Starting motors

Technical principles and selection criteria

White Paper

The right solution for starting three-phase induction motors
The first electric motors were developed back in the mid-19th century. After Werner von Siemens had his dynamo patented in 1866, electric motors soon spread worldwide and are used today in a broad range of applications. The basic principle of the motor, i.e. generating electrical energy from rotating motions, has remained the same. However, the last 150 years have seen numerous evolutions in the optimization of electric motors and their control, which have also led to more options to choose from for starting electric motors.

Three-phase induction motors are currently the most widely used electric motors in industry. For this reason, this document describes the technical principles of starting and operating three-phase induction motors to serve as a quick reference. It is not essential to read the complete text in order. You will gain an overview of the most important applications for electric motors and the key criteria for selecting the start type. Current trends such as energy efficiency and digitalization are also examined. The document thus serves as a decision-making aid for choosing the right technology for the individual application.

A white paper from: Siemens.

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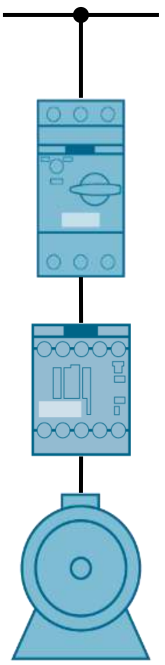
Starting of motors: Technical principles

A motor feeder generally consists of at least two components: the electric motor is started by a switching element, e.g. a contactor; a protective device is responsible for protecting the motor from overload, e.g. a circuit breaker (motor starter protector) or an overload relay. A distinction is made between the following start types, depending on the design of the motor feeder:

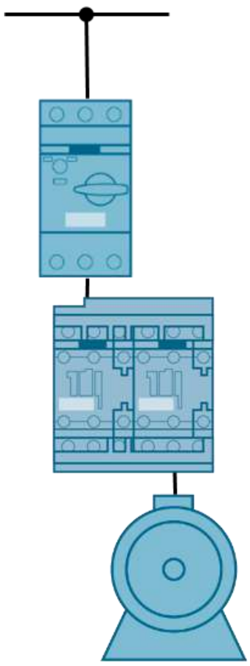
Direct-on-line and reversing start

With the direct-on-line start, also known as across-the-line start, the motor is controlled by an individual switching element (e.g. a contactor) and is switched on with full power. The inrush current and the starting torque are very high in this case, which can cause disturbances to the supply system, e.g. voltage dips, and a high mechanical load on the installation.

The permissible motor size for a direct-on-line start is dependent on the area of use. For example, there are power companies that no longer permit a direct-on-line start for motors rated 5.5 kW or higher. On the other hand, much larger motors are operated with direct-on-line start in industrial plants with independent supply systems.



Direct-on-line start setup



Reversing start setup

Advantages	Disadvantages
Low acquisition costs	
Suitable for Safe Torque Off (STO) due to electrical isolation	
Fast ramp-up based on maximum torque	
Easy configuration	High grid load
Easy maintenance	Mechanical wear in the installation
Proven and available worldwide	Permitted by power companies only for low to medium power ratings
Low power loss	

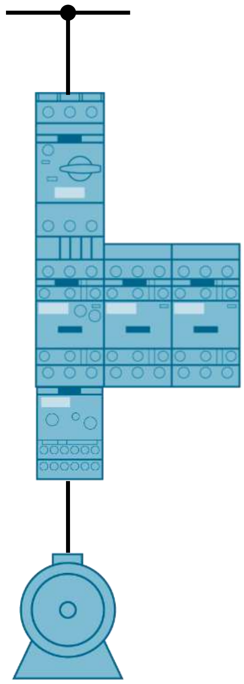
Conventionally, the direct-on-line start and reversing start is implemented electromechanically using a combination of circuit breaker and contactor or contactor and overload relay. With so-called motor starters, however, compact devices are also available that combine both functions in one device.

Typical applications:

- Universal use
- Motors up to 250 kW that can be operated at fixed speed and directly started.

Contactor assembly for star-delta (wye-delta) start

The starting of a motor with a contactor assembly for star-delta start requires three contactors: star contactor, delta contactor and line contactor. With the star-delta start, the starting current is reduced to approximately 1/3 due to the star connection. Once the motor has reached its rated torque, the star connection changes over to delta connection with the help of a special timing relay. This produces a further smaller current spike, which, however, is significantly lower overall than that of the direct-on-line start.



Setup of a motor feeder with contactor assembly for star-delta start

Advantages	Disadvantages
Reduced starting current	Medium grid load
Medium to high power range (>7.5 kW)	For simple basic applications
Low power loss	Medium mechanical load
Suitable for safety applications, electrical isolation	More space required in the control panel
Preassembled star-delta starters available	More wiring costs (6 wires to the motor)
Simple technology, widespread global use, thus easy to maintain	Lower starting torque not sufficient for some applications

Typical applications:

- Universal use
- Applications in which starting current spikes must be avoided
- Applications in which torque spikes must be prevented
- Larger motors up to approx. 500 kW

Soft starters

Soft starters can generally be used for applications in the low to high power range (1.1 kW to 1200 kW). The thyristors installed in the soft starter significantly reduce the current spikes and torque impulses that arise during the soft start compared to a direct-on-line start. Some soft starters have additional integrated features such as soft stop, DC braking, dry-running protection, pump cleaning and protection from hydraulic shock. Another particular feature is the creep speed function of the SIRIUS 3RW soft starter, which allows a motor to be temporarily controlled at low speed in both directions of rotation during operation in order, for example, to position parts on a conveyor belt.

The soft starter built-in components help to considerably eliminate contact wear to reduce maintenance.

In regular operation, the soft starter only needs three motor cables. But, if it is wired to an inside-delta circuit so that a larger motor can be started with a smaller soft starter, six supply cables to the motor are needed. However, this variant requires a three-phase controlled soft starter (cost-optimized versions are often only two-phase). Modern soft starters are usually equipped with electromechanical bridging contacts. Associated with this, the power loss during operation – after startup and before stopping – can be significantly reduced.

Setup of a motor feeder with soft starter

Advantages	Disadvantages
Higher power ranges	Higher temperature load on the motor
Continuous and impulse-free torque increase	Electrical isolation only possible with contactor
Soft starting (and in some cases soft stopping)	Higher power loss due to active thyristors
Low current or torque spikes	Higher limitation of the maximum number of starts per hour
Individually configurable starting (and in some cases stopping)	No (or little) speed control
Only three cables to the motor	
Generally more compact than comparable frequency converter	Larger in size than comparable direct-on-line starter
Lower in price than comparable frequency converter	Higher in price than comparable direct-on-line starter

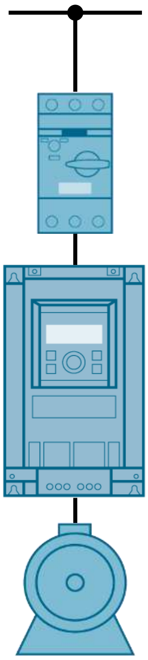
Typical applications:

- Applications in which a soft start is needed (e.g. conveyor belt)
- Applications in which a soft stop is needed (e.g. pumps)

Frequency converters

A frequency converter (FC) is always needed when variable speed is required or special operational demands exist. The FC changes the frequency and amplitude of the AC voltage, This influences the speed of the motor. Many FCs are also fitted with sensor inputs for monitoring the current status (thus, for example, the current speed and angular position) of the motor.

When mechanical valves are replaced (e.g. in pump applications) by a variable-speed controller with frequency converter, higher energy efficiency can be achieved in existing installations. In addition, FCs are available that can even recover energy in four-quadrant operation, e.g. when braking loads.



Setup of a motor feeder with frequency converter

Advantages	Disadvantages
Open-loop and closed-loop speed control	Reactors and filters needed depending on the application (see section on power grid pollution)
	Higher heat losses must be taken into account when dimensioning the control panel
	Larger size than a soft starter
Rated torque in all frequency ranges	Higher power losses for the energy efficiency examination
Energy recovery capability in some cases	
Low overall energy consumption with speed adjustment	

Typical applications

- Multi-purpose applications (variable speed adjustment)
- Applications having power requirements that cannot be precisely planned (variable adjustment of the motor power to the actual requirement to increase energy efficiency)

Basic applications for starting motors

Pumps

Pumps are devices for transporting or delivering liquids.

The ability to quickly reach the desired delivery rate is particularly important in pump applications. The starting torque must be adjusted depending on the application. In such cases, it may be advantageous to control the start-up.

Also a sudden shutdown of the pump or an abrupt pump stop can produce hydraulic shocks that can mechanically load the installation to such an extent that destruction may result.

Problems may also occur during production that can damage the entire installation over the long term. For example, the pump may run dry due to inadequate liquid supply, causing overheating of the pump and, in the case of highly flammable materials, ignition of the delivered liquid. The dry-running protection function of the SIMOCODE motor management system is therefore also certified for use in the hazardous area. Additional details are described at length in the "Dry-running protection" white paper.

Blockages are another typical challenge that is faced in particular in the water and wastewater industry due to fouling of the pump impeller. If not detected in time, this can lead to a system standstill and in turn to destruction of the motor. Switching devices with measuring capability monitor the active power of the motor and recommend that the pump be cleaned in such critical cases. These types of systems are commonly used in high-availability applications, where the costs resulting from a pump failure are many times the cost of the device. The SIRIUS 3RW55 soft starter, for example, has a monitoring function suitable for this.

Ventilating

Ventilating is understood to mean the transport or delivery of a gaseous medium by a continuous-flow machine called a ventilator. An impeller inside a housing is typically used for this.

Large ventilators can experience so-called heavy starting and thus extended starting times. This must be taken into account when selecting the switching device. If bearing damage due to unwanted standstill of the rotor blades is to be prevented, the ventilator can be operated at reduced speed, i.e. the rotor turns at minimum speed even during non-use.

Compressing

Compressing is also understood to mean the transport or delivery of a gaseous medium by a continuous-flow machine – but in this case the result is always a compressed state of matter. These machines are called compressors.

Depending on the application, compressors are designed as open or closed systems. Open systems usually operate with pressure vessels that can be equipped with simple fixed-speed solutions (direct-on-line or soft starter) and two-state controllers (regulating between minimum and maximum pressure), whereas fast-acting actuators are preferred for closed systems. The closed-loop control is then usually carried out by highly-dynamic, variable-speed drive systems.

In comparison with other applications, compressing has a much higher switching frequency. A high amount of process heat is also produced.

Conveying

Conveying describes the transporting of piece goods and bulk goods of any type.

Soft starting and stopping is often required to protect the mechanical components of the conveyor system and/or the conveyed goods from damage, e.g. due to tipping. In other cases, the speed of the conveyor belt is flexibly adjusted to the different conveyed goods. This generally only works with variable-speed drive systems.

Processing

Practically all industry sectors use processing machines. An example is the use of mixing, chopping, sorting and portioning machinery in the food & beverage industry. Other uses are found in wastewater treatment, the pharmaceutical industry and the cement and stone industry.

In the process industry, in particular, high motor loads sometimes arise due to the materials to be processed, which demand extreme torques from the motor especially during starting. The breakaway torque is often the leading factor for the motor selection in this case. In addition, special requirements of the application, e.g. for centrifuges, mixers or mills, must be taken into account when dimensioning the drive train. Many manufacturers offer dimensioning tools to support the application engineer in carrying out this less than straightforward task. For example, Siemens offers the Simulation Tool for Soft Starters (STS) for this. Here, the application can already be preset when the 3RW soft starter is selected.

However, a motor can suffer serious damage not just when starting but also during operation due to equipment blockages. Preventative measures, such as installation of an intelligent overload shutdown, must be taken for this. For applications in which, for example, the material being mixed solidifies, a destroyed motor will be the lesser of the damage. In such cases, an emergency operation must be possible in spite of a detected overload. This requires special motor protection devices that can be used to deliberately handle such requirements of the equipment owner.

The special case of heavy starting

When a motor start involves especially high load and inertia torques, this is referred to as heavy starting or high-inertia starting. Note that in the case of heavy starting the entire drive train must be capable of addressing these special challenges. That is, it is not only the motor that has to withstand the special loads but also the cables and the switching and protective devices. While a relatively high reserve still exists when a motor is started cold, this reserve is quickly reduced after several consecutive starts or when the motor is hot.

Various particularities must be noted with regard to the motor starter equipment. The switching capacity of the contacts, e.g. the contact of the contactor, must be dimensioned for the higher starting currents, and the protective device requires a different tripping characteristic. In the case of thermal overload relays, this is specified by the so-called class. In the case of electronic protective devices, the class can often be configured and adjusted according to the respective requirement. The class specifies the maximum permissible overload duration before tripping. The details for this are formulated in IEC/EN 60947. In particularly critical cases, thermistor motor protection relays are used. These monitor the thermistors installed in the motor winding and, thus, the temperature. The degree of protection achieved is often referred to as thermistor-type (full) motor protection.

One way to reduce the starting current during heavy starting is to use soft starters. However, these must also be selected appropriately for the increased loads. Intelligent versions of soft starters can make the optimal setting of the startup parameters themselves by analyzing the current motor characteristics (automatic parameterization, e.g. for SIRIUS 3RW55 soft starter). Because the torque of the motor is reduced as the starting current is reduced, soft starter use is limited to applications without elevated breakaway and starting torques. Typical applications are ventilators and centrifugal pumps. For applications such as long conveyor belts having especially stringent torque requirements, better results can be achieved with frequency converters because they can surpass the torques specified on the motor rating plate thanks to the voltage and frequency regulation.

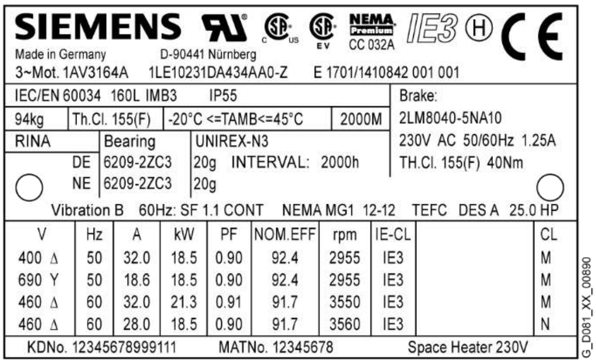
Criteria for selecting the start type

Many factors should be considered when selecting the ideal motor starting solution. The electrical planner must take into account not only the technical specifications of the application itself but also economic and legal factors.

Duty types of electric motors

The mode of operation envisaged for the motor plays a major role in the dimensioning of motor starters and frequency converters. Normally, the technical specifications of a motor for continuous duty are indicated on the rating plate (Abbreviation: S1). The switching and protective devices must also be designed for this. For example, in this case a motor starter protector is set to the rated current indicated on the motor rating plate.

If other duty types, e.g. short-time duty, arise because of the application, the overloading of the motor would be permissible because the thermal limit temperature is not reached. A typical example of this is the motor of an infrequently opened and closed roller shutter. In such cases, suitable setting values of the protective devices are calculated using correction tables of the motor manufacturer, or the motors are designated by definition for this duty type along with the correct rated motor current value to be set. When dimensioning the controller in these cases, the important thing is not to exceed the permissible ON time.



Rating plate of a motor with specification of values for duty type S1

The most common duty types are:

S1 – Continuous duty

- Constant load state with rated power
- State of thermal equilibrium is reached

S2 - Short-time duty

- Constant load state
- State of thermal equilibrium is not reached
- Long enough rest for system cooling to (θ – θ0) < 2 K
- Limit temperature of components is not reached → tB set correspondingly short
- (↑Load current ⇒ ↓Load period)

S3 - Intermittent periodic duty

- Constant load state
- Sequence of identical duty cycles (load and rest periods can vary)
- State of thermal equilibrium is not reached
- Thermal equilibrium of equipment components is not reached during temperature rise or during cooling

S9 - Duty with non-periodic load and speed variations

- Non-periodic load/speed variation within the permissible operating range
- Frequent load peaks over rated power
- Suitably selected continuous load must be taken as basis for load cycle
- Combination of short-time, intermittent and continuous duty

You will find other less commonly used duty types in IEC 60034-1.

Fixed speed / Variable speed

In most cases, the choice of fixed speed or variable speed can be made quickly based on the type of application. In between, however, is a gray area, which makes the choice difficult for the engineer. If the fixed speed start is the solution of choice, questions quickly arise regarding direct-on-line or reversing operation and star-delta or soft start. In addition, considerations such as equipment flexibility, energy efficiency, condition monitoring, predictive maintenance as well as the costs for components, installation and operation play a crucial role. Sometimes, a combination of both technologies represents the best solution. Pump cascades (multiple pumps in parallel) are a common example for this. While fixed speed drives cover the base load requirements in a graduated manner, a frequency converter takes over the fine control of the required delivery rate.

If a fixed-speed operation is possible, the acquisition costs are more favorable from the outset than for a variable-speed drive. Compared with an identically-rated frequency converter, a motor starter (fixed-speed drive) also requires much less space. This difference is magnified as the motor rating increases. In addition, a fixed-speed solution generally has a much lower power loss than a variable-speed solution. However, if a flexible installation is called for, for example, to handle produced goods having varying consistency or to change process speeds for different products, the speed adjustment is essential.

Apart from the above-mentioned typical starting types of a three-phase asynchronous motor, there are some derived versions that will still have a reason for being in the future for special applications, one example of which is slip ring motors. These enable a high starting torque with a low starting current at the same time. The high maintenance effort due to the obligatory slip rings is the reason for the rather rare use today.

In addition to slip ring motors, there is still another motor variant that despite – or precisely because of – its simple construction, is still being used in industry today. This is the pole changing motor, a special known type of which is the Dahlander motor. With this type of motor, the speed can be regulated by the engaging or disengaging of motor windings. This allows a change between rated speed and half the rated speed.

These motors are particularly attractive due to their purely electromechanical control and their simple but rugged design. They are used mostly where infinitely variable speed control is not required and the application is adequately operated with two speeds. A typical application is the precise positioning in simple conveyor technology that would not be possible at full speed.

With continuous technical advancements and electronic solutions for variable speed technology, they are likely to become cheaper overall; however, fixed speed solutions are still viable. When applicable, depending on the motor application, fixed speed solutions are inexpensive and straightforward.

A major problem for many equipment owners is so-called "power grid pollution" caused by irregular frequency that changes. Rapid switching operations cause undesired secondary effects such as harmonics and electromagnetic interference. In principle, each of the above-named start types will cause pollution of the power grid. All in all, it is recommended that applicable standards and guidelines for the electrical equipment of machines be complied with to avoid undesired effects on electromagnetic compatibility (EMC) and the overall installation.

Design and mounting

Space for electrotechnical equipment is a scarce commodity in many machine designs. For this reason, many machine builders choose a decentralized design. Another reason for this is that it allows the machine builder to significantly increase the share of factory assembled units. These completely preinstalled machine units can be put into production faster at the end customer because the local wiring effort (including the possible sources or error) is reduced and the time for commissioning is also significantly reduced.

Motor starters with a high degree of protection are ideally suited for this type of design. They are mounted near the motor without an additional enclosure. They are usually provided with a fieldbus connection, and all the connecting cables are plug-in cables. This also leads to much faster recovery time during service.

If the decentralized design with high degree of protection is not opted for, the control boxes are often mounted directly onto the machine chassis. For these motor starters, which are also decentralized from the controller, the critical form factor is the footprint as well as the depth. Most standard solutions of load feeders are then unsuitable here and are often even overdimensioned. Compact solutions, and in some cases hybrid solutions, are called for here. Various versions up to 11 kW are available on the market – with and without fieldbus connection as needed. Solutions for higher power ratings are the domain of discretely mounted products. It is important that these are well matched in terms of their mechanical and electrical specifications.

Wiring costs

Compact motor starters in combination with clever infeed systems and a fieldbus connection allow a significant reduction in wiring costs. This is true for both centralized and decentralized designs. Only the limited power rating of these motor starter versions limits their use. The SIMATIC ET 200SP motor starters up to 5.5 kW motor power are a typical representative with fieldbus connection. The so-called energy bus and all the control connections are implemented more or less without tools by stringing together the basic modules. The motor starters themselves are then just snapped in and locked. The SIRIUS 3RM1 motor starters are well-suited for slightly smaller applications. With up to 3 kW motor power and compatible infeed system for the 400 V wiring, a larger number of motor starters, as is typically found in conveyor system applications, can be quickly and economically mounted.

Communication

In the Industry 4.0 era, communication plays a crucial role. A majority of devices and machines in an industrial plant are networked with one another. This allows the user to control the plant centrally and to read out and evaluate various values. Compact devices such as motor starters, soft starters and frequency converters have a large range of functions that make additional hardware unnecessary. Thus, measuring and communication functions – also in combination with safety applications – have almost become the standard. The decision as to which bus system is to be used is usually made at a higher level.

The Siemens portfolio offers interfaces for the common bus systems and communication standards currently on the market:

- IO-Link
- AS-Interface
- Profibus
- Profinet (and other Ethernet-based communication standards)
- Modbus TCP / Modbus RTU
- OPC UA

Motor starters equipped in this way are usually also compact in design and considerably reduce the wiring effort in the control cabinet.

Digitalization

With the integration of measurement and statistical data of the low-voltage controls such as ET 200SP motor starters in cloud systems (e.g. Siemens MindSphere) of the Industrial Internet of Things (IIOT), the customer has the capability of evaluating a wide variety of data. Together with additional sensor information from his systems, this can then be intelligently and advantageously networked. Devices with OPC UA protocol, e.g. the SIMOCODE motor management system, can be directly linked to the cloud.

In combination with Siemens MindSphere and the MindApp SIRIUS Asset Monitor there are completely new capabilities for increasing the system transparency through information on operating times and downtimes, fault diagnostics, and energy consumption. As a consequence, for example, motor faults can be detected early on various terminal devices, e.g. tablets or smartphones (mobile devices), once the load conditions unexpectedly change.

One of the most frequently used methods for this is to monitor the active power of the motor. This allows the user to detect whether the motor is running with its intended power or a deviation exists. These deviations can, for example, arise due to a blocked or dirty pump (see Chap. Pumps). These restrictions cause the motor to run less efficiently and to consume more current than in normal operation. This increases the operating costs for one thing. For another, the motor can overhead due to overload or be shut down by the protective device. This interrupts the process and a system standstill is the result. With the SIRIUS 3RW55 soft starter or the SIMOCODE motor management system and their monitoring functions, for example, these failure-associated costs can be prevented. Thus, maintenance costs are reduced and the application can oftentimes be continued without interruption.

Functional safety (safety applications)

Based on their design and functionality, machinery and equipment can entail risks. For this reason, the Machinery Directive requires a risk assessment for every machine. In a second risk mitigation step, safety measures are defined to ensure a safe state of the equipment and to prevent hazards for humans, machines and the environment or achieve an acceptable residual risk.

The type and scope of the safety measures is dependent on the assessment of the hazard risk as part of the risk assessment. For the risk mitigation, a determination is made of the safety requirements and of the safety level that a measure taken on the machine or equipment must achieve. This is defined as Performance Level (PL a to PL e according to EN ISO 13849-1) or as Safety Integrity Level (SIL1 to SIL3 according to EN 62061).

A resulting technical protective measure for control of motors is the safe shutdown in an emergency and the prevention of an unwanted restart. As an example, the safety function can be implemented for each motor feeder using safe evaluation units (e.g. a safety relay).

In general, the possibility always exists to connect a double, thus redundant, contactor circuit on the line side of a motor feeder that guarantees electrical isolation even in the case of a failure. For the latter, Siemens offers the so-called Z-connector for the main circuit, which can reduce wiring costs and errors. For the safe shutdown of a soft starter, a contactor (SIL 1/ PL c), a combination of circuit breaker and contactor (SIL 2/ PL d) or two contactors (SIL 3/ PL e) must be connected on the line side. In all applications, the safe shutdown must be monitored, for example, with a safety relay or by a fail-safe controller.

For the safe operation of frequency converters and compact motor starters, there are already product variants on the market in which the necessary safety technology is already integrated. As a result, a motor feeder in a space-saving design up to SIL 3 or PL e level is possible, for example. With the fail-safe 3RM1-F motor starters, up to four devices (contactors, overload relays) can be eliminated. The safety level achieved by a product is indicated in the technical specifications.

Economic aspects

Economic aspects also play a role in selecting the right motor start solution. The choice generally comes down to the acquisition costs and the operating costs. Typically, the acquisition costs increase as the complexity and performance of the selected solution increase. For example, the purchase price of a simple combination of contactor and circuit breaker is less than that of a frequency converter. However, installation and engineering costs must be included in the acquisition costs, which may be more favorable for compact motor starters, for example, compared with a combined solution of individual devices.

When it comes to operating costs, energy efficiency plays a key role. For example, with an IE3/IE4 motor, it is possible to quickly amortize the higher acquisition costs for a fixed speed drive in continuous operation. Even the replacement of older motors running in continuous duty with more efficient models can be quickly amortized. In applications with frequent starts, it may be better to choose an IE3 motor over an IE4 motor because of the lower starting currents. Relative newcomers on the market are reluctance motors. In most cases, they can only be started with special drive electronics. However, the additional expense can quickly pay for itself during operation due to the higher efficiency of the motors. When placing motors on the market, the current efficiency standards and guidelines in the countries in which the motors will be used must be taken into account. For example, IE2 motors with fixed-speed drive starters can no longer be used within the EU. More details about this can be found in EU Regulations 640/2009 and 04/2014.

It is not only the selection of the motor that is important for the economic viability of an installation. The associated motor controller and switching device can also influence the balance sheet for the installation. In principle, frequency converters have the highest energy demand from a purely technical view. However, in some applications a frequency converter can be much more efficient than an industrial control assembly. If, for example, continuous operation with low speed is more appropriate than multiple motor starts, the operating costs with a frequency converter can be significantly lower. For this reason, finding the right start type for the application is key when planning the installation, in order to optimize the ratio of investment costs to operating costs.

Besides selecting the right type of switching device, finding a device that is as low-maintenance or as easy to maintain as possible is also important. Soft starters such as SIRIUS 3RW55, for example, are low-maintenance devices from the ground up.

Overview: Comparison of start types

	Direct-on-line start	Contactor assembly for star-delta (wye-delta) start	Soft starters	Frequency converters
Speed control	No	No	Limited	Yes
Typical power range	Up to 4/5.5 kW	4/5.5 kW to 500 kW	4/5.5 kW and higher	Universal use
Reduce current spikes	No	Yes	Yes	Yes
Space requirement	Low	High	Medium	High
Mechanical load of the installation	High	Medium	Low	Low
Device wear	Present	Present	Low	Not present
Communication capability	Optional	Optional	Optional	Optional
Safety functions	Optionally integrated	Additional hardware needed	Optional	Optionally integrated
Acquisition costs	Low	Medium	Medium	High

Trends and developments

The trend toward increased digitalization is also finding its way into the starting and controlling of motors. Functions like recording of certain measurements or monitoring of the application are migrating from the controller directly to the feeders. Already today, compact devices such as motor starters, soft starters and frequency converters have a large range of functions that make additional hardware unnecessary. And, safety functions and communication capability are now almost always standard.

The trend toward direct connection of devices to mobile devices, web servers and the cloud can be expected to increase. New apps which allows access to measured data and product functions at any time and regardless of location support improved condition monitoring for increasing productivity. The developments in artificial intelligence (AI) are showing great potential for even more accurate prediction of future faults with the ever more diverse data that is acquired in the field (predictive maintenance).

The trend in design and control engineering is to improve efficiency. The selection and dimensioning of products will be increasingly automated in the future. Tools such as the TIA Selection Tool of Siemens already support this today. A wide range of tested switching and protection assemblies also facilitate product selection. Extensive CAx data on the products produced by manufacturers is already providing significant saving potential for the design and sizing of motor feeders in ECAD systems. Modular engineering can further reduce the amount of effort needed. That is why Siemens will soon be providing so-called engineering modules, i.e. preconfigured partial circuits, for complete feeders.

More stringent legal requirements for energy efficiency have already been imposed in recent years. This has led manufacturers to improve the efficiency of devices in the area of industrial controls as well, for example, through use of so-called hybrid technology in motor starters and soft starters (such as ET 200SP motor starters and 3RW5 soft starters). Besides their basic electromechanical equipment, these products also contain electronic functional units. After starting using thyristors, the devices automatically change over to electromechanical contacts in order to minimize wear and the power losses during closed-loop control. This can reduce operating costs over the long term. Another advantage is the reduced temperature of the switching device and thus of the control cabinet, which is achieved by bridging the semiconductors.

Further efficiency initiatives can be expected in the future, arising from policy makers as well as from the economic demands of machinery and plant owners. The plant owners may benefit from new incentive measures if, thanks to modern drive and control technology, they monitor and purposefully control their energy use.

Appendix

Products of Siemens

The portfolio of SIRIUS industrial controls is the largest on the market, offering switching devices with over 50,000 combination tests and approvals. A completely new and innovative device generation of circuit breakers, contactors and overload relays all the way to load feeders in 7 sizes up to 250 kW are available. The strength of the portfolio is its modular structure across all sizes. In this way, suitable load feeders (direct-on-line, reversing or star-delta starters) can be easily combined, whether fuseless or fused, and supported by time-saving connection technology.

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In addition, Siemens provides you with a series of compact complete units as well as soft starters and frequency converters:

Product	Function	Power range	Degree of protection	Safety Integrated	Communication capability	Metering functions
SIRIUS 3RA2 load feeders	Direct-on-line and reversing start	0.06 to 37 kW	IP20	No	IO-Link, AS-Interface	Optional current (with SIRIUS 3RR2 relay)
SIRIUS 3RM1 motor starters	Direct-on-line and reversing start	0 to 3 kW	IP20	Integrated	No	No
SIMATIC ET 200SP motor starter	Direct-on-line and reversing start for distributed I/O	0.12 to 5.5 kW	IP20	Integrated	PROFINET	Integrated: current
M200D motor starters	Direct-on-line and reversing starters with soft start function for mounting outside the control panel	0 to 5.5 kW	IP65	No	AS-Interface, PROFIBUS, PROFINET	Integrated: current
ET 200pro motor starters	Direct-on-line and reversing starters for mounting outside the control panel	0 to 5.5 kW	IP65/66/67	Integrated	PROFIBUS, PROFINET	Integrated: current
SIRIUS 3RW30/40 soft starters	Basic Performance soft starter	1.5 to 250 kW	IP20 / IP00	No	No	No
SIRIUS 3RW52 soft starters	General Performance soft starter	5.5 to 560 kW	IP00	No	Optional PROFINET, PROFIBUS, Modbus, Ethernet IP	Integrated: current
SIRIUS 3RW55 soft starters	High Performance soft starter	5.5 to 1200 kW	IP00	On request	PROFINET, PROFIBUS, Modbus, Ethernet IP	Integrated: current, voltage, power

SINAMICS V20 frequency converters	Standard Performance frequency converter	0.12 to 30 kW	IP20	No	USS, Modbus RTU	Integrated: current, voltage, power, speed
SINAMICS G120C frequency converters	Standard Performance frequency converter	0.55 to 132 kW	IP20	Integrated	PROFINET IRT, PROFIsafe, PROFIenergy	Integrated: current, voltage, power
SINAMICS G120 frequency converters	Standard Performance frequency converter	0.55 to 250 kW	IP20	Integrated	Frame size FSAA 0.55 kW to FSC 18.5 kW with PROFINET, PROFIBUS DP, EtherNet/IP, USS/Modbus RTU. Frame size FSD 22 kW to FSF 132 kW with PROFINET, Ethernet/IP PROFIsafe, PROFIenergy	Integrated: current, voltage, power
SINAMICS G120X frequency converters	Industry-specific frequency converter	0.75 to 630 kW	IP20, IP21 (with roof mounting kit)	Integrated	PROFINET, PROFIBUS*, EtherNet/IP, Modbus RTU/USS*, BACnet MS/TP*, * In preparation (2019)	Integrated: current, voltage, power

You will find all information on the named products and numerous selection configurators in the Siemens Industry Mall.

mall.industry.siemens.com

The TIA Selection Tool enables error-free configuration without expert knowledge through intelligent configurators and selection wizards. Desktop and cloud versions enable cross-team collaboration with maximum flexibility.

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APS Industrial is headquartered in Melbourne and in addition has a national network of offices in Adelaide, Perth, Sydney, Brisbane and Tasmania supported by strategic local stockholdings and expert technical and application knowledge.

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