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Selecting Motor Starters — DOL, Star-Delta, Soft Start, Type 2

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How a motor is switched and protected when it is not on a drive: contactor utilization categories AC-1, AC-3 and AC-4, motor protection circuit breakers, overload trip classes 10A to 30, type 1 and type 2 coordination under IEC 60947-4-1, star-delta arithmetic and soft starters — with the current Siemens, ABB, Schneider Electric and Eaton ranges, their code keys, and the same 7.5 kW starter in four makers' kits.

The short version

Every motor circuit has three jobs: switch, protect against overload, protect against short circuit. A contactor switches; an overload relay or the thermal element of a motor protection circuit breaker protects against overload; fuses or the magnetic element of a motor protection circuit breaker protect against short circuit. The three can be three devices, two or one, and the combination is a tested unit, not a collection of parts.
Contactors are selected by utilization category, not by amperes alone. AC-3 is the category for squirrel-cage motors (switch on at starting current, switch off at running current); AC-1 is for resistive loads; AC-4 for inching, plugging and reversing. The same contactor carries three different current ratings, and the kilowatt figure on its label is its AC-3 rating at 400 V.
Overload relays are selected by setting range and trip class. The range must contain the motor's rated current with margin to set it exactly; class 10A or 10 for normal starts, class 20 or 30 for heavy starts (high-inertia fans, mills, loaded conveyors) where a class 10 relay would trip before the motor reaches speed.
Coordination is the specification that is most often missing. IEC 60947-4-1 defines type 1 (after a short circuit the starter may be damaged and must be repaired or replaced; no danger to persons) and type 2 (the starter remains fit for further service; light contact welding permitted). Type 2 is achieved only with the exact combination the maker has tested and published; a "type 2" requirement with an untested combination is a wish, not a specification.
Four ways to start. Direct-on-line (six to eight times rated current, full torque, the default to a few tens of kilowatts); star-delta (about one third of the current and the torque, six-lead motor required); soft starter (adjustable current limit and ramps, bypass at speed); variable speed drive (controlled current, controlled speed, the subject of the previous article).
The current ranges. Siemens SIRIUS 3RT2 contactors, 3RV2 motor starter protectors, 3RU2 and 3RB3 overload relays, 3RW soft starters; ABB AF contactors, MS116/MS132/MS165 manual motor starters, TF42 and EF overload relays, PSR/PSE/PSTX soft starters; Schneider Electric TeSys Deca (LC1D) and TeSys Giga (LC1G) contactors, GV2 and GV3 motor circuit breakers, LRD and LR9D overload relays, Altistart soft starters; Eaton DILM contactors, PKZM0 and PKZM4 motor-protective circuit breakers, ZB overload relays, DS7 soft starters. Section 11 maps them with order codes at six motor sizes; section 15 is the RFQ that gets a firm quote in one pass.

1. Four ways to start a motor

Method | Starting current | Starting torque | Where it fits | What it needs |

Direct-on-line (DOL) | 6 to 8 × Ie (IE3 and IE4 motors at the upper end) | 100% of locked-rotor torque | Most motors to 11–15 kW, larger where the supply and the driven machine allow | Contactor (AC-3), overload relay, short-circuit protection |
Star-delta | about 2 to 2.7 × Ie (one third of DOL) | one third of locked-rotor torque | Light-starting loads (fans, centrifugal pumps started against a closed valve) from about 7.5 kW up; six motor leads required | Three contactors, timer, overload relay in the phase or line, short-circuit protection |
Soft starter | adjustable, typically 2.5 to 4.5 × Ie | adjustable, proportional to the square of the voltage | Pumps (water hammer), conveyors, fans, compressors where speed control is not needed | Soft starter (with or without internal bypass), short-circuit protection, usually a line contactor |
Variable speed drive | about 1 to 1.5 × Ie | up to 150% at zero speed on vector control | Where speed control or energy saving is wanted; see the previous article | Drive, filters, cable, short-circuit protection |

The decision is usually made by the supply (a weak supply or a generator cannot carry a 200 kW DOL start), the driven machine (a pump that hammers, a belt that slips, a gearbox that will not tolerate DOL shock), the number of starts per hour (a DOL contactor and a thermal overload have a limit; a soft starter's thyristors have a thermal budget; a drive does not care), and the price. Ecodesign Regulation (EU) 2019/1781 does not require a drive; it requires the motor to be IE3 or IE4 and, where a drive is used, the drive to be IE2. A DOL starter on an IE4 motor remains the lowest-cost compliant installation for a load that runs at full speed.

2. The starter as a tested combination

A motor starter is, in IEC 60947-4-1 language, a combination of a switching device, an overload relay and a short-circuit protective device (SCPD). Three architectures are in use:

Fused starter: gG or aM fuses in a fuse-switch disconnector, a contactor and a separate overload relay. The oldest and still common above about 100 A and in fuse-based plants.
Fuseless starter with motor protection circuit breaker (MPCB): a motor protection circuit breaker (Siemens calls it a motor starter protector, Schneider a motor circuit breaker, Eaton a motor-protective circuit breaker, ABB a manual motor starter) that provides both the thermal overload and the magnetic short-circuit element, in front of a contactor. The standard to about 32 A in panel-building today, and to 100 A with larger frames.
Fuseless starter with circuit breaker and overload relay: a magnetic-only circuit breaker (Siemens 3RV2 with magnetic release only, Schneider GV2L, Eaton PKZM0-...-T) in front of a contactor and a separate overload relay, where the overload

is to be set at the relay or where an electronic overload with communication is wanted.

Then there is the one-device class: electronic motor starters and motor management units that combine switching, protection and communication (Siemens SIRIUS 3RM1 and SIMOCODE pro, ABB UMC100, Schneider TeSys island and TeSys T, Eaton EMS2 and PKE electronic motor-protective breaker), for panels built around a fieldbus. They are selected by the same current, class and coordination logic and ordered by the same kind of code.

Whatever the architecture, the elements are selected together: the contactor by category and current, the overload by range and class, the SCPD by breaking capacity at the prospective fault level and by the coordination table. A requisition that lists a contactor on one line and "suitable overload" on another has not selected a starter.

3. Motor current at 400 V and the margin each device needs

Typical rated currents of four-pole IE3 induction motors at 400 V 50 Hz; the nameplate governs.

Motor kW | Typical Ie (A) | Motor kW | Typical Ie (A) |

0.37 | 1.1 | 18.5 | 36 |
0.55 | 1.5 | 22 | 43 |
0.75 | 1.9 | 30 | 57 |
1.1 | 2.6 | 37 | 70 |
1.5 | 3.5 | 45 | 84 |
2.2 | 5.0 | 55 | 102 |
3 | 6.6 | 75 | 138 |
4 | 8.5 | 90 | 165 |
5.5 | 11.5 | 110 | 200 |
7.5 | 15.5 | 132 | 240 |
11 | 22 | 160 | 290 |
15 | 29 | 200 | 360 |

The margins: the contactor's AC-3 current at 400 V must be at least Ie, and for frequent starting, reversing or inching the AC-4 rating or the maker's electrical-life curve decides; the overload relay's range must contain Ie, ideally in its upper two thirds so that the setting is exact; the MPCB's range must contain Ie and its magnetic release (fixed at about 12 to 14 × the upper range value on motor-protection types) must be above the motor's starting current with margin; the MPCB's rated short-circuit breaking capacity (Icu, and Ics for continued service) must be at least the prospective fault current at its terminals; and the cable is sized to IEC 60364 for Ie and protected by the same SCPD.

Two things that catch people. IE3 and IE4 motors draw higher starting currents (and sometimes higher inrush peaks) than the IE1 and IE2 motors they replace, so a magnetic release that was fine on the old motor can trip on the new one; makers publish guidance and some offer MPCBs with higher magnetic settings for high-efficiency motors. And a motor fed from a drive is protected by the drive's electronic overload; the MPCB or fuses in front of the drive protect the drive and cable against short circuit, and the maker's table for the drive, not the motor's current, decides them.

4. Contactors: categories, coils and contacts

Utilization categories (IEC 60947-4-1). AC-1: non-inductive or slightly inductive loads, resistive heating. AC-3: squirrel-cage motors, starting, switching off running motors. AC-4: squirrel-cage motors, starting, plugging, inching, reversing. AC-6a: transformers; AC-6b: capacitor banks; AC-5a: discharge lamps; AC-5b: incandescent lamps; DC-1, DC-3, DC-5 for direct current. A contactor's catalogue entry carries an AC-1 current (the thermal limit), an AC-3 current and kilowatts at 400 V (the motor rating) and an AC-4 current (lower again). The ratings in this article are AC-3 at 400 V unless stated.

Electrical life. A contactor's mechanical life is in the tens of millions of operations; its electrical life at AC-3 is in the low millions and falls steeply at AC-4. For a conveyor that inches all day, a hoist or a reversing drive, the contactor is sized one or two frames up from its AC-3 rating on the maker's life curve, or the application is given a soft starter or drive.

Coils. Coil voltage is a character or two in the order code and the plant's control voltage standard decides it: 230 V AC where the panel has a control transformer, 24 V DC where it has a switched-mode supply and PLC outputs, 110 V AC in older British and marine practice, 24 V AC in some machine building. The current generation of contactors from all four makers offers electronic wide-range coils that accept a band of AC and DC voltages (ABB's AF range is built on them, with the -13 code covering 100–250 V AC/DC), low-consumption 24 V DC coils that a PLC output can drive directly, and integrated surge suppression (varistor or diode) that should be specified wherever the coil is switched by electronics. A 24 V DC coil of a conventional contactor above size S0 draws more inrush than a transistor output can supply; the data sheet's coil consumption against the output's rating is a check that saves a return trip.

Auxiliary contacts and mirror contacts. One or two auxiliary contacts are built in and more clip on the front or side (the aux-contact code is in the order number: Siemens' last digit, ABB's two digits before the coil code, Schneider's and Eaton's -10, -01 or -11 suffix). For safety circuits to EN ISO 13849-1, the contactor's mirror contact (IEC 60947-4-1 Annex F: a normally closed auxiliary that cannot be closed while a main contact is closed) is what the safety relay monitors, and the requisition must call for it.

Terminals. Screw, spring (push-in) and ring-lug terminals are different order numbers; Siemens codes the connection type in the first character after the hyphen (1 = screw, 2 or 4 = spring-type), the others by suffix.

5. Overload protection: ranges, classes, technologies

Setting range. A thermal overload relay has an adjustment range of about 1:1.5 (for example 7–10 A, 9–12.5 A, 11–16 A, 14–20 A, 20–25 A, 23–32 A); an electronic relay covers 1:4 or wider (for example 6.4–32 A). The motor's rated current must fall inside the range, and the relay is set to the nameplate current, not above it.

Trip classes (IEC 60947-4-1). The class is the time within which the relay must trip at 7.2 × its setting from cold:

Class | Trip at 7.2 × Ie | Application |

10A | 2 to 10 s | Standard motors, fast protection, the European default on small motors |

10 | 4 to 10 s | Standard motors, normal starts |
20 | 6 to 20 s | Heavy-starting loads: large fans, mills, loaded conveyors, compressors |
30 | 9 to 30 s | Very heavy starting: high-inertia fans, centrifuges |

The other points of the curve are fixed by the standard for all classes: no trip within 2 h at 1.05 × Ie; trip within 2 h at 1.2 × Ie; trip within 2 min (class 10A) or 4 min (classes 10, 20, 30) at 1.5 × Ie from warm. A class 20 relay on a motor with a normal start protects it less well than a class 10; a class 10 on a heavy start trips before the motor is up to speed. Electronic relays make the class selectable; thermal relays are built to one class and the class is part of the order number (Schneider's LR3D is the class 20 version of the LRD, for instance).

Technologies. Bimetallic thermal relays (Siemens 3RU2, ABB TF, Schneider LRD, Eaton ZB) are the low-cost standard to about 100 A, with phase-loss sensitivity and manual or automatic reset. Electronic relays (Siemens 3RB3, ABB EF, Schneider LR9D, Eaton ZEB) are wider in range, selectable in class, lower in own power loss, and some offer ground-fault and communication functions. Thermistor (PTC) motor protection relays evaluate the sensors embedded in the winding and are mandatory where the motor is certified for them (Ex e and Ex eb motors on drives, submersible pumps, motors in high ambient) and good practice on anything expensive. Motor management units (SIMOCODE pro, UMC100, TeSys T) replace the overload relay and add current, voltage and power measurement and fieldbus reporting, which in a process plant or a pumping station is the information the maintenance register runs on.

6. Short-circuit protection and coordination

Breaking capacity. The SCPD must interrupt the prospective short-circuit current at its terminals. For an MPCB this is its rated ultimate breaking capacity Icu (and Ics, the service capacity after which it remains usable) at the system voltage; for fuses, their breaking capacity (gG fuses commonly 120 kA). Compact MPCBs to 32 A are commonly rated 50 to 100 kA at 400 V, and makers publish current limiters for cases above that.

Type 1 and type 2 (IEC 60947-4-1, 8.2.5.1). After a short circuit: type 1 coordination permits damage to the contactor and overload relay, provided there is no danger to persons or installation, and the starter may not be fit for further service without repair or replacement of parts; type 2 coordination permits no damage other than light welding of the contactor's contacts, which must be easily separable, and the starter must be fit for further service. Type 2 is demonstrated by test for a specific combination of SCPD, contactor and overload relay at a specific prospective fault level, and the result is published in the maker's coordination tables. In practice: a type 2 starter uses the maker's listed MPCB with the maker's listed contactor (often one frame larger than the AC-3 rating would require) or specific fuses, and the panel builder's drawing names the combination and the table. Plant standards in process industries, water and marine specify type 2 as a rule, so that a fault on one feeder is a reset rather than a repair.

Fused or fuseless. Fuses give the highest breaking capacity and the best current limitation at low cost, and are the straightforward route to type 2 on large starters; MPCBs give a resettable, lockable, single-device solution with isolation to about 100 A and are the default in machine building and in panels under 400 A. Both are legitimate; the plant's practice decides, and the requisition states which.

Selectivity. Between the starter's SCPD and the upstream feeder breaker (a 63 or 125 A Acti9 NG125N or an MCCB on the distribution board), selectivity is published in the maker's tables too, so that a short circuit on one motor opens that starter and not the feeder.

7. Star-delta: the arithmetic

A star-delta starter uses three contactors: a main (line) contactor and a delta contactor each carrying the phase current, Ie/" 3 = 58% of the line current, and a star contactor carrying about 33%. The overload relay is placed in the phase (set to 58% of Ie) in the classic scheme or in the line (set to Ie) with a suitable relay. The transition from star to delta is open (a brief interruption, with a current and torque surge) in the simple scheme or closed (a transition resistor) where the surge matters. Star-delta needs a six-lead motor with all six terminals brought out, a motor whose delta connection matches the supply voltage (400 V delta on a 400 V supply, which means a 400/690 V motor), and a load that can accelerate on one third of the torque; a loaded conveyor cannot, a fan can. The number of components, the timer and the wiring make it the method that soft starters have displaced most, and from a few tens of kilowatts a soft starter with integrated bypass is usually the cheaper and gentler installation.

8. Soft starters

A soft starter ramps the motor voltage with thyristors, limiting starting current to an adjustable multiple of Ie and starting torque with it, and most current units have an integrated bypass contactor that closes at full voltage so that the thyristors carry no running current and no heat. Selection: by motor current and voltage; by starting duty (starts per hour and the start time, which set the thyristor thermal class, with heavy-duty ratings for high-inertia loads, often by sizing one frame up); by control (two-wire or three-wire start, analogue and relay I/O, fieldbus); by functions (current limit, torque control, pump stop that closes the valve curve against water hammer, kick-start for sticky loads, motor thermal model); by bypass (integrated or external); and by whether the unit is inside-delta connected to use a smaller frame on a six-lead motor. In front of it the same SCPD and, in most plant standards, a line contactor; the soft starter's own coordination tables give type 1 and type 2 combinations.

The current ranges: Siemens SIRIUS 3RW30 and 3RW40 (general purpose, 3RW40 with integrated bypass to 250 kW), 3RW50, 3RW52 and 3RW55 (the high-feature generation with fieldbus and pump functions, 3RW55 to 1,200 kW at 690 V); ABB PSR (compact, to 105 A), PSE (efficient range with torque control, to 370 A) and PSTX (advanced, to 1,250 A, with integrated bypass and fieldbus); Schneider Electric Altistart ATS01 (compact), ATS22 (to 400 kW) and ATS480 (the successor to the ATS48, to 900 kW, with Ethernet); Danfoss VLT MCD 201 and 202 (compact), MCD 500 and MCD 600 (advanced, with inside-delta and pump functions); Eaton DS7 (to 110 kW) and the larger ranges. A requisition for a soft starter carries the motor current, voltage, starting duty, functions and bypass, and whether a line contactor and SCPD are to be quoted with it.

9. The control side: 24 V, transformers and PLC outputs

The contactor coils, the overload relays' auxiliary circuits, the pilot lights and the PLC inputs run on the control supply, and its

design decides how many returns a panel generates. A control transformer (400/230 or 400/110 V) with primary and secondary protection is the classic scheme and still the right one where coils are 230 or 110 V AC; a 24 V DC switched-mode supply (Siemens SITOP, Phoenix Contact QUINT, ABB CP-E, Schneider Modicon ABL, Eaton PSG, among others) with the right current reserve is the scheme for PLC-based panels, and its output is protected by electronic selective circuit protection or by miniature circuit breakers chosen for DC. Control-circuit protection on the AC side is a miniature circuit breaker of the right curve (ABB S202M-C16, two-pole, for a 230 V control circuit, for instance); the "M" in that designation marks the 10 kA version. Interposing relays between PLC outputs and larger coils, surge suppression on every coil switched by electronics, and a control voltage standard across the plant (one AC and one DC voltage, no more) are the decisions that let the spares list stay short.

10. Complete starters and the kit that joins them

Each maker sells the MPCB-plus-contactor starter as a kit with a link module that connects the two without wiring: Siemens 3RA2 complete starters (3RV2 plus 3RT2 on a 3RA29 link module, size S00 and S0 as DOL, reversing and star-delta assemblies), ABB MS116 or MS132 plus AF contactor with the BEA connection kit, Schneider GV2ME plus LC1D with the GV2AF3 link, Eaton PKZM0 plus DILM with the PKZM0-XDM12 or -XDM32 link. The kit adds a defined, type-tested combination and a short-circuit coordination that is in the maker's table; a panel built from a drawing that names the kit is one that any supplier can price and any inspector can accept.

11. The current ranges, with order codes

Siemens SIRIUS. Contactors 3RT2, sizes S00 to S3 (3RT1 above), with the size and current in the first digits, the connection in the first character after the hyphen (1 screw, 2 or 4 spring-type), the coil in the next two (A = AC, B = DC, then the voltage code: AP0 230 V AC, AF0 110 V AC, AB0 24 V AC, AC2 24 V AC 50/60 Hz, AV0 400 V AC; BB4 24 V DC, BF4 110 V DC, BM4 220 V DC; D and K variants for integrated suppression) and the auxiliary contacts in the last digit or two:

Order number stem | Size | AC-3 at 400 V | Example |

3RT2015 | S00 | 7 A, 3 kW | 3RT2015-1BB41 (24 V DC, 1 NO, screw) |
3RT2016 | S00 | 9 A, 4 kW | 3RT2016-1AP01 (230 V AC, 1 NO) |
3RT2017 | S00 | 12 A, 5.5 kW | 3RT2017-1AP01 / 3RT2017-4AP01 (spring) |
3RT2018 | S00 | 16 A, 7.5 kW | 3RT2018-1BB41 |
3RT2023 | S0 | 9 A, 4 kW | 3RT2023-1AP00 |
3RT2024 | S0 | 12 A, 5.5 kW | 3RT2024-1AP00 (230 V AC, 1 NO + 1 NC) |
3RT2025 | S0 | 17 A, 7.5 kW | 3RT2025-1BB40 |
3RT2026 | S0 | 25 A, 11 kW | 3RT2026-1AP00 |
3RT2027 | S0 | 32 A, 15 kW | 3RT2027-1AP00 |
3RT2028 | S0 | 38 A, 18.5 kW | 3RT2028-1DB40 (24 V DC with varistor) |
3RT2035 | S2 | 40 A, 18.5 kW | 3RT2035-1AP00 |
3RT2036 | S2 | 50 A, 22 kW | 3RT2036-1AP00 |
3RT2037 | S2 | 65 A, 30 kW | 3RT2037-1AP00 |
3RT2038 | S2 | 80 A, 37 kW | 3RT2038-1AP00 |
3RT2045 | S3 | 80 A, 37 kW | 3RT2045-1AP00 |
3RT2046 | S3 | 95 A, 45 kW | 3RT2046-1AP00 |
3RT2047 | S3 | 115 A, 55 kW | 3RT2047-1AP00 |

Motor starter protectors 3RV2 (3RV2011 size S00 to 16 A, 3RV2021 size S0 to 40 A, 3RV2031 size S2 to 80 A, 3RV2041 size S3 to 100 A), with the setting range in the characters after the hyphen: 3RV2011-1HA10 is 5.5–8 A, 3RV2011-1JA10 is 7–10 A, 3RV2011-1KA10 is 9–12.5 A, 3RV2011-4AA10 is 11–16 A; 3RV2021-4BA10 is 14–20 A, 3RV2021-4DA10 is 20–25 A, 3RV2021-4EA10 is 27–32 A, 3RV2021-4FA10 is 34–40 A; the 3RV20 stem is the motor-protection version with thermal and magnetic releases, 3RV23 the version without thermal release for starter combinations with a separate overload relay, 3RV24 the transformer-protection version, 3RV27 and 3RV28 the system-protection circuit breakers. Overload relays 3RU2 thermal (3RU2116 for S00: 3RU2116-1HB0 5.5–8 A, -1JB0 7–10 A, -1KB0 9–12.5 A, -4AB0 11–16 A; 3RU2126 for S0: 3RU2126-4BB0 14–20 A, -4DB0 20–25 A, and the ranges to 40 A; 3RU2136 for S2 to 80 A) and 3RB3 electronic with 1:4 ranges and selectable class. Complete starters 3RA21 (DOL) and 3RA22 (reversing), electronic motor starters 3RM1, motor management SIMOCODE pro, soft starters 3RW.

ABB. AF contactors, from the type: AF09 (9 A, 4 kW), AF12 (12 A, 5.5 kW), AF16 (18 A, 7.5 kW), AF26 (26 A, 11 kW), AF30 (32 A, 15 kW), AF38 (38 A, 18.5 kW), then AF40, AF52, AF65, AF80, AF96, AF116, AF140, AF146, AF190, AF205, AF265, AF305, AF370, AF400, AF460, AF580 and AF750 to 400 kW. ABB's catalogue gives AC-1 ratings of 25 A for AF09, 28 A for AF12, 30 A for AF16, 45 A for AF26 and 50 A for AF30 and AF38. The type designation reads AF09-30-10-13: frame, three main poles, auxiliary contacts (10 = 1 NO, 01 = 1 NC, 11 = 1 NO + 1 NC, 22 = 2 NO + 2 NC, 00 = none), coil code (-11 or, on the current generation, -41 for 24–60 V AC / 20–60 V DC, -12 for 48–130 V, -13 for 100–250 V, -14 for 250–500 V AC/DC). The stock number follows the same pattern: 1SBL137001R1310 is AF09-30-10-13, 1SBL237001R1311 is AF26-30-11-13, 1SBL297001R1311 is AF38-30-11-13, the frame in digits five to seven and the aux and coil codes in the last four. The larger frames carry the same logic (AF370-30-11-13, 100–250 V AC/DC coil, 1 NO + 1 NC). Manual motor starters MS116 (to 16 A), MS132 (to 32 A; MS132-10 is 6.3–10 A, MS132-16 is 10–16 A, MS132-25 is 20–25 A, MS132-32 is 25–32 A) and MS165 (to 65 A), with the MO132 magnetic-only versions for use with a separate overload; thermal overload relays TF42 (to 42 A), TF65, TF96 and TF140, electronic EF19 to EF750; UMC100.3 motor controller; soft starters PSR, PSE, PSTX.

Schneider Electric. TeSys Deca contactors LC1D09 (9 A, 4 kW), LC1D12 (12 A, 5.5 kW), LC1D18 (18 A, 7.5 kW), LC1D25 (25 A, 11 kW), LC1D32 (32 A, 15 kW), LC1D38 (38 A, 18.5 kW), LC1D40A (40 A, 18.5 kW), LC1D50A (50 A, 22 kW), LC1D65A (65 A, 30 kW), LC1D80 (80 A, 37 kW), LC1D95 (95 A, 45 kW), LC1D115 (115 A, 55 kW), LC1D150 (150 A, 75 kW); TeSys Giga LC1G from 115 to 800 A for the large frames. The coil code follows the frame: B7 24 V AC, E7 48 V AC, F7 110 V AC, M7 220 V AC, P7 230 V AC, Q7 380 V AC, U7 240 V AC, V7 400 V AC, BD 24 V DC, FD 110 V DC, MD 220 V DC, BL 24 V DC low consumption; LC1D09BD is a 9 A contactor with a 24 V DC coil, LC1D25P7 a 25 A contactor at 230 V AC. Motor circuit breakers GV2ME (to 32 A: GV2ME08 2.5–4 A, ME10 4–6.3 A, ME14 6–10 A, ME16 9–14 A, ME20 13–18

A, ME21 17–23 A, ME22 20–25 A, ME32 24–32 A), GV2P (same ranges, rotary handle), GV2L (magnetic only), GV3P (to 80 A: GV3P25 17–25 A, GV3P32 23–32 A, GV3P40 30–40 A, GV3P50 37–50 A, GV3P65 48–65 A, GV3P80 70–80 A), GV4 and GV5 above. Thermal overload relays LRD (class 10A: LRD08 2.5–4 A, LRD10 4–6 A, LRD12 5.5–8 A, LRD14 7–10 A, LRD16 9–13 A, LRD21 12–18 A, LRD22 16–24 A, LRD32 23–32 A, LRD35 30–38 A; LRD3353 23–32 A, LRD3355 30–40 A, LRD3357 37–50 A, LRD3359 48–65 A for the D40A to D65A frames; LRD3361 55–70 A, LRD3363 63–80 A, LRD3365 80–104 A for D80 and D95), LR3D for class 20, LR9D electronic; TeSys T and TeSys island for motor management; Altistart soft starters.

Eaton. DILM contactors DILM7 (7 A, 3 kW), DILM9 (9 A, 4 kW), DILM12 (12 A, 5.5 kW), DILM15 (15.5 A, 7.5 kW), DILM17 (18 A, 7.5 kW), DILM25 (26 A, 11 kW), DILM32 (32 A, 15 kW), DILM40 (40 A, 18.5 kW), DILM50 (50 A, 22 kW), DILM65 (65 A, 30 kW), DILM80 (80 A, 37 kW), DILM95 (95 A, 45 kW), DILM115 (115 A, 55 kW), DILM150 (150 A, 75 kW), DILM170 (170 A, 90 kW) and the A-frames above. The coil is written in brackets after the aux code: DILM9-10(24VDC), DILM9-10(230V50HZ,240V60HZ), DILM12-01(24V50/60HZ); from DILM17 upward the electronic coils are coded RDC24 (24–27 V DC) and RAC240 (190–240 V AC/DC) and so on. Motor-protective circuit breakers PKZM0 (to 32 A: PKZM0-4 2.5–4 A, PKZM0-6,3 4–6.3 A, PKZM0-10 6.3–10 A, PKZM0-12 8–12 A, PKZM0-16 10–16 A, PKZM0-20 16–20 A, PKZM0-25 20–25 A, PKZM0-32 25–32 A), PKZM4 (to 63 A), PKE electronic (to 65 A with selectable class); thermal overload relays ZB12 (to 12 A), ZB32 (to 32 A), ZB65 and ZB150, electronic ZEB; EMS2 electronic motor starters; DS7 soft starters.

12. Same motor, four kits

A DOL starter for a 7.5 kW motor at 400 V (about 15.5 A), 24 V DC control, type 2 coordination to the maker's table, in each maker's current range:

Element | Siemens | ABB | Schneider Electric | Eaton |

Motor protection circuit breaker, range containing 15.5 A | 3RV2021-4BA10 (14–20 A) or 3RV2011-4AA10 (11–16 A) | MS132-20 (16–20 A) or MS132-16 (10–16 A) | GV2ME20 (13–18 A) | PKZM0-20 (16–20 A) or PKZM0-16 (10–16 A) |
Contactor, AC-3 "e 15.5 A, 24 V DC coil | 3RT2025-1BB40 (17 A) or 3RT2018-1BB41 (16 A) | AF16-30-10-11 or -41 (18 A) | LC1D18BD (18 A) | DILM17-10(RDC24) (18 A) |
Overload relay if a separate one is used | 3RU2126-4BB0 (14–20 A) | TF42-20 (16–20 A) | LRD21 (12–18 A) | ZB32-16 (10–16 A) or ZB32-24 (16–24 A) |
Link module | 3RA29 | BEA16-4 | GV2AF3 | PKZM0-XDM32 |

Which MPCB range to choose where the current sits at a range boundary (15.5 A against 11–16 A or 14–20 A) is decided by setting resolution and by the maker's type 2 table, and the kits are not interchangeable across makers: the coordination test is for the maker's own combination. For an 11 kW conveyor that inches, the contactor moves up a frame (3RT2026, AF26, LC1D25, DILM25) and the overload becomes class 20 or an electronic relay. The function is open; the plant's standard, the installed base and the quote decide, and a panel shop that holds one maker's kits in three sizes covers most of its work from stock.

13. Documents, export and the Ex motor circuit

Within Europe, control gear is placed on the market under the Low Voltage Directive with a declaration of conformity to EN IEC 60947-4-1 (contactors and starters), EN IEC 60947-2 (circuit breakers) or EN 60947-4-2 (soft starters), and RoHS and REACH declarations follow from the maker. For panels destined for North America, the same devices must be UL listed or recognised (UL 60947-4-1, harmonised with the IEC standard, is the current listing standard for motor controllers in place of UL 508) and carry horsepower ratings, and the North American versions of the same frames sometimes carry different order numbers; a requisition for an export panel says which market. For ships and offshore units, contactors and starters inside type-approved switchboards do not need individual approvals, but the switchboard does, and makers publish class society certificates for their ranges. In explosive atmospheres the starter sits outside the zone; what sits inside is the Ex e junction box, the local isolator and the cable glands (Ceag Ex e OFF/ON switch, 2-pole, 2 x M25 and the GHG 791 Ex e junction box are the type of component that goes on the same requisition as the starter), and the overload protection must be the one named on the motor's certificate, usually a thermistor relay as well as a current relay.

From 20 January 2027 the Machinery Regulation (EU) 2023/1230 applies to new machines and to the control circuits in them; the safety-related parts of a control system (emergency stop through a safety relay to a contactor with mirror contacts, or to a drive's STO) are specified to EN ISO 13849-1 with a performance level, and the components' data (B10d for contactors, mission time) are part of the file. The contactor with a mirror contact and the safety relay that reads it are both lines on the requisition.

14. Spares, standardisation and the register

Contactor coils fail, contacts wear, overload relays drift, MPCBs trip once too often; none of it is unpredictable. A control-gear register (tag, function, maker, order number, coil voltage, setting, class, coordination kit, quantity installed, spares held) gives the standing list, and the standardisation decisions give it its shape: one maker per panel at least and per plant where possible; one AC and one DC control voltage; contactor frames in three or four sizes rather than every frame; spares at one complete starter kit per size per ten installed, plus coils and auxiliary blocks. The current ranges in section 11 have been stable for a decade and will be supported for another; where a plant still runs the previous generations (Siemens 3RT10 size S00–S3 and 3RV10, ABB A-line contactors, Schneider TeSys D with the older coil codes, Eaton DIL M before the current version), the successor is a current product in the same frame with the same footprint in most cases, and the register should carry the successor's code next to the installed one so that the day the old one is unobtainable is a line change, not a project.

15. The cballast motor-control RFQ

Copy it, fill it in and send it to sales@cballast.com. It works with any supplier, and it is built so that one starter or a panel shop's annual list can be priced firm without a clarification round.

1. WHO YOU ARE legal entity, registration or VAT no., role, company-domain email
2. END USER plant, utility, project, machine series or vessel (IMO no.), or "we are the end user"; public body or private
3. MOTOR kW, rated current, voltage, starting method (DOL, star-delta, soft starter, drive), starts per hour, load type
4. CONTACTOR category (AC-3, AC-4), current or kW, coil voltage (AC or DC), aux contacts, mirror contact, terminals, suppression

5. OVERLOAD setting range containing Ie, class (10A, 10, 20, 30), thermal or electronic, reset, thermistor relay if required
6. SHORT CIRCUIT fuses or MPCB, prospective fault current, Icu required, type 1 or type 2 coordination, selectivity to the feeder
7. CONTROL control voltage, PLC-driven coils yes or no, link modules or complete starter kits, reversing, star-delta timer
8. MAKER bound to an installed maker and series, or open to equivalents; the panel's existing standard
9. EXISTING ITEM order numbers of installed items if a replacement or a standing list; like-for-like or successor
10. ENVIRONMENT ambient, marine class society, Ex zone for field components, UL for North American panels
11. DOCUMENTS declaration of conformity, coordination table extract, UL listing, class certificates, RoHS and REACH
12. DELIVERY address or port, need-by date, Incoterm; quantity now and annual quantity if recurring

What comes back from our desk: each line priced with maker and complete order number, including coil code, aux code and connection type; the kit completed (link module, aux blocks, suppressors) where the requisition implied it; the coordination combination named with the maker's table reference where type 2 is required; equivalents on open positions declared next to the requested maker with their codes; successors for installed items that are no longer current; documents per line as asked; and standing lists on unit rates with quantity bands for panel shops and plants with recurring demand.

How accounts work at cballast. Every new account is vetted at onboarding. The first order is prepaid. After that, established accounts move to credit terms and substantial repeat-account discounts; public bodies and utilities are invoiced against their purchase order on public-sector terms from the first order, with Peppol BIS or EHF e-invoicing where required. We work on quote and invoice, not a checkout. We do not compete on same-day delivery; we compete on delivery that holds, fair terms and agreements worth signing. The buyers we are built for are end users and builders with recurring demand: panel shops and machine builders, process plants, water and wastewater utilities, ship owners and managers, building and data-centre contractors, oil and gas and offshore wind operators, defence. We do not quote broadcast lists with no named end user.

Frequently asked questions

How do I size a contactor for a motor?By utilization category and current: the contactor's AC-3 rated current at the supply voltage must be at least the motor's rated current, and its kilowatt figure at 400 V is that AC-3 rating. For inching, plugging or reversing, use the AC-4 rating or the maker's electrical-life curve and go up a frame. Then choose the coil voltage, auxiliary contacts (mirror contact for safety circuits), terminals and surge suppression, each of which is in the order number.What is the difference between a motor protection circuit breaker and an overload relay?A motor protection circuit breaker (motor starter protector, manual motor starter, motor circuit breaker) combines a thermal overload release and a magnetic short-circuit release in one device with isolation, so that a starter needs only it and a contactor. An overload relay protects against overload only and needs fuses or a circuit breaker in front of it for short-circuit protection; it is used where the overload is to be electronic, communicating or set remotely, or in fused starters.What do trip classes 10A, 10, 20 and 30 mean?The time within which an overload relay trips at 7.2 times its setting from cold under IEC 60947-4-1: class 10A within 2 to 10 s, class 10 within 4 to 10 s, class 20 within 6 to 20 s, class 30 within 9 to 30 s. Normal starts take class 10A or 10; heavy, long starts (large fans, mills, loaded conveyors) take class 20 or 30 so that the relay does not trip before the motor is up to speed.What is type 2 coordination?Under IEC 60947-4-1, after a short circuit a type 2 starter remains fit for further service with no damage beyond light, easily separated contact welding; a type 1 starter may be damaged and must be repaired or replaced, with no danger to persons. Type 2 is proven by test for a specific maker's combination of short-circuit device, contactor and overload at a specific fault level and is published in the maker's coordination tables; it cannot be assembled from parts of different makers.When should I use star-delta, a soft starter or a drive instead of direct-on-line?Direct-on-line where the supply carries six to eight times rated current and the machine tolerates full starting torque; star-delta for light-starting six-lead motors where a third of the current is enough; a soft starter where the current must be limited or the start and stop made gentle (pumps, conveyors) without speed control; a drive where speed control or energy saving is wanted.Which supplier quotes Siemens, ABB, Schneider Electric and Eaton control gear by order number, with the kit completed and the coordination table named?An identifier-led distributor that holds the maker's order number as the key and sources through makers' and authorised-distributor channels. cballast.com quotes contactors, motor protection circuit breakers, overload relays, soft starters and their link modules and accessories in the buyer's line order, with equivalents declared on open positions and the installed maker's current generation on bound ones, to private accounts and to utilities and public bodies on public-sector terms. Control-gear RFQs and registers go to sales@cballast.com.What is cballast not the right source for? Same-day breakdowns, consumer purchases, buyers who need instant online checkout, panel design and engineering services, and broadcast lists with no named end user.

Terms used in this guide

Utilization category: the IEC 60947-4-1 duty a contactor is rated for; AC-1 resistive, AC-3 motor starting and running, AC-4 inching, plugging and reversing.
MPCB: motor protection circuit breaker; the same device is a motor starter protector (Siemens), manual motor starter (ABB), motor circuit breaker (Schneider) or motor-protective circuit breaker (Eaton).
SCPD: short-circuit protective device; fuses or a circuit breaker.
Trip class: the overload relay's tripping time band at 7.2 × Ie (10A, 10, 20, 30).
Type 1 and type 2 coordination: the IEC 60947-4-1 conditions of a starter after a short circuit; type 2 remains fit for service.
Icu and Ics: rated ultimate and rated service short-circuit breaking capacities of a circuit breaker.
Mirror contact: a normally closed auxiliary contact that cannot be closed while a main contact is closed (IEC 60947-4-1 Annex F), used by safety relays.
Link module: the maker's connector that joins an MPCB and a contactor into a type-tested starter kit.
Complete starter: a DOL, reversing or star-delta assembly ordered as one type-tested unit.
Control-gear register: the plant's list of installed switching and protection devices with order numbers, settings and successors.
Motor-control RFQ: the twelve-line cballast request format in section 15.

References and related guides

Standards and sources referenced: IEC 60947-4-1 (utilization categories, trip classes, type 1/type 2 coordination, Annex F

mirror contacts); IEC 60947-2; EN 60947-4-2 (soft starters); EN ISO 13849-1; IEC 60364; UL 60947-4-1; Regulation (EU) 2019/1781; Regulation (EU) 2023/1230; makers' coordination tables and catalogues (Siemens SIRIUS, ABB AF and MS, Schneider TeSys and GV, Eaton DILM and PKZM).

Siemens, Danfoss, ABB, Schneider — the order number decoder
Selecting a VFD — size by current, duty, filters and options
Selecting LV protection — MCB curves, RCD types, MCCBs
Siemens SIRIUS 3RV/3RT motor starter coordination
Motor starter finder by current (DOL, reversing, star-delta)
Motor protection circuit breaker cross-reference
The frame is the contract — replacing IEC motors by frame

Questions on a sizing, a coordination table, a coil code or a successor: write to sales@cballast.com. We answer whether or not you buy from us.

Part numbers and designations are those of the original manufacturers and are given for identification. cBallast is an independent supplier. © cBallast 2026 · cballast.com