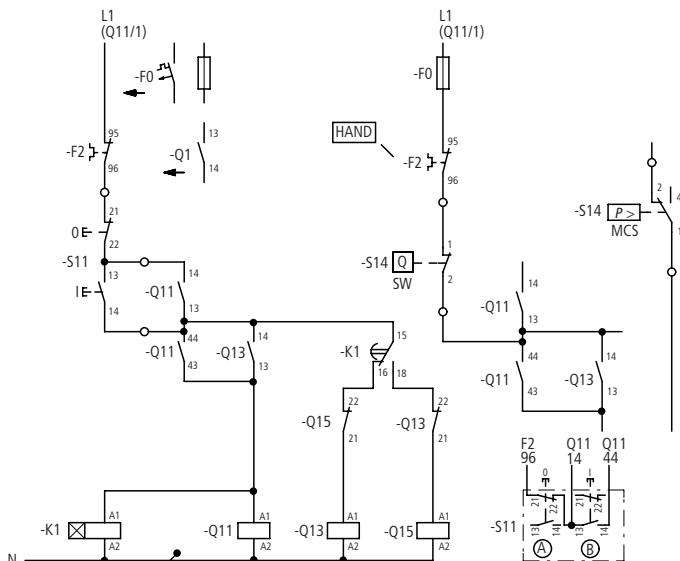
When the set changeover time has elapsed, K1/17–18 opens the circuit of Q13 and after 50 ms closes the circuit via K1/17–28 of Q15. Star contactor Q13 drops out. Delta contactor Q15 closes and switches motor M1 to full mains voltage. At the same time, normally closed contact Q15/22–21 interrupts the 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 the overload relay F2, or via the normally open contact 13–14 of the motor-protective circuit-breaker or circuit-breaker.

Automatic star-delta starters SDAINL EM

Pushbutton

Two-wire control



Two-way pushbutton
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 8-49

Method of operation

Pushbutton I energizes star contactor Q13, the normally open contact Q13/14–13 applies voltage to mains contactor Q11: Q11 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 the 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.

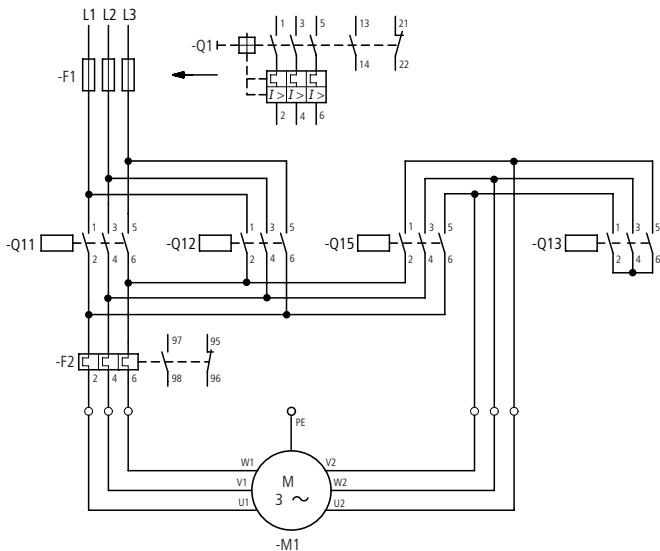
The motor cannot be started up again unless it has previously been disconnected by pushbutton 0, or in the event of an overload, by the normally closed contact 95–96 of the overload relay F2, or via the normally open contact 13–14 of the motor-protective circuit-breaker or circuit-breaker.

All about Motors

Star-delta switching of three-phase motors

Automatic reversing star-delta starter SDAIUL

Reversing



Rating of switchgear

$$Q11, Q12 = I_e$$

$$F2, Q15 = 0.58 \times I_e$$

$$Q13 = 0.33 \times I_e$$

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 \times 0.58

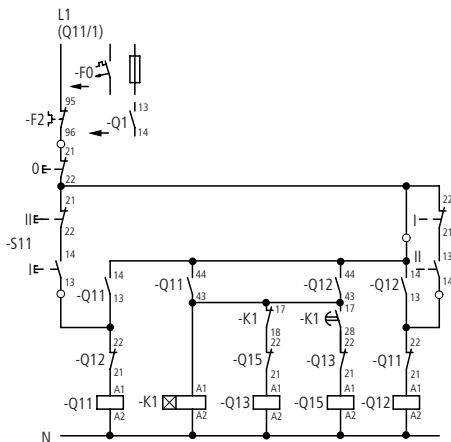
For other arrangements of overload relay

→ section "Star-delta starters with overload relay", page 8-37

All about Motors

Star-delta switching of three-phase motors

Reversing after actuation of pushbutton 0



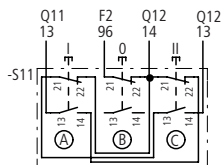
Three-way pushbutton

Control circuit devices

I = Clockwise

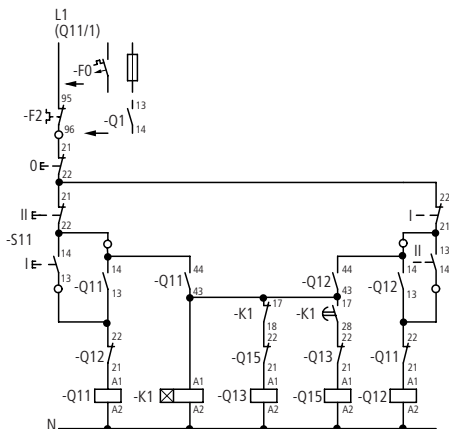
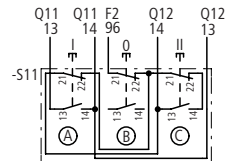
0 = Stop

II = Anticlockwise



Star-delta switching of three-phase motors

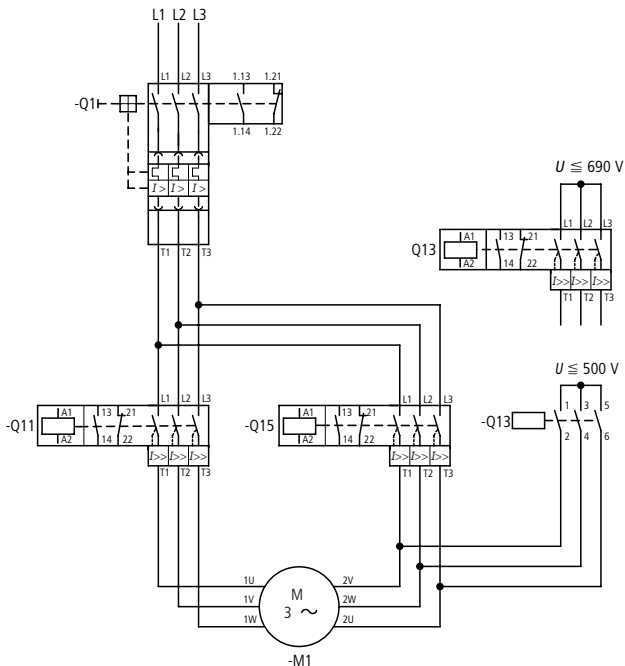
Three-way pushbutton
Control circuit devices
I = Clockwise
0 = Stop
II = Anticlockwise



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 the normally closed contact 95–96 of the overload relay F2.

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. The normally open contact 44–43 fitted to each mains contactor energizes the star contactor Q13. Q13 energizes and switches on motor M1 in the star connection. At the same time, timing relay K1 starts. When the set changeover time has elapsed, K1/17–18 opens the circuit of Q13. Q13 drops out. K1/17–28 closes the circuit of delta contactor Q15.

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



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

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

All about Motors

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

S11	RMQ-Titan, M22-...
Q1	PKZ2/ZM-...
Δ Q15	S/EZ-PKZ2
Υ Q13	DILOM $U_e \leq 500$ V AC
Υ Q13	S/EZ-PKZ2 $U_e \leq 660$ V AC
K1	ETR4-11-A
Q11	S/EZ-PKZ2
F0	FAZ

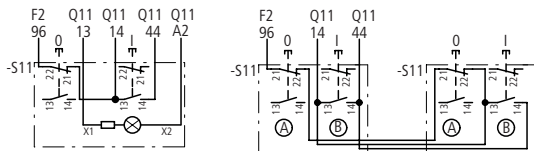
t	t_{Υ} (s)	15–40
N	Motor protection	$(\Upsilon) + \Delta$
	Setting	l

All about Motors

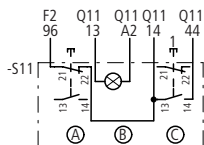
Control circuit devices for star-delta starting

Automatic star-delta starters SDAINL

Three-wire control

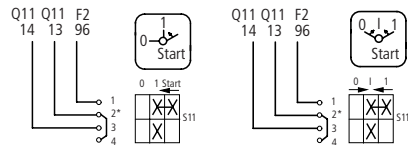


Illuminated pushbutton



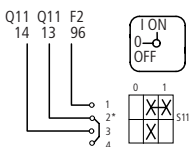
Two-way pushbutton with indicator light

Two two-way pushbuttons

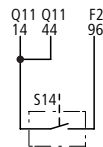


Spring-return switch T0-1-15511 with automatic return to position 1.

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



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

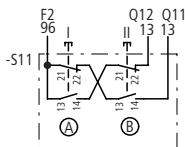


e.g. selector switch
Rotary switch T
Position switch AT
Float switch SW
Pressure switch MCS

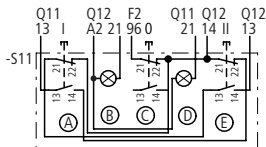
All about Motors

Control circuit devices for star-delta starting

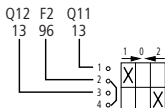
Three-phase reversing contactor DIUL reversing star-delta starter SDAIUL



Two-way pushbutton¹⁾ 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

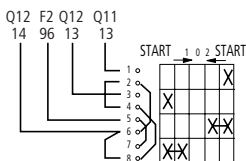
Spring-return switch¹⁾
T0-1-8214, without self-maintaining circuit (inching)

Automatic return to 0 only for reversing contactors



FS 684

Changeover switch¹⁾
Switch T0-1-8210 remains in position 1 or 2

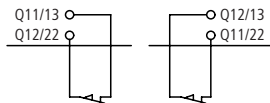


FS 140660

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

Position switch

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



¹⁾ Overload relay 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 $\Delta/Y/Y$ $Y/Y/Y$
Output ratio 1/1.5–1.8 0.3/1

The $\Delta/Y/Y$ configuration comes nearest to satisfying the most usual requirement for constant torque. It has the additional advantage that, because nine terminals are available, Y/Δ starting can be used to provide smooth starting or to reduce the starting current for the low speed condition (→ section "Motor windings", page 8-54).

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	–	–
No. 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.

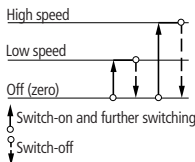
All about Motors

Pole-changing motors

Motor circuit

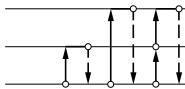
Circuit A

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



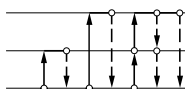
Circuit B

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 (→ page 8-82).

Preferred speed combinations are:

Speeds	1000/1500/3000	750/1000/1500	750/1500/3000	= separate winding (in the circuit diagrams)
No. of poles	6/4/2	8/6/4	8/4/2	
Circuit	X	Y	Z	

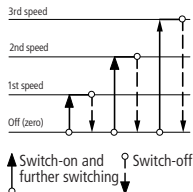
All about Motors

Pole-changing motors

Motor circuit

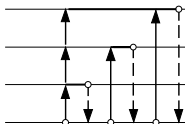
Circuit A

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



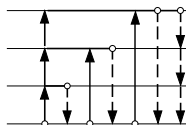
Circuit B

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	500/1 000	2nd winding	$1\,500/3\,000 = 500/1\,000/1\,500/3\,000$
or 1st winding	500/1 000	2nd winding	$750/1\,500 = 500/750/1\,000/1\,500$

For motors having 3 or 4 speeds the non-connected winding has to be opened at certain pole ratios to avoid inductive circulating currents. This is achieved via 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

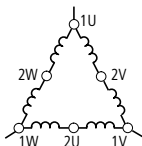
2 speeds

2 separate windings

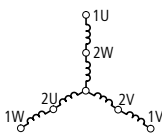
Tapped winding

with Υ Δ starting at low speed

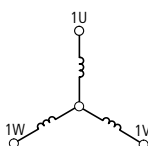
Low speed Δ



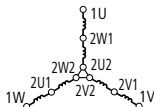
Low speed Υ



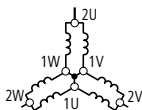
Low speed



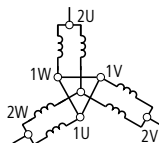
Low speed Υ



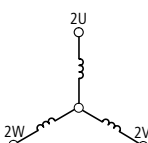
High speed $\Upsilon\Upsilon$



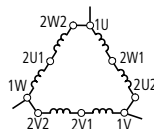
High speed $\Upsilon\Upsilon$



High speed



Low speed Δ



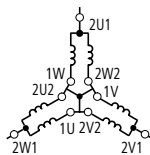
8

→ page 8-59

→ page 8-59

→ page 8-63

High speed $\Upsilon\Upsilon$



→ page 8-72

All about Motors

Motor windings

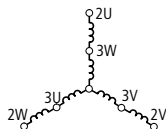
Tapped winding

3 speeds

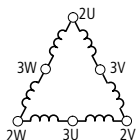
Motor circuit X

2 windings, medium and high speed – tapped winding

2

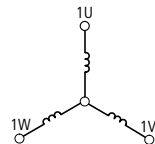


or 2



Low speed
Separate winding

1

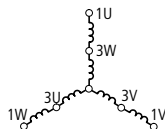


→ page 8-81

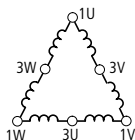
Motor circuit Y

2 windings, low and high speed – tapped winding

2

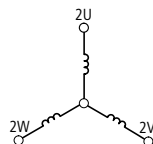


or 2



Medium speed
Separate winding

1

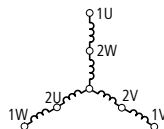


→ page 8-83

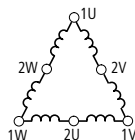
Motor circuit Z

2 windings, low and medium speed – tapped winding

2

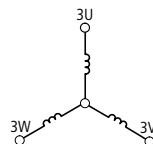


or 2



High speed
Separate winding

1



→ page 8-85

Notes

All about Motors

Multi-speed contactor

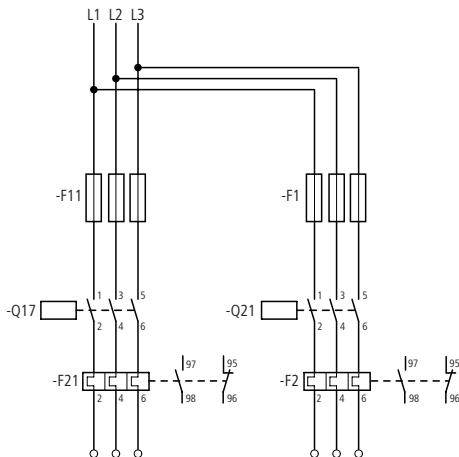
Certain operating sequences for multi-speed motors may be necessary, or undesirable, depending on the nature of the drive. If, for example, the starting temperature rise is to be reduced or high inertia loads are to be accelerated, it is advisable to switch to low speed first and then to high speed.

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 relay

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.



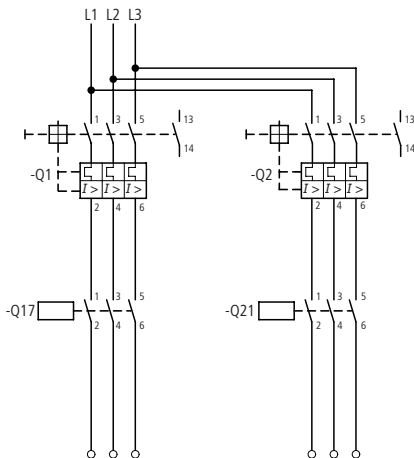
All about Motors

Multi-speed contactor

Fuseless arrangement

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.



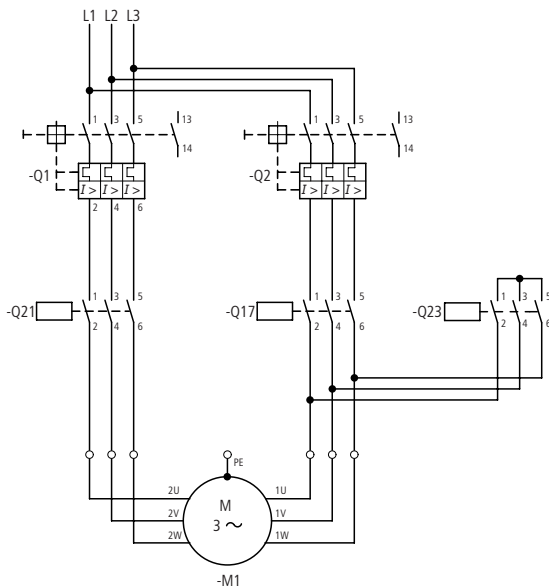
All about Motors

Multi speed switch for 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 8-54

Synchronous speeds

One multi-speed winding

All about Motors

Multi speed switch for three-phase motors

Motor terminals	1U, 1V, 1W	2U, 2V, 2W
No. of poles	12	6
rpm	500	1 000
No. of poles	8	4
rpm	750	1 500
No. of poles	4	2
rpm	1 500	3 000
Contactors	Q17	Q21, Q23

Rating of switchgear

Q2, Q17 = I_1 (low speed)

Q1, Q21 = I_2 (high speed)

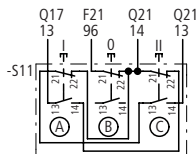
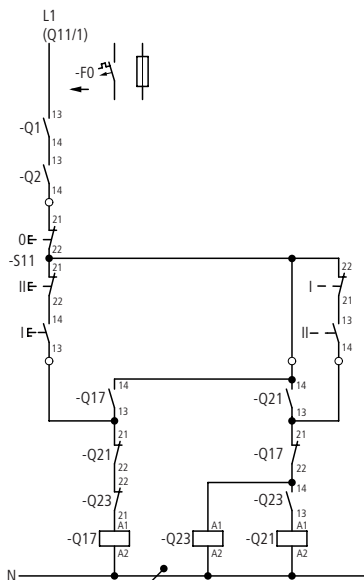
Q23 = $0.5 \times I_2$

All about Motors

Multi speed switch for three-phase motors

Circuit A (→ page 8-53)

1 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 → page 8-67, → page 8-68, → page 8-69

Method of operation

Pushbutton I energizes mains contactor Q17 (low speed). Q17 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.

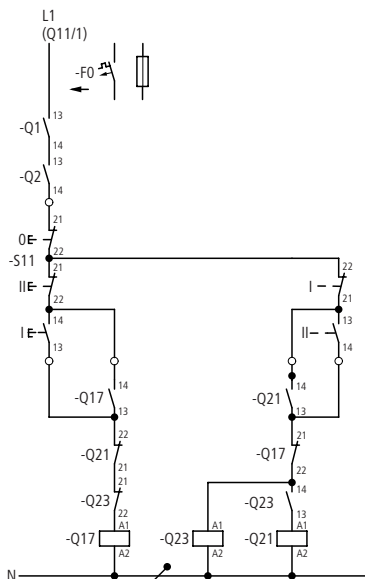
Speed can be changed either after pressing pushbutton 0 (circuit A) or directly by pressing the appropriate pushbutton (circuit C), depending upon the circuit. The motor can be switched off either by pressing pushbutton 0, or in the event of an overload, by normally open contact 13–14 of the motor-protective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

All about Motors

Multi speed switch for three-phase motors

Circuit C (→ page 8-53)

1 three-way pushbutton

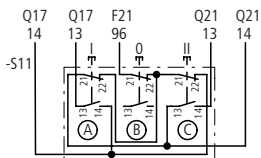


Three-way pushbutton

I: Low speed (Q17)

0: Stop

II: High speed (Q21 + Q23)



Q17: Mains contactor, low speed

Q23: Star contactor

Q21: Mains contactor, high speed

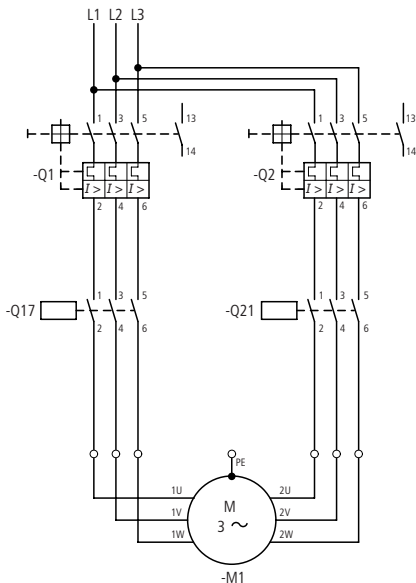
For connection of further control circuit devices → page 8-70

All about Motors

Multi speed switch for three-phase motors

2 separate windings, non-reversing, 2 speeds

Multi-speed contactor UPDIUL, fuseless
without overload relay



Rating of switchgear

Q1, Q17 = I_1 (low speed)

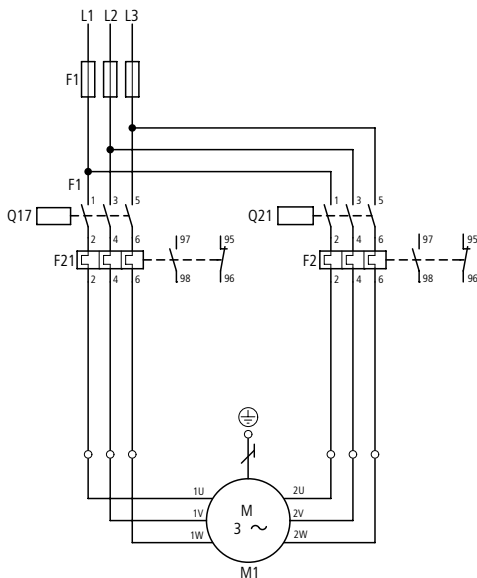
Q2, Q21 = I_2 (high speed)

All about Motors

Multi speed switch for three-phase motors

2 separate windings, non-reversing, 2 speeds

Multi-speed contactor UPDIUL, with fuses and overload relay



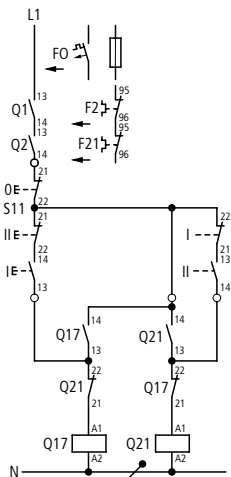
Fuse size in accordance with data on the rating plate of the overload relays F2 and F21. If overload relays F2 and F21 cannot be protected by a common fuse, then use circuit as in → page 8-57. → section "Motor windings", page 8-54.

All about Motors

Multi speed switch for three-phase motors

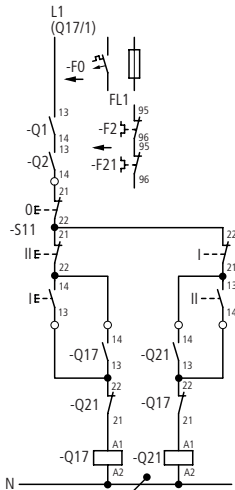
Circuit A (→ page 8-53)

1 three-way pushbutton



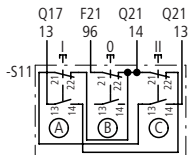
Circuit C (→ page 8-53)

1 three-way pushbutton



Q17: Mains contactor, low speed

Q21: Mains contactor, high speed

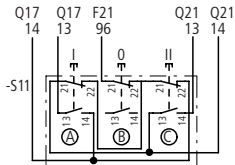


Three-way pushbutton

I: Low speed (Q17)

O: Stop

II: High speed (Q21 + Q23)



For connection of further control circuit devices, see → page 8-71.

All about Motors

Multi speed switch for three-phase motors

Method of operation

Actuation of pushbutton I energizes the coil of contactor Q17. Q17 brings in the motor at low speed, 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.

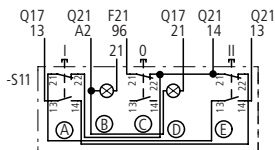
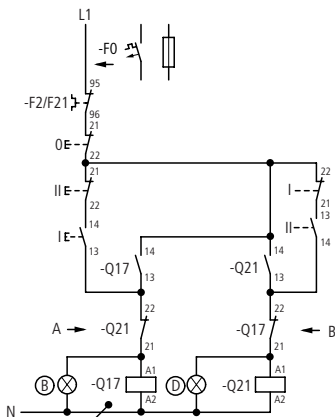
All about Motors

Control circuit devices for multi-speed contactors UPDIUL

2 separate windings, non-reversing, 2 speeds

Circuit A (→ page 8-53)

One three-way pushbutton with indicator lights



Control circuit devices

I = Low speed (Q17)

0 = Stop

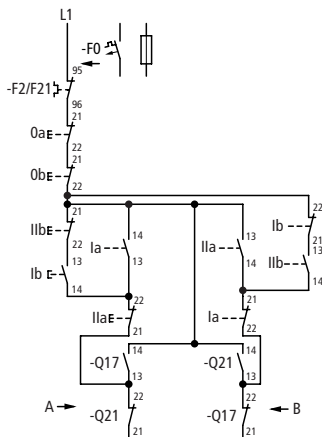
II = High speed (Q21)

All about Motors

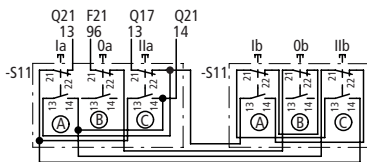
Control circuit devices for multi-speed contactors UPDIUL

Circuit A (→ page 8-53)

2 three-way pushbuttons



8



Control circuit devices

I: Low speed (Q17)

0: Stop

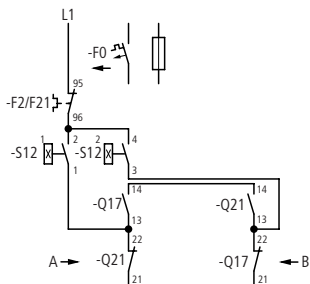
II: High speed (Q21)

Remove existing links and rewire

All about Motors

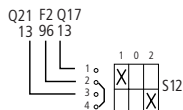
Control circuit devices for multi-speed contactors UPDIUL

Circuit A (→ page 8-53)



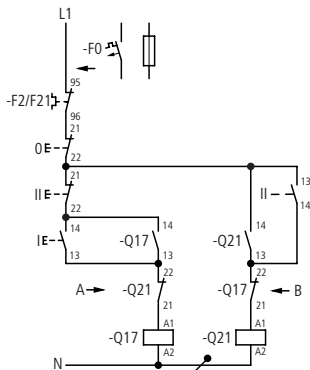
T0-1-8210 changeover switch

Always set overload relay to manual reset



Circuit B (→ page 8-53)

1 three-way pushbutton

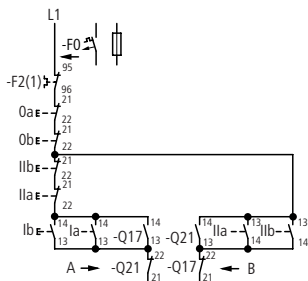


All about Motors

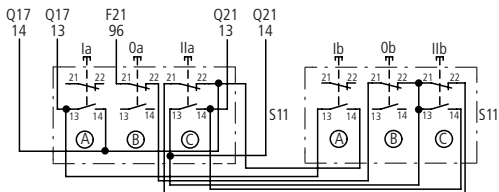
Control circuit devices for multi-speed contactors UPDIUL

Circuit B (→ page 8-53)

2 three-way pushbuttons



Control circuit device for circuit B

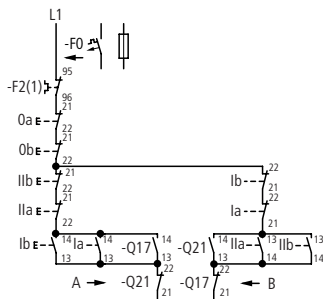


All about Motors

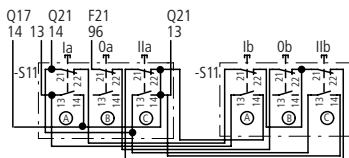
Control circuit devices for multi-speed contactors UPDIUL

Circuit C (→ page 8-53)

2 three-way pushbuttons



Control circuit device for circuit C



All about Motors

Multi speed switch for three-phase motors

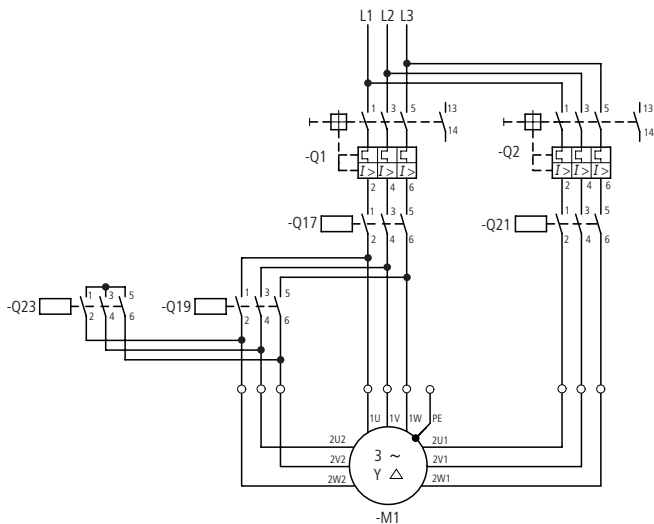
Tapped winding, non-reversing, 2 speeds

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

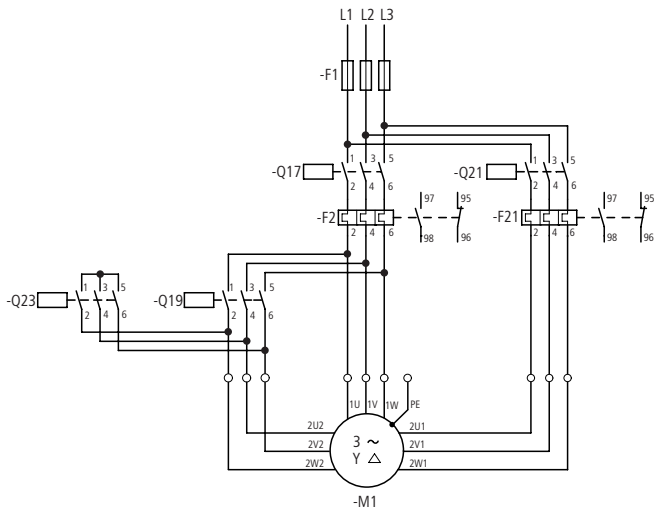
(high speed)

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

All about Motors

Multi speed switch for three-phase motors

With **fuses** and overload relay



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

→ page 8-57.

→ section "Motor windings", page 8-54.

All about Motors

Multi speed switch for three-phase motors

Circuit

Low speed selected only from zero, high speed only via low speed without actuation of the Stop button.

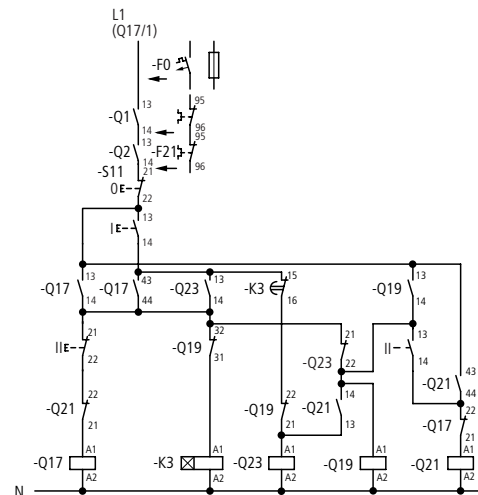
Three-way

pushbutton

I: Low speed
(Q17, Q19)

0: Stop

II: High speed
(Q21, Q19,
Q23)



Q17: Mains contactor, low speed

Q19: Delta contactor
Q21: Mains contactor, high speed

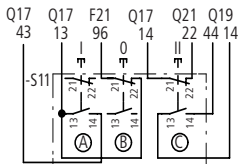
K3: Timing relay
Q23: Star contactor

Method of operation

Actuation of pushbutton I energizes the coil of star contactor Q23, and 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 cuts in. When the set time has elapsed, K3/15–16 opens the circuit of Q23. Q23 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.



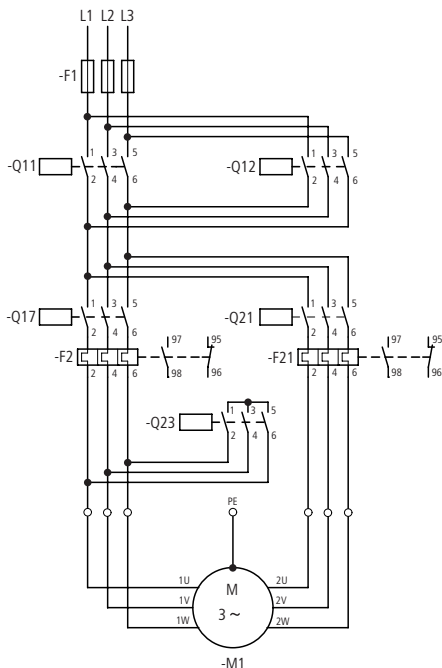
All about Motors

Multi speed switch for 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 = $0.5 \times I_2$ (high speed)

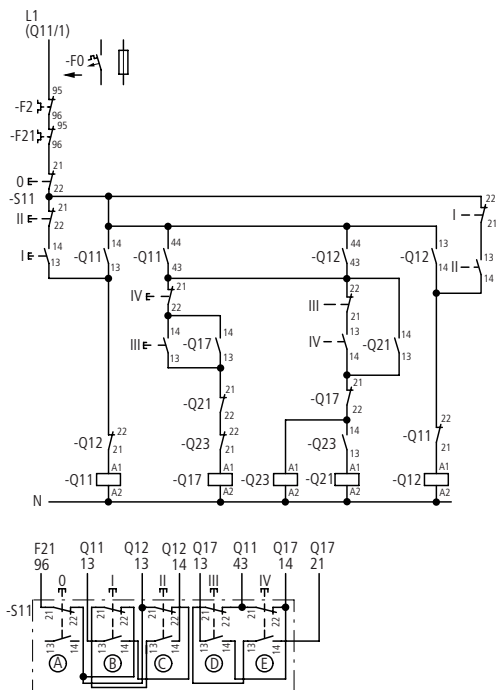
All about Motors

Multi speed switch for three-phase motors

Five-way pushbutton

Circuit

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)

Method of operation

Contactors Q11 is energized by pressing pushbutton I. Contactors 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 Q21/21–22 makes low-speed pushbutton III inoperative. Pushbutton 0 must be pressed before any change in speed or direction.

All about Motors

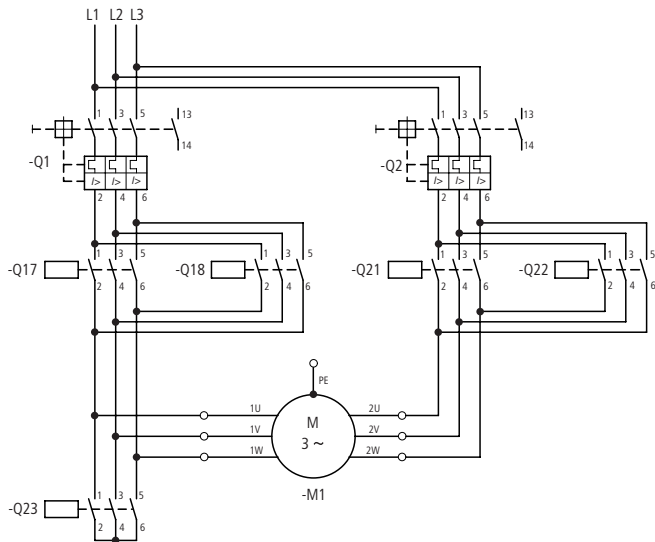
Multi speed switch for three-phase motors

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)

$Q2, Q21, Q22 = I_2$

$Q23 = 0.5 \times I_2$

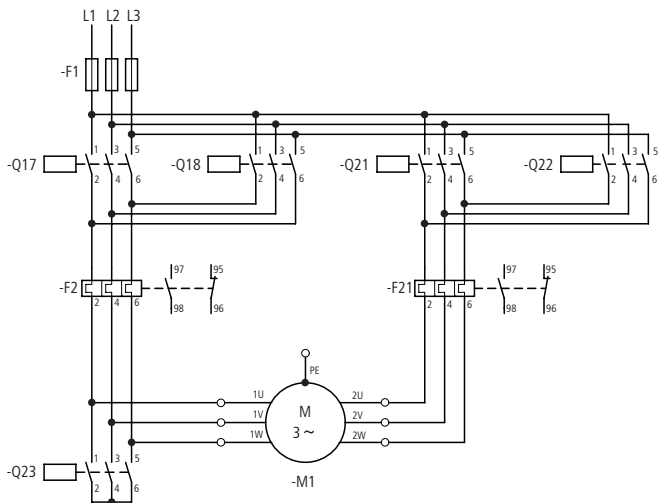
(high speed)

All about Motors

Multi speed switch for three-phase motors

Multi-speed contactor UPIUL

With **fuses** and overload relay



Rating of switchgear

$F2, Q17, Q18 = I_1$
(low speed)

$F21, Q21, Q22 = I_2$

$Q23 = 0.5 \times I_2$
(high speed)

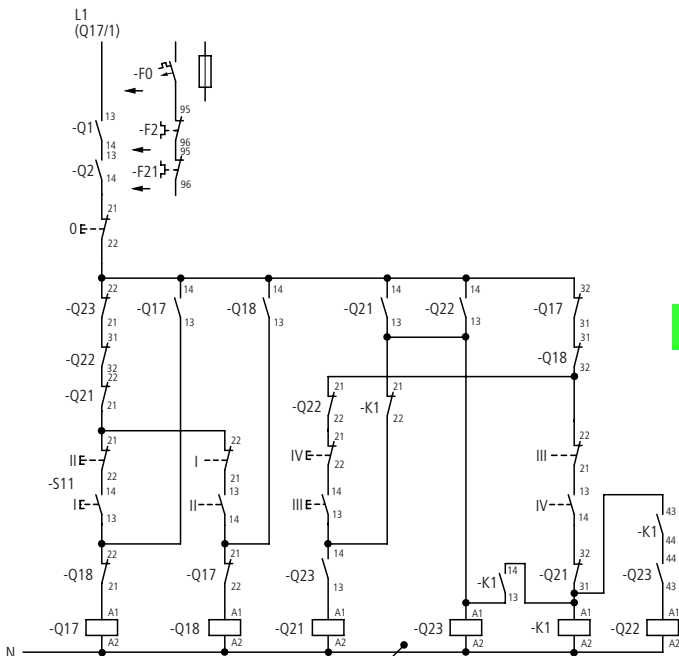
Overload relays F2 and F21 are not used on multi-speed contactors without motor protection

All about Motors

Multi speed switch for 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

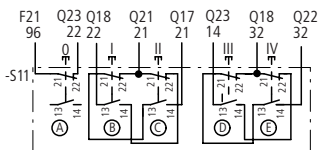
Q23: Star contactor

K1: Contactor relay

Q22: Fast back

All about Motors

Multi speed switch for 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)

Method of operation

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.

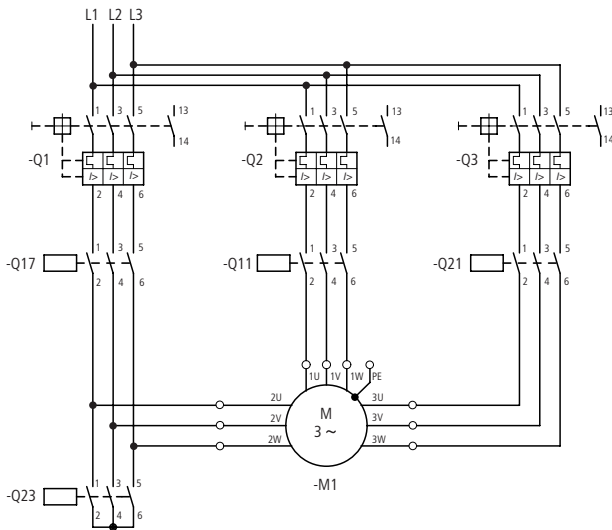
All about Motors

Multi speed switch for 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
→ page 8-83



→ section "Motor circuit X", page 8-55

Synchronous speed

Winding	1	2	2
Motor terminals	1U, 1V, 1W	2U, 2V, 2W	3U, 3V, 3W
No. of poles	12	8	4
Rpm	500	750	1500
No. of poles	8	4	2
Rpm	750	1500	3000

No. 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)

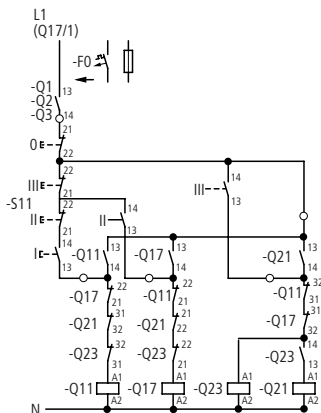
Q23 = $0.5 \times I_3$

All about Motors

Multi speed switch for three-phase motors

Circuit of motor winding: X

Circuit A



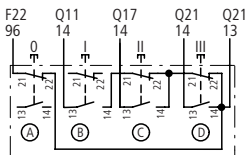
- Q11: Low speed winding 1
 Q17: Medium speed winding 2
 Q23: High speed winding 2
 Q21: High speed winding 2

Method of operation

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

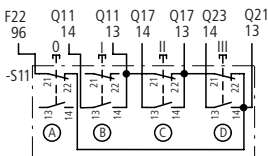
Circuit A

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.



Four-way pushbutton

0: Stop

I: Low speed (Q11)

II: Medium speed (Q17)

III: High speed (Q21 + Q23)

overload, normally open contact 13–14 of the motor-protective circuit-breaker or circuit-breaker can also switch off.

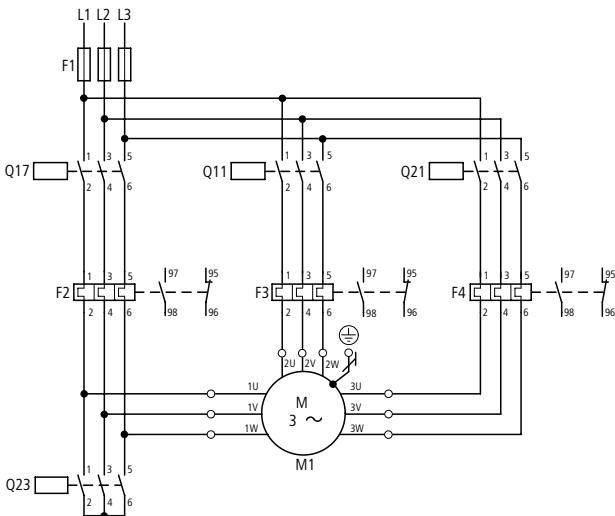
All about Motors

Multi speed switch for 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 → page 8-81



→ section "Motor circuit Y", page 8-55

Synchronous speed

Winding	2	1	2
Motor terminals	1U, 1V, 1W	2U, 2V, 2W	3U, 3V, 3W
No. of poles	12	8	6
Rpm	500	750	1000
No. of poles	8	6	4

Rpm	750	1000	1500
Contactors	Q17	Q11	Q21, Q23

Rating of switchgear

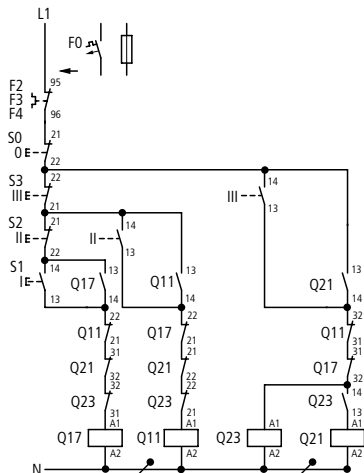
F2, Q17 = I_1 (low speed)
 F3, Q11 = I_2 (medium speed)
 F4, Q21 = I_3 (high speed)
 Q23 = $0.5 \times I_3$

All about Motors

Multi speed switch for 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

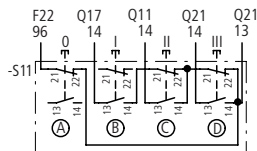
Method of operation

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.

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.

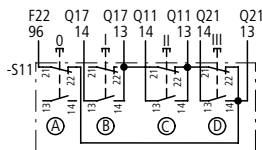
Four-way pushbutton

0: Stop

I: Low speed (Q17)

II: Medium speed (Q11)

III: High speed (Q21 + Q22)



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.

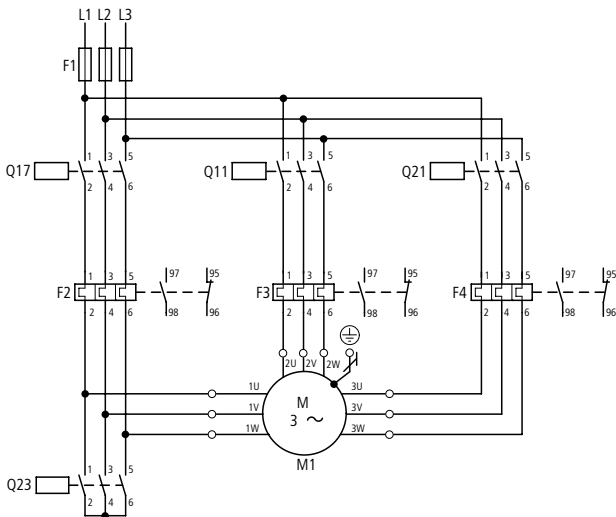
All about Motors

Multi speed switch for 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 → page 8-57



→ section "Motor circuit Z", page 8-55

Synchronous speed

Winding	2	2	1
Motor terminals	1U, 1V, 1W	2U, 2V, 2W	3U, 3V, 3W
No. of poles	12	6	4
Rpm	500	1000	1500
No. of poles	12	6	2
Rpm	500	1000	3000
No. of poles	8	4	2

Rpm	750	1500	3000
Contactors	Q17	Q21, Q23	Q11

Rating of switchgear

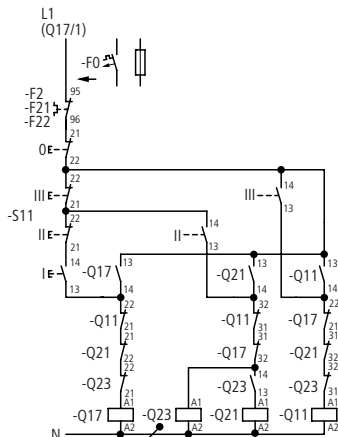
F2, Q17 = I_1 (low speed)
 F4, Q21 = I_2 (medium speed)
 F3, Q11 = I_3 (high speed)
 Q23 = $0.5 \times I_3$

All about Motors

Multi speed switch for 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

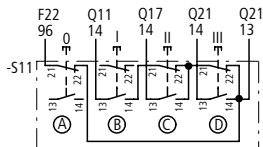
Q11: High speed winding 1

Method of operation

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

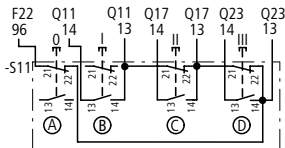
Circuit A

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.



Four-way pushbutton

0: Stop

I: Low speed (Q17)

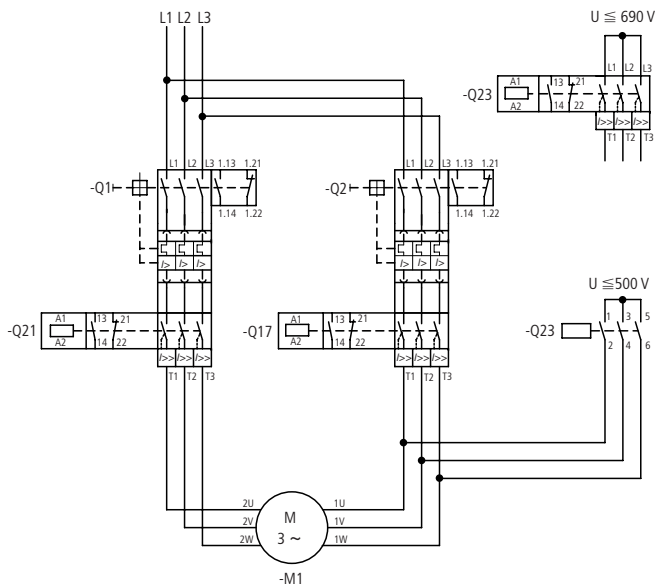
II: Medium speed (Q21 + Q23)

III: High speed (Q11)

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-breaker PKZ2

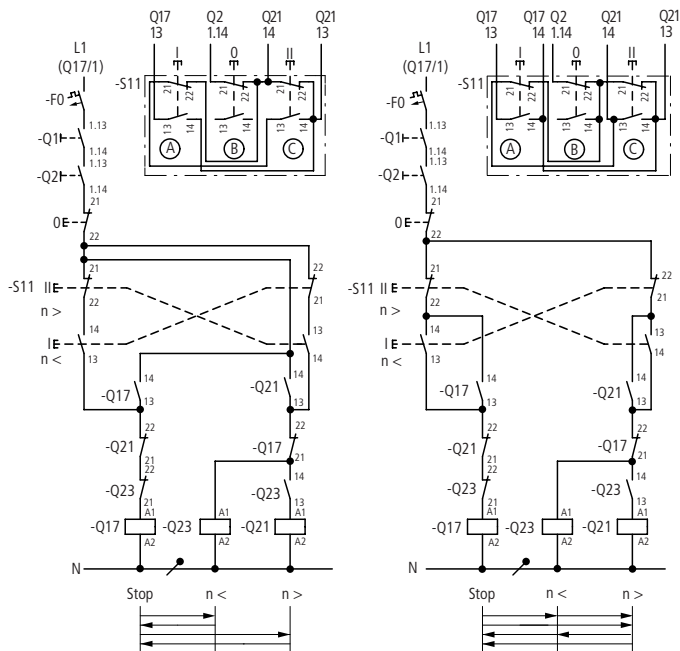


8

No. of poles	12	6
Rpm	500	1000
No. of poles	8	4
Rpm	750	1500
No. of poles	4	2
Rpm	1500	3000

All about Motors

Multi speed switch with motor-protective circuit-breaker PKZ2



Circuit A → page 8-53

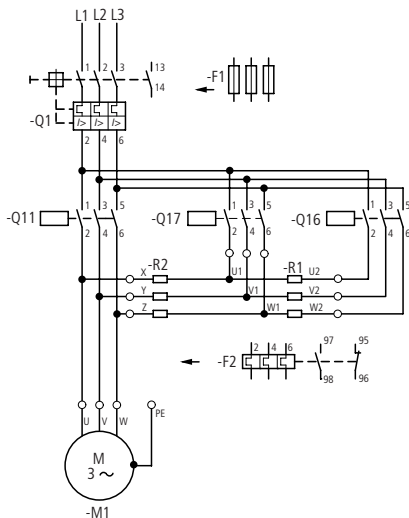
Circuit C → page 8-53

S11	RMQ-Titan, M22-...	—	—	—
Q1, Q21	PKZ2/ZM-.../S	$n >$	—	—
Q2, Q17	PKZ2/ZM-.../S	$n <$	—	—
Q23	DIL0M	$\Upsilon n > U_e \leq 500 \text{ V}$	—	—
Q23	S/EZ-PKZ	$\Upsilon n > U_e \leq 660 \text{ V}$	F0	FAZ

All about Motors

Three-phase automatic stator starters

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



Use F2 when using F1 instead of Q1.

Rating of switchgear:

Starting voltage $= 0.6 \times U_e$

Starting current $= 0.6 \times \text{motor full-load current}$

Starting torque $= 0.36 \times \text{motor full-load current}$

Q1, Q11 $= I_e$

Q16, Q17 $= 0.6 \times I_e$

Starting voltage $= 0.6 \times U_e$

Three-phase automatic stator starters

All about Motors

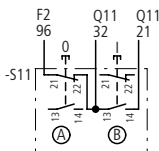
Three-phase automatic stator starters

Three-wire control

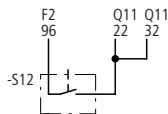
Two-way pushbutton

I = ON

0 = OFF



Two-wire control



Method of operation

Pushbutton I energizes step contactor Q16 and timing relay K1. Q16/14–13 – maintain themselves via 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 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, which bypasses the second starting stage R2, and the motor runs at rated speed. Q11 maintains itself via Q11/14–13. Q16, Q17, K1 and K2 are

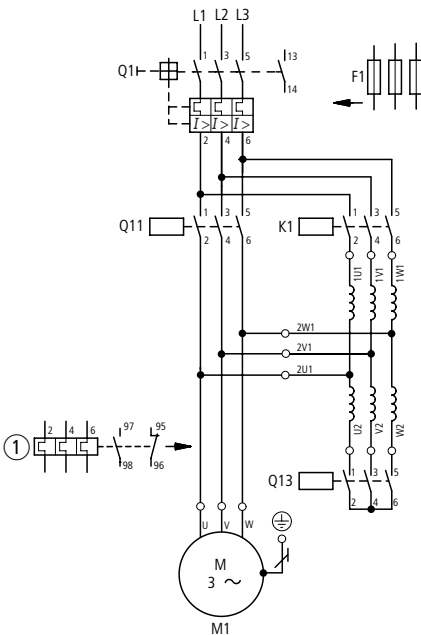
de-energized by normally closed contacts Q11/22–21 and Q11/32–31. The motor is switched off either after actuation of pushbutton 0, or in the event of an overload, by normally closed contact 95–96 of the overload relay F2 or normally open contact 13–14 of the motor-protective circuit-breaker or circuit-breaker.

Step contactor 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.

All about Motors

Three-phase automatic stator starters

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



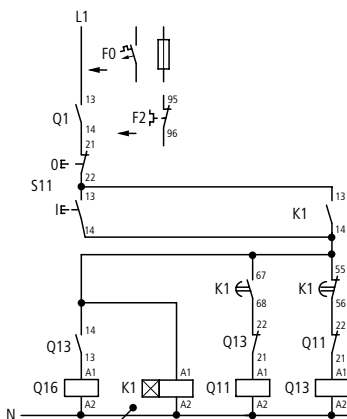
Use F2 when using F1 instead of Q1.

Rating of switchgear

Starting voltage	$= 0.7 \times U_e$ (typical value)	Tightening torque	$= 0.49 \times$ motor full-load current
Starting current	$= 0.49 \times$ motor full-load current	Q1, Q11	$= I_e$
I_A/I_e	$= 6$	Q16	$= 0.6 \times I_e$
t_A	$= 10$ s	Q13	$= 0.25 \times I_e$
S/h	$= 30$		

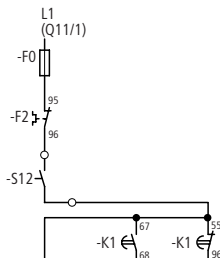
All about Motors

Three-phase automatic stator starters



Two-wire control

Always set overload relay to manual reset (automatic reset)



Q16: Step contactor

K1: Timing relay

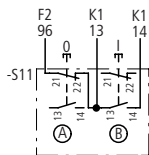
Q11: Mains contactor

Q13: Star contactor

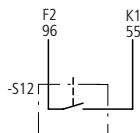
Three-wire control

I: ON

O: OFF



Two-wire control



Method of operation

Actuation of pushbutton I simultaneously energizes star contactor Q13, timing relay K1 and, via normally open contact Q13/13–14, step contactor K16, 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 – K16 de-energizes: The starting transformer is disconnected, and the motor runs at rated speed.

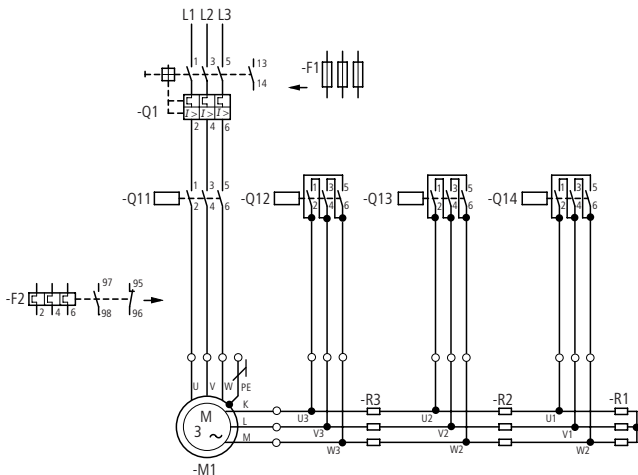
The motor cannot start up again unless previously switched off by actuation of pushbutton O, or in the event of an overload, by normally closed contact 95–96 of the overload relay F2. With two-wire control, overload relay F2 must always be set to manual reset. If the motor has been switched off by F2,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

All about Motors

Three-phase automatic rotor starters

Three-phase automatic rotor resistance starters DAINL

3-stage, rotor 3-phase

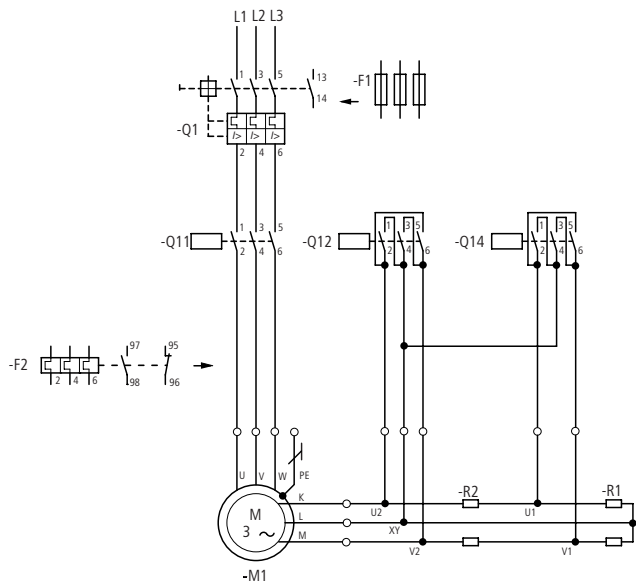


Use F2 when using F1 instead of Q1.

All about Motors

Three-phase automatic rotor starters

2-stage, rotor 2-phase



Use F2 when using F1 instead of Q1.

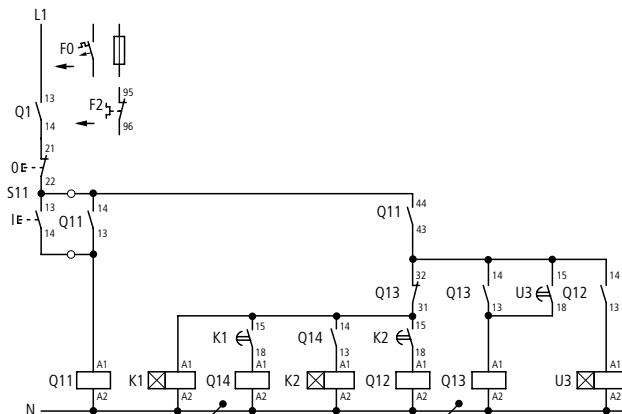
Rating of switchgear

Starting current	$= 0.5 - 2.5 \times I_e$
Starting torque	$= 0.5$ to pull-out torque
Q1, Q11	$= I_e$
Step contactors	$= 0.35 \times I_{\text{rotor}}$
Final step contactors	$= 0.58 \times I_{\text{rotor}}$

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

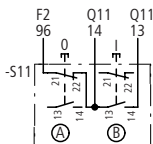
Q13: Final step contactor

K3: Timing relay

Two-way push-button

I: ON

O: OFF



For connection of further control circuit devices: → section "Control circuit devices for star-delta starting", page 8-49

All about Motors

Three-phase automatic rotor starters

Method of operation

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 Q14. Step contactor Q14 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 Q13 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 with 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 contactors Q13 and/or 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.

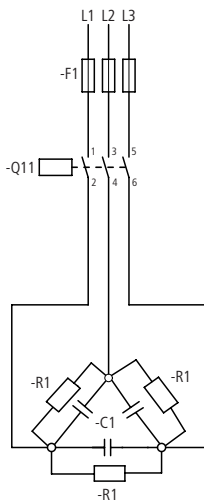
When there are more than three stages, the additional step contactors, timing relays and resistors have appropriate increasing designations.

All about Motors

Switching of capacitors

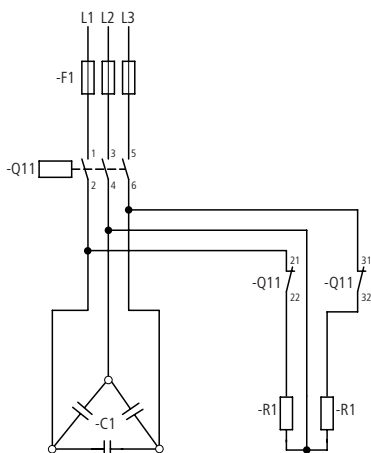
Contactors for capacitors DIL

Individual circuit without
quick-discharge resistors



R1 discharge resistors fitted in
capacitor

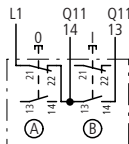
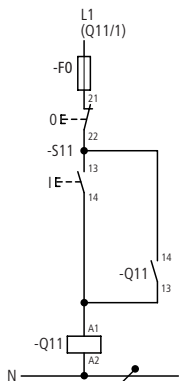
Individual circuit with quick-discharge resistors



R1 discharge resistors fitted to contactor

All about Motors

Switching of capacitors

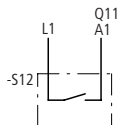


Two-way pushbutton

For connection of further control circuit devices: → section "Control circuit devices for star-delta starting", page 8-49

Two-wire control

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.



Method of operation

Pushbutton I energizes contactor Q11. Q11 energizes and maintains itself via its own auxiliary contact 14–13 and pushbutton 0. Capacitor C1 is now energized. Discharge resistors R1 are not operative 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.

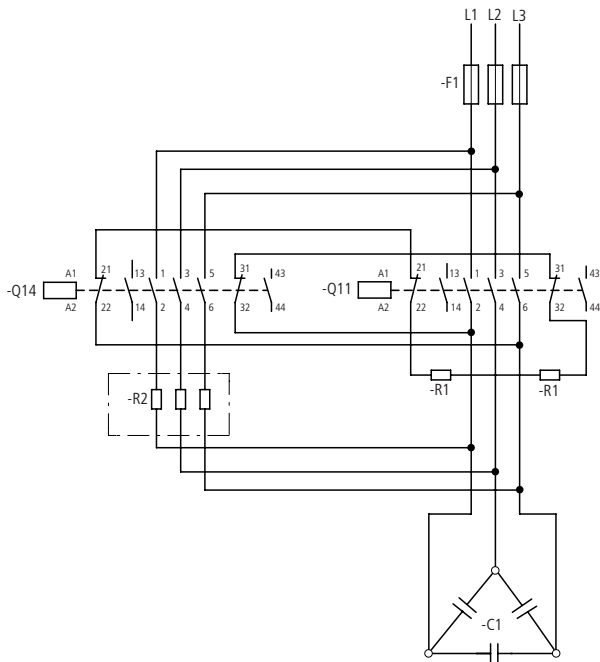
All about Motors

Switching of capacitors

Capacitor contactor combination

Capacitor contactor with pilot contactor and series resistors. Individual and parallel circuit

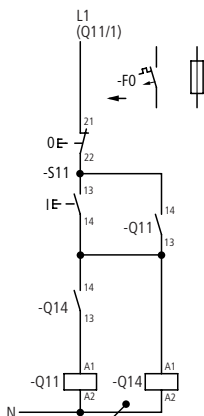
with and without discharge resistors and with series resistors.



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



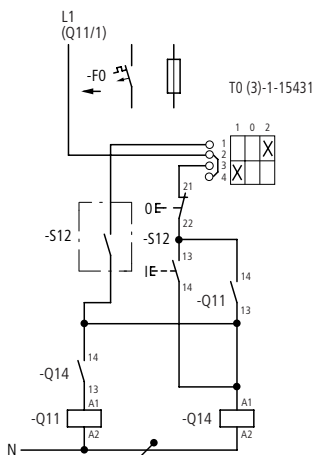
Q11: Mains contactor

Q14: Pilot contactor

Actuation by two-way pushbutton S11

Method of operation

Actuation by two-way pushbutton S11:
Pushbutton I energizes pilot contactor Q14. Q14 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.



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

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.

All about Motors

Duplex pump control

Fully automatic control for two pumps

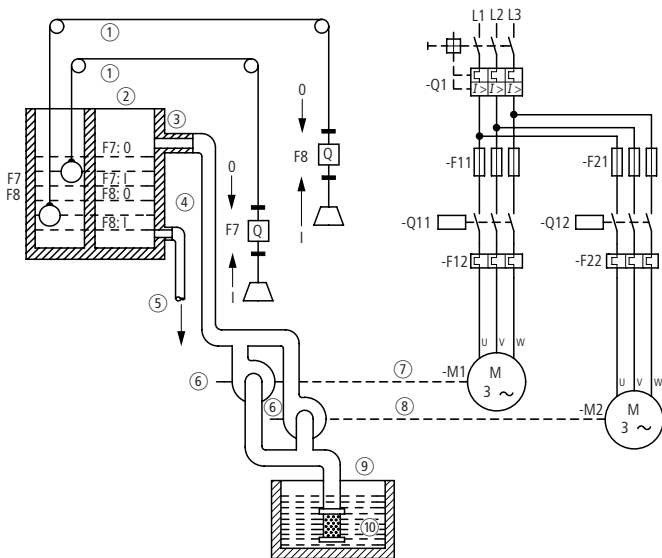
Starting sequence of pumps 1 and 2 can be selected by control switch S12

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

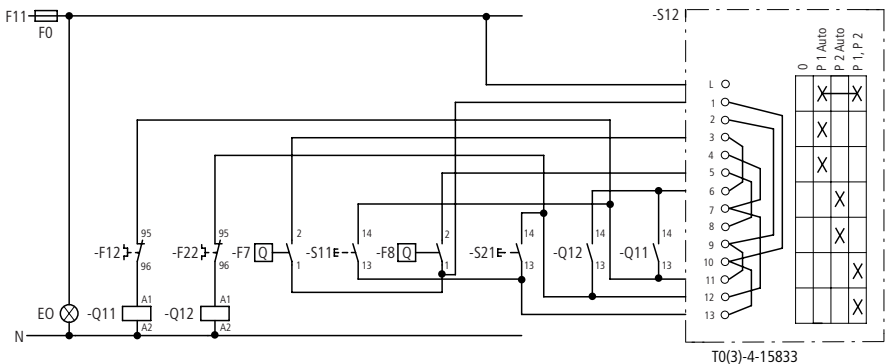
⑥ Centrifugal or reciprocating pump

⑦ Pump 1

⑧ Pump 2

⑨ Suction pipe with filter

⑩ Well



Float switch F7 closes before F8

Method of operation

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

Q11: Pump 1 mains contactor

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.

Q12: Pump 2 mains contactor

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

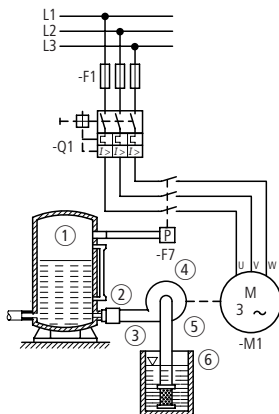
On the version of duplex pump control with automatic load sharing (T0(3)-4-15915), S12 has a further position: the sequence of operations is automatically reversed after each cycle.

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

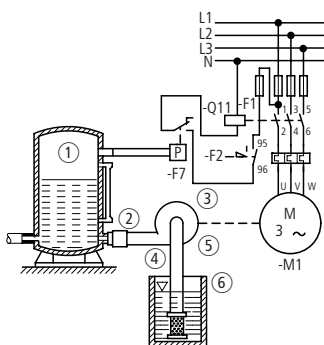
⑤ Suction pipe with filter

⑥ Well

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 automatic reset

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

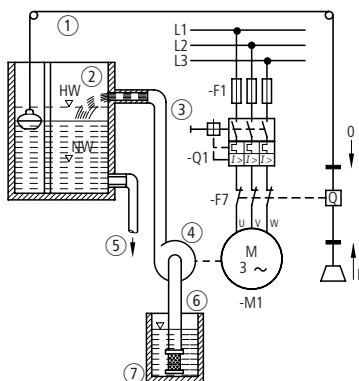
⑤ Suction pipe with filter

⑥ Well

All about Motors

Fully automatic pump control

With 3-pole float switch SW (main circuit)



F1: Fuses (if required)

Q1: Motor-protective switch, 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

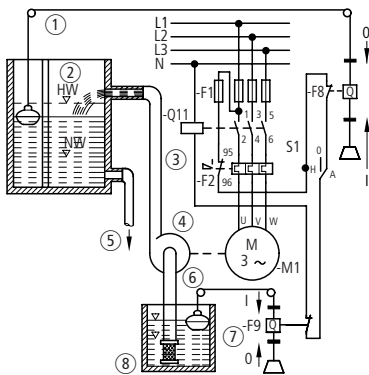
⑥ Suction pipe with filter

⑦ Well

All about Motors

Fully automatic pump control

With single-pole float switch SW (control circuit)



- F1: Fuses
- Q11: Contactor or automatic star-delta starter
- F2: Overload relay with automatic reset
- 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

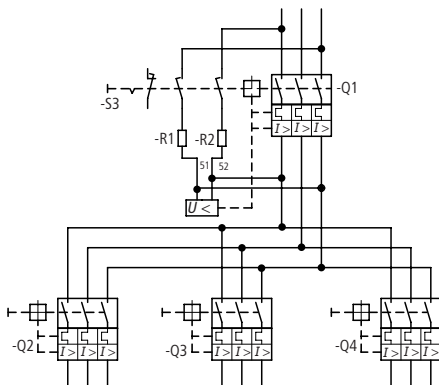
All about Motors

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.

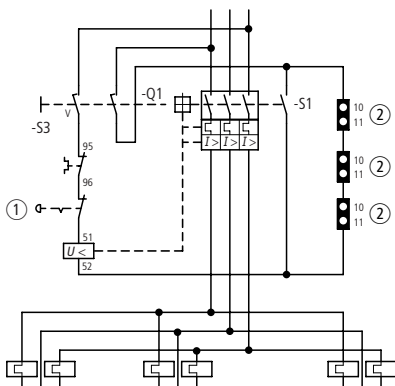


All about Motors

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

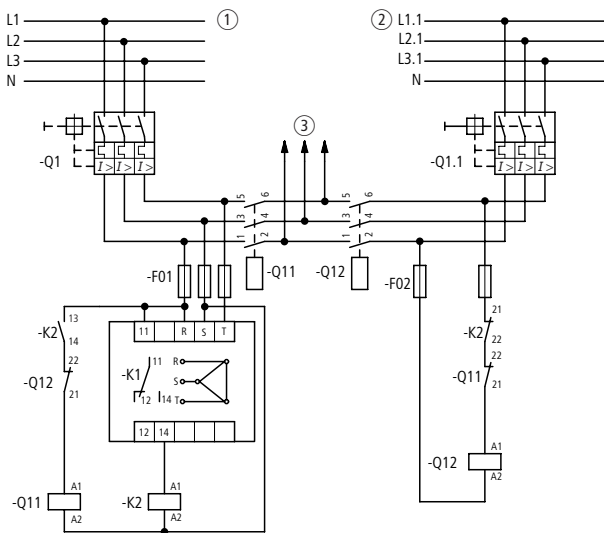
All about Motors

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 $U_{on} = 0.95 \times U_n$
Drop-out voltage $U_b = 0.85 \times U_{on}$



- ① Main supply
② Auxiliary supply

- ③ To load

Method of operation

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 of Contactor Q12 (auxiliary supply) and normally open contact K2/13–14 closes the circuit of contactor Q11. Contactor

Q11 energizes and switches the mains supply on the loads. Contactor Q12 is also interlocked against main supply contactor Q11 via normally closed contact Q11/22–21.