Protective devices in the main and control circuits

Suitable measures must be taken to protect the cables in the main and control circuits against overload and short circuit and to protect the motor against damage to the windings caused by excessive heating.

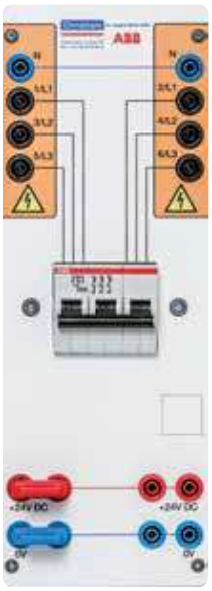
The cables can be protected by fuses or line circuit breakers, for example, and the motor can be protected by motor circuit breakers or motor protection relays.

Protective devices
are low-voltage switchgear (up to 1000 V) which protect equipment (including cables) against thermal overload and the effects of short circuits.

Line circuit breaker
Line circuit breaker

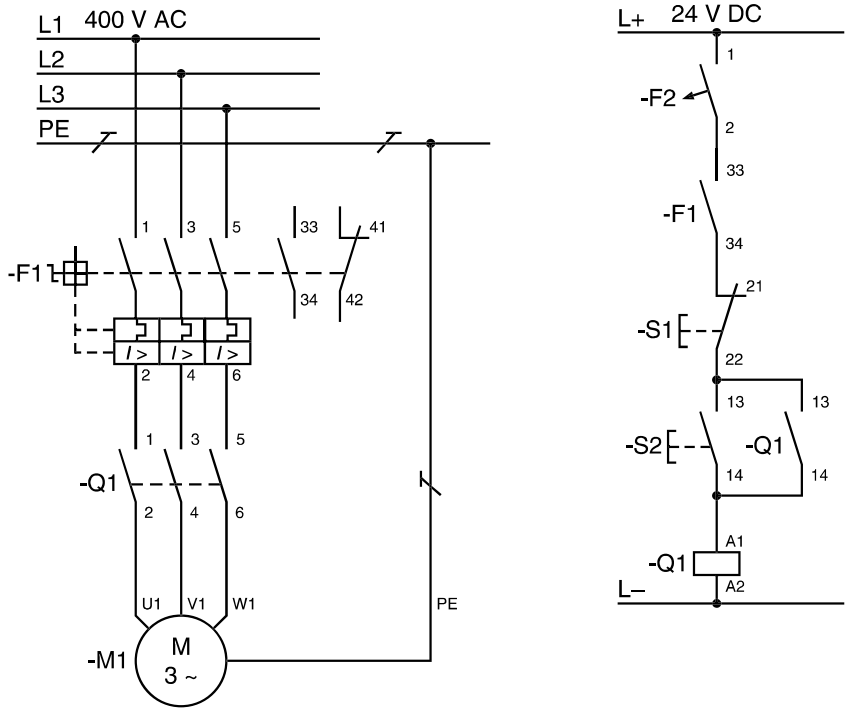
Necessary hardware

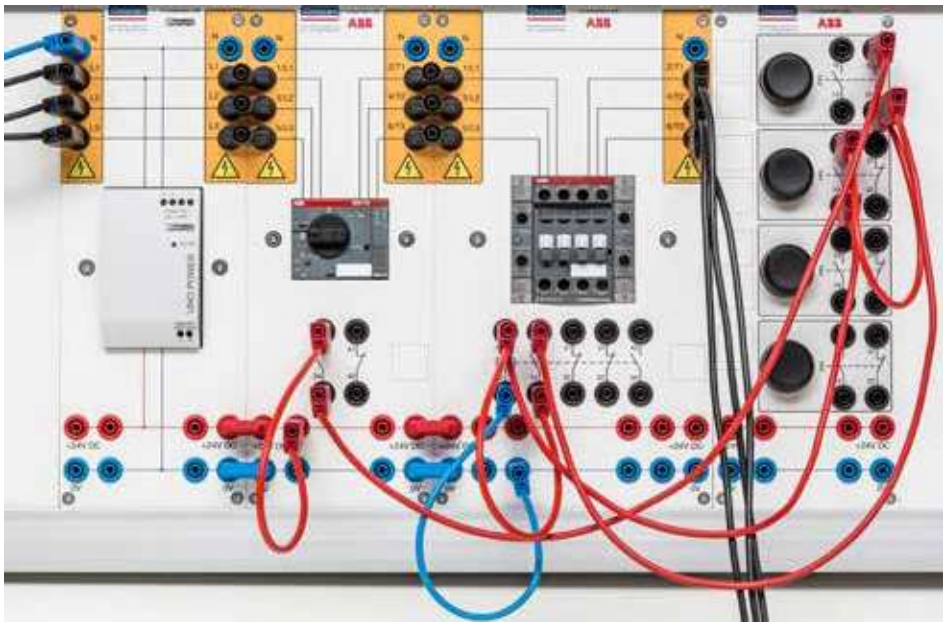
1 24 V DC voltage supply
1 switch assembly
1 button assembly
2 auxiliary contactors
1 main contactor
1 motor circuit breaker
1 motor protection relay
4 line circuit breakers
1 three-phase motor



Caution!
Note the voltage for which the phase windings of the three-phase motor are rated.

11. Construct the following circuit.





a) What preparations need to be made in order to ensure that contactor Q1 is activated and latches?

Switch on motor circuit breaker F1.
Switch on line circuit breaker F2.
Actuate button S2.

F1
Motor circuit breaker; predominantly used here for protection and not for three-pole switching.

Main contactor Q1 is responsible for switching the motor.

Caution!
Make sure that the motor you are using is rated for the string voltage.

Note
F2 is not used, as the power supply unit used features integrated overload and short circuit protection.

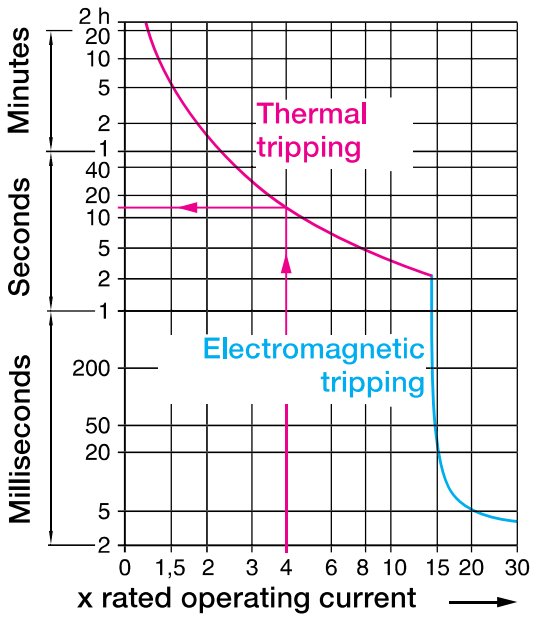
b) Does the main circuit have cable protection?
Comment on this.

Intrinsically safe motor circuit breaker F1 is also responsible for cable protection.

A motor circuit breaker is intrinsically safe if it can safely shut down a short-circuit current of up to 6000 A.

Line circuit breakers must also be able to do this.

c) The figure below shows the tripping curve of a motor circuit breaker.
Explain the curve.



Two areas are shown:
Thermal tripping as per motor protection relay (slow).
Electromagnetic tripping: Immediate response at approx. 15 · I_N.

Compare the curve of the motor circuit breaker with the curve of the motor protection relay (page 28).

Time functions

Ready-made functional units, time relays, are used in electrical control technology to implement time functions. These are usually divided as follows:

– Switch-on delay (activation delay)

– Switch-off delay (deactivation delay)

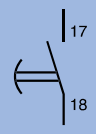
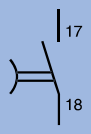
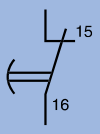
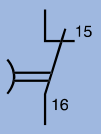
– Pulse generation (with one-off pulse as a wiping relay)

– Flasher relay (for constantly repeating pulses)

Basic operation:

Storage of an auxiliary variable following the application of a control signal. An output signal is generated once the storage device reaches a defined content. The same applies when the control signal is switched off.

Identification of delayed switching contacts

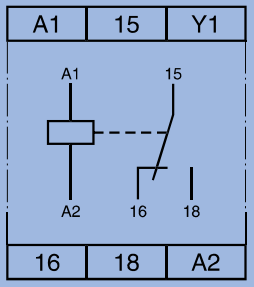
NO contact, delayed on	NO contact, delayed off	NC contact, delayed off	NC contact, delayed on
			

Operating status display
Green LED: Control voltage present
Red LED: Output relay activated

Rotary switch for preselecting the time range

Rotary switch for fine adjustment of the time value

Rotary switch for selecting the time function



■ **Multifunction relays**
combine multiple time functions in a single device.

Cost-effective thanks to simplified storage.

■ **Switch-on delay**
Timing element is started → Time elapses → Switching takes place once the time has elapsed

TB

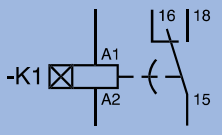
Switch-on delay (activation delay)

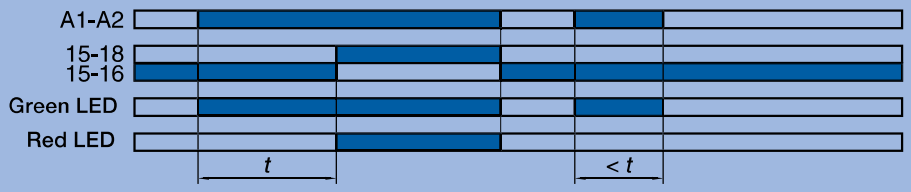
The countdown starts when the control voltage is applied to A1, A2. Once the set time has elapsed, the output relay is activated.

When the control voltage at A1, A2 is switched off, the output relay returns to its neutral position and the time interval is deleted.

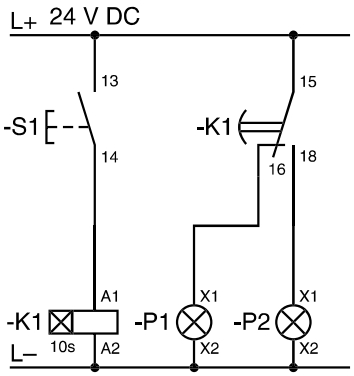
If the control voltage is switched off before the set time has elapsed, the time interval is deleted. The output relay is not activated.

Control input A1, Y1 has no function here.





1. Construct the circuit illustrated below. Set the delay to 10 seconds. What do you notice when you actuate S1 for 5 seconds and 15 seconds in succession?



Actuate for 5 seconds

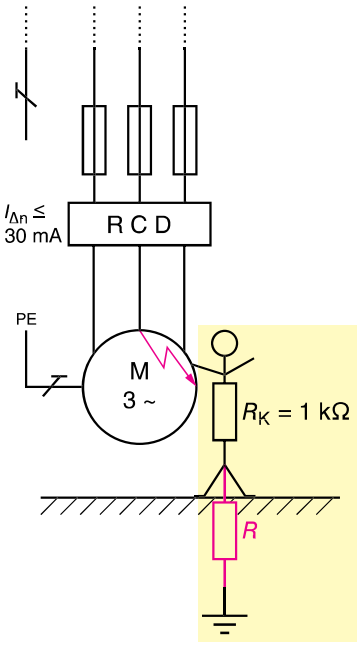
P1 lights up, P2 cannot be switched on

Actuate for 15 seconds

P1 on, P2 off
Actuate S1 → after 15 s: P1 off, P2 on
Release S1 → P1 on, P2 off

The time relay does not have any storage properties.

11. The standard requires additional protection in the TN system in the form of an RCD with $I_{\Delta n} \leq 30$ mA at sites with increased current sensitivity.



What influence does the resistance R have on the current sensitivity of a human body with a body resistance of R_K = 1 kΩ?

R_K and R form a voltage divider with a value of U_0 = 230 V.
Maximum contact voltage U_L = 50 V.
R must be at least sufficiently high enough to ensure that the voltage at R_K does not exceed 50 V (AC).

12. Why does VDE not stipulate the use of an RCD with $I_{Dn} \leq 10$ mA?

It can trip at just 5 mA.
Even when there are no faults in the system, leakage currents can add to this value, which would cause the RCD to trip.

■ **Increased current sensitivity**

TB

■ **AC**
U_L = 50 V

■ **DC**
U_L = 120 V

U_L is the maximum permissible contact voltage.

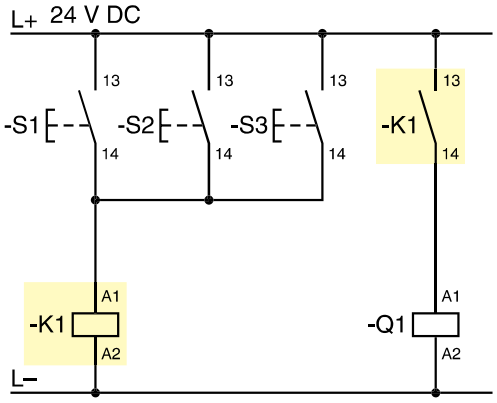
■ **I_n**
Rated residual current of the fault current protective device (RCD).

13. Operational reliability of control systems: Operating current principle and off-load current principle.

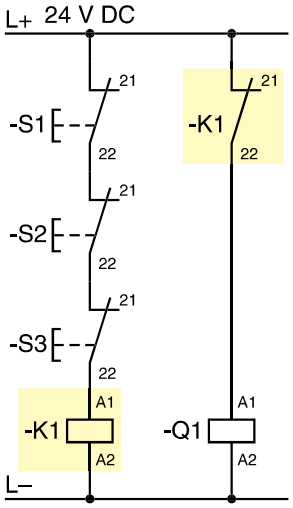
Operating current principle
Operating current circuit: Current only flows when the circuit has to work under normal operating conditions.

Off-load current principle
Off-load current circuit: Current only flows when the circuit does not have to work under normal operating conditions, i.e. is in its idle state.

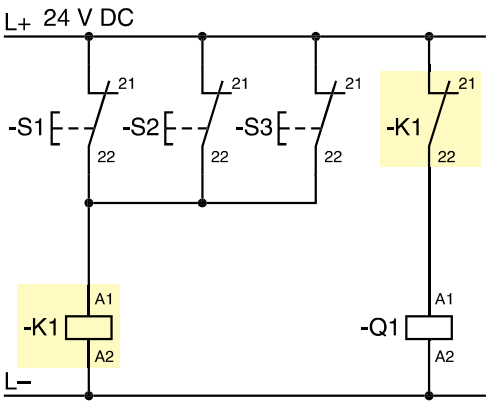
Circuit 1



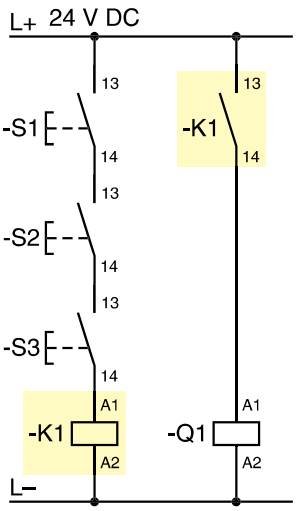
Circuit 2



Circuit 3



Circuit 4



a) Assign the following terms to circuits 1 to 4:
AND, OR, NAND, NOR

Circuit 1	Circuit 2	Circuit 3	Circuit 4
OR	NOR	NAND	AND

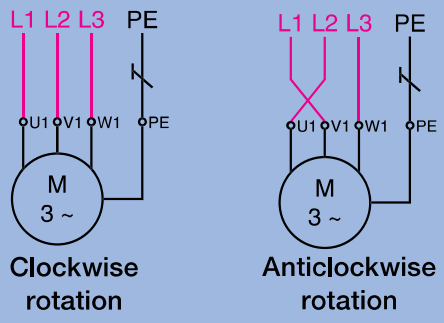
b) Which circuits are working according to the off-load current principle and which according to the operating current principle?

Circuit 1	Circuit 2	Circuit 3	Circuit 4
Operating current principle	Off-load current principle	Off-load current principle	Operating current principle

Reversing mechanism

The direction of rotation of three-phase motors can be changed by reversing two phase conductor connections.

- Clockwise rotating field: L1 → U1, L2 → V1, L3 → W1



The direction of rotation of the motor can be changed by means of a contactor control system. This is known as a reversing mechanism and is a type of motor starter.

Necessary hardware

1 24 V voltage supply

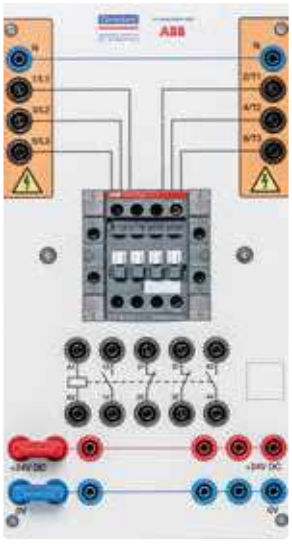
2 main contactors

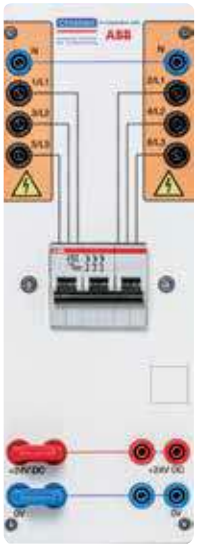
1 motor circuit breaker

4 line circuit breakers

1 button assembly

1 three-phase motor





Note

Make sure that the three-phase motor you are using is rated for the voltage.

Consider whether to connect the motor in a star or a delta configuration.

1. Complete the main circuit of a reversing mechanism.
Construct the circuit.

■ **Caution!**
Do not switch on the main circuit until you have consulted your trainer.