Motor Control Handbook

A guide for electrical contractors

MOTOR CONTROL AND DRIVES

NHP Electrical Engineering Products Pty Ltd

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Introduction

This NHP Motor Control Handbook 2018 provides technical information of a general nature about low voltage switchgear, protective devices and their combination. Written in an easily understood manner it is for use by appropriately qualified and competent persons and will assist them in designing and producing their own simple or complex control systems. In the event of faults, a knowledge of the circuit diagrams contained herein may also aid in rapid fault location and rectification.

Whilst NHP has made every attempt to ensure the accuracy and reliability of the information provided in this Handbook, the information is provided "as is" without warranty of any kind and any reliance you place on such material is therefore strictly and entirely at your own risk. Changes to material or information (e.g. changes to applicable standards and regulations, technical progress or improvement) after publication may impact upon its accuracy. Users of this Handbook are responsible for assessing its relevance and verifying the accuracy of the content for their specific purposes and NHP will not be liable for any loss, damage, cost or expense incurred or arising by reason of any person or organisation relying on the information in this Handbook. NHP further reserves the right to make changes at any time to this Handbook, and without notification.

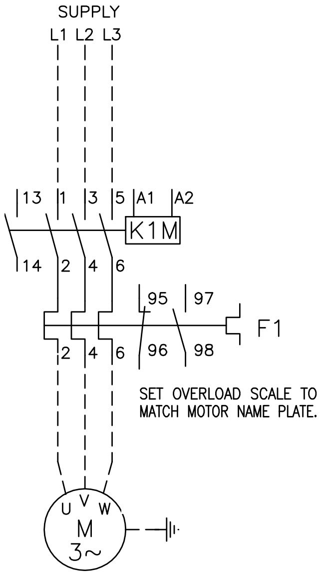


Table of contents

1. Introduction

1.1 Equipment overview

The following pages contain a brief explanation on the various equipment types common to motor starting applications

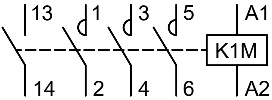
Motor starting with Sprecher+Schuh CA7 and CA8 contactors

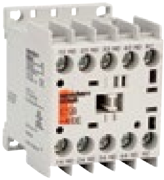
Contactors are capable of switching large motor currents whilst using standard wiring and control gear. This is achieved by energising the coil of a contactor, which closes the main contacts allowing the full load current to the motor.

A contactor works in the same manner as a relay but generally switches 3 phases and can handle high motor starting currents.

Because only a small coil voltage and current is required to activate the contactor coil, it is also easy to integrate into an automatic control system where the contactor can be controlled by electronic control systems.

Contactors are one of the two main components that make-up a motor starter, the second one being overload relays. Contactors are the control device and overload relays are the protection device. Hence, contactors are normally used in conjunction with an overload protection device.

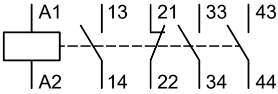




Load switching with Sprecher+Schuh CS7 and CS8 industrial control relays

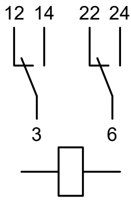
Industrial control relays contain a contact system suitable for the switching of auxiliary circuits (command, signalling and interlocking circuits), in control circuits with higher voltage ratings.

Operation is by energising the coil of the relay, which closes the contact system allowing a current path.



Load switching with Finder general purpose relays

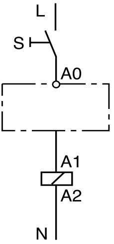
General purpose relays are similar to industrial control relays in that they contain a contact system suitable for the switching of auxiliary circuits in control circuits. General purpose relays are physically small in size and are designed for switching low amperage current.

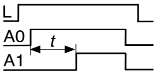


Time delay relays with Sprecher+Schuh CRZE7 electronic timers and CA7 contactors

Electronic timers are mounted on the contactor or control relay coil terminals A1, A2.
The timers provide a set of auxiliary contacts that change state with a time delay after the contactor is energised or de-energised. Timers are available in On-delay and Off-delay versions, and both versions include a normally open N/O and normally closed N/C output contact as standard.

For On-delay function, the relay is energised at the end of the delay time, whereas with Off-delay, once the control signal is interrupted the relay is de-energised at the end of the delay time.

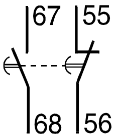




On delay

Timing devices with Sprecher+Schuh CZE7 pneumatic timers and CA7 contactors

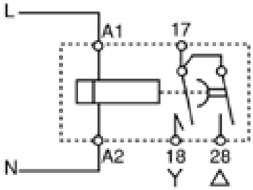
Pneumatic time delay relays are mounted on the contactor or control relay in place of an auxiliary contact block. The contacts of the timing element switch according to the set time, switching mechanically, on closing or opening of the contactor.

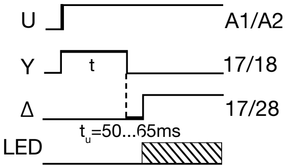


Time delay relays with Sprecher+Schuh RZ7 electronic timers

Time delay relays provide a simple form of time-based control which allows the user to open or close the contacts based on a specified timing function.

Time delay relays are used within a control circuit. For example, on delay, or off delay. With star-delta motor starting, timing relays are used to initiate the changeover, after a set period of time, from star to delta connection.

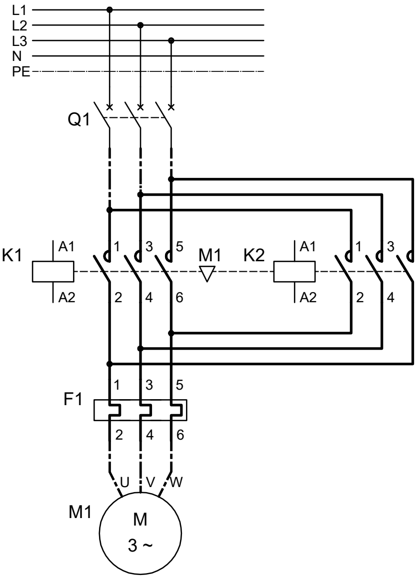




Refer to section 10.5 Timers for full description of all timing functions

Interlocking devices with Sprecher+Schuh CA7 and CA8 contactors

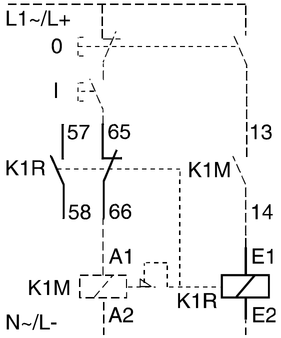
Mechanical interlocking together with electrical interlocking prevents the simultaneous closing of two contactors due to surges or manual actuation. This is required for situations whereby the simultaneous making of two contactors would cause a short-circuit, for example, in changeover or reversing applications.



Mechanical latching with Sprecher+Schuh CA7 contactor and CV7 latch

Mechanical latching devices can be directly mounted onto the contactor or control relay. The mechanical latch prevents the contactor from returning to it's rest position after being de-energised. The mechanical latch module incorporates a de-latching magnet to allow the contactor to drop-out. This can be accomplished via a voltage pulse or manually.

A mechanical latch is used to save power in the control circuit when the contactors are to remain energized for long periods or when the contactors cannot change state during a voltage interruption. A typical application for mechanical latching is lighting circuits.



Motor Protection with Sprecher+Schuh

Thermal overload relays are a protection device that can detect the amount of current in the circuit. If the level becomes too high, the overload will send a signal to indicate the trip and further disconnect the load.

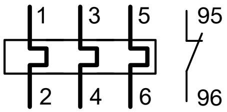
Overload relays are used to avoid the motor overheating which can lead to a reduction in the expected motor life and ultimately, motor failure.

Causes of overloads can typically include:
- Excessive load
- An incorrectly sized motor
- Low or imbalanced incoming voltage

It is important to understand that there are two types of Overload devices. The Thermal overload; sometimes referred to as the bi-metal overload and the electronic overload.

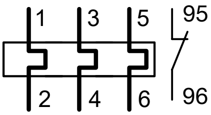
Sprecher+Schuh CT7N and CT8 thermal overload relays

A thermal overload detects the heat created by the current within the circuit. Simply put, excess current creates heat and this causes the bi-metal strip in the overload device to heat up and trip contacts are used to open the contactor coil circuit.



Electronic Motor Protection with Sprecher+Schuh CEP7 overload relays

The electronic overload relay monitors the current via built-in current transformers. If the current exceeds a predetermined amount and time, the device will trip. Compared to a thermal overload relay, the current setting range of the CEP7 is very large 5:1. In addition, the overload electronics produces quick-acting phase failure protection.

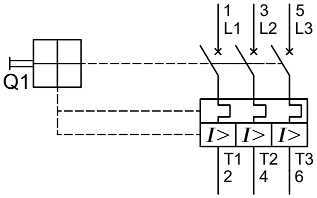


Sprecher+Schuh KTA7/KTC7 motor protection circuit breakers

Motor protection circuit breakers (MPCB) are a particular type of circuit breaker designed for motor protection. They are a circuit breaker and thermal overload within the one device, hence they provide short circuit protection, thermal motor protection, protection of connecting and turning motors off and on. The motor protection circuit breaker has an adjustable thermal overload trip and a non-adjustable magnetic short-circuit trip.

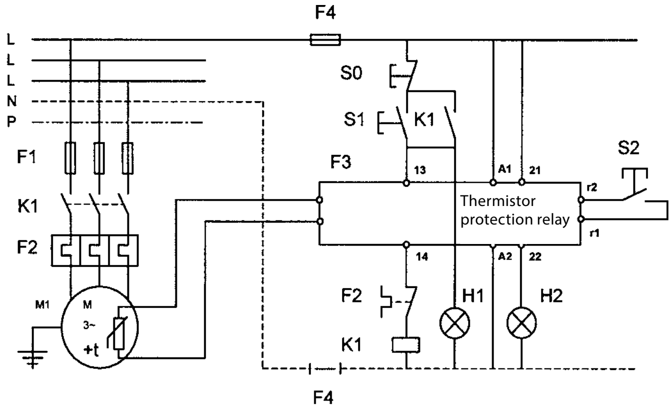
The selection of a motor protection circuit breaker is dependent on rated current, fault rating capacity, available space and circuitry components.

- KTA7 motor protection circuit breakers are suitable for standard motor control applications
- KTC7 motor protection circuit breakers should be selected for high efficiency motors which have a high inrush that can cause nuisance tripping on the standard KTA7 product

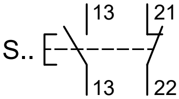


Thermistor protection with Sprecher+Schuh RT7 relays

These thermistor-type protection units are a device that directly monitors the temperature of a given object via a PTC (positive temperature coefficient) resistor, acting as a temperature sensor typically placed on the motor windings. The outcome is an independent and reliable method of thermal protection that also takes external environmental influences into account.



PTC thermistor embedded in motor windings



Control devices with Sprecher+Schuh D7 pushbuttons

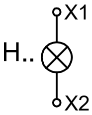
These control devices which are mounted on the outside of an enclosure, serve for operating of contacts, on or off or performing changeover functions, for devices to be actuated in a control circuit.

Pushbuttons are actuated by finger pressure on the button face, and there are different functional types of pushbutton operators; Momentary pushbuttons, operate when pressed, and if finger pressure is removed, the pushbutton reverts to its normal position (e.g. for momentary / impulse contact control).

Latched pushbuttons remain in the depressed position after being pressed. They are released by a second pressing action where they revert to the normal position (e.g. for maintained contact control).

Mushroom operator type pushbuttons offer an increased surface area for reliable actuation when wearing gloves.

Emergency Stop buttons (sometimes referred to as Estops) are latched in the depressed state when pressed, and are unlatched by 'twist-to-release' or pull action. Emergency Stop buttons may also include a locking device, where unlatching is only by means of a key.



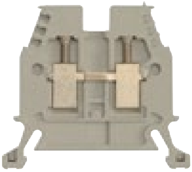
Signalling devices with Sprecher+Schuh D7 pilot lights

These signalling devices (pilot lights) are mounted on the outside of an enclosure, and are used for visual indication.

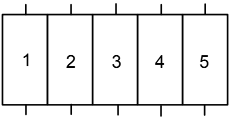
Pilot lights are connected in such a way so that they illuminate when the associated power device is in the operating circumstance being monitored. Common operating circumstances which utilise pilot lights include power available, run, ready, and trip. Typically, red pilot lights are used to indicate run, green pilot lights are used to indicate ready, and yellow pilot lights are used to indicate trip or caution.

For contactors, pilot lights are connected so that they illuminate when the associated contactor is on. They are operated by an auxiliary contact on the contactor being monitored. In this way, the pilot light correctly indicates the contactor switching state. In addition, pilot lights are sometimes used in conjunction with sound and other warning devices.

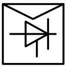
Wiring with Sprecher+Schuh V7 terminals



Terminals are detachable connector elements for electrical conductors. The through terminals facilitate the connection of conductors or serve as terminals for external lines to the devices, equipment combinations and switch cabinets. The conductors are held directly by screws or nuts or by means of a clamping element.



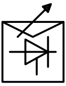
Controlled starting with Sprecher+Schuh PCS soft starters



Soft starters are a reduced voltage start that works by electronically controlling the voltage applied to the motor. Voltage from the 3 phase power line is controlled through a solid state device, such as a SCRs (silicon controlled rectifier) or thyristors. These devices (SCRs or thyristors) are switched (on/off), which then applies voltage (3 phase) to the motor in a controlled state, allowing the motor to slowly ramp to full speed.

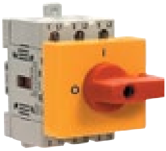
Soft starters reduce the mechanical torque to the load and reduce starting current peaks and are a component or assembled in a switchboard or control panel.

Speed and process control with Allen-Bradley PowerFlex variable speed drives



A variable speed drive (VSD) alters the speed of an electric motor by changing the frequency. Voltage from the 3 phase (or single phase) power line is converted to DC voltage through a AC to DC converter. Solid state devices, referred to as IGBT (insulated gate bi-polar transistors) are switched to create a 3 phase waveform to the motor. This switching allows the drive to control the frequency and voltage, allowing you to control the motor speed with infinite control (zero – full speed).

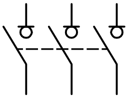
VSDs can vary the speed of the motor at any time during the process for any duration, which yields the benefits of process control and energy savings.



Isolation of motor loads with Sprecher+Schuh L7 load-break switches

The load-break switch is a mechanical switching device capable of making, carrying and breaking currents under normal circuit conditions.

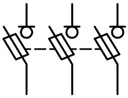
Load-break switches are designed for use in local motor isolation and disconnect switch applications. The inclusion of the handle allows for manual operation.



Circuit protection with Wohner fuses and fuse switches

These fuses are an electrical safety device that operates to provide overload and short circuit protection of an electrical circuit. The fuse itself is a metal wire or strip that melts when too much current flows, which breaks the circuit in which it is connected, thereby protecting the circuit's other components from damage due to excessive current.

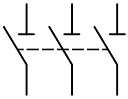
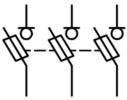
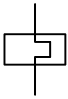
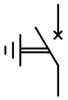
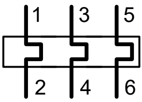
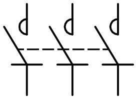
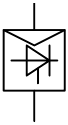
A fuse switch is a switch in series with a fuse in a single housing or enclosure.

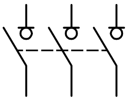
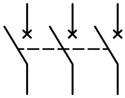
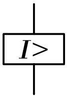
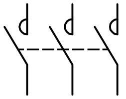
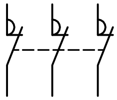
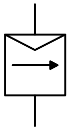


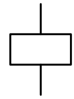
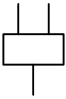
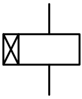
2. General

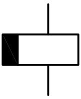
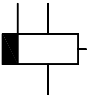
2.1 Graphical symbols with nomenclature for circuit diagrams

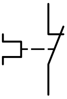
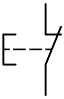
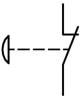
These are the symbols as per AS/NZS 1102.107:1997, and industry standards which show the common devices and control functions utilised in association with the control of motors.

Drawing symbol	Item
	Isolator switch
	Load break fuse switch
	Thermal overload trip element
	Earth leakage circuit breaker
	Overload relay
	Solid state contactor
	Electronic starter

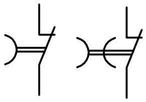
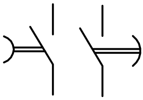
Drawing symbol	Item
	Load break isolator switch
	Circuit breaker
	Short circuit trip element
	Contactor - normally open poles
	Contactor – normally closed poles
	Starter – DOL non reversing

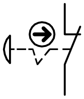
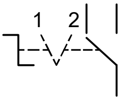
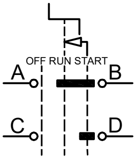
	Drawing symbol	Item
Component controls		Coil
		Dual winding coil
		On delay timer coil
Control contacts		Normally open – closes on actuation
		Normally closed – opens on actuation
		Change over contact
		Late break contact
		Early make contact

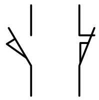
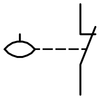
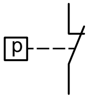
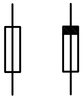
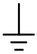
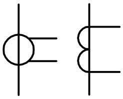
Drawing symbol	Item
	Off delay timer coil
	Delay timer with initiating input

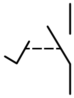
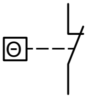
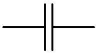
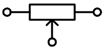
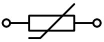
	Thermal over-load contact
	Pushbutton – momentary with N/O contact
	Pushbutton – momentary with N/C contact
	Mushroom head pushbutton, with N/C contact

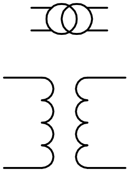
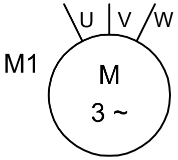
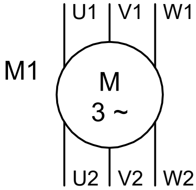
Control contacts

Drawing symbol	Item
	N/C – opens instantly, delay on closing
	N/C – delay on opening
	N/O – delay on closing
	N/O - delay on opening

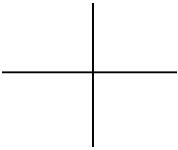
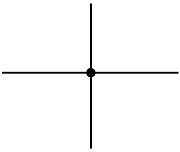
Drawing symbol	Item
	Emergency Stop switch. Latching operator with mushroom head. Arrow – denotes positive opening operation
	2 position rotary switch
	3 position "turn to operate" switch. Spring return from right to centre. 2 contacts

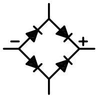
	Drawing symbol	Item
External control functions		Position / limit actuated contact
		Float / level actuated contact
		Pressure actuated contact
Other devices		Control circuit fuse
		Indicating light. Colour code added next to symbol
		Surge diverter
		Earth / ground symbol
		Current transformer

Drawing symbol	Item
	Foot actuated contact / switch
	Temperature actuated contact
	Capacitor
	Inductor
	Resistor
	Potentiometer
	Thermistor / RTD

	Drawing symbol	Item
Other devices		Voltage transformer
		Meter. Function letter added inside
		Motor AC, 3 phase. Star or delta connected
		Motor AC, 3 phase, 6 wire connected, 2 speed, star/delta, dual winding

Wiring connections

Drawing symbol	Item
	Power wiring installed between devices
	Control wiring installed between devices
	Wiring – for future or customer installation
	No connection
	Wiring junction connection
	Terminal for connection of wiring

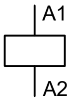
Drawing symbol	Item
	Plug in connection
	Bridge rectifier
	Mechanical interlock
	Mechanical latching device

2.2 Marking and identification of terminals of contactors and associated overload relays

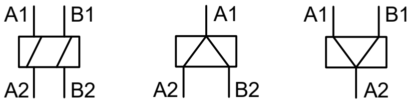
Per IEC 60947-4-1, the purpose of identifying terminals of contactors and associated overload relays is to provide information regarding the function of each terminal or its location with respect to other terminals or for other use.

2.2.1 Marking and identification of terminals of contactors

Coil terminals are always marked alphanumerically



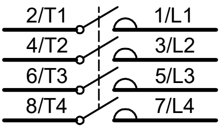
Contactor coil



Coils having two windings in parallel. Four or three terminals

2.2.1.2 Marking and identification of terminals of main circuits

The terminals of the main circuits are marked by single figure numbers and an alphanumeric system.



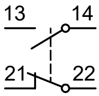
Note: Terminals may also be identified on the wiring diagram supplied with the device.

2.2.1.3 Marking and identification of terminals of auxiliary circuits

The terminals of auxiliary circuits are marked or identified on the diagrams by two figure numbers:

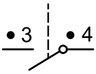
- The unit number is a function number;
- The figure of the tens is a sequence number.

The following examples illustrate such a marking system:



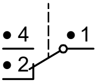
Function numbers 1, 2 are allocated to circuits with break contacts and function numbers 3, 4 to circuits with make contacts.

Examples:



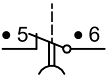
Note: The dot (•) in the above examples take the place of the sequence numbers which should be added appropriately to the application.

The terminals of circuits with change-over contact elements are marked by the function numbers 1, 2 and 4.

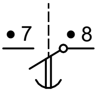


The function numbers 5 and 6 (for break contacts) and 7 and 8 (for make contacts) are allocated to terminals of auxiliary circuits containing auxiliary contacts with special functions.

Examples:



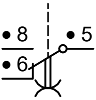
Break contact delayed on closing



Make contact delayed on closing

The terminals of circuits with change-over contact elements with special functions are marked by function numbers 5, 6 and 8.

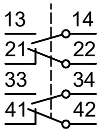
Example:



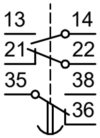
Sequence number

Terminals belonging to the same contact element are marked by the same sequence number. All contact elements having the same function have different sequence numbers.

Examples:



Four contact elements



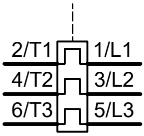
Three contact elements

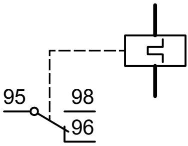
2.2.2 Marking and identification of terminals of overload relays

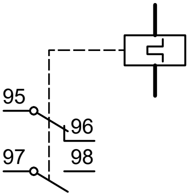
The terminals of the main circuits of overload relays are marked in the same manner as the terminals of the main circuits of contactors.

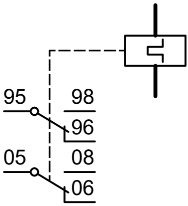
The terminals of the auxiliary circuits of overload relays are marked in the same manner as the terminals of the auxiliary circuits of contactors with specific functions. The sequence number is 9; if a second sequence number is required, it is 0.

Examples:









Alternatively, terminals may be identified on the wiring diagram supplied with the device.

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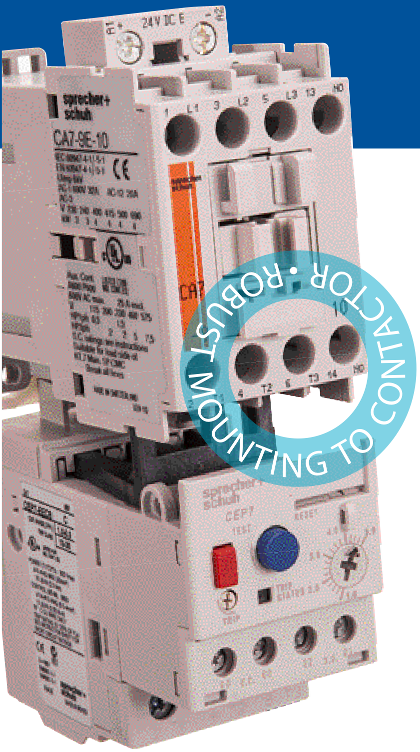
ELECTRONIC MOTOR CONTROL



Superior motor control with CA7 Contactors and CEP7 Overloads.

A CA7 Contactor with CEP7 electronic overload surpasses the competition by covering the current range of up to 7 separate traditional bimetallic overloads in a single unit. Save on:

- Energy usage
- Design space
- Stock simplicity

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Available from your local wholesaler branch

2.3 Terminal markings for electric motors

Terminal markings for electric motors according to standard IEC 60947.

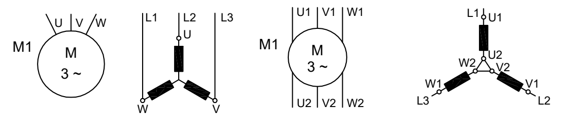
Motor terminal markings consist of letters and numbers. These are arranged without gaps.

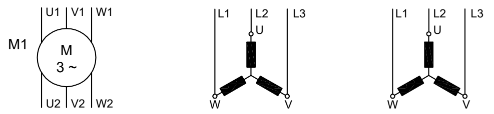
Example: U1: U, V, W = identification for winding phases.

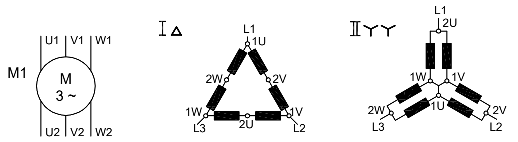
Number after the letter = number on winding phase; 1 = start of winding, 2 = end of winding (tappings are numbered consecutively from 1, by 3, 4 and so on).

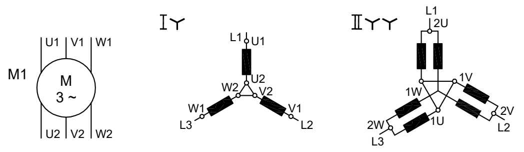
Three phase Squirrel-cage motors Design or type of circuit	Number of motor terminals	Motor terminal markings
1 speed -1 winding	3	U, V, W
	6	U1, V1, W1 U2, V2, W2
2 speeds -2 separate windings	6	1U, 1V, 1W 2U, 2V, 2W
2 speeds - Dahlander or PAM (Pole Amplitude Modulation) circuit -1 winding, reversible - low speed in series-delta-connection Δ - high speed in parallel-star-connection YY	6	1U, 1V, 1W 2U, 2V, 2W
2 speeds -Dahlander or PAM circuit -1 winding, reversible -low speed in series-star-connection Y -high speed in parallel-star-connection YY	6	1U, 1V, 1W 2U, 2V, 2W

Motor windings and types of circuit with connection examples



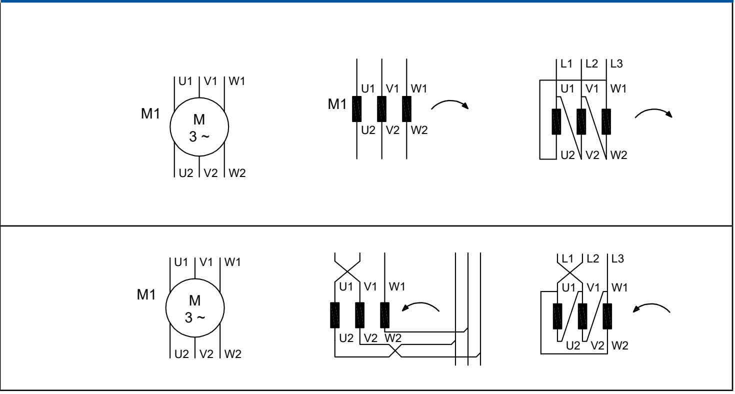






Three phase Squirrel-cage motors Design or type of circuit	Number of motor terminals	Motor terminal markings
1 speed in delta-connection (operation) -changeover facility for star-delta-starting -connection example for clockwise motor rotation	6	U1, V1, W1 U2, V2, W2
1 speed in delta-connection (operation) -connection example for anticlockwise motor rotation	6	U1, V1, W1 U2, V2, W2

Motor windings and types of circuit with connection examples



3. Starting and switching motors

3.1 Selection criteria overview

Electrical motors must be accelerated from rest up to the operating speed with a starting device. In the case of variable speed drives, the motor controller must also manage the motor speed during operation. The motor and method of starting selected depend on the load torque, the desired starting characteristic (starting current, acceleration) and on the characteristic of the supply.

3.1.1 Main criteria for the selection of the starting method

When making the decision whether to use a

- Direct-on-line starter
- Electromechanical starter for the starting with reduced current or
- Electronic motor control devices (soft starters, variable speed drives)

  the following items should be taken into account to find a suitable solution from the points of view of application and productivity:

- How high is the torque required to start the load?
- Can transmission components such as belts, gearboxes or chains be damaged by the high starting torque with direct starting?
- Does the plant require gentle and continuous acceleration or are torque peaks permissible?
- Are there any restrictions with respect to supply loading?
- Do technologically more complex products offer additional functions for optimisation of the application (for example pre-warning functions of motor protection relays, mirror contacts for safety controllers, communication links etc.)?
- Are features of controlled coasting to a stop or braking to be taken into account?
- Are aspects of speed control to be taken into account once the motor has started (for example from process engineering or energy saving perspectives)?

The selection of suitable starting methods is a critical factor in achieving optimum economic efficiency in every motor control application. The table in section 3.4 provides guidance with respect to the various methods for starting squirrel-cage induction motors.

Note: For assistance in selecting the best starting method for your application requirements, contact NHP.

3.2 Selecting the right contactor for an application

There are a few factors that must be considered to ensure you pick the right contactor, but the main ones are:

1. The type of load
2. The current or kW rating required
3. The coil voltage
4. Any accessories required

For motor loads the most common rating is called AC-3. AC-3 means starting and stopping 3 phase motors and is the majority of applications for contactors. Motors are 'inductive' loads which have a large starting current.

For reversing starters, two contactors are required and if the duty includes inching or jogging the motor, you may need to use AC-4 ratings. Generally, applications like crane hoist would use this duty; otherwise you can still use AC-3.

If you are switching a heater bank or some lighting loads you can use AC-1 ratings. AC1 means switching 'Non Inductive' or resistive' loads. The contactor ratings for AC-1 are higher than AC-3.

The second factor to consider is the current or kw rating of the motor (Motor nameplate full load current or kW) or the current rating of the heater load for AC-1. Next, the coil voltage (or control voltage) used to activate the coil must be known. It is often a different voltage to the motor mains 3 phase voltage. Applying incorrect voltage to a coil will cause it to burn out so you need get this one right.

What type of auxiliary contacts and accessories are required? For example It may include a mechanical interlock for a reversing starter.

3.3 Selecting the right overload for an application

When it comes to overload relay selection, the major difference between electronic overloads – commonly referred to as EOL's - and thermal bi-metal relays is that EOL's have a more accurate tripping tolerance band.

Overload selection is based on the Motor Nameplate Full Load Current rating of the motor it will be protecting and because overloads are normally fitted directly to contactors, this needs to be considered as there may be a number of different versions for the same current rating. Ultimately, the final selection of the part number is determined by which size contactor it is being fitted to.

Correct trip class selection can be determined from the motors maximum locked rotor current and maximum locked rotor time. This information can be typically found on the Motor Nameplate or from the manufacturer.

By simply downloading **NHP's Contactor Select App** on the iTunes App Store, you can select the right contactor and overload for your application in seconds.

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3.4 Characteristic features of the commonly used starting methods for squirrel-cage induction motors

Kind of motor	**Starting procedures for squirrel-cage standard motors (typical values)**		
Method of starting	**Direct on Line (DOL)**	**Y–Δ- (star delta)**	**Auto- transformer**
Mains	strong	weak	weak-medium
Load during start	full	low	low-medium
Relative starting current I_A/ I_e	6 ... 8 (= I_{AD})	1.3 ... 2.7 (= 1/3 I_{AD})	1 ... 5 (=0.25…0.65 I_{AD}) selectable
Relative starting torque T_A/T_e	1.5 ... 3 (= T_{AD})	0.5 ... 1 (= 1/3 T_{AD})	0.4 ... 2 (=0.25…0.65 T_{AD})
Run-up time (normal)	0.2 ... 5 s	2 ... 15 s	2 ... 20 s
Run-up time (heavy duty start)	5 ... 30 s	15 ... 60 s	20 ... 60 s
Characteristic features	High acceleration with high starting current	Start with reduced torque and current; current and torque peaks at switchover	Similar to Y–Δ, but without switchover-interruption; selectable steps
Application area	Sites with strong power supply which permit the high starting torque	Motors which are only loaded after run-up	Remote / rural and high torque loads

Notes:

I_A = Motor starting current

I_e (FLC) = Rated operational current of motor

T_A= Motor-Starting torque

T_e (FLT) = Rated operational torque of motor

k = Voltage reduction factor

T_{AD} = Motor starting torque at full voltage

[1]) Start frequency controlled, torque wide range adjustable

Soft starters	Variable speed drives
weak-medium	weak
low-medium	low-medium
2 ... 6	1 ... 2
0.15 … 2 $T_A = k^2 \cdot T_{AD}$	T_A adjustable [1])
0.5 ... 10 s	0.5 ... 10 s
10 ... 60 s	5 ... 60 s
Adjustable starting characteristics. Also controlled Stop possible. No harmonics	High available torque at low current. Adjustable starting characteristics. Harmonic mitigation to be considered
Starts which require a gentle or adjustable torque characteristic, or reduced starting currents	Usually for operational speed adjustment. Energy saving possible

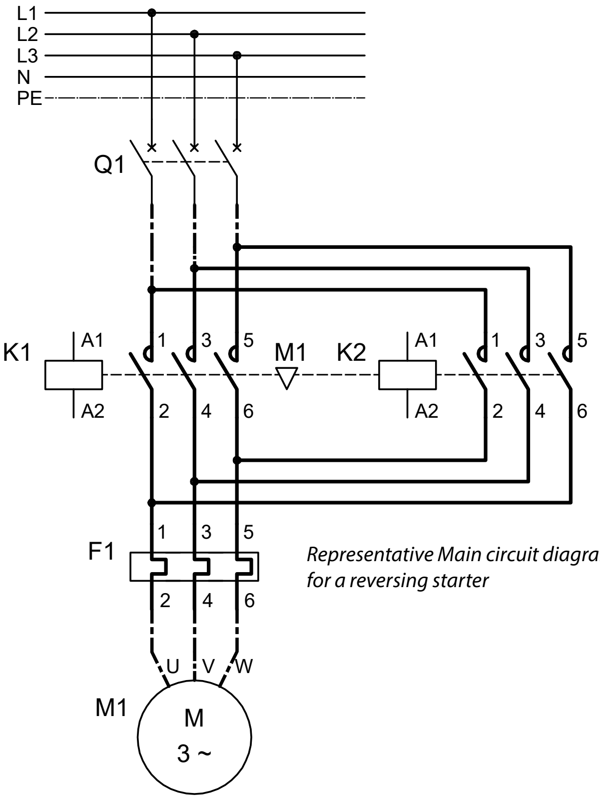
4. Diagram types

A diagram is a graphical representation of the circuit. It shows how the circuit elements must be connected to enable a predetermined function to be fulfilled. In the power and installation fields, circuits are always drawn in the power-off, switched-off state. There are various diagram types: circuit diagram, schematic wiring diagram, simplified diagram.

4.1 Circuit diagram

The circuit diagram shows clearly the sequence of the control process, without regard to the physical arrangement of the equipment. According to task and effect, a distinction is made between main, control and measuring circuits, etc. For the extensive circuit diagrams of larger systems, the use of drawing proformas with section numbers is recommended. By this means it will be easier to locate the switching elements of the different equipment.

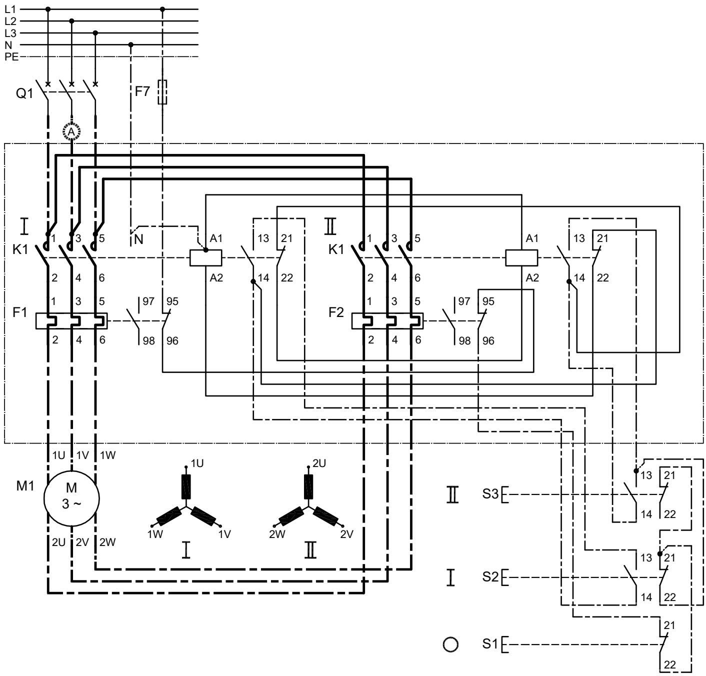
Main circuit



Representative Main circuit diagram for a reversing starter

4.2 Schematic wiring diagram

The schematic diagram contains all the equipment, all elements and connections for main and control circuits being shown in their correct spatial locations. In the case of small diagrams, the schematic wiring diagram is clear and easily surveyed. With larger diagrams it can soon become difficult to survey and requires a large outlay on drawings. In spite of this, the schematic wiring diagram is still widely used.

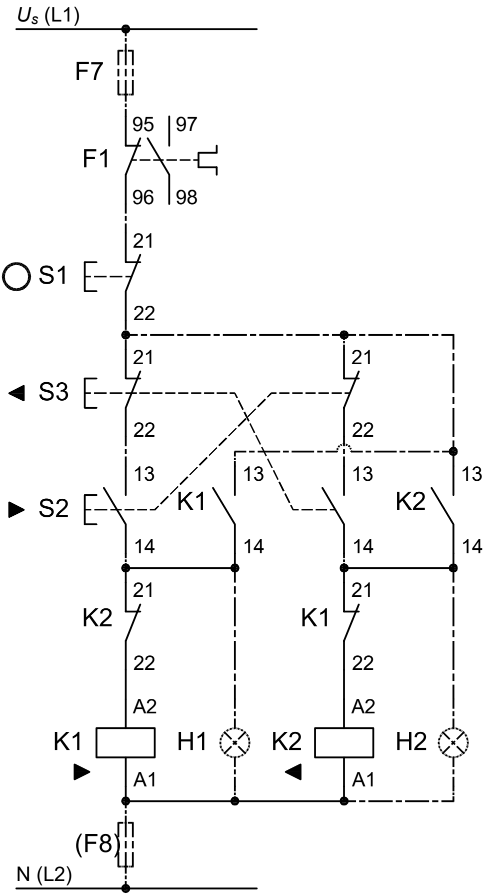


Representative schematic diagram for a 2 speed motor with separate motor windings

4.3. Control circuit diagrams

4.3.1 Momentary contact control

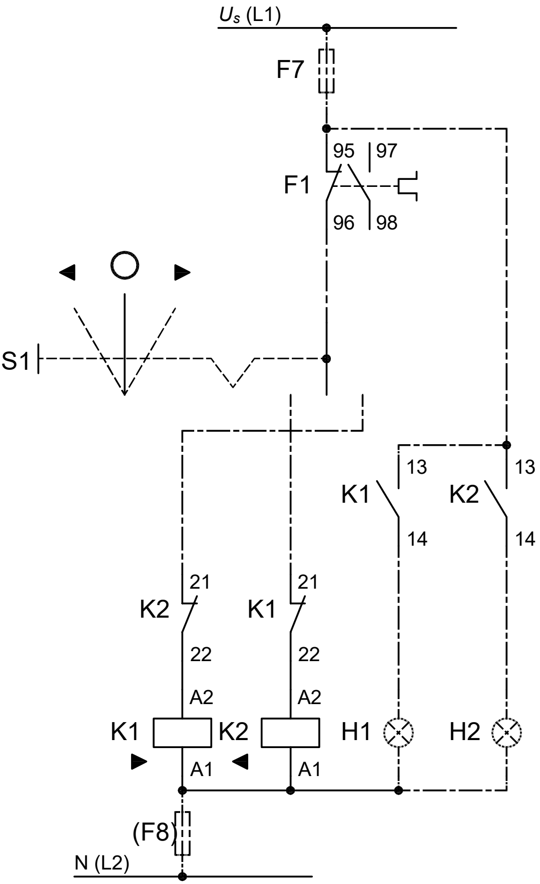
Momentary or impulse contact control can be achieved using momentary pushbuttons and/or selector switches with momentary action.



Representative control circuit diagram for a 2 speed motor with separate motor windings

4.3.2 Maintained contact control

Maintained contact control can be achieved by using latched pushbuttons and/or selector switches.



Representative control circuit diagram for a 2 speed motor with separate motor windings

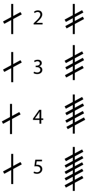
4.4 Simplified diagram

Simplifications to circuit diagrams can be of practical value for:

- Improving ease of use
- Reducing the number of circuit documents

Simplifications should only be made to the extent that the informative value of the circuit diagram is not impaired and its use rendered more difficult.

By far the most frequent simplification is the single-line representation of multiple conductor systems. The terminal markings here can be omitted as long as they are already contained in the detailed documentation.



Two conductors

Three conductors e.g. L1/L2/L3

Four conductors e.g. L1/L2/L3/PE

Five conductors e.g. L1/L2/L3/N/PE

The diagrams in chapters 5…7 are structured on the following principle:

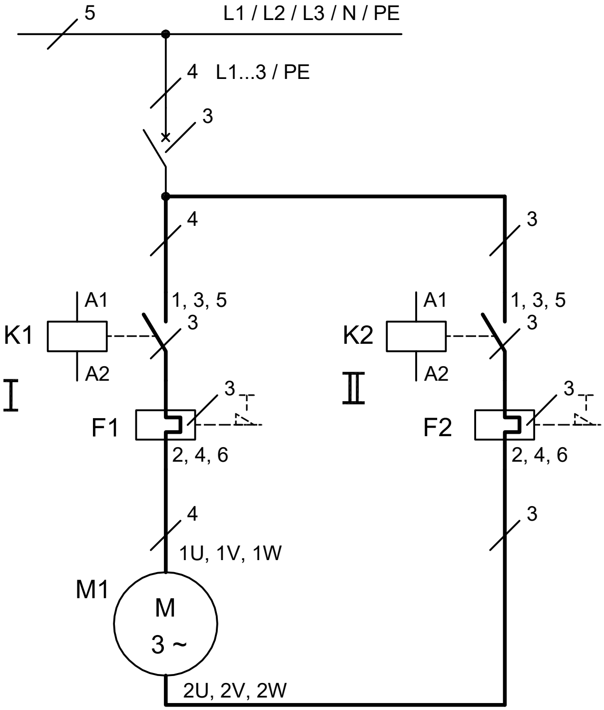
- Circuit diagram for main circuit and control circuit (auxiliary circuit)
- Description of functional sequence
- Application information
- Characteristics (special technical features)
- Application examples

The circuit diagrams are relatively generic; however the designation of the terminals can differ from that shown on the drawings on certain devices.

The specific circuit diagrams for the devices are to be found on Sprecher+Schuh data-sheets and are available from NHP.

Please take into account your local Service and Installation Rules (SIR), as well as any site specific requirements.

Where required, diagrams can be combined.



Representative simplified diagram for a 2 speed motor

5. Direct on line starters and reversing starters

5.1 Several command locations

Contactors and starters can be actuated from several locations using the concept below.

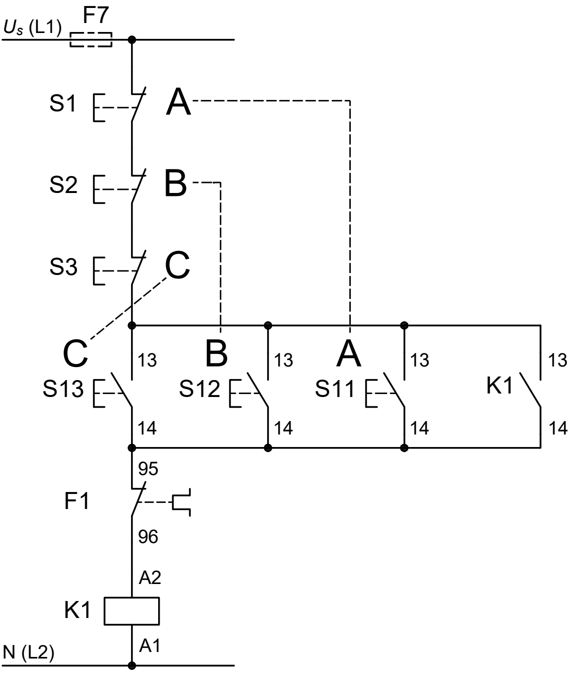
5.1.1 Momentary contact control

- Connect ON command button contacts in parallel
- Connect OFF command button contacts in series

In this way ON and OFF can be selected as required and independently from one another at any of the three locations A, B or C.

Control circuit

Momentary contact control



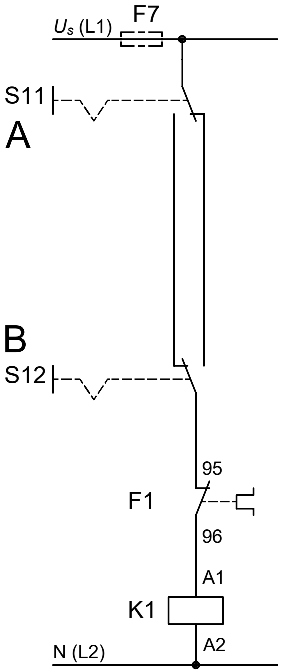
5.1.2 Maintained contact control

Two-way switching allows activation from either switch. Operation optional by

- Switch S11 – command location A or
- Switch S12 – command location B

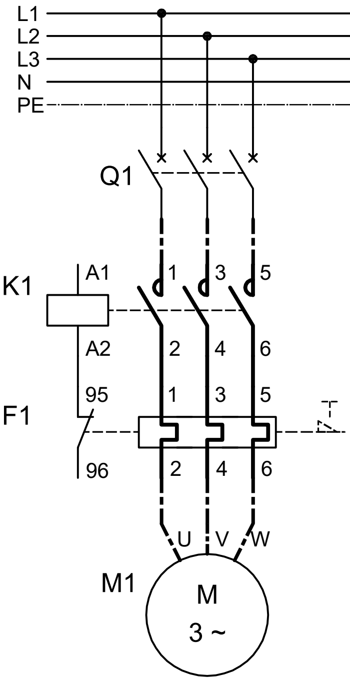
Control circuit

Maintained contact control



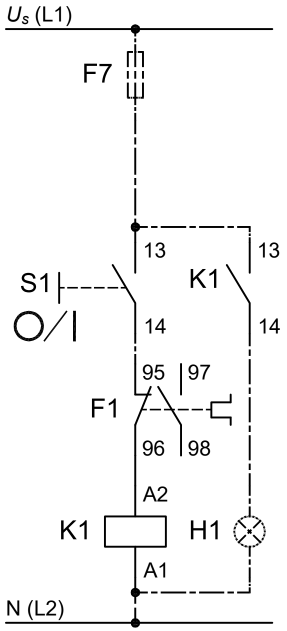
5.2 Direct on line starters (Contactor with overload relay)

Main circuit



Control circuit

Maintained contact control

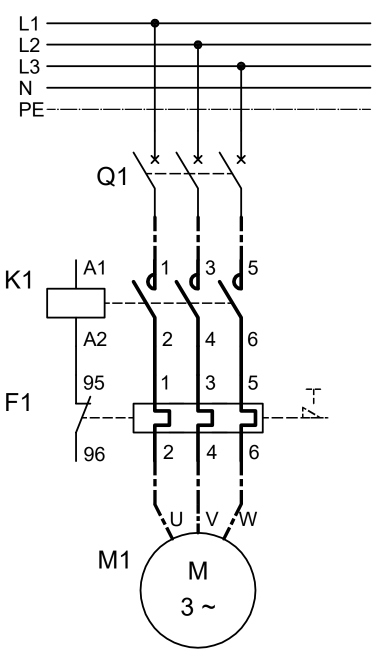


5.2.1 Maintained contact control

Connection	Connections to be made on installation
Switching on **I**	Actuate control switch S1: 13-14 (O → I). Control circuit to contactor coil K1: A2 is made. Contactor coil system actuates main contacts (K1:1-2, 3-4, 5-6) and auxiliary contacts (K1: 13-14). K1 is closed and the load is connected to the mains. With control switch S1 closed, the starting command is maintained – contactor K1 remains closed. A break in the control voltage causes the contactor to drop out. Reapplying control voltage closes the contactor once more. Therefore, any connected devices are on.
Switching off **O**	Takes place by: - Actuate control switch S1: 13-14 (from I → O) or - Responding to thermal overload relay F1: 95-96 or responding to the control circuit fuse F7. The control voltage U_s to contactor coil K1: A2 is interrupted, causing contactor K1 to drop out. The mains contacts disconnect the load from the mains.
Note	To prevent danger for e.g. the operating personnel, uncontrolled restarting of machines and equipment should be avoided (thermal overload relay to «Manual reset»). On the other hand, the restarting of equipment can be necessary for certain purposes. Reliable signalling (e.g. by means of lamp H1) can be provided by means of the auxiliary contact K1: 13-14.
Contactor sizing	According to the motor rated operational current I_e AC-3. For applications such as high number of operations per hour, inching duty or ambient temperatures above 60° C, you may need to use a different current rating. Consult NHP for advice.
Characteristics	Locked rotor starting current 4…8 I_e (FLC) Locked rotor torque 1.5…3 T_e (FLT) Acceleration time 0.2…5s Example of application: Direct switching of three-phase motors.

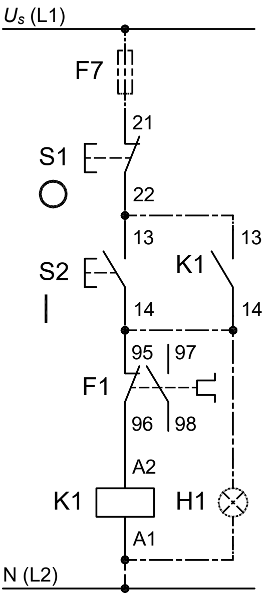
5.2 Direct on line starters (Contactor with overload relay)

Main circuit



Control circuit

Momentary contact control



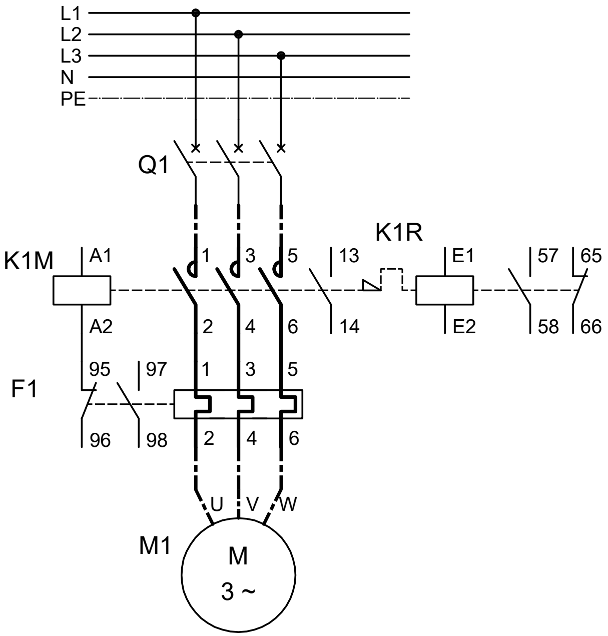
NHP

5.2.2 Momentary contact control

Connection	Connections to be made on installation
Switching on I	Actuate ON button S2: 13-14 (I). Control circuit to contactor coil K1: A2 is made. Contactor K1 coil system actuates main contacts (K1:1-2, 3-4, 5-6) and auxiliary contacts (K1: 13-14). K1 is closed and the load is connected to the mains. Normally open contact K1: 13-14 ensures that control voltage U_s is not interrupted after releasing switch S2 (self-holding contact). Therefore contactor K1 remains closed. An unintentional control voltage interruption causes the closed contactor to drop out.
Switching off O	Takes place by: - Actuation of OFF button S1: 21-22 (O) or - Responding to thermal overload relay F1: 95-96 or responding to control circuit fuse F7. The control voltage U_s to contactor coil K1:A2 is interrupted, causing contactor K1 to drop out. To recommence the start procedure, reactuate button S2.
Note	No automatic remaking of contactor takes place following a supply failure (control voltage interruption). Unintentional, automatic restart is not possible. Signalling (e.g. by means of signal lamp H1) can be provided by means of the self-holding contact K1: 13-14 or via a separate auxiliary contact.
Contactor sizing	According to the motor rated operational current I_e AC-3. For applications such as high number of operations per hour, inching duty or ambient temperatures above 60° C, you may need to use a different current rating. Consult NHP for advice.
Characteristics	Locked rotor starting current 4…8 I_e (FLC) Locked rotor torque 1.5…3 T_e (FLT) Acceleration time 0.2…5s Example of application: Direct switching of three-phase motors.

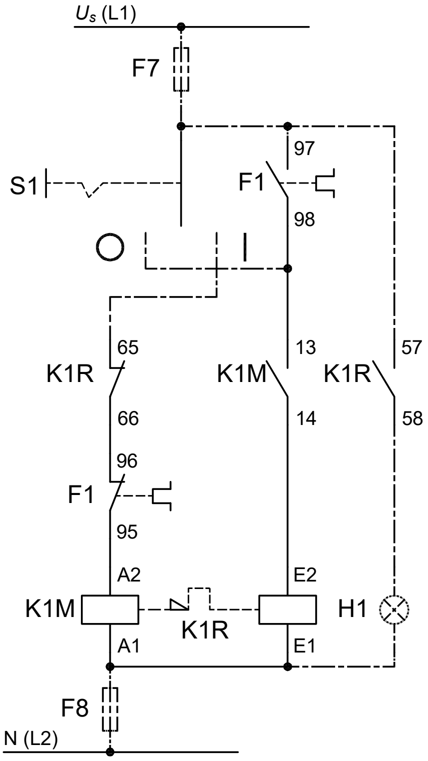
5.3 Direct on line starters with mechanical latch

Main circuit



Control circuit

Maintained contact control

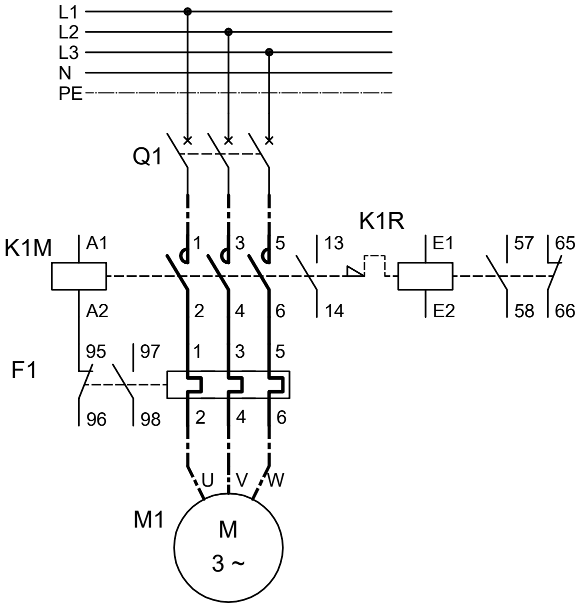


5.3.1 Maintained contact control

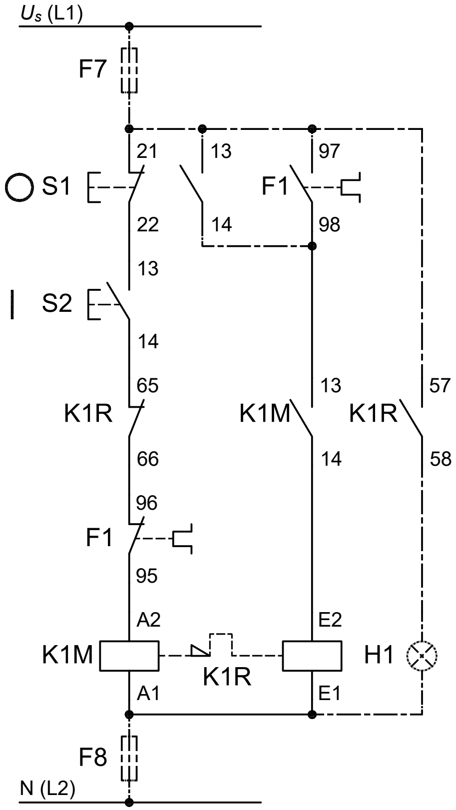
Connection	Connections to be made on installation
Switching on **I**	Takes place by: - Actuation of control switch S1 (O→I). The actuating of S1 completes the control circuit to contactor coil K1M: A2. Contactor K1M closes (contacts K1M: 13-14 close) Latch K1R engages (contacts K1R: 57-58 close) Latch mechanism K1R holds the starter mechanically in the start position without the coil system being continuously energised. In delayed fashion contact K1R: 65-66 switches off control voltage to contactor coil K1M:A2.
Switching off **O**	Takes place by: - The changeover of control switch S1(I → O). The actuating of S1 completes the control circuit to the tripping coil of latch K1R:E2. The latch mechanism unlocks, causing contactor K1M to drop out. The control circuit to the tripping coil is opened by contact K1M: 13-14.
Note	By the responding to the overload relay, the control circuit of - Starting coil K1M is opened by contact F1: 95-96 - Cut-off coil K1R is closed by contact F1: 97-98, Thus the contactor drops out in each case (trip-free release). Operation signalling is provided with signal lamp H1 by means of contact K1R: 57-58. It must be ensured that the control circuit to cut-off coil K1R is interrupted. Command contact S1 can have either two or three switching positions.
Contactor Sizing	According to the motor rated operational current I_e AC-3, For applications with ambient temperatures above 60° C, you may need to use a different current rating. Consult NHP for advice.
Examples of applications	Controls with maintenance of the switching state in the event of a power failure.

5.3 Direct on line starters with mechanical latch

Main circuit



Control circuit
Momentary contact control



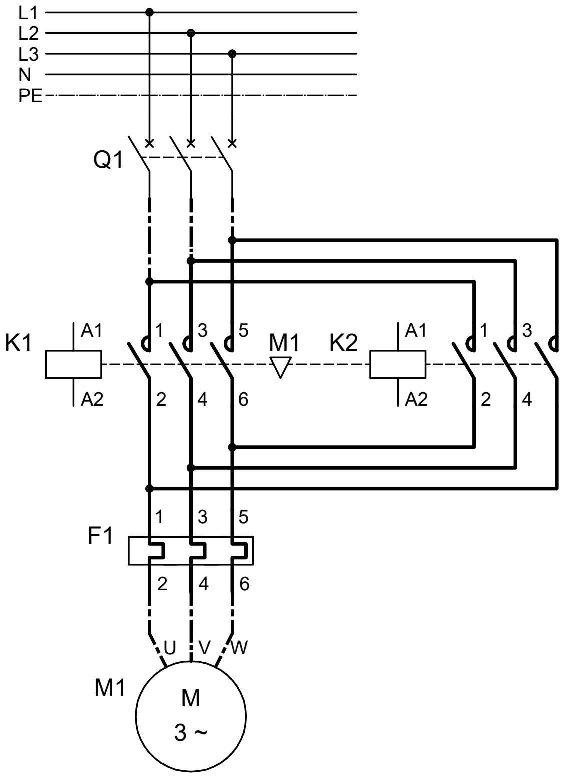
5.3.2 Momentary contact control

Connection	Connections to be made on installation
Switching on **I**	Takes place by: - Actuation of ON button S2: 13-14 (I). The control circuit to contactor coil K1M: A2 is completed by the start impulse. Contactor K1M closes (contacts K1M: 13-14 close) Latch K1R engages (contacts K1R: 57-58 close) Latch mechanism K1R holds the starter mechanically in the start position without the coil system being continuously energised. In a delayed fashion contact K1R: 65-66 switches off the control voltage to contactor coil K1M: A2.
Switching off **O**	Takes place by: - Actuation of OFF button S1: 21-22 (O). The control circuit to the tripping coil of latch K1R: E2 is completed by the cut-off impulse. The latch mechanism unlocks, causing contactor K1M to drop out. The control circuit to the tripping coil is opened by contact K1M: 13-14.
Note	By the responding of the overload relay, the control circuit of - Starting coil K1M is opened by contact F1: 95-96 - Cut-off coil K1R is closed by contact F1: 97-98, Thus the contactor drops out in each case (for trip-free release). Operation signalling is provided with signal lamp H1 by means of contact K1R: 57-58. It must be ensured that the control circuit to cut-off coil K1R is interrupted.

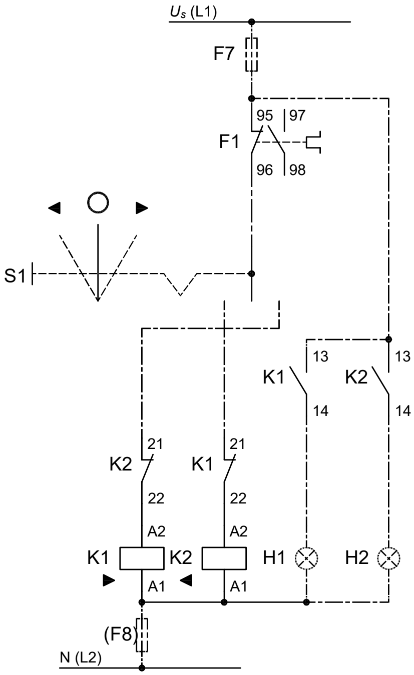
Connection	Connections to be made on installation
Contactor Sizing	According to the motor rated operational current I_e AC-3, For applications with ambient temperatures above 60° C, you may need to use a different current rating. Consult NHP for advice.
Examples of applications	Controls with maintenance of the switching state in the event of a power failure.

5.4 Reversing starters

Main circuit



Maintained contact control

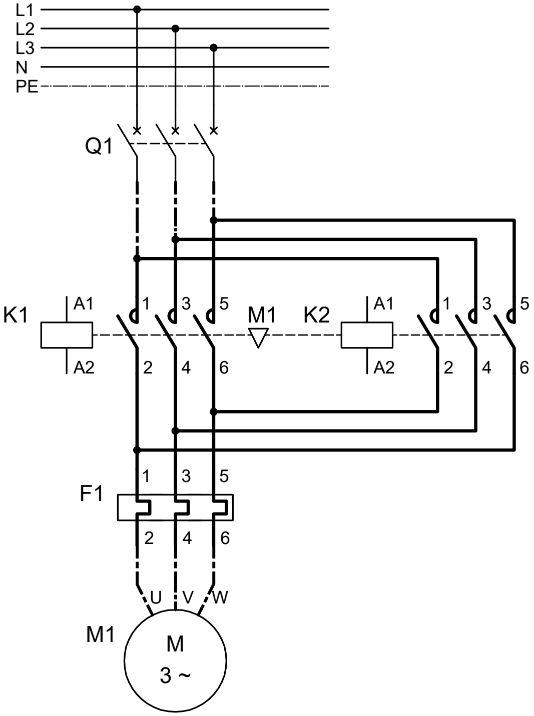


5.4.1 Maintained contact control

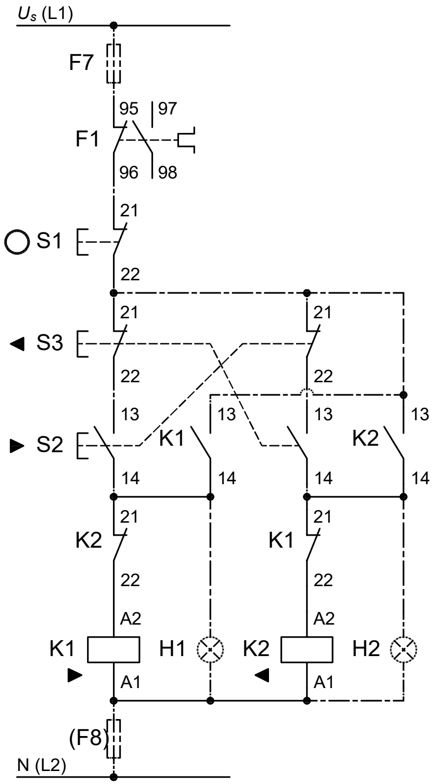
Connection	Connections to be made on installation
Switching on I	Actuate control switch S1 either clockwise (▶) or anticlockwise (◀) according to motor rotation required. **Clockwise** Actuate control switch S1 (▶) - Contactor coil system actuates main contacts (K1: 1-2, 3-4, 5-6) and auxiliary contacts (K1: 13-14) - K1 is closed and the load is connected to the mains for clockwise motor rotation -Electrical interlocking: auxiliary contacts (K1:21-22) are opened, preventing anticlockwise motor rotation - With control switch S1 closed the starting command is maintained – contactor K1 remains closed for clockwise motor rotation **Anticlockwise** Actuate control switch S1 (◀) - Contactor coil system actuates main contacts (K2: 1-2, 3-4, 5-6) and auxiliary contacts (K2: 13-14) - K2 is closed and the load is connected to the mains for anticlockwise motor rotation - Electrical interlocking: auxiliary contacts (K2:21-22) are opened, preventing anticlockwise motor rotation - With control switch S1 closed the starting command is maintained – contactor K2 remains closed for anticlockwise motor rotation **Note:** Contactors K1 and K2 can be mechanically interlocked for additional reliability and safety
Switching off O	Takes place by: - Actuation of control switch S1 to O (off position) - Responding to thermal overload relay contact F1: 95-96 or control circuit fuses (S) F7 (F8). The control voltage U_s to contactor coil K1 (with clockwise rotation), respectively K2 (with anticlockwise rotation) is interrupted, causing the closed contactor to drop out.

Connection	Connections to be made on installation	
Characteristics Locked rotor starting current Locked rotor starting torque Acceleration time	Clockwise 4…8 I_e 1.5…3 T_e 0.2…5 s	Anticlockwise 4…8 I_e 1.5…3 T_e 0.2…5 s
Examples of applications	Motors for cranes, conveyors, spindle motors, thread-cutting units and roller doors.	
Contactor dimensioning	Both contactors K1 and K2 according to the motor rated operational current I_e AC-3. For applications such as high number of operations per hour, inching duty or ambient temperatures above 60° C, you may need to use a different current rating. Mechanical interlock required. Consult NHP for advice.	

Main circuit



Control circuit
Momentary contact control



5.4.2 Momentary contact control

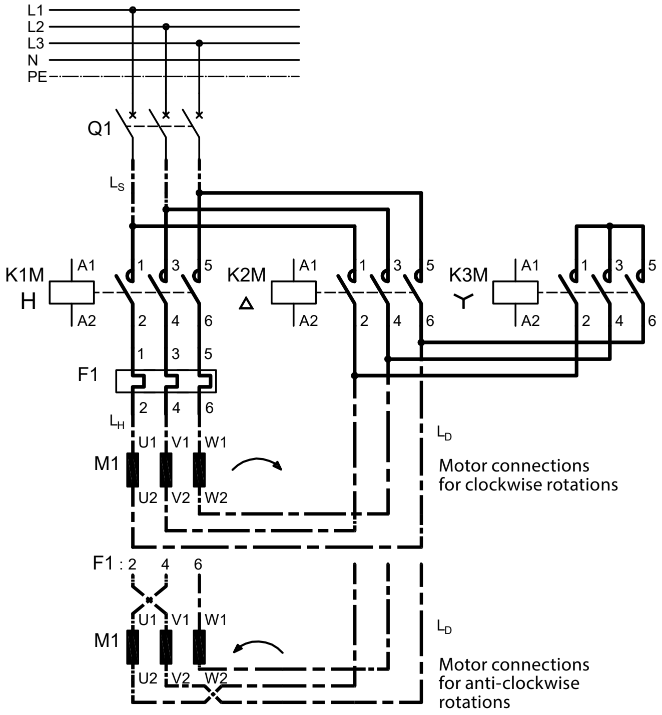
Connection	Connections to be	
Switching on I	Actuate control button S2 either clockwise (▶) or S3 anticlockwise (◀) according to motor rotation required. **Clockwise** Actuate control switch S2 (▶) - Interruption of contactor K2 control circuit - Closing of contactor K1 - Self-holding of K1 by contact K1: ..13-..14 **Anticlockwise** Actuate control switch S3 (◀) - Interruption of contactor K1 control circuit - Closing of contactor K2 - Self-holding of K2 by contact K2: ..13-..14	
Switching off O	Takes place by: - Actuation of control switch to O (off position) - Responding to thermal overload relay contact F1: 95-96 or control circuit fuses (S) F7 (F8). The control voltage U_s to contactor coil K1 (with clockwise rotation), respectively K2 (with anticlockwise rotation) is interrupted, causing the closed contactor to drop out.	
Characteristics	Clockwise	Anticlockwise
Locked rotor starting current	4…8 I_e	4…8 I_e
Locked rotor starting torque	1.5…3 T_e	1.5…3 T_e
Acceleration time	0.2…5 s	0.2…5 s
Reversal	The changeover from clockwise to anticlockwise rotation can take place direct since switches S1 and S2 are electrically interlocked via contacts S1: 21-22, S2: 21-22 Actuation of button S2 (◀) causes: -Drop-out of contactor K1 by means of contact S2: 21-22 -The time-delayed closing of contactor K2 (reversing time t_u min. 50ms) -The self-holding of K2 by means of contact K2: ..13-..14.	

Connection	Connections to be made
Note	Reversal of motor rotation direction from anticlockwise to clockwise takes place in reversed sequence. Reversal using for instance, limit switches with quick-break action necessitates an additional interruption of 40 ms; use timer element Z 01 in place of contacts K1, K2: 21-22. Direction of rotation is signaled with lamps H1 and H2. Contactors K1 and K2 can be mechanically interlocked for additional reliability and safety.
Examples of applications	Motors for cranes, conveyors, spindle motors, thread-cutting units and roller doors

6. Reduced voltage starters

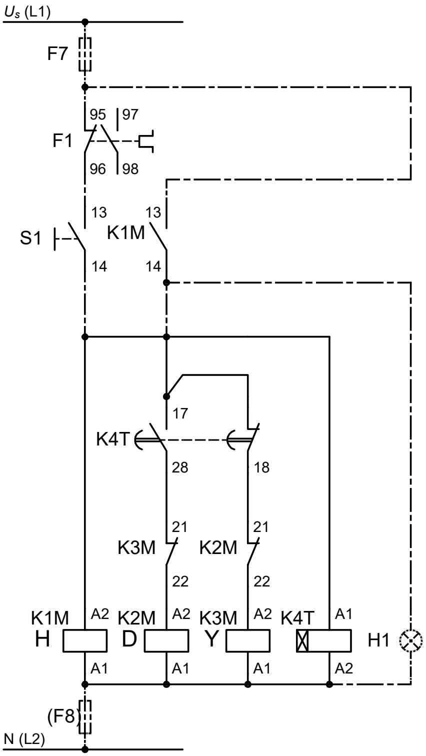
6.1 Star-delta starters

Main circuit



I_e = motor rated operational current
= current in the supply leads L_s
Y = star
Δ = delta

Maintained contact control

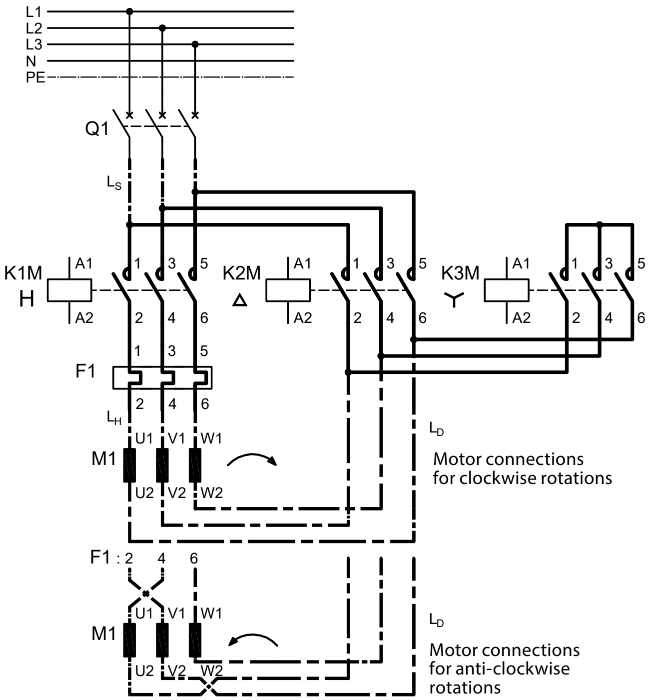


6.1.1 Maintained contact control

Connection	Connections to be made
Description	A traditional method for reducing starting current is the YΔ (star delta) circuit; the voltage at the motor winding in the Y-circuit being reduced as opposed to the voltage in the Δ-circuit by a factor 1/3. The torque and the locked rotor starting current in the Y-circuit being still approx. 30% of the values with Δ-connection. As soon as the motor reaches 80% rated speed in Y-connection, it's windings are switched to Δ.
Switching on **I**	Actuate control switch S1 - Closing of contactor K1M, closing of contact K1M:13-14 - Closing of star contactor K3M - Interruption of delta contactor K2M (K3M:21-22 opens) - Closing of timer K4T, time setting is initiated - Once timer has expired interruption of star contactor K3M occurs (K2M:21-22 opens) - K4T:17-28 contacts close and delta contactor K2 closes
Switching off **O**	Takes place by: - Opening control switch S1:13-14 or - Responding to thermal overload relay F1:95-96 or responding to the control circuit fuse F7(F8). The control voltage U_s to contactor coil K1M and K2M:A2 is interrupted, causing contactor K1 and K2 to drop out. The main contacts disconnect the load from the mains
Contactor dimensioning	Contactors K1M and K2M according to 0.58 I_e . Contactor K3M according to 0.34 I_e (starting time < 20s, up to 12 starts/h).
Lead dimensioning	Minimum line cross-section L_s, L_D corresponding to fuse F9. Line cross-section L_H corresponding to 0.58 I_e. Set scale F1 (designation YΔ, i.e. scale value = $\sqrt{3}$ • current in F1) to 0.58 I_e.

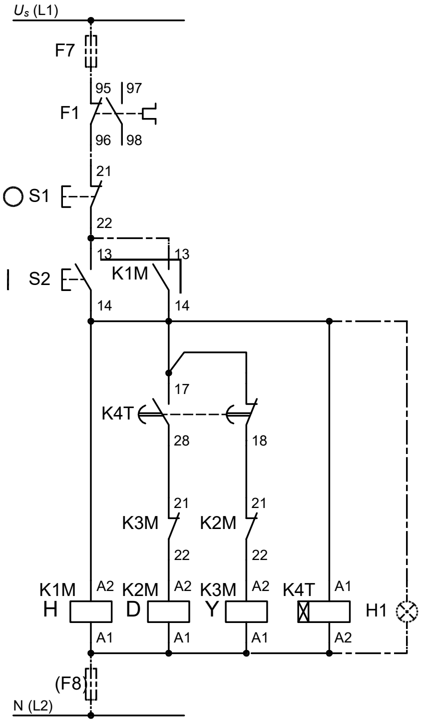
Connection	Connections to be	
Time delay when changing over from star to delta	Delay of approx. 40 ms due to brief delay of auxiliary contact block, guarantees short-circuit proof changeover with the briefest possible current-free pause.	
Clockwise and anticlockwise motor rotation	Connection in conformity with circuit diagram provides for minimum motor loading due to reversing surge. Direction of rotation changed by reversing U1, V1 and U2, V2 on motor.	
Characteristics	Y-Connection Starting	After Delta transition at 80% n_s 93% n_s
Locked rotor starting current	1.5…2.4 I_e	3.3…5 I_e 1.5…2.4 I_e
Locked rotor starting torque	0.4…0.8 T_e	1.5…2.5 Te 1….2 T_e
Acceleration time	2….16s	1…8s 0.2…4s
Example of application:	Starting of large three-phase motors in a weak network.	

Main circuit



I_e = motor rated operational current
= current in the supply leads L_s
Y = star
Δ = delta

Momentary contact control



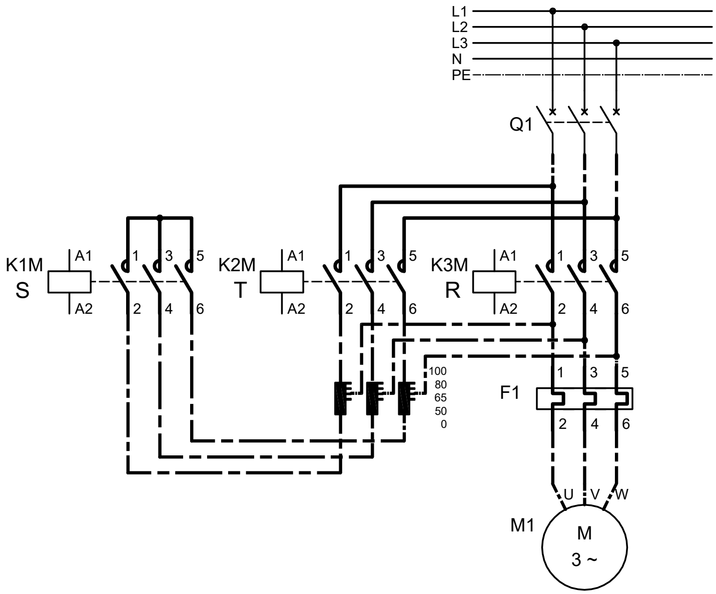
6.1.2 Momentary contact control

Connection	Connections to be made
Description	A traditional method for reducing starting current is the YΔ (star delta) circuit; the voltage at the motor winding in the Y-circuit being reduced as opposed to the voltage in the Δ-circuit by a factor 1/3. The torque and the locked rotor starting current in the Y-circuit being still approx. 30% of the values with Δ-connection. As soon as the motor reaches 80% rated speed in Y-connection, it's windings are switched to Δ.
Switching on **I**	Actuation of control switch S2: - Closing of main contactor K1M with timer K4T and star contactor K3M, motor runs in star connection. After expiry of the time set at timer K4T, contact K4T: 65-66 opens and contact K4T: 57-58 closes, causing star contactor K3M to drop out. After approx. 40 ms, contact K4T:17-18 closes, causing delta contactor K2M to close. The motor continues to run in delta connection. Electrical interlocking of star and delta contacts is achieved via contacts.
Switching off **O**	Takes place by: - Actuation of control switch S1: 21-22 or - The responding to thermal overload relay F1 by means of contact F1: 95-96 or control circuit fuse(s) F7 (F8). Interruption in control voltage U_s causing contactors and timer to drop out.
Contactor dimensioning	Contactors K1M and K2M according to 0.58 I_e . Contactor K3M according to 0.34 I_e (starting time < 20s, up to 12 starts/h).

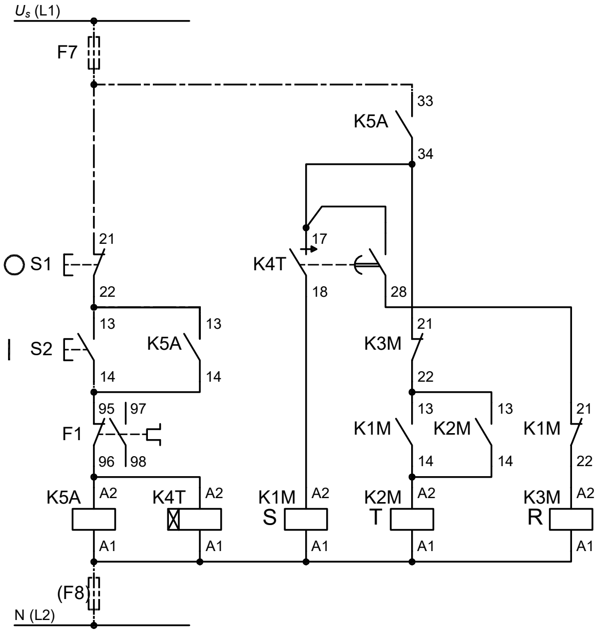
Connection	Connections to be made		
Lead dimensioning	Minimum line cross-section L_s, L_D corresponding to fuse F9. Line cross-section L_H corresponding to 0.58 I_e. Set scale F1 (designation YΔ, i.e. scale value = √3 • current in F1) to 0.58 I_e.		
Time delay when changing over from star to delta	Delay of approx. 40 ms due to brief delay of auxiliary contact block, guarantees short-circuit proof changeover with the briefest possible current-free pause.		
Clockwise and anticlockwise motor rotation	Connection in conformity with the circuit diagram provides for minimum motor loading due to reversing surge. Direction of rotation changed by reversing U1, V1 and U2, V2 on motor.		
Characteristics	Y-Connection Starting	After Delta transition at 80% n_s	93% n_s
Locked rotor starting current	1.5…2.4 I_e	3.3…5 I_e	1.5…2.4 I_e
Locked rotor starting torque	0.4…0.8 T_e	1.5…2.5 T_e	1….2 T_e
Acceleration time	2….16s	1…8s	0.2…4s
Example of application:	Starting of large three-phase motors in a weak network.		

6.2 Autotransformer starters

Main circuit



Control circuit
Momentary contact control



6.2.1 Momentary contact control

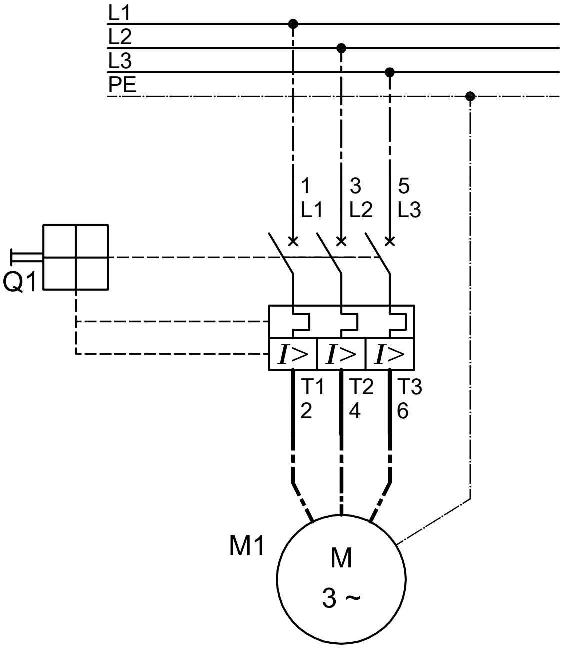
Connection	Connections to be made
Description	As opposed to star-delta circuits, only three motor lines and connections are required here. Therefore, the motor starts with the voltage reduced by the transformer ratio and a correspondingly smaller current. By this means the mains current is reduced by the square of the transformer ratio, although it is in most cases appreciably higher since it includes the relatively high transformer losses. On the other hand, the motor torque falls by a square of the voltage at the windings. Usually the autotransformers have three selectable tapping's in each phase for matching the motor starting characteristics to the starting conditions.
Switching on	Actuation of control switch S2: 13-14 causes: - Closing of control contactor K5A - Starting of the time set at timing relay K4T by contact K5A : 13-14 and - Closing of star contactor K1M by means of contact K4T: 17-18 - Contact K1M: 13-14 causes transformer contactor K2M to close The following takes place after expiry of the set time at timing relay K4T: - Opening of contact K4T : 17-18, causing drop-out of star contactor K1M - Closing of the delay contact K4T: 17-28 and thus the closing of main contactor K3M - Transformer contactor K2M drops out by means of contact K3M: 21-22.
Switching off	Takes place by: - Actuation of control switch S1: 21-22 or - the responding to thermal overload relay F1 by means of contact F1: 95-96 or control circuit fuse(s) F7 (F8). Interruption of control voltage U_s causing the dropout of auxiliary contactor, contactors and timing relay.
Notes	Starting transformers are only supplied for limited number of operations per hour and short starting times (short-time operation transformer).

Connection	Connections to be		
Contactor dimensioning	The main contactor is selected according to the motor rated operational current. Transformer contactor and star contactor are only made for a brief period during starting, but they cannot usually be selected according to this short-time loading because they have to possess sufficient closing/opening capacity, with both contactors dropping out in a random fashion during starting, (the star contactor at each start during changeover).		
Characteristics	Starting	After line at 80% n_s	93% n_s
Locked rotor starting current	1.3…5 I_e	3.3…5.5 I_e	2.2…3.5 I_e
Locked rotor starting torque	1…2.4 T_e	1.5…2.5 T_e	1….1.6 T_e
Acceleration time	2.5….50s	1…8s	1…10s
Example of application:	Starting of large three-phase motors in a weak network.		

7. Additional applications

7.1 Circuit breakers KTA7 for motor starting

Main circuit



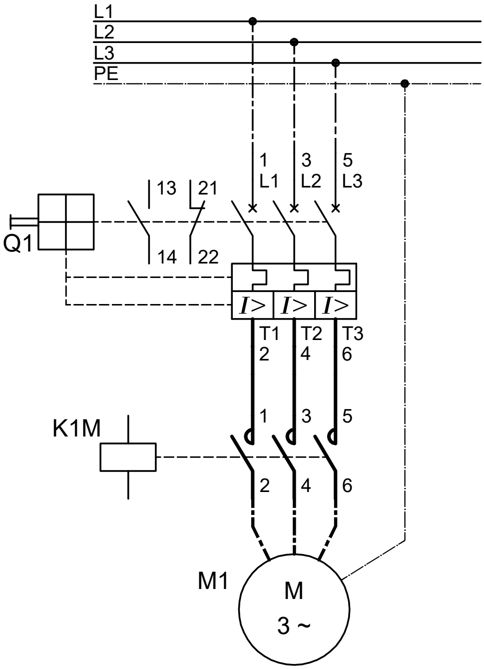
Manually actuated circuit breakers can be employed for the switching and protection of motors in continuous or low frequency operation.

For effective ON and OFF switching with remote control or with a high frequency of operation, a contactor is connected on the load side. The circuit breaker then functions as an overload and short-circuit protection, whilst the normal operating currents are switched by the contactor.

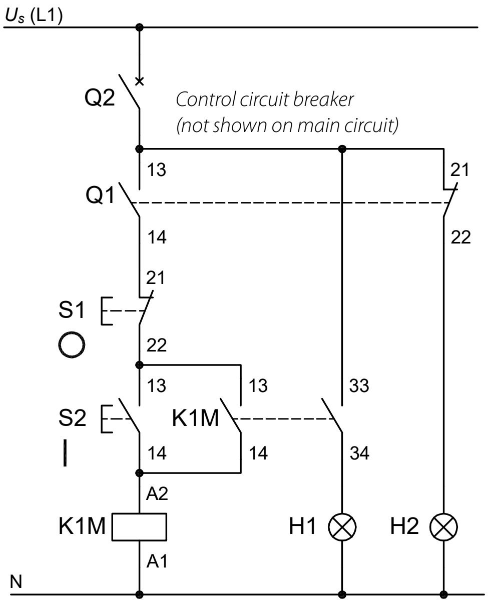
The contactor can be controlled from one or more command locations via maintained or momentary contacts.

7.2 Circuit breakers KTA7 with contactor

Main circuit



Control circuit
Momentary contact control



H1 Operation
H2 Maintenance

7.2.1 Momentary contact control

Switching on **I**	Actuate MPCB Q1 and pushbutton S2 - Contactor K1M is closed - Contacts K1M:13-14 and 33-34 close, ensuring uninterrupted supply after S2 button is released - Motor is now connected to mains
Switching off **O**	Takes place by: - Actuation of the off button S1 - MPCB Q1: 13-14 removes power from coil, opening the contactor K1M - Tripping of the MPCB, causing contacts 21-22 to close and signal a fault - Tripping of the circuit breaker upstream

7.3 Electrical heating, lamps and illumination equipment

Correct contactor selection is important to ensure efficiency of use and longevity of both the equipment and switchgear in use.

The following table contains an overview of the AC ratings covered in this topic and a description of the typical applications associated with them.

Category	Typical Application
AC-1	Non-inductive or slightly inductive loads, resistance furnaces
AC-5b	Switching of incandescent lamps
AC-6b	Switching of capacitor banks
AC-21	Switching of resistive loads, including moderate overloads
DC-1	Non-Inductive or slightly inductive loads, resistance furnaces

7.3.1 Electrical heating devices

Electrical heating devices are for example used for heating rooms, industrial resistance furnaces and air conditioning plants.

When contactors are used utilisation category AC-1 should be used as a basic for AC current and DC-1 for direct current. For manual switching, a load-switch with corresponding load-switching capacity (AC-21) is sufficient.

Lamps and illumination equipment

Lamps can basically be divided into two categories, with selection of the contactor being dependent on the type of lamp being used. The following table indicates the AC rating that will need to be used to select the correct contactor:

Tungsten Filament Lamps	Utilisation category
General purpose incandescent	AC-5b
Special purpose incandescent	AC-5b
Infrared	AC-5b
Sodium iodine	AC-6b

Discharge Lamps (with Ballast)	Utilisation category
Fluorescent lamps - mercury vapour	AC-6b
High/low pressure sodium	AC-6b
Quartz	AC-5b
Halogen metal-vapour	AC-5b

8. Soft starters PCS

8.1 Soft starter typical application duty ratings

Soft starter ratings are strongly influenced by the starting time and starting current characteristics of the driven machine. The following table, is designed to be used in conjunction with the soft starter current ratings table to ensure accurate soft starter selection.

Application	Duty
Agitator	Heavy
Atomiser	Heavy
Bottle washer	Normal
Centrifuge	Severe
Chipper	Severe
Compressor – Recip (Loaded)	Severe
Compressor – Recip (Unloaded)	Heavy
Compressor – Screw (Loaded)	Heavy
Compressor – Screw (Unloaded)	Normal
Conveyor – Belt	Severe
Conveyor – Roller	Normal
Conveyor – Screw	Heavy
Crusher – Cone	Normal
Crusher – Jaw	Severe
Crusher – Rotary	Normal
Crusher – Vertical impact	Normal
Debarker	Normal
Dryer	Severe
Dust collector	Normal
Edger	Normal
Fan – Axial (Damped)	Normal
Fan – Axial (Un-damped)	Severe
Fan – Centrifugal (Damped)	Normal
Fan – Centrifugal (Un-damped)	Severe

NHP

8.1 Soft starter typical application duty ratings

Application	Duty
Fan – High pressure	Severe
Grinder	Normal
Hydraulic power pack	Normal
Mill	Severe
Mill – Ball	Severe
Mill – Hammer	Severe
Mill – Roller	Severe
Mixer	Severe
Palletiser	Severe
Planer	Normal
Press	Normal
Pump – Bore	Normal
Pump – Centrifugal	Normal
Pump – Positive displacement	Heavy
Pump – Slurry	Severe
Re-pulper	Severe
Rotary table	Heavy
Sander	Heavy
Saw – Bandsaw	Severe
Saw – Circular	Normal
Separator	Severe
Shredder	Severe
Slicer	Normal
Tumbler	Heavy

The above table is intended as a guide only. Individual machine and motor characteristics will determine the actual start current and start time requirements.

Notes: Normal duty rating - 350% FLC, 10 second start
Heavy duty rating - 400% FLC, 20 second start
Severe duty rating - 450% FLC, 30 second start

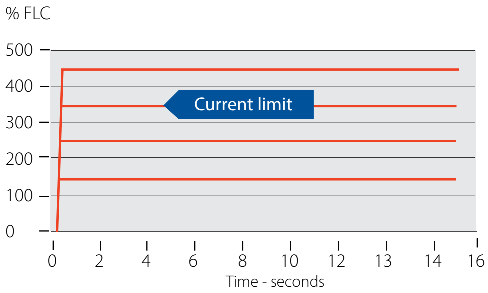
8.1.1 Applying PCS starting modes to your application

The starting mode selected on the PCS soft starter depends on the application and what the primary goal of achievement is. The below information is to be used as a guide, for detailed and specific information, including PCS product brochure please refer to NHP.

To reduce high inrush currents or to reduce peak demand utility charges

This can be accomplished by using the Current Limit Start mode. The current limit setting can be adjusted to provide 150%, 250%, 350% or 450% of full load amps during start. The start time is also user adjustable to 2, 5, 10 or 15 seconds.

Note: if the motor is not up to speed after the selected time elapses, the PCS will transition to full voltage.



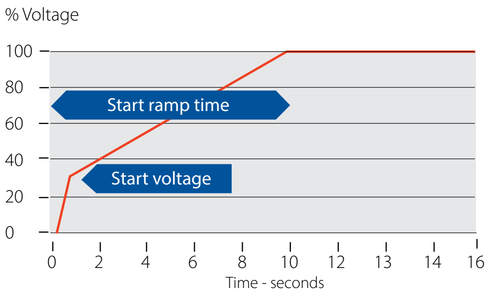
Applications:

- All applications where the main focus is to reduce electrical stress although significant mechanical advantages will also be realised.
- Ideal for high inertial loads, e.g., fans, chippers, grinders, etc.

To reduce excessive starting torque or to reduce damage, loss or spillage of product

This can be accomplished by using the Timed Voltage Ramp Soft Start mode. The timed voltage ramp soft start mode offered by the PCS has the most general application. User adjustments for initial torque and start ramp allow the PCS to be configured for a variety of applications.

The initial torque can be adjusted to 15%, 25%, 35% or 65% of locked rotor torque. The start ramp time can be adjusted to 2, 5, 10 or 15 seconds.



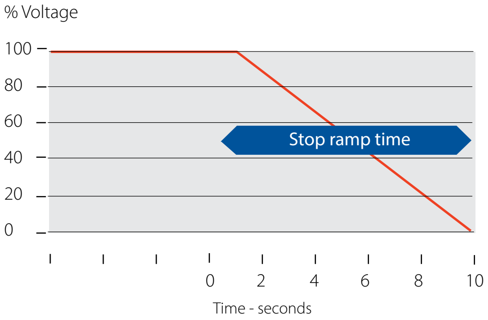
Applications:

- All applications where the main focus is to reduce mechanical stress although significant electrical advantages will also be realised.
- Ideal for pumps, conveyors, small fans, compressors, etc.

To minimise damage to product caused by sudden stopping

This can be accomplished using the Soft Stop mode. The soft stop function can be used to extend the stopping time of the motor and connected load. When enabled, the ramp down time can be set to either once, twice or three times the start ramp time setting.

The motor will stop when the output voltage from the PCS reaches the point where the load torque is greater than the motor torque.

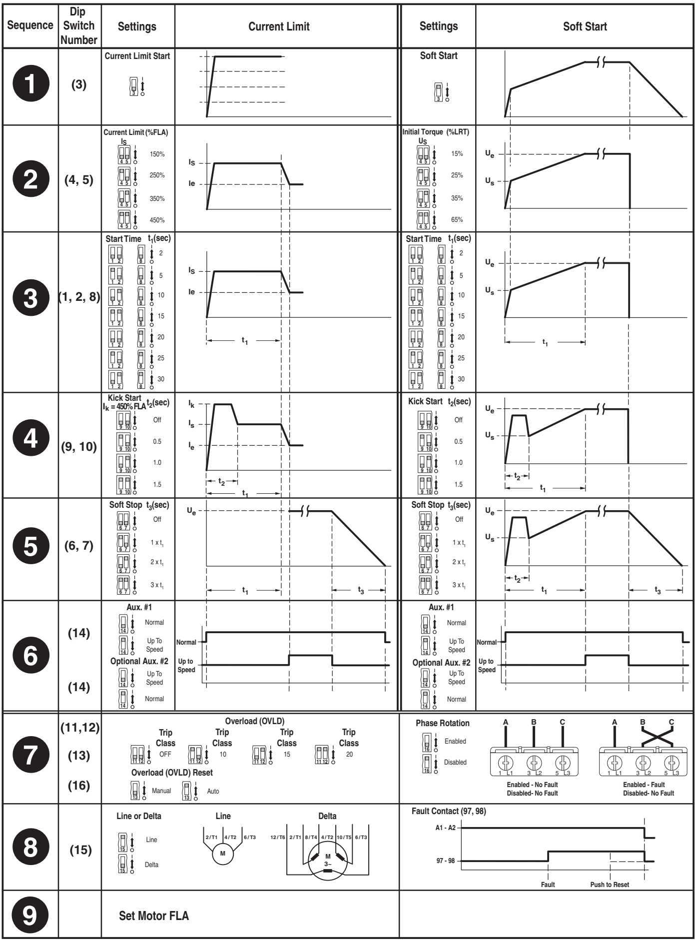


Applications:

- Any application where sudden stopping may cause damage to products or injury to persons being transported.
- Typical examples include pumps and conveyors.

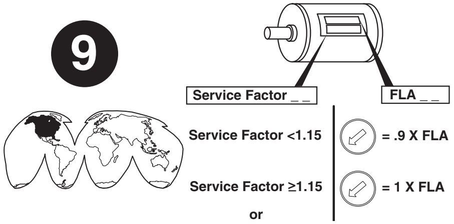
8.2 Setup

8.2.1 DIP switches and motor full load current

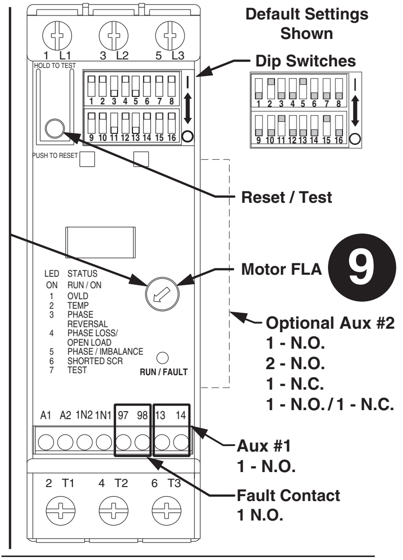


To adjust overload trip current, turn dial until the desired current is aligned with the ▲ pointer. Trip rating is 120% of dial setting.

When using the PCS in 6 wire (inside delta) mode, the overload current must be set to 58% of the motor FLC.



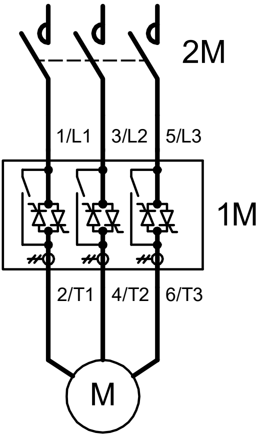
If the service factor is unknown, set to 90% of motor FLC



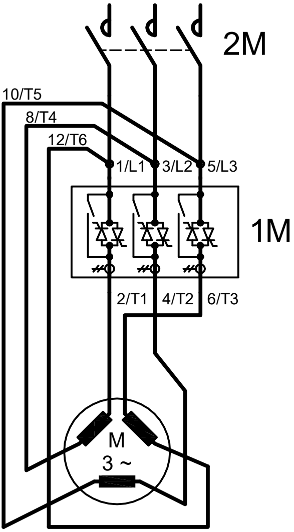
8.2.2 Main circuit

Ensure DIP switch is set in the position which matches the motor connection. Note that Delta mode refers the PCS soft starter being inside the "delta loop".

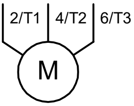
Main circuit
Line connected
(3 wire motor connection)



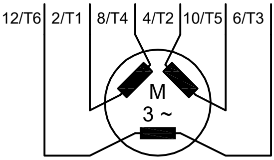
Main circuit
Inside delta connected
(6 wire motor connection)



Line



Delta

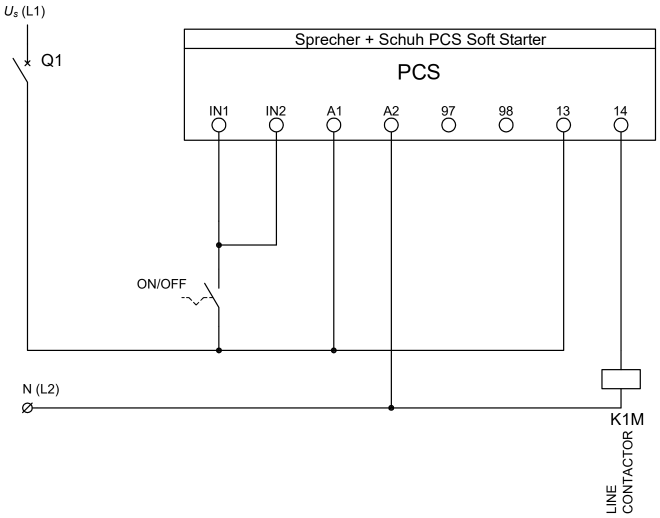


1M = PCS soft starter

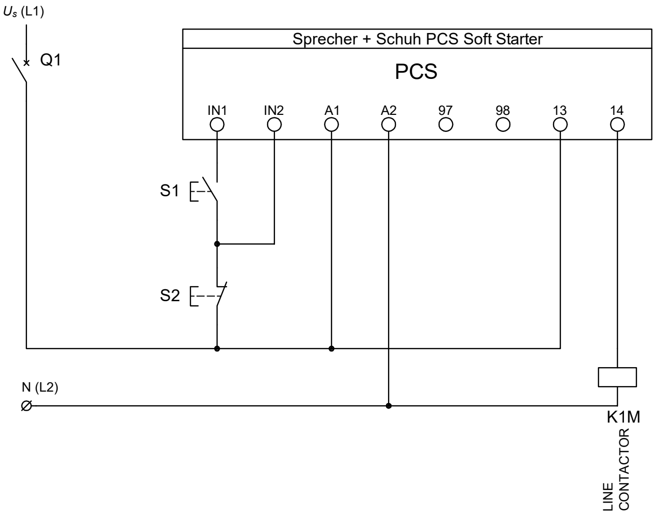
2M = Optional line contactor – useful for isolation and disconnecting the motor in the event of a trip / fault condition. Also known as isolation contactor.

8.2.3 Control circuit

Maintained contact control (two-wire control)



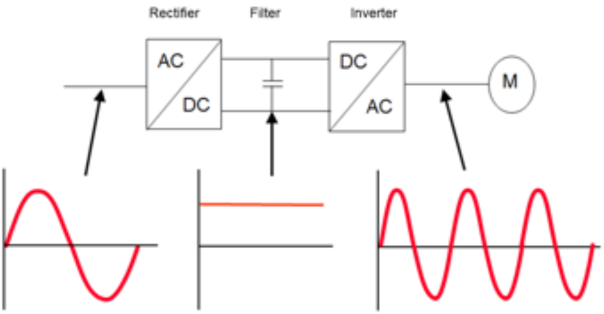
Momentary contact control (three-wire control)



9. Variable Speed Drive

9.1 Introduction

- A Variable Speed Drive (VSD) is a device that controls the rotational speed of an AC electric motor by controlling the frequency and voltage of the electrical power supplied to the motor. VSDs allow a motor to continuously operate in low slip providing optimal control of acceleration, deceleration and operating speed. One key benefit which sets VSDs apart from other reduced voltage starting techniques is that it allows full motor torque at speeds up to the synchronous speed of the applied motor.
- A typical 6-pulse drive consists of three main power structures
  - The rectifier bridge converts the AC supply to DC
  - The filter circuit absorbs any remaining ripple thereby offering a smooth DC supply
  - The inverter converts the DC supply to pseudo AC using Pulse Width Modulation allowing control of the pulse width and frequency which in turn controls the motor voltage and speed
- The VSD also consists of a control section which oversees the operation of the drive and attached motor. It continuously monitors the VSD power structures and controls the inverter as required. The control circuit is also responsible monitoring and operation of the VSD's internal protection features as well as any motor protection features.

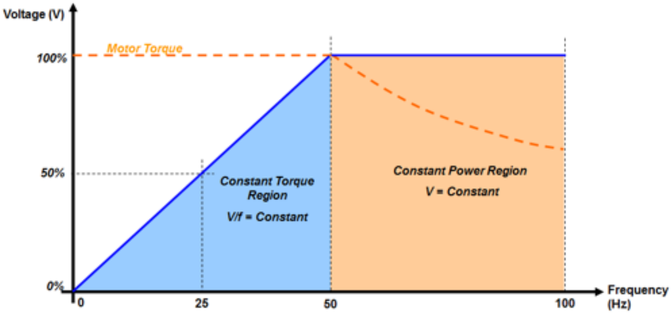


9.1.1 Regions of Operation

A motor attached to a VSD is able to operate in one of two regions;

- The Constant Torque region - spans from 0V to 100%V and from zero speed until motor rated speed. By maintaining a constant V/f (Volts per Hertz) ratio the VSD enables the motor to generate motor rated torque theoretically, from zero speed until rated speed.
- The Constant Power region – any speed above rated motor speed.

As the V/f ratio cannot be held constant above rated speed due to the voltage being clamped at 100%, the drive will enable the motor to operate at constant power, however, the available torque will decrease. Therefore, a motor can be commanded to run faster than rated speed provided there is sufficient torque available and provided the motor is mechanically capable of operation at higher speeds.



9.2 VSD Control Algorithms

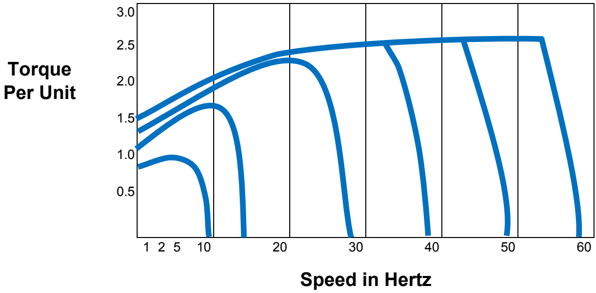
9.2.1 Overview

The control method determines how the VSD controls the motor operation. Choosing a method depends on the type of application and it is important to select the correct method as it can make or break your application.

Discussed below are a few of the most commonly used control methods.

9.2.2 Volts/Hertz (V/Hz) Control

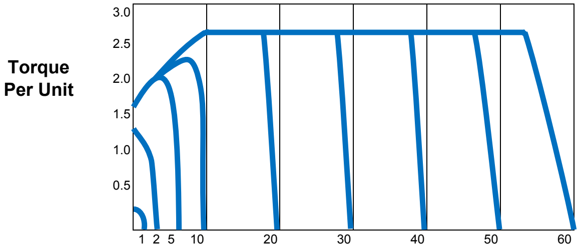
- This method takes a speed reference from an external source and varies the speed of the motor by maintaining a constant V/Hz ratio
- It's a simple method and gives the ability to have high frequency references
- A drawback is the lack of starting torque available at low speeds (only 150% at ~3 Hz)
- This method is well suited for most applications, typically fans and pumps



Graph is a theoretical curve and to be taken as a rough guide only

9.2.3 Sensorless Vector Control

- Similar principle to V/Hz control however this method provides much better speed regulation and the ability to produce a high starting torque
- Controls both the magnitude and angle between the voltage and current whereas the V/Hz method only controls magnitude
- This method can be operated in both open and closed loop control
- The auto tune feature is required to automatically detect motor parameters
- Suited for applications that require high dynamic performance, situations where the motor runs at very low speeds and applications that require direct control of motor torque



Graph is a theoretical curve and to be taken as a rough guide only

9.3 VSD Benefits

- Energy savings
- Speed control optimises factory processes and thus improves process control
- Inherent direction control
- Low start currents (theoretically gives way for infinite motor starts with low system impact)
- Soft starting/stopping capabilities protects equipment
- Improves system reliability
- Over-speed capability

9.4 Product Selection

A lot of information is required to ensure the selected VSD is adequate to meet the needs of the user and application.

- Is the motor suitable for use with VSD?
- What is the application duty rating? (normal or heavy)

  - This rating defines the overload capability of the VSD.

  - Normal duty: Current limitations up to 110% of rated current for 60 seconds max

  - Heavy duty: Current limitations up to 150% of rated current for 60 seconds max
- What voltage rating is required?
- What is the motor power rating (kW) and full load current (FLC) rating?
- What IP rating is needed? What environment will the VSD be installed in?
- What control capabilities (number of I/O) are required?
- What communications (if any) are required?

10. Timers

A Timer (Time Delay Relay) is a device that provides a time delay between 2 events or processes.

Switching off a light globe consist of two separate events or processes i.e. flicking off the switch and light turning off. Without a timer the two events occur simultaneously.

Legend

T	= Time (sec, min, hr)
1 C/O	= 1 changeover contact
2 C/O	= 2 changeover contacts
	= Time Delayed changeover contact

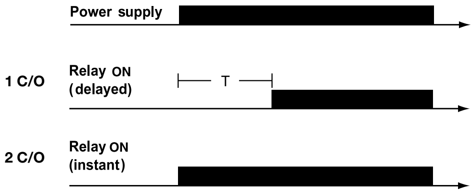
10.1 On Delay Timer

Also known as:

- Delay ON
- Delay "ON Energisation"
- Delay "ON Make"
- Delay "ON Operate"

Mode of Operation

- Timing starts immediately when power is applied.
- Delayed output relay turns ON after the set time (T)
- On the 2 C/O version the second output relay is selectable to operate as either instantaneous or
  delayed output. For example: 2 delay or (1 delay + 1 instant).
  Instantaneous output will mirror the power supply status.
- Disconnection of supply at any time will turn the output relays OFF and reset the delay time (T).
  The instantaneous output relay will mirror the power supply.



Typical Applications

- Stagger start of motors to limit peak current
- Security systems, delay system lock down for set period. It allows the person setting the alarm to clear the area.

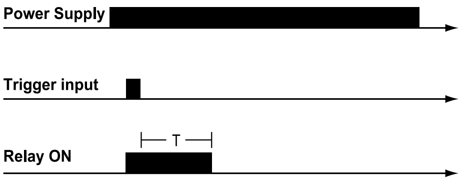
10.2 Off Delay Timer

Also known as:

- Delay OFF
- Delay "ON De-energisation"
- Delay "ON Break"

Mode of operation

- Power must be connected for timer to operate. The output relay turns ON as soon as signal is applied
- Timing starts on trigger release. The output relay turns OFF after a set time delay (T)
- Disconnection of supply at any time will reset both the relay output and delay time (T)



Typical applications

- Stairwell light operated via momentary "ON" switch
- Switch OFF delay of toilet exhaust fan
- If used in conjunction with a light circuit the timer will allow the fan to continue to operate (for a set delay time) after the light has been turned OFF

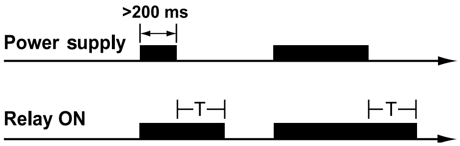
10.3 True Off Delay Timer

Also known as:

- True Delay OFF
- True Delay "ON Break"
- True Delay "ON De-energisation"

Mode of operation

- The output relay turns ON as soon as power is connected
- Timing starts on loss of power
- The output relay turns OFF after the delay time (T)
- True OFF Delay timer require a minimum charge time before operation Please consult specs as the charge time will vary depending on the model and the set delay time (T)

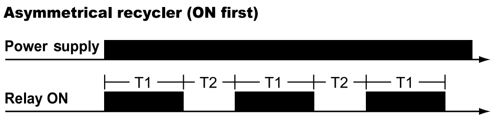


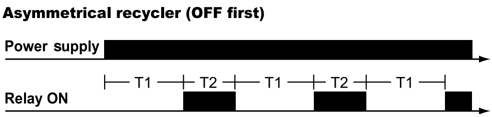
Typical Applications

Switching on an extractor fan if a machine is on and to switch it off for a fixed period of time after the last machine has turned off

10.4 Asymmetrical Recycler

Timer operates as soon as power is connected. The output relay will continuously cycle "ON / OFF" as long as power is connected. The duration of delay time "T1" and "T2" are independently adjustable. The cycle can be set to begin with either the "ON" or "OFF" state.





Typical applications

- Running a discharge pump for 1hr every 10 hrs cycle
- Turning a beacon "ON" for 2 secs every 6 secs cycle

10.5 Multifunction Timer

The multifunction timer incorporates 7 of the most popular functions in a single unit.

1. [Dr] OFF Delay
2. [Op] ON Delay
3. [In] Interval
4. [Id] Double Interval
5. [Io] Fleeting OFF (ie. Interval on trigger open)
6. [R] Symmetrical Recycling (ON first)
7. [Rb] Symmetrical Recycling (OFF first)

The timer can be wired to operate on "Automatic" or "Manual" start. Please refer to details on the specific timing functions as "Automatic" and "Manual start" operation is not applicable to every function.

Important notes

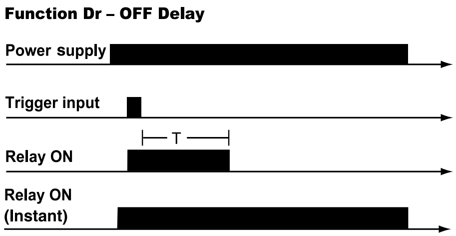
- On the 2 C/O version the second output relay is selectable to operate as either instantaneous or delayed output. i.e. 2 delay or (1 delay + 1 instant)
- In the case of "Automatic start/trigger", timing will start as soon as power is applied. Trigger input (ie. terminal "Y1" or "5") must be bridged to the supply (ie. Terminal "A1" or "2").
- In the case of "Manual start/trigger" timing will start after the trigger signal (via external switch "S") has been applied.

Multifunction Timer

10.5.1 [Dr] Off delay (manual start)

As soon as signal is applied the output relay turns on. Timing starts on trigger release.

The output relay turns OFF after a set time delay. Interruption of supply at any time will reset both the relay output and delay time (T).



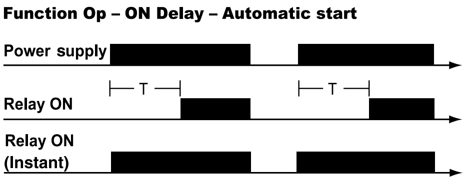
10.5.2 [Dr] Off delay (manual start)

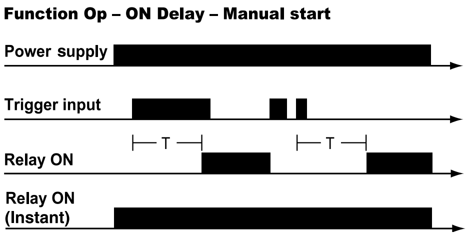
The output relay turns ON after a set time delay.

In the case of "Automatic" start / signal, timing will start immediately on power up.

On "Manual" signal, timing will start on the rising edge of the "Trigger" pulse. Subsequent application of signal pulse before the delay time (T) has elapsed will reset the time delay.

Interruption of supply at any time will reset both the relay output and delay time (T).





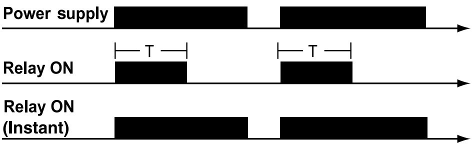
10.5.3 [In] Interval (automatic and manual start)

In the case of "Automatic start" the output relay turns ON as soon as power is applied. Timing begins immediately and the output relay will remain ON for the set time delay (T). Interruption of supply at any time will reset both the relay output and timing.

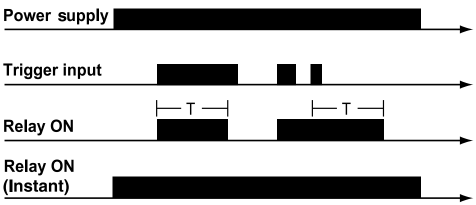
In the case of "Manual start" the output relay turns ON as soon as trigger signal is applied. Timing will begin on the rising edge of the trigger signal.

The output relay turns OFF after the delay time (T). Subsequent trigger pulses prior to the delay time (T) have elapsed will reset the timing. The output relay however will remain in the ON state.

Function In – Interval – Automatic start



Function In – Interval – Manual start

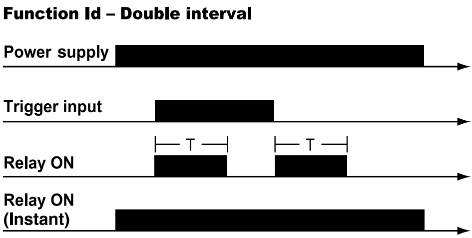


10.5.4 [Id] Double interval (manual start)

As soon as trigger signal is applied the output relay turns ON and timing begins. The output relay then turns OFF after the delay time (T) for the 1st interval whether the trigger signal is maintained or not.

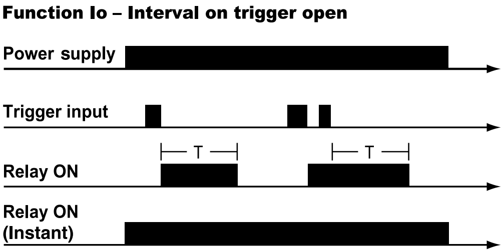
Double Interval is only applicable if the trigger signal is applied for longer than the 1st delay time (T) and then released. As soon as the trigger signal is released the output relay turns ON for another delay time (T) ie "Double Interval".

Interruption of supply at any time will reset both the relay output and the timing.



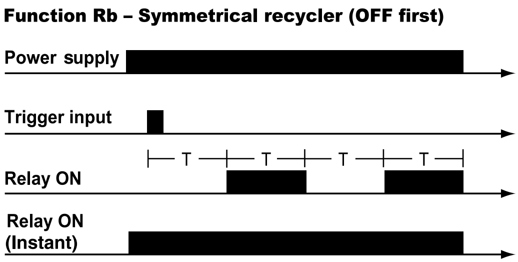
10.5.5 [Io] Interval on trigger open (manual start)

The output relay turns ON as soon as the trigger signal is released. Timing will start on the falling edge of the trigger signal. The output relay turns OFF after the delay time (T). Subsequent reapplication of trigger signal and release prior the output relay turns OFF will reset the delay time (T).



10.5.7 [Rb] Symmetrical recycler 'off' first (automatic and manual start)

The time period begins as soon as the trigger signal input contact is closed. The relay is OFF during the set delay period, after this time it operates for the same time period. This sequence continues with equal OFF- and ON-time periods until power supply is interrupted.



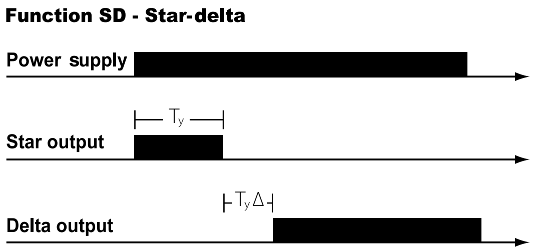
10.6 Star Delta Timer

Mode of Operation

When power is applied to the timer, the output relay changes over to the Star (Y) configuration for a duration of T_y .

At the end of the T_y the output relay goes back to its normal open state for a duration of power supply being applied.

At the end of $T_y\Delta$, the output relay changes over to the Delta configuration and remains closed until power is disconnected from the timer.

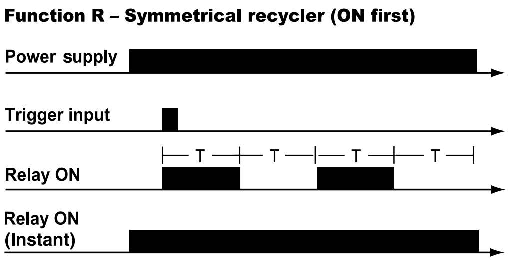


Typical applications

- Star-delta starters

10.5.6 [R] Symmetrical recycler 'on' first (automatic and manual start)

The relay operates and the time period begins as soon as the trigger signal input contact is closed. After the set delay period the relay releases for the same time period. This sequence continues with equal ON- and OFF-time periods until the power supply is interrupted.

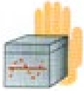
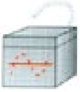
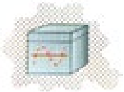


10.6 IP Ratings Chart

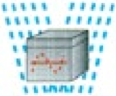
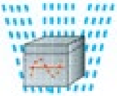
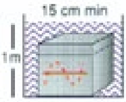
Protection grades against contact and foreign bodies - ingress protection (IP)

The Ingress Protection Scale

First Number
Protection Against Solid Objects

IP	TEST	
0		No protection.
1		Protected against solid objects up to 50mm. (eg. accidental touch by hands).
2		Protected against solid objects up to 12.5mm (eg. fingers).
3		Protected against solid objects over 2.5mm (tools + small wires).
4		Protected against solid objects over 1mm (tools + small wires).
5		Protected against dust - limited ingress permitted (no harmful deposit).
6		Totally protected against dust.

Second Number
Protection Against Liquids

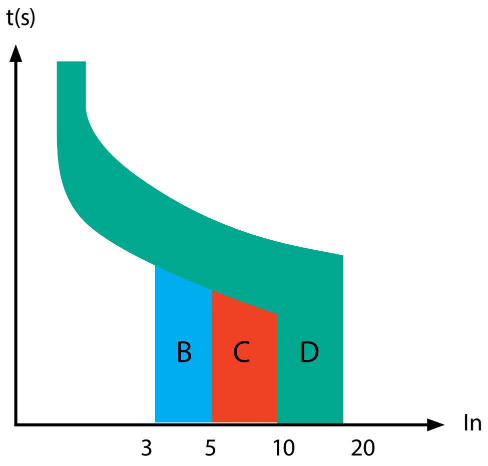
IP	TEST	
0		No protection.
1		Protected against vertical falling drops of water.
2		Protected against direct sprays of water up to 15° from the vertical.
3		Protected against spray to 60° from the vertical.
4		Protected against water sprayed from all directions - limited ingress permitted.
5		Protected against low pressure jets of water from all directions - limited ingress permitted.
6		Protected against strong jets of water eg. for use on shipdecks - limited ingress permitted.
7		Protected against the affects of immersion between 15cm and 1m.
8		Protected against long periods of immersion under pressure.
9K		Protected against close range, high pressure, high temperature (80˚C) water jets

10.7 Circuit Breakers

Circuit breakers are switching devices capable of making, carrying and breaking currents under normal circuit conditions. They are also capable of making, carrying for a specified time and breaking currents under specified abnormal circuit conditions such as a short circuit.

These timely conditions are denoted by the miniature circuit breaker's curve type. The three main curve types are B, C and D and selection of the curve type is application dependant. For example, a circuit breaker may require a greater tolerance of normal periods of overcurrent conditions such as an in-rush current in general motor starting applications. Hence, knowledge of the application is imperative to circuit breaker and curve selection.

A graphical representation of the main curve types is shown below:



Incorrect selection of the curve type can cause nuisance tripping, damage of equipment and injury.

The following table categories the different curve types along with general information and typical applications to make selection simple.

B Curve	C Curve	D Curve
• 3-5x rated current of the device • Used for control circuits • Fault loop impedance • Long cable runs • Car park lighting, bridges etc	• 5-10x rated current of the device • Most common MCB • General circuit applications • General motor starting	• 10-20x rated current of the device • High in rush loads • Transformers • Motors starting high inrush

Please contact NHP for more information and detail on MCB tripping characteristics.

10.8 Short circuit coordination for motor starting time current curves

Fuses and circuit breakers can be used as short-circuit protective devices for the contactors. The test criteria that apply in this case are stipulated by EN 60947-4-1.

Coordination types

Two types of assignment are defined in the standards that correspond to two different levels of damage.

The following applies to both types of assignment:

In the event of a short-circuit, the short-circuit protective device used must be able to disconnect the overcurrent that occurs. Persons or other parts of the system must not be put at risk.

Coordination type 1

- The load feeder (e.g. motor starter) can be inoperable after each short-circuit.
- Damage to the contactor and the overload relay is permissible and it is only possible to continue operation after defective devices have been repaired or replaced.

Coordination type 2

- After a short-circuit, there must be no damage to the load feeder devices.
- However, the contactor contacts can lightly weld if they can be easily separated again without distorting the contact pieces.
- Allows for the starter to be returned to service, until a maintenance inspection can be scheduled

Further information

For further information, including component selection and specification tables to suit Type 2 Coordination, please contact NHP.

11. Appendix

11.1 AC Motor Currents Table

Standard motors have 3 windings, with 6 connection terminals.

3 phase 4 pole 50/60 Hz motors [1] [2]

kW [1]	hp	230-240V A	400V A	415V A	440V A	690V A	1000V A	1100V A
0.18	0.3	1.0	0.6	0.58	0.55	0.35	0.3	0.3
0.37	0.5	1.9	1.1	1.05	1.0	0.64	0.4	0.4
0.55	0.75	2.7	1.5	1.4	1.3	0.87	0.6	0.6
0.75	1	3.2	1.9	1.8	1.7	1.1	0.8	0.8
1.1	1.5	4.6	2.7	2.6	2.4	1.6	1.1	1
1.5	2	6.3	3.6	3.5	3.2	2.1	1.5	1.4
2.2	3	8.5	4.9	4.7	4.4	2.8	2	1.9
3	4	11.3	6.5	6.3	5.9	3.8	2.7	2.5
4	5.5	15	8.5	8.2	7.8	4.9	3.4	3.1
5.5	7.5	20	11.5	11.1	10.4	6.7	6	4.3
7.5	10	27	15.5	14.9	14	8.9	7	5.6
11	15	38	22	21	20	13	9	8
15	20	51	29	28	26	17	12.1	10.5
18.5	25	61	35	34	32	21	15	13
22	30	72	41	40	37	24	18	15.5
30	40	96	55	53	50	32	23	21
37	50	115	66	64	60	39	28	25
45	60	140	80	77	73	47	33	30
55	75	169	97	93	88	57	40	36
75	100	230	132	127	120	77	55	50
90	125	278	160	154	145	93	65	59
110	150	340	195	188	178	113	80	73
132	180	400	230	222	210	134	95	86
160	220	487	280	270	255	162	115	105
185	250	570	327	315	300	187	135	123
200	270	609	350	337	320	203	145	132
220	300	675	385	371	350	222	160	145
250	340	748	430	414	390	250	180	164
280	375	830	480	463	436	280	200	182
300	400	920	520	500	473	300	210	191
315	420	940	540	520	490	313	220	200
355	475	1061	610	588	555	354	250	227
400	540	1200	690	665	625	400	285	259
450	600	-	770	742	700	446	320	291
500	680	-	850	819	770	493	350	318
560	750	-	950	916	860	551	390	355
630	850	-	1060	1022	960	615	440	400
710	950	-	1190	1147	1080	690	500	455
800	1070	-	1346	1297	1220	780	560	509
900	1200	-	1518	1463	1370	880	630	573
1000	1340	-	1673	1613	1510	970	700	636

Single phase motors

kW	hp	230-240V A
0.18	0.25	2.5
0.37	0.5	4
0.55	0.75	5
0.75	1	6.3
1.1	1.5	9
1.5	2	12
2.2	3	18
3	4	23
4	5	28
5.5	7.5	39
7.5	10	50

Notes: [1])

[1]) Standard values for standard squirrel-cage motors, in conjunction with IEC 60947-4-1 Table G.1:

Rated operational currents for motors with n = 1500/min (4 pole), possible deviation ± 10 % depending on type and manufacturer, ± 50 % for small motors.

Deviation of rated operational currents for motors with other speeds (greater deviations for smaller motors):

With n = 3000 rpm (2 pole): –2 %…–10 %

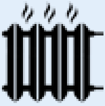
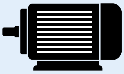
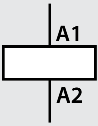
With n = 1000 rpm (6 pole): +2 %…+10 %

With n = 750 rpm (8 pole): +5 %…+20 %

[2]) The power factor is usually around 0.8, but this varies with the size and speed of the motor.

Efficiency ranges from 80% in small motors to greater than 95% for large premium efficiency motors.

11.2 Utilisation categories

Utilisation Categories	
CONTACTORS 	**CONTROL RELAYS** 
AC-1 – **Non-inductive or slightly inductive AC loads** Examples: Heaters, furnaces 	**AC-12 –** **Control of resistive loads and solid-state loads with isolation by optocouplers** Examples: Heaters, furnaces 
AC-3 – **Squirrel cage motors – starting and switching off motors during running** Examples: AC squirrel cage motors for lifts, conveyors, compressors, pumps, mixers 	**AC-15 –** **Control of AC electromagnetic loads** Examples: Switching the AC coil of a contactor 
Other Contactor ratings **AC-4 –** Squirrel cage motors – plugging or inching **DC-1 –** Non-inductive or slightly inductive DC loads **DC-3 –** Shunt connected DC motors – starting, plugging or inching **DC-5 –** Series connected DC motors – starting, plugging or inching	***Other Control Relay ratings*** **DC-12 –** Control of DC resistive loads **DC-13 –** Control of DC electromagnets e.g. contactor coil

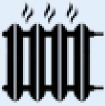
For control and switching of lighting loads contact NHP.

SWITCHES AND ISOLATORS

AC-21A, AC-21B –

Switching of AC resistive loads including moderate overloads

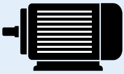
Examples: Heaters, furnaces



AC-23A, AC-23B –

Switching of motor loads or other highly inductive loads

Examples: AC squirrel cage motors for lifts, conveyors, compressors, pumps, mixers



Other Switch/Isolator ratings

DC-21 – Switching of DC resistive loads including moderate overloads

DC-23 – Switching of DC motor loads or other highly inductive DC loads

Note: The 'A' or 'B' suffix denotes frequency of switching operation.

A – Frequent operation (in close proximity to the load)

B – Infrequent operation (further upstream of load)

11.3 Motor terminology

The motor nameplate gives us many of it's important motor characteristics, design and performance data.

Motor Nameplate

KW Rated kW is the power the motor is designed to deliver at its shaft with rated frequency and voltage applied at its terminals.

Amps The current drawn by the motor at rated voltage and frequency with full rated power delivered to its shaft.

Service Factor This is a measure of the reserve margin built into a motor. It is expressed as a multiplier of the rated kW FLC and determines permissible kW FLC loading which may be carried continuously under normal environmental conditions. A corrective factor is needed for overload protection:

S.F = 1.15 $\rightarrow$ $I_r = 1 \times I_{n\ mot}$

S.F = 1.00 $\rightarrow$ $I_r = 0.9 \times 1_{n\ mot}$ (derate overload setting)

I_r = Overload protective setting

Locked Rotor Current Current motor draws at standstill with full voltage applied (initial starting current is higher than the FLC.

Efficiency The efficiency at rated output. Energy efficient motors will be identified on the nameplate.

Volts The motor rated voltage. The voltage that should be present at the motor terminals when delivering rated power.

RPM The speed of the output shaft when delivering rated power; synchronous speed less slip.

Hertz The frequency of the supply system for which the motor is designed.

Duty Is either Intermittent or Continuous. Intermittent will include a time after which the motor must be shut down and allowed to cool to prevent injury to the insulation. Continuous means that the motor may be run continuously for years.

Bearings Indication of antifriction bearings installed.

Temperature The abbreviations AMB or TEMP on a motor nameplate indicate the maximum ambient temperature environment for motor operation. Ambient means the temperature of the air surrounding the motor. In general, maximum ambient temperature for motors is 40ºC.

This general rule holds unless the motor is specifically designed for a different temperature.

IE2

Type	3 ~ Motor	**Weight**	42kg	IEC 60034-1	
Ser No.	xxxxxxxxxxxx	**Ins.cl.**	F	**IP**	55
Year	2018	**Hz**	50	**kW**	7.5

V		**r/min**	**A**	**cos ϕ**	**Duty**
690	Y	1488	8.9	0.81	S1
400	D	1488	15.5	0.81	S1
415	D	1489	14.9	0.80	S1

IE2 – 89.5 (100%) – 87.7 (75%) – 86.5 (50%)
Nmax 3200 r/min

IE3

3 ~ Motor Model: AN-EXAMPLE-1
Serial: 1300-123-456

SF 1.15 CONT
IP55
Ins cl. F AMB 40°C

V	Hz	kW	r/min	A	cos φ	Duty
690 Y	50	110	1486	113	0.85	S1
415 D	50	110	1487	188	0.83	S1

IEC/EN compliance 800 kg

Examples of motor nameplates

11.4 Time current curves

Time Current curves

Time current curves show the overload relay tripping times for a given multiple of full load current. They are tested by the overload relay manufacturer and are based on tripping times from cold (room ambient) start conditions and hot start conditions.

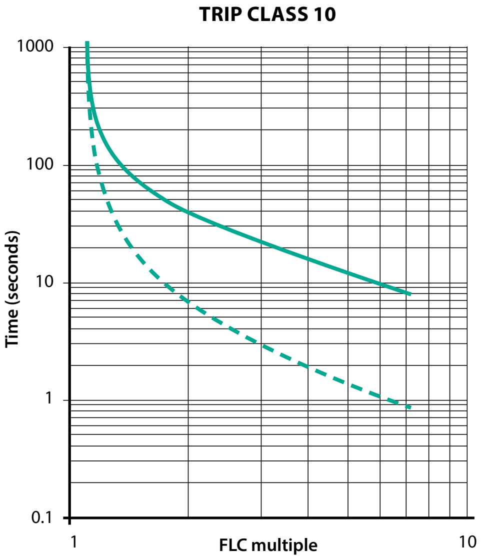
- Hot Start

  - A Hot Start is considered any time that a motor has been restarted in less than 30 minutes from the previous start.

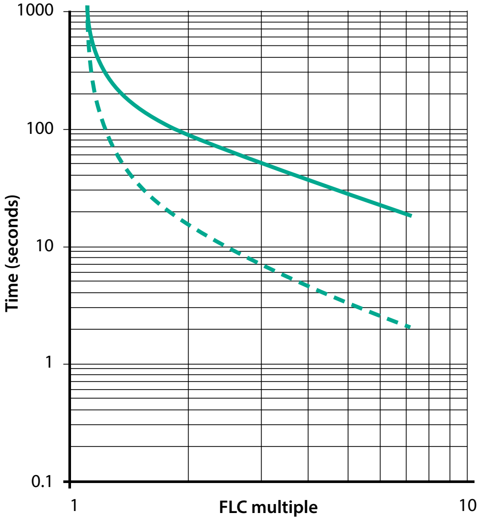
- Cold Start

  - A Cold Start is when a motor has not been run for at least 30 minutes.

Examples



TRIP CLASS 30



TRIP CURVE LEGEND

Cold trip
Hot trip

Overload trip class selection

Correct trip class selection can be determined from the motors maximum locked rotor current and maximum locked rotor time. This information can be typically found on the Motor Nameplate or from the manufacturer.

AUSTRALIA
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SALES 1300 NHP NHP

sales@nhp.com.au

NEW ZEALAND
nhp-nz.com

SALES 0800 NHP NHP

sales@nhp-nz.com

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